Management Strategic Plan
Framework Rare Plant Management Plan for Conserved Lands in Western San Diego County

Prepared for

San Diego Association of Governments

Prepared by

Conservation Biology Institute and AECOM
in collaboration with
San Diego Management and Monitoring Program

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EXECUTIVE SUMMARY

The Conservation Biology Institute (CBI) and AECOM Technical Services, Inc. (AECOM) worked with the San Diego Management and Monitoring Program (SDMMP) and other regional partners to prepare a Framework Rare Plant Management Plan (F-RPMP) for Management Strategic Plan (MSP) rare plants in the Management Strategic Planning Area (MSPA) in San Diego County, California. The Rare Plant Management Group Steering Committee guided development of the plan, while species Working Groups provided technical expertise (Appendix A). The plan was funded by the San Diego Association of Governments (SANDAG). The F-RPMP is a living document that will be updated over time.

The F-RPMP provides the framework to manage MSP rare plants on conserved lands in western San Diego County. This document does not replace existing NCCP obligations or requirements, and recommendations in the plan are advisory and meant to be implemented voluntarily if land owners and managers so desire. Plan recommendations are consistent with the intent of regional NCCP plans. The F-RPMP aligns directly with goals, objectives, and actions in the regional *Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: A Strategic Habitat Conservation Roadmap* (MSP Roadmap), and is informed by regional and preserve-specific monitoring data and studies.

The F-RPMP includes a general section and species-specific sections or chapters. In the general section, we discuss (1) the relationship of this plan to the MSP Roadmap and other regional plans, (2) the overall approach to rare plant management in the region, and (3) key factors for managing rare plants, including regional monitoring, research, management priorities and strategies, Best Management Practices, and potential sources of funding for management. Guidelines or recommendations in the general section are widely applicable to all MSP rare plants.

The species-specific section includes chapters for four MSP rare plants (*MSP target plants*):

- *Acanthomintha ilicifolia* (San Diego thornmint)
- *Acmispon prostratus* (Nuttall's acmispon)
- *Chloropyron maritimum* ssp. *maritimum* (Salt marsh bird's-beak)
- *Deinandra conjugens* (Otay tarplant)

The species chapters summarize information relevant to each target plant, including goals and objectives per the MSP Roadmap, life history and ecological information, status and trends, threats and stressors, genetic considerations, and regional population structure. We use this information to identify management priorities and recommendations. We compile species-specific BMPs and identify additional research needs for each target species. The SDMMP intends to prepare chapters for additional MSP rare plants in the future.

ACKNOWLEDGEMENTS

The San Diego Rare Plant Management Group Steering Committee provided guidance on the structure and content of the Framework Rare Plant Management Plan (F-RPMP), while many biologists and land managers provided expertise through species-specific working groups, interviews, and rare plant data collection (per the San Diego Management and Monitoring Program's Inspect and Manage rare plant program). All of these efforts were critical to plan development. Refer to Appendix A for a list of all participants.

In addition, the following biologists reviewed and commented on the plan:

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Dr. Kristine Preston of the San Diego Management and Monitoring Program (SDMMP) provided overall direction and resources to develop the F-RPMP, and also reviewed and commented on the plan. Emily Perkins and Annabelle Bernabe of SDMMP prepared rare plant data and graphics. Finally, the San Diego Association of Governments (SANDAG) funded development of the F-RPMP.

PHOTO CREDITS

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ABBREVIATIONS

BMP	Best Management Practice
CBI	Conservation Biology Institute
CMSP	Connectivity Monitoring Specific Plan
CNDDB	California Natural Diversity Database
CNLM	Center for Natural Lands Management
EDRR	Early Detection Rapid Response
EMP	Environmental Mitigation Program
HCP	Habitat Conservation Plan
IMG	Inspect and Manage
IPSP	Invasive Plant Strategic Plan
MOM	Master Occurrence Matrix
MSCP	San Diego Multiple Species Conservation Plan
MSP	Management Strategic Plan for Conserved Lands in Western San Diego County
MSP F-RPMP	MSP Framework-Rare Plant Management Plan for Conserved Lands in Western San Diego County
MSP priority plant	MSP rare plant in the Species Management Focus Group
MSP rare plant	Rare plant addressed in MSP Roadmap
MSP Roadmap	Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: *A Strategic Habitat Conservation Roadmap*
MSP SCBBP	MSP Rare Plant Seed Collection, Banking, and Bulking Plan for Conserved Lands in Western San Diego County
MSP target plant	MSP rare and priority plant addressed in species chapters in the F-RPMP and SCBBP
MSPA	MSP Roadmap Area
MU	Management Unit
NCCP	Natural Community Conservation Plan
PAF	Plant Assessment Form
RSA	Rancho Santa Ana Botanic Garden
SANDAG	San Diego Association of Governments
SDMMP	San Diego Management and Monitoring Program
SDNHM	San Diego Natural History Museum
SDZG	San Diego Zoo Global
TNC	The Nature Conservancy
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1.0 INTRODUCTION

The Conservation Biology Institute (CBI) and AECOM Technical Services, Inc. (AECOM), in coordination with the San Diego Management and Monitoring Program (SDMMP) and other regional partners, developed a Management Strategic Plan (MSP) Framework Rare Plant Management Plan (F-RPMP) for conserved lands in western San Diego County. This plan was funded by the San Diego Association of Governments (SANDAG), and is a living document that will be updated over time.

The F-RPMP fulfills an objective in the regional *Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: A Strategic Habitat Conservation Roadmap* (MSP Roadmap, SDMMP and The Nature Conservancy [TNC] 2017) and an achievement milestone in the *TransNet* Environmental Mitigation Program (EMP) Regional Management and Monitoring fiscal year 2019-2020 Work Plan (Strategic Goal 1.1).

The MSP Roadmap applies to conserved lands (excluding military lands) within the MSP Roadmap Area (MSPA; Figure 1) (SDMMP and TNC 2017). The MSPA is divided into 11 Management Units (MUs) to facilitate coordinated management (Figure 2). The SDMMP delineated MUs by geography, vegetation, and threats and stressors, and MU size varies significantly, with smaller MUs found near the coast and larger MUs found inland.

The MSP Roadmap addresses 57 rare plant species (*MSP rare plants*) within the MSPA (Figure 3). All of these species are covered under one or more Natural Community Conservation Plans (NCCPs). The SDMMP placed the 57 MSP rare plants into two management groups depending on the potential level of management needed for their long-term persistence: the Species Management Focus Group (32 species) and the Vegetation Management Focus Group (25 species). Species in the former category will likely require specific management measures, while species in the latter category are expected to persist by managing the vegetation community (SDMMP and TNC 2017).

The 32 MSP rare plants in the Species Management Focus Group are priorities for monitoring and management (*MSP priority plants*). These species are further categorized by potential risk of loss of either the species or significant occurrences[1] from the MSPA.

In this document, we develop species-specific management guidelines for four MSP priority plants (*MSP target plants*). Refer to Table 1 for a list of all 57 MSP rare plants. Table 1 also indicates which of these species are MSP priority and/or MSP target plants. Table 2 defines management categories for Species and Vegetation Management Focus Groups.

[1] A rare plant occurrence is similar to a 'population' without regard to whether individuals interbreed. The SDMMP follows California Natural Diversity Database (CNDDB) guidelines on defining unique occurrences based on distance (SDMMP 2019).

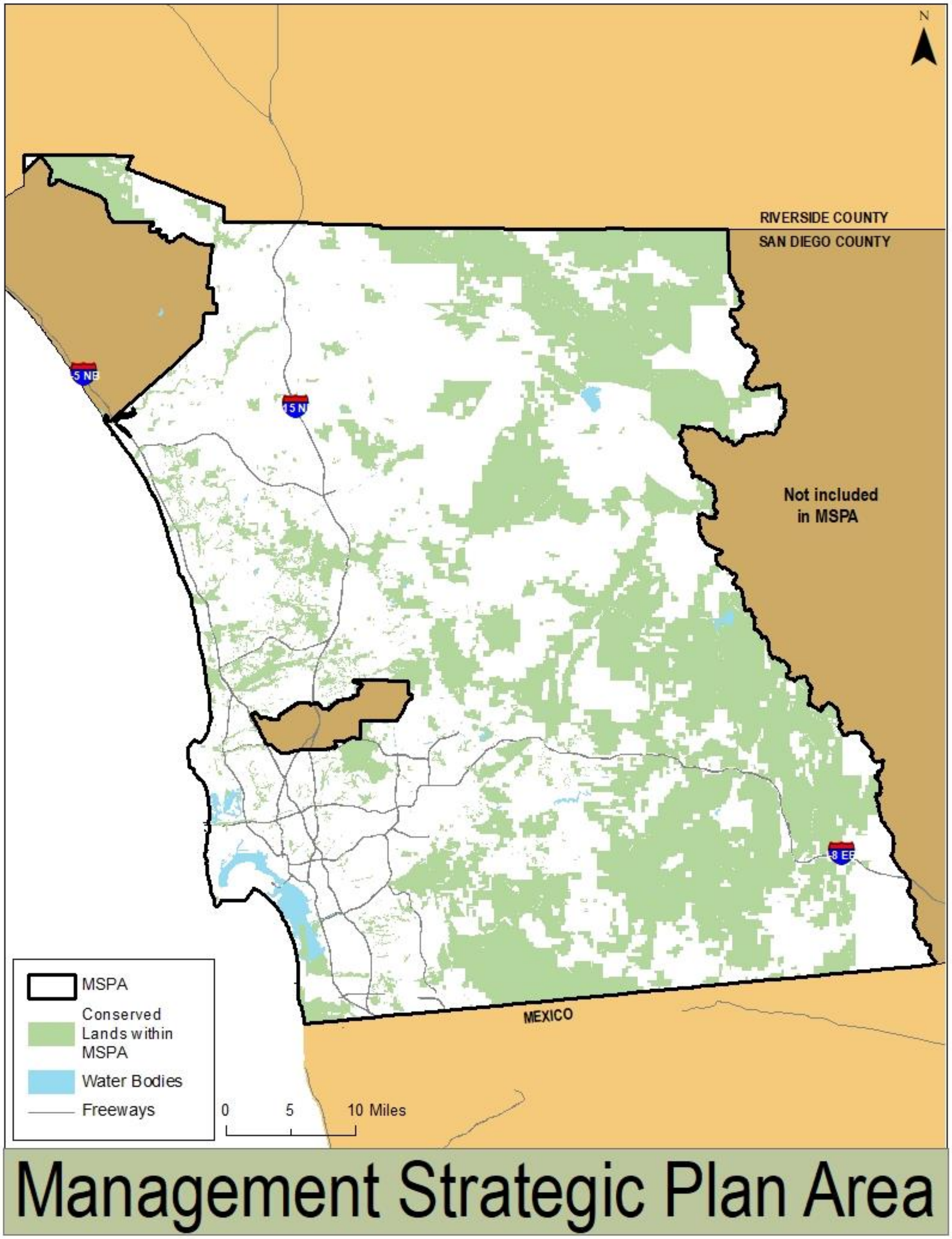


Figure 1. MSP Roadmap Area (MSPA) in Western San Diego County.

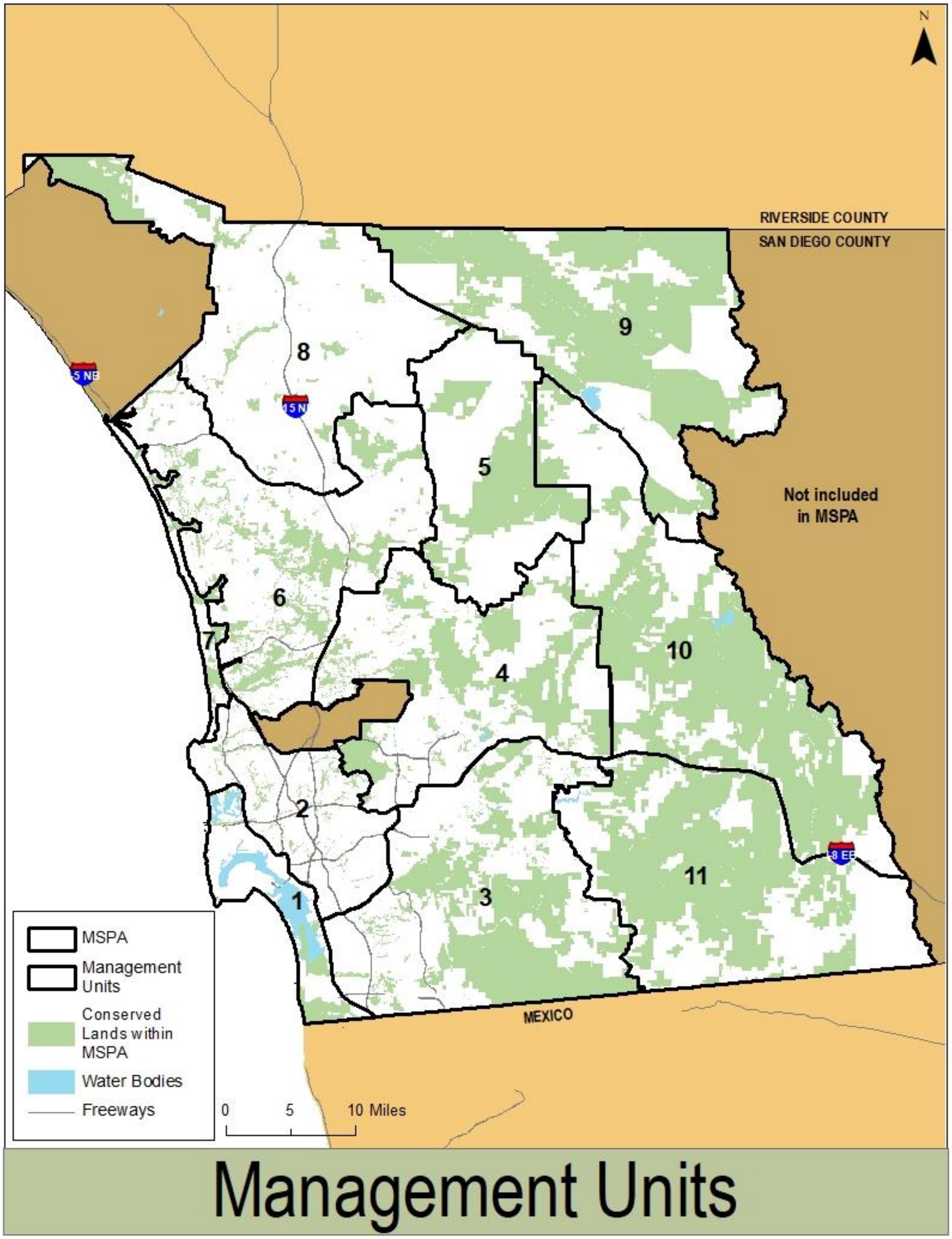


Figure 2. Management Units (MUs) within the MSPA.

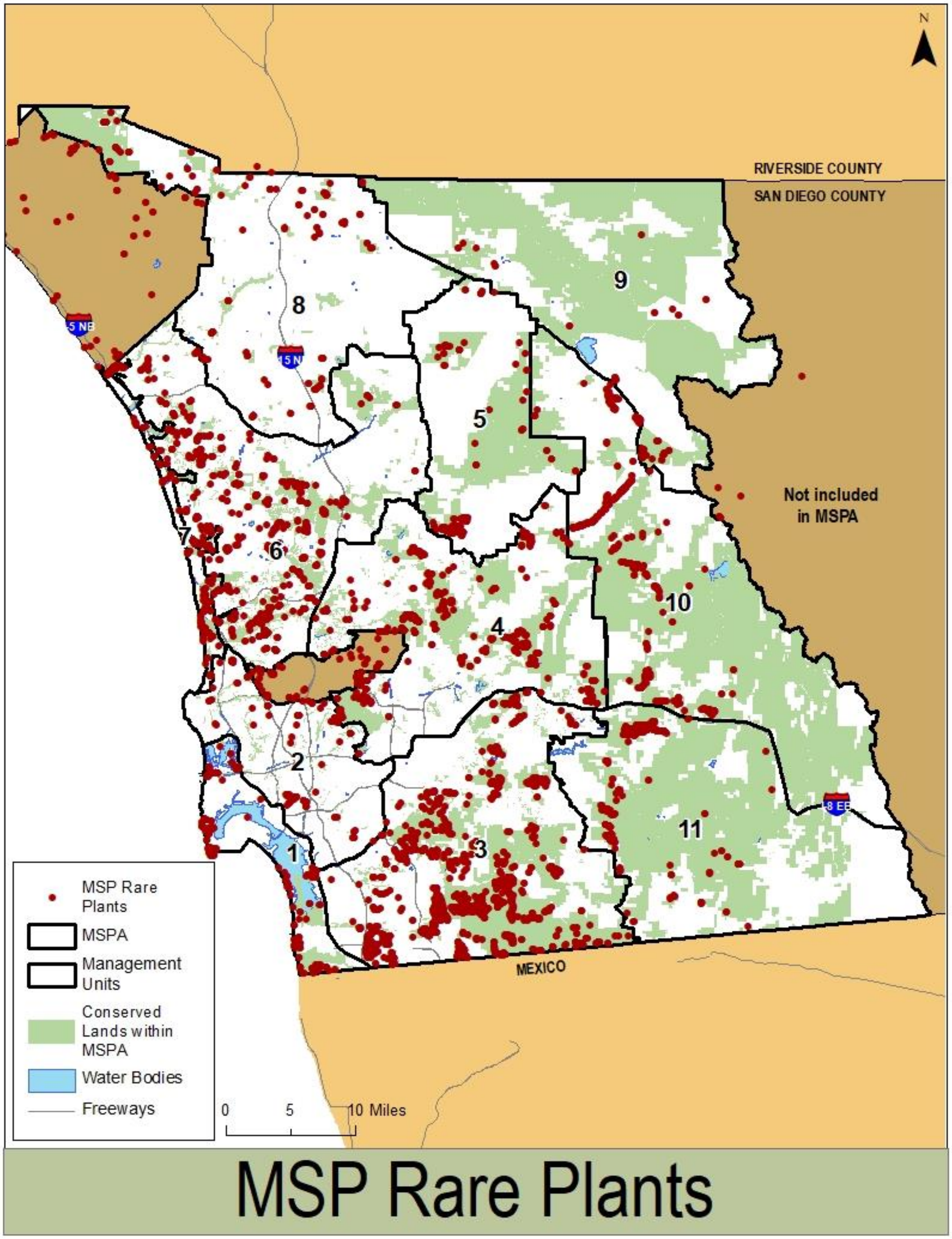


Figure 3. MSP Rare Plants Detected since 2000 within the MSPA.

Table 1. MSP Rare Plant Species.[1]

Scientific Name[2]	Common Name	Management Category[3]	MSP Rare Plants[4]	MSP Priority Plants[5]	MSP Target Plants[6]
Acanthomintha ilicifolia	San Diego thornmint	SO	✓	✓	✓
Acmispon prostratus	Nuttall's acmispon	SO	✓	✓	✓
Adolphia californica	California adolphia	VG	✓		
Agave shawii var. *shawii*	Shaw's agave	SL	✓	✓	
Ambrosia pumila	San Diego ambrosia	SO	✓	✓	
Aphanisma blitoides	Aphanisma	SL	✓	✓	
Arctostaphylos glandulosa ssp. *crassifolia*	Del Mar manzanita	VF	✓		
Arctostaphylos otayensis	Otay manzanita	VF	✓		
Arctostaphylos rainbowensis	Rainbow manzanita	VF	✓		
Atriplex coulteri	Coulter's saltbush	VF	✓		
Atriplex parishii	Parish brittlescale	VF	✓		
Baccharis vanessae	Encinitas baccharis	SO	✓	✓	
Bloomeria clevelandii	San Diego goldenstar	SS	✓	✓	
Brodiaea filifolia	Thread-leaved brodiaea	SS	✓	✓	
Brodiaea orcuttii	Orcutt's brodiaea	SO	✓	✓	
Brodiaea santarosae	Santa Rosa brodiaea	SS	✓	✓	
Calochortus dunnii	Dunn's mariposa lily	VG	✓		
Ceanothus cyaneus	Lakeside ceanothus	VF	✓		
Cenaothus verrucosus	Wart-stemmed ceanothus	VF	✓		
Centromadia parryi ssp. *australis*	Southern tarplant	VF	✓		
Chloropyron maritimum ssp. *maritimum*	Salt marsh bird's-beak	SL	✓	✓	✓
Chorizanthe orcuttiana	Orcutt's spineflower	SL	✓	✓	
Clinopodium chandleri	San Miguel savory	SL	✓	✓	
Comarostaphylis diversifolia ssp. *diversifolia*	Summer-holly	VG	✓		
Cylindropuntia californica var. *californica*	Snake cholla	VF	✓		
Deinandra conjugens	Otay tarplant	SS	✓	✓	✓
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	✓	✓	
Dudleya blochmaniae	Blochman's dudleya	SL	✓	✓	
Dudleya brevifolia	Short-leaved dudleya	SL	✓	✓	
Dudleya variegata	Variegated dudleya	SS	✓	✓	

Table 1. MSP Rare Plant Species.[1]

Scientific Name[2]	Common Name	Management Category[3]	MSP Rare Plants[4]	MSP Priority Plants[5]	MSP Target Plants[6]
Dudleya viscida	Sticky dudleya	SS	✓	✓	
Ericameria palmeri ssp. *palmeri*	Palmer's goldenbush	VF	✓		
Eryngium aristulatum var. *parishii*	San Diego button-celery	VF	✓		
Erysimum ammophilum	Coast wallflower	SL	✓	✓	
Euphorbia misera	Cliff spurge	VF	✓		
Ferocactus viridescens	San Diego barrel cactus	VF	✓		
Fremontodendron mexicanum	Mexican flannelbush	SL	✓	✓	
Hazardia orcuttii	Orcutt's hazardia	SL	✓	✓	
Hesperocyparis forbesii	Tecate cypress	VF	✓		
Iva hayesiana	San Diego marsh-elder	VG	✓		
Lepechinia cardiophylla	Heart-leaved pitcher sage	SL	✓	✓	
Lepechinia ganderi	Gander's pitcher sage	VG	✓		
Monardella hypoleuca ssp. *lanata*	Felt-leaved monardella	VF	✓		
Monardella stoneana	Jennifer's monardella	SL	✓	✓	
Monardella viminea	Willowy monardella	SL	✓	✓	
Navarretia fossalis	Spreading navarretia	VF	✓		
Nolina cismontana	Chaparral nolina	SL	✓	✓	
Nolina interrata	Dehesa nolina	SO	✓	✓	
*Orcuttia californica**	California Orcutt grass	SL	✓	✓	
Packera ganderi	Gander's ragwort	SO	✓	✓	
Pinus torreyana ssp. *torreyana*	Torrey pine	VF	✓		
Pogogyne abramsii	San Diego mesa mint	VF	✓		
*Pogogyne nudiuscula**	Otay mesa mint	SL	✓	✓	
Quercus dumosa	Nuttall's scrub oak	VF	✓		
Quercus engelmannii	Engelmann oak	VF	✓		
Rosa minutifolia	Small-leaved rose	SS	✓	✓	
Tetracoccus dioicus	Parry's tetracoccus	SS	✓	✓	

[1] MSP plant species as defined in the MSP Roadmap (SDMMP and TNC 2017).
[2] Plant species nomenclature generally follows Baldwin et al. 2012.
[3] Management Category: **SL** = at risk of loss from MSPA, **SO** = significant occurrences at risk of loss from MSPA, **SS** = stable and persistent, but require species-specific management; **VF** = limited distribution or require vegetation management, **VG** = may benefit from management for VF species. See Table 2 for full definitions.
[4] MSP rare plants = all plant species in the MSP Roadmap, which are covered under one or more NCCPs.

[5] MSP priority plants = all MSP rare plants in the Species Management Focus Group. MSP priority plants with an asterisk (*) are monitored per the Vernal Pool Management and Monitoring Plan (City of San Diego 2017) rather than the Inspect and Manage (IMG) program. All MSP priority plants are also MSP rare plants.
[6] MSP target plants = species included in the species chapters of this document. MSP target plants are also MSP rare and priority plants.

Table 2. Management Focus Groups and Categories.

Management Category[1]	Definition
Species Management Focus Group	
SL	Species at high risk of loss from MSP Roadmap Area (MSPA) without immediate management action above and beyond daily maintenance activities.
SO	Species with significant occurrence(s) at high risk of loss from MSPA without immediate management action above and beyond daily maintenance activities.
SS	Species with occurrences stable and persistence at lower risk than SL and SO species, but still require species-specific management actions.
Vegetation Management Focus Group	
VF	Species with limited distribution in the MSPA or needing specific vegetation characteristics requiring management.
VG	Species is not managed specifically, but may benefit from vegetation management for VF species.

[1] Focus group/management category designations and definitions per the MSP Roadmap (SDMMP and TNC 2017).

1.1 Overview

The F-RPMP includes a general section and species-specific sections or chapters that provide the framework to manage MSP rare plants in the MSPA. In the general section, we discuss (1) the relationship of this plan to the MSP Roadmap and other regional plans, (2) the overall approach to rare plant management in the region, and (3) key factors for managing rare plants, including:

- Regional monitoring to inform management
- Management-oriented research
- Management priorities and strategies
- Best management practices (BMPs)
- Potential funding sources

Information in the general section is broadly applicable to all MSP rare plants, with a focus on MSP priority plants. Information in the species chapters is specific to the MSP target plants:

- *Acanthomintha ilicifolia* (San Diego thornmint)
- *Acmispon prostratus* (Nuttall's acmispon)
- *Chloropyron maritimum* ssp. *maritimum* (Salt marsh bird's-beak)
- *Deinandra conjugens* (Otay tarplant)

The species chapters summarize information relevant to each MSP target plant, and identify species-specific management strategies, management actions, and BMPs. The SDMMP will prepare chapters for additional MSP priority plants in the future.

Guidelines in the F-RPMP incorporate recommendations from the western San Diego County Regional Rare Plant Management Group Steering Committee (Rare Plant Management Group Steering Committee) and species-specific Working Groups, and from monitoring, management, restoration, and research and experimental studies, among others. Refer to Appendix A for a list of Rare Plant Management Group Steering Committee and Working Group participants and the reference section for sources used to develop the F-RPMP.

1.2 Purpose and Need

San Diego County has a history of conserving and managing rare plants that dates back to at least the 1980s. A number of factors hindered the success of early efforts, such as (1) insufficient data on species biology, genetics, and ecosystem processes, (2) small preserve sizes, (3) lack of long-term monitoring and adaptive management programs, and (4) insufficient funding. Despite shortcomings, many of these early efforts contributed significantly to current management practices for rare plants.

With the approval of the San Diego Multiple Species Conservation Plan (MSCP; City of San Diego 1998) and other large-scale Natural Community Conservation Plans (NCCPs) or Habitat Conservation Plans (HCPs) in the region, a number of land owners/managers developed or expanded their rare plant monitoring and management programs. For example, the City of San Diego started monitoring rare plants on City lands in 1999. They currently monitor 20 rare plant species, including 16 MSP priority rare plant species and 4 MSP target species, and use monitoring data to develop and implement management actions for rare plant species (e.g., San Diego thornmint in Los Peñasquitos Canyon and Mission Trails Regional Park). Likewise, the Center for Natural Lands Management (CNLM) has monitored and managed rare plants on their preserves in San Diego County since 2000. Consistent monitoring provides land managers with the data to identify population trends and respond to threats in a timely fashion.

Despite the efforts of individual land managers, management and monitoring of rare plants on conserved lands in western San Diego County was generally not well coordinated before 2014. As a result, many rare plant species – or occurrences of rare plant species – have not received appropriate levels of attention. Significant milestones in regional monitoring and management in the last decade include:

2008: SANDAG established the SDMMP to coordinate management and monitoring across the region.

2013: SDMMP developed the MSP.

2014, 2015: SDMMP and partners developed and tested the Inspect and Manage (IMG) rare plant monitoring protocol for the MSP rare plant monitoring objective.

2017: SDMMP and TNC (2017) updated and expanded the MSP to create the MSP Roadmap.

The original MSP and revised MSP Roadmap presented a comprehensive approach for managing multiple species within the region by establishing biological goals and measureable objectives to implement management actions.

The IMG rare plant monitoring program has expanded since 2014 to include as many land managers (or their representatives) as possible (Table 3). The SDMMP analyzes data collected by program participants yearly to identify status and trends for MSP priority plants across the region, and these monitoring data inform the regional and preserve-level priorities and recommendations in this document.

Table 3. IMG Monitoring Program: Growth and Participation.

Attribute	Year				
	2014	2015	2016	2017	2018
Number of Species Monitored	15	19	25	17	15
Number of Occurrences Monitored	59	80	235	205	227
Number of Participating Groups[1]	---	---	39	50	42

[1] Participating groups include federal, state, and local resource or government agencies, utility companies, water districts, military installations, consulting firms, Home Owner Associations, private companies, non-profit organizations (including land conservancies), universities, and volunteers.

This F-RPMP provides a strategic approach to rare plant management that (1) identifies and prioritizes rare plant species and occurrences requiring management, (2) directs management actions and management funding where they are most needed or will be most effective, and (3) provides participating land managers with information needed to manage their occurrences effectively.

Developing the F-RPMP is possible because of the efforts of many individuals and institutions over the years, including land managers, biologists, botanists, researchers, ecologists, government and non-governmental entities, private organizations, and others that contribute or provide:

- Rare plant monitoring data
- Research or experimental studies and data
- BMPs

- Support for related activities (e.g., seed banking, propagation)
- Supplemental funding for management activities

1.3 Relationship to MSP Roadmap and other Regional Plans

There are a number of regional strategic plans or documents for western San Diego County that relate directly or indirectly to MSP rare plants. The MSP Roadmap (SDMMP and TNC 2017) is the overarching document that guides monitoring and management in the region and incorporates elements of many earlier plans. We summarize key plans below; refer to Table 4 for sources and links to these and other regional documents related to rare plant management.

Management Strategic Plan for Conserved Lands in Western San Diego County (MSP)

The MSP provides a comprehensive approach for managing multiple species within the region by establishing biological goals and measurable objectives to implement management actions (SDMMP 2013). The MSP categorizes and prioritizes species and vegetation communities, identifies geographic locations for management actions, provides specific timelines for implementation, and establishes a process for coordination and implementation. For MSP priority species, the document summarizes status, identifies management threats, develops management approaches, and outlines regional and MU goals and objectives.

The F-RPMP refines species-specific information in the MSP by updating status, threats, and management actions based on IMG monitoring data and research or other studies.

Management and Monitoring Strategic Plan for Conserved Lands in Western San Diego County: A Strategic Habitat Conservation Roadmap (MSP Roadmap)

The MSP Roadmap expands on the 2013 MSP by including monitoring, adaptive management, additional species, vegetation communities, and threats derived, in part, from other planning documents in the region (e.g., Connectivity Monitoring Strategic Plan [SDMMP 2011], Invasive Plant Strategic Plan [CBI et al. 2012]). The MSP Roadmap also includes a Wildfire Element that addresses plant fire risk and management actions, as well as databases and mapping tools ("MSP Portal") that are available on the SDMMP interactive website: https://sdmmp.com/portal.php

Preparing the F-RPMP is an objective in the MSP Roadmap (MGT-PRP-MGTPL).[2] This document addresses specific action items under this objective, including:

[2] MGT-PRP-MGTPL indicates that this is a Management (MGT) objective to prepare (PRP) a management plan (MGTPL).

Table 4. Regional Plans or Documents Related to MSP Rare Plant Management in the MSPA.[1]

Regional Plan	Source[2]	Link(s) to Document or Relevant Sections
Management Strategic Plan for Conserved Lands in Western San Diego County (MSP)	SDMMP 2013	Volume 1: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_588f7c6408184 Volume 2: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_588f7ce9c0f68 Volume 3: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_588f7d49c7d8b
Management and Monitoring Strategic Plan for Conserved Lands in western San Diego County: *A Strategic Habitat Conservation Roadmap* (MSP Roadmap)	SDMMP and TNC 2017	Volume 2A: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_590233783f742 Volume 2B: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_59024838d1636 Volume 2C: https://sdmmp.com/view_article.php?cid=CID_eperkins%40usgs.gov_590233f2e2c53
Connectivity Monitoring Strategic Plan for the San Diego Preserve System (CMSP)	SDMMP 2011 SDMMP 2014	https://sdmmp.com/view_article.php?cid=CID_tedgarian%40usgs.gov_57acfb763b9ff https://sdmmp.com/view_article.php?cid=CID_tedgarian%40usgs.gov_57acf913214cc
Management Priorities for Invasive Non-native plants: A Strategy for Regional Implementation, San Diego County, California (IPSP)	CBI et al. 2012	https://sdmmp.com/view_article.php?cid=CID_201604011922_38
Vernal Pool Management and Monitoring Plan	City of San Diego 2017	https://www.sandiego.gov/sites/default/files/vp-mmp.pdf
Framework Management Plan: Guidelines for Best Practices with Examples of Effective Monitoring and Management	Lewison and Deutschman 2014	https://sdmmp.com/view_article.php?cid=CID_201604011922_110
Adaptive Management Framework for the Endangered San Diego thornmint (*Acanthomintha ilicifolia*), San Diego County, California	CBI 2014a	https://sdmmp.com/view_article.php?cid=CiteID_1603251358356080
Otay Tarplant Management Vision	CBI 2012	https://databasin.org/groups/92c7bce8d88d43b3a800dd686195007e/ (see Supporting documents/South County grasslands/Project documents/OTP Goals and Objectives 10-29-12)

[1] Table includes only regional plans related to MSP priority plants, with a focus on the four target plants covered by this document.
[2] Source: CBI = Conservation Biology Institute, SDMMP = San Diego Management and Monitoring Program, TNC = The Nature Conservancy. Refer to reference section for full citations.

- Consult the Rare Plant Working Group Steering Committee and species-specific Working Groups for input and recommendations
- Prioritize occurrences for management
- Prioritize management actions over a 5-year timeframe
- Submit project metadata and the F-RPMP to the MSP Web Portal

In addition, the F-RPMP aligns with species-specific goals and objectives in the MSP Roadmap, including Wildfire and Connectivity elements (as appropriate).

Invasive Plant Strategic Plan (IPSP)

The IPSP is the State's first strategic plan for managing invasive plants at a regional level (CBI et al. 2012). The IPSP refined or developed Plant Assessment Forms (PAF) for 55 invasive plant species in San Diego County to reflect regional status and threats, and identified near-term management and monitoring priorities for 29 invasive plant species. The IPSP prioritized on-the-ground projects based on invasive plant impacts, with special consideration of narrow endemic plant species (including several MSP rare plants). The IPSP has been implemented regionally by the County of San Diego, Department of Weight and Measures (County). The County treats invasive plants, identifies and maps new invasive plant targets (Early Detection Rapid Response [EDRR] species), and distributes EDRR information to the conservation community: see https://sdmmp.com/view_article.php?cid=SDMMP_CID_187_5cfe79926f7b1 (Giessow 2019).

The F-RPMP recommends management actions to address priority IPSP species and other invasive plant species that impact MSP target plants (Section 4).

Connectivity Monitoring Strategic Plan (CMSP)

The CMSP addressed mammals and birds, and indicated that future revisions would address connectivity monitoring for invertebrates and plants (SDMMP 2011). The CMSP acknowledged the importance of population connectivity for demographic exchange, gene flow, species movement among core areas and patches, and shifts in geographic range in response to environmental stressors such as wildfire and climate change (SDMMP 2011).

In 2014, the SDMMP held a regional meeting to address connectivity for MSP species and pollinators, and incorporated results into the MSP Roadmap as Connectivity Element 4. The F-RPMP builds on the Connectivity Element by providing species-specific recommendations to maintain or enhance connectivity for MSP target species and pollinators.

San Diego Thornmint Adaptive Management Framework Plan

This regional framework plan reviewed status and threats, developed conceptual models for management, identified potential environmental correlates and opportunity areas for restoration, developed detailed goals and objectives, and compiled or developed BMPs and monitoring metrics for San Diego thornmint in San Diego County (CBI 2014a).

The SDMMP incorporated key elements of this plan into the MSP Roadmap. The F-RPMP will build on both the Adaptive Management Framework Plan and the MSP Roadmap by updating status and threats information, and refining opportunity areas, BMPs, and monitoring metrics for San Diego thornmint, as needed.

Otay Tarplant Management Vision

CBI, in partnership with TNC and with input from other biologists and land managers, prepared a framework for coordinated management of Otay tarplant in MU 3 of the MSPA (CBI 2012). The Otay Tarplant Management Vision identified key areas to manage or restore Otay tarplant occurrences and improve connectivity for pollinators, and developed both landscape-level and preserve-specific goals and objectives for this species.

The SDMMP incorporated elements of the Management Vision into both the MSP and MSP Roadmap. The F-RPMP updates the underlying data and assumptions and refines management priorities, objectives, and actions for Otay tarplant.

1.4 Relationship to Seed Collection, Banking, and Bulking Plan

The MSP Roadmap includes objectives to develop two closely related framework plans for rare plants: the F-RPMP and an MSP Seed Collection, Banking, and Bulking Plan for Conserved Lands in Western San Diego County (SCBBP). The F-RPMP identifies priorities, locations, and actions to manage rare plant occurrences, while the SCBBP provides guidelines to implement selected management actions. For example, where the F-RPMP calls for restoring occurrences of a target species, the SCBBP details seed collecting, banking, and bulking practices to maximize both genetic diversity and restoration success.

1.5 Relationship to Preserve Management

The F-RPMP provides the framework to manage MSP rare plants on conserved lands in western San Diego County. This document does not replace existing NCCP obligations or requirements. Further, recommendations in this plan are advisory and not required. Rather, they are to be implemented voluntarily if land owners and managers so desire. Plan recommendations are also meant to be consistent with the intent of regional NCCP plans. The F-RPMP aligns directly with goals, objectives, and actions in the MSP Roadmap, and is informed by regional and preserve-specific monitoring data and studies.

This document provides land managers with species- and occurrence-specific management strategies, priorities, actions, and BMPs for managing rare plant occurrences. In addition, rare plant occurrences monitored through the regional IMG rare plant monitoring program and prioritized for management in the F-RPMP may be eligible for funding assistance through SANDAG's *Transnet* EMP land management grants, depending on grant cycle priorities.

2.0 MANAGEMENT APPROACH

Within the San Diego region, we use a three-tiered approach to rare plant management that includes (1) regional monitoring to assess status and threats of MSP priority species, (2) regional studies (research, experiments) to fill gaps in knowledge regarding rare plant biology and management practices, and (3) monitoring and study results to set priorities for management at regional and local (preserve) levels.

2.1 REGIONAL MONITORING TO INFORM MANAGEMENT

The MSP Roadmap identifies an IMG monitoring objective for 30 of the 32 MSP priority rare plant species[3] on conserved lands within the MSPA from 2014-2021. This objective is implemented by land managers, contracted biologists, and volunteers, in coordination with the SDMMP. Participants collect data on status, habitats, and threats of rare plant occurrences using a standardized rare plant monitoring protocol (Figure 4), and submit data to the SDMMP at the end of each monitoring season. The SDMMP analyzes these data for regional trends and posts a comprehensive dataset online for use by land managers and scientists. Results inform management needs and prioritize regional funding for management.

Figure 4. IMG Rare Plant Monitoring.

Table 5 presents the IMG monitoring schedule for MSP priority plants for 2017-2021. In general, annual plant species are monitored yearly, herbaceous perennial species (including geophytes) are monitored biannually, and shrubs are monitored at 5-year intervals.

[3] Two MSP priority rare plant species are monitored through the Vernal Pool Management and Monitoring Plan (VPMMP) (City of San Diego 2017) rather than the IMG rare plant monitoring program: California Orcutt grass (*Orcuttia californica*) and Otay mesa mint (*Pogogyne nudiuscula*).

Table 5. Monitoring Schedule for MSP Priority Rare Plants.

Scientific Name	Common Name	Monitoring Frequency[1]
Acanthomintha ilicifolia	San Diego thornmint	Annually
Acmispon prostratus	Nuttall's acmispon	Annually
Agave shawii var. *shawii*	Shaw's agave	5-year intervals after 2016
Ambrosia pumila	San Diego ambrosia	2-year intervals after 2018
Aphanisma blitoides	Aphanisma	2-year intervals after 2017
Baccharis vanessae	Encinitas baccharis	2-year intervals after 2017
Bloomeria clevelandii	San Diego goldenstar	3-year intervals after 2018
Brodiaea filifolia	Thread-leaved brodiaea	2-year intervals after 2017
Brodiaea orcuttii	Orcutt's brodiaea	Annually
Brodiaea santarosae	Santa Rosa basalt brodiaea	2018
Chloropyron maritimum ssp. *maritimum*	Salt marsh bird's-beak	Annually
Chorizanthe orcuttiana	Orcutt's spineflower	Annually
Clinopodium chandleri	San Miguel savory	2-year intervals after 2016
Deinandra conjugens	Otay tarplant	Annually
Dicranostegia orcuttiana	Orcutt's bird's-beak	Annually
Dudleya blochmaniae	Blochman's dudleya	Annually
Dudleya brevifolia	Short-leaved dudleya	Annually
Dudleya variegata	Variegated dudleya	2-year intervals after 2016
Dudleya viscida	Sticky dudleya	5-year intervals after 2016
Erysimum ammophilum	Coast wallflower	2-year intervals after 2017
Fremontodendron mexicanum	Mexican flannelbush	3-year intervals after 2019
Hazardia orcuttii	Orcutt's hazardia	2-year intervals after 2016
Lepechinia cardiophylla[2]	Heart-leaved pitcher sage	2-year intervals after 2019[2]
Monardella stoneana	Jennifer's monardella	3-year intervals after 2016
Monardella viminea	Willowy monardella	Annually
Nolina cismontana	Chaparral nolina	5-year intervals after 2019
Nolina interrata	Dehesa beargrass	5-year intervals after 2017
Orcuttia californica[3]	California Orcutt grass	Annually
Packera ganderi	Gander's ragwort	3-year intervals after 2018
Pogogyne nudiuscula[3]	Otay mesa mint	Annually
Rosa minutifolia	Small-leaved rose	5-year intervals after 2016
Tetracoccus dioicus	Parry's tetracoccus	3-year intervals after 2019

[1] Per the SDMMP Inspect and Manage (IMG) monitoring schedule from 2017-2021: https://sdmmp.com/view_article.php?cid=CID_kpreston@usgs.gov_59fb526f6814f

[2] Monitor species if extant occurrences are discovered.

[3] Monitor and manage species per Vernal Pool Monitoring and Management Plan (City of San Diego 2017).

This schedule is informed by monitoring results and available funding, and may change in the future. During each year, the goal is to monitor as many MSP priority rare plant species (per the schedule) and occurrences as possible to ensure a comprehensive dataset across the region.

The IMG rare plant monitoring protocol and data are available at:

> https://sdmmp.com/view_project.php?sdid=SDID_sarah.mccutcheon%40aecom.com_57cf0196dff76

2.2 Regional Studies to Inform Management

Species-specific research or experimental studies complement monitoring data by addressing issues related to conservation and management in greater detail. Management strategies and actions in this document are informed by studies on genetics, hydrology, invasive plants, pollinators, habitat suitability and climate scenario modeling, restoration experiments, seed biology, and soil characteristics. We describe the value of these studies for rare plant management and discuss specific studies briefly in Section 3, and incorporate relevant findings into species chapters (Section 4).

2.3 Regional and Preserve-level Management Priorities

Regional management is intended to benefit a species throughout the MSPA, whereas preserve-level (local) management benefits an occurrence directly, rather than the species as a whole. We structure management priorities in a step-wise fashion at multiple scales to ensure the long-term persistence of MSP rare plants and occurrences within the MSPA. Regional and preserve-level management priorities are based primarily on the results of regional monitoring and research. At the regional level, we also consider other factors, such as regional population structure (Section 3.6).

In general, regional management priorities address threats that affect multiple occurrences across preserve boundaries (e.g., fire, connectivity, widespread invasive species), while preserve-level management priorities apply to a specific preserve or occurrence (e.g., trampling, erosion).

Management actions to address regional management priorities can be implemented by regional entities or partners working across the region, by a land manager on one or multiple preserves, or by multiple land managers working together on multiple preserves. Examples of regional management priorities include:

- Identify species/occurrences to manage based on IMG rare plant monitoring data
- Identify threats that are best managed regionally or across preserve boundaries
- Develop/refine habitat suitability models
- Identify habitat that functions as refugia from threats or accommodates species migrations

- Conduct research to fill gaps in species knowledge and inform management
- Conduct experimental studies to develop or refine BMPs
- Develop a permanent seed source (seed bank) for conservation and propagation
- Maintain monitoring data in a centralized location (i.e., SDMMP)

Management actions to address preserve-level management priorities can be carried out by land managers or other responsible entities. Where occurrences straddle preserve boundaries, it may be appropriate to manage on multiple preserves and/or across preserve boundaries, with coordination between land managers. Note that some land managers may have legal requirements to monitor and manage occurrences that are not otherwise prioritized for management. In addition, managing marginal occurrences may increase their value over time, particularly if threats are controlled and the occurrence is stabilized. Examples of preserve-level management priorities include:

- Assess status and trends and identify threats
- Conduct routine management to address threats and monitor response
- Reintroduce seed to increase population size
- Conduct preserve-specific experiments to develop or refine BMPs for management

3.0 GENERAL FRAMEWORK FOR SPECIES MANAGEMENT

This section summarizes the types of information needed to develop a framework plan for management. For many MSP rare plants, this information has been collected during the IMG monitoring program, surveys, or research or experimental studies. Where data gaps exist, we base assumptions on the best available information with the understanding that F-RPMP will be refined as data gaps are filled. Table 6 lists information available for the MSP target plants.

3.1 Life History and Ecological Information

Life history includes traits or attributes that affect survival and reproduction (e.g., growth form, dispersal mode, breeding system). In the context of rare plant management, we focus on attributes that influence species persistence, such as habit, population structure, floral display/plant size, reproductive strategy, and gene flow, among others. The focus is on identifying measurable aspects of species response for monitoring and to inform management actions. Key attributes may differ between species.

Ecological information refers to biotic or abiotic factors that influence a species or function as indicators for species presence. This information is used to identify potential habitat, refine species distribution models, and target appropriate sites to survey for new occurrences or reintroduce, introduce, or translocate occurrences.

3.2 Species Status and Trends

Species status considers both the current and historic distribution of a species across its range. We use this information to identify species that are geographically and edaphically restricted, determine whether occurrences are extant or extirpated, and assess survey coverage. Information on species status is used with other data to identify environmental covariates and threats and develop or refine species distribution models.

We consider the size of an occurrence when assessing trends across a species. As discussed in later sections, large occurrences are generally more resilient to stochastic events than small occurrences and can serve as a source of genetic diversity through gene flow or propagules (seed, corms) to conserve or restore a species. For some species, the size of an occurrence fluctuates widely on a spatial or temporal basis, often in response to climatic factors.

General Terms

Abiotic: A nonliving entity such as climate or soil that influences or affects an ecosystem or biotic (living) organisms.

Biotic: A living entity, such as a plant or animal, or the effect of that organism on an ecosystem.

Edaphic: Related to or influenced by soil.

Extant: Still in existence or living; not lost or destroyed.

Extirpated: Lost or destroyed; generally refers to an occurrence.

Resilience: The ability of a species or occurrence to recover or return to a previous state following disturbance.

Stochastic: A random event or variable that cannot be predicted (e.g., fire, flooding).

Table 6. Information Available for MSP Target Species.

Information Needs	Attribute	Status[1,2]			
		ACIL	ACPR	COMAM	DECO
Life History & Ecological Information	Habit	✓	✓	✓	✓
	Population structure	✓	✓	✓	
	Population fluctuations	✓	✓	✓	✓
	Population trends	✓	✓	✓	✓
	Germination/establishment requirements	✓	✓	✓	✓
	Reproductive mode	✓		✓	✓
	Pollination ecology	✓		✓	✓
	Dispersal mode, dispersal agents	✓		✓	
	Seed biology	✓	✓	✓	✓
	Geographic or edaphic restrictions	✓	✓	✓	✓
	Hydrology	N/A	N/A	✓	N/A
	Vegetation	✓	✓	✓	✓
Species Status & Trends	Current locations	✓	✓	✓	✓
	Historic locations	✓	✓	✓	✓
	Population status (extant, extirpated)	✓	✓	✓	✓
	Population	✓	✓	✓	✓
	Species distribution model	✓	---	---	✓
Threats and Stressors	Varied (IMG data)	✓	✓	✓	✓
Genetics	Genetic diversity	✓	---	✓	✓
Regional Population Structure	Gaps/opportunities for gene flow, connectivity, expansion	✓	---	---	✓
BMPs	Management methods	✓	✓	✓	✓

[1] ACIL = San Diego thornmint (*Acanthomintha ilicifolia*), ACPR = Nuttall's acmispon (*Acmispon prostratus*), COMAM = salt marsh bird's-beak (*Chloropyron maritimum* ssp. *maritimum*), DECO = Otay tarplant (*Deinandra conjugens*).

[2] Status of species-specific information: ✓ = some information available; --- = no information available; N/A = not applicable to species.

Further, species that form a persistent soil seed bank may express only a portion of the total occurrence at a given time. Nonetheless, estimates of size can indicate the potential resilience of an occurrence in a regional context, particularly when expressed as size classes, collected over time, correlated to environmental variables, and compared to other occurrences monitored during the same year.

3.3 Threats and Stressors

Threats and stressors are defined as 'processes that may impact MSP species and necessitate the need for management to ensure species persistence' (SDMMP 2013, SDMMP and TNC 2017). In the MSP Roadmap, the terms 'threat' and 'stressor' are used interchangeably. Threats and stressors may be (1) natural or anthropogenic, (2) past (historical), ongoing, and/or likely to occur in the future, and (3) regional or local (preserve-level) in scale. Examples of regional threats include climate change or altered fire frequency. Examples of local threats include off-highway vehicles or unauthorized access.

Table 7 lists threats identified in the MSP Roadmap (with some modifications specific to rare plants). From 2014-present, the IMG monitoring program has collected specific threats information for MSP priority rare plant occurrences. We briefly describe the potential effects of these threats on rare plants below and summarize these in Table 8. Refer to the MSP Roadmap, Volume 2B for an expanded discussion of threats and stressors in the MSPA (SDMMP and TNC 2017) and Section 4 for threats and stressors documented for MSP target species.

Table 7. Regional and Preserve-level Threats and Stressors.

Threat/Stressor	Landscape Scale
Altered Fire Regime	Regional, Preserve
Altered Hydrology/Erosion	Regional, Preserve
Climate Change	Regional
Herbivory and Predation	Preserve
Human Use of Preserves	Preserve
Invasive Animal Species	Regional, Preserve
Invasive Plant Species	Regional, Preserve
Loss of Connectivity	Regional, Preserve
Loss of Genetic Diversity	Regional, Preserve
Urban Development	Regional, Preserve
Nitrogen Deposition	Regional

Table 8. Potential Effects of Threats and Stressors on MSP Rare Plants and Habitat.[1]

Threat/Stressor	Potential Impact													
	Fire Frequency	Fire Intensity	Invasive Plants	Plant Diversity	Plant Fitness	Pollinators	Precipitation	Reproduction	Soil Biology	Soil Seed Bank	Species Mortality	Temperature	Vegetation	Water
Altered Fire Regime	✓	✓	✓	✓	✓	✓		✓		✓	✓		✓	
Altered Hydrology/Erosion			✓		✓			✓		✓	✓			✓
Climate Change	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Herbivory and Predation								✓		✓	✓			
Human Use of Preserves	✓		✓		✓	✓		✓			✓		✓	
Invasive Animal Species						✓		✓		✓	✓			
Invasive Plant Species	✓	✓		✓	✓	✓		✓	✓	✓			✓	✓
Loss of Connectivity	✓	✓	✓	✓	✓	✓		✓					✓	
Loss of Genetic Diversity					✓			✓			✓			
Urban Development	✓	✓	✓	✓	✓	✓		✓	✓		✓		✓	✓
Nitrogen Deposition	✓	✓	✓	✓	✓				✓				✓	✓

[1] ✓ = potential impact.

Altered Fire Regime

Altered fire regimes impact MSP rare plants and habitats by killing species directly, reducing the soil seed bank, providing gaps for invasive species to colonize, and converting habitat to less desirable types. By artificially suppressing fire, we increase fuel loads and fire intensity. However, overly frequent fires prevent plants from maturing, reproducing, and contributing to the seed bank, and can promote invasion of nonnative grasses and forbs. In addition, nonnative grasses may increase fire intensity by introducing (or increasing) fine fuels into the system. Altered fire regimes can act at regional and preserve-levels.

Fuel modification is a fire-related threat that may impact rare plants at the preserve-level. Thinning or eliminating vegetation lessens fuel loads, but may impact rare plants directly and create gaps for invasive species.

Altered Hydrology/Erosion

Altered hydrology and erosion can threaten MSP rare plants and habitats in or near wetlands or drainages, on steep terrain, and on erodible soils. For example, urban runoff that increases soil moisture or flows in drainages may create conditions unsuitable for the target species and suitable for invasive plants. Likewise, erosion along roads, gullies, or slopes may undercut individual plants or remove the soil seed bank.

Climate Change

Climate change may adversely affect plant species in various ways, including (1) altered climatic conditions (e.g., temperature, rainfall) that may affect a species' ability to persist in a given location; (2) shifts in flowering times that may result in lower pollination success, loss of compatible pollinators, or increased hybridization; (3) altered photosynthetic rates and nutrient uptake that may result in increased growth and competition or an increase in herbivores; (4) increased rate of spread of invasive species that may outcompete rare plant species; and (5) increased fire frequency that may result in loss of individuals or habitat type conversion (Anacker et al. 2013, Loarie et al. 2008, Parmesean and Yohe 2003, Walther et al. 2002, and others). In addition, climate change poses a particular threat to plants due to their relative lack of mobility. While plant species' ranges shift naturally, the rate of shift may be outpaced by changing climatic conditions, thus affecting the ability of some species to persist. The most vulnerable species are those that occur in small populations, are limited in distribution, or are closely associated with certain habitats or edaphic conditions (Loarie et al. 2008). For the latter, the presence of suitable habitat near existing habitat and within range of dispersal capabilities may be important to long-term survival.

Herbivory and Predation

Herbivory is a type of predation in which animals consume plant materials. This interaction may or may not be fatal to the organism being consumed. Indeed, some interactions may be positive for the plant (e.g., insects or small mammals gathering and dispersing seed). With respect to rare plants, we refer to both herbivory and seed predation. Herbivory poses a threat to rare plants when it impacts the ability of an individual to survive and/or reproduce. Likewise, seed predation that results in loss of reproductive potential (e.g., seed that is killed or too damaged to germinate) may affect the long-term persistence of a species that relies on a soil seed bank for survival.

Human Use of Preserves

Human use of preserves can impact rare plants directly (e.g., habitat degradation, trampling) or indirectly (e.g. introducing invasive species, increasing fire risk). Land managers, biologists, utility service staff, fire agency personnel, and recreational users may all impact rare plant occurrences. We also consider past activities where their effects persist on the landscape.

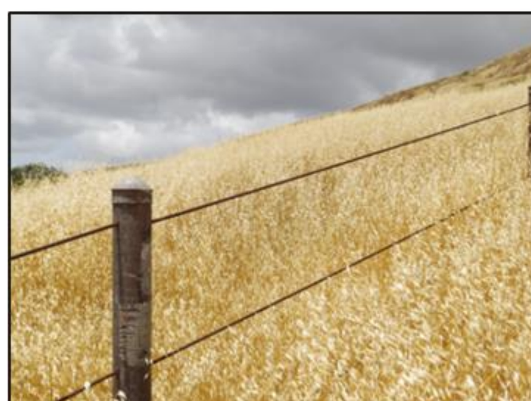
Monitoring, Management, and Maintenance Activities. Personnel involved in monitoring, managing, and maintaining rare plant occurrences may introduce invasive species on boots, clothing, equipment, and vehicle tires, or trample target species or habitat.

Recreational Use/Unauthorized Trails. Recreational users can spread invasive species on boots, clothing, bike tires, or dogs. In addition, recreational uses may inadvertently damage or kill MSP rare plants by trampling plants and habitat and increasing fire risk.

Road Maintenance. Authorized road maintenance activities (e.g., grading, blading) may threaten rare plants where they remove native vegetation or impact MSP rare plants directly.

Utilities (power lines, transmission towers). Utility companies may threaten rare plants during operational activities by removing vegetation, running over plants, and introducing invasive species on vehicle tires or equipment.

Past Agricultural Activities. Agricultural activities often convert native vegetation to less desirable (nonnative) associations (habitat type conversion). The legacy of these activities persists in many areas, as evidenced by a high cover nonnative grasses, forbs, and thatch.



Invasive Animal Species

A number of invasive animal species may impact MSP species in the MSPA. The SDMMP is currently developing a regional invasive animal species management plan that will provide clear next steps for managing these species. In this section, we discuss two invasive animals known to impact or potentially impact MSP plant species: Argentine ant (*Linepithema humile* [formerly *Iridomyrmex humilis*]) and feral pigs (*Sus scrofa*). Refer to the MSP Roadmap, Volume 2b for an expanded discussion of invasive species and their impacts in the MSPA.

Argentine Ants. While there has been much attention on the adverse effects of Argentine ants on native ants and animal species that rely on them (Holway and Suarez 2006, Suarez et al. 1998), this invasive ant may affect some MSP rare plants, as well. In a literature review of the effects of Argentine ants on rare plants, CBI (2000) identified the following, potential impacts:

- Argentine ants may reduce the numbers of native insect species and individuals present in inflorescences, resulting in decreased pollination and seed output.
- Argentine ants may alter the spatial distribution of seeds, thereby reducing the percentage of seeds that germinate and establish, while increasing seed predation. Over time, this could deplete the soil seed bank.

LeVan et al. (2014) demonstrated that Argentine ants likely decreased the number of seeds produced by San Diego barrel cactus (*Ferocactus viridescens*) by displacing native ants and deterring pollinators. Argentine ants are a particular concern for ant-pollinated plants, which are characterized by (1) a prostrate or low-growing habit, (2) small, inconspicuous flowers close to the stem, (3) intertwining plants, (4) few seeds per flower, and (5) small pollen volume and nectar quantity (Hickman 1974). Using these criteria, cushion plants such as Orcutt's spineflower (*Chorizanthe orcuttiana*) could be at-risk.

Feral Pigs. Feral pigs have been eliminated or nearly eliminated from San Diego County (Jones 2016). Nonetheless, we include pigs as a potential threat in the event that the pig population increases in the future. The rooting activities of feral pigs destroy native plants, including above-ground biomass and below-ground structures such as bulbs or corms (Tremor 2013, CBI 2009).

Invasive Plant Species

Nonnative, invasive plants pose one of the greatest threats to the biological integrity of preserve lands because of their ability to displace native species, degrade wildlife habitat, and alter ecosystem processes (e.g., Belnap et al. 2005, Ehrenfeld 2003, Evans et al. 2001, Cox 1999, Wilcove et al. 1998, D'Antonio and Vitousek 1992, Huenneke et al. 1990, Vitousek 1990). Monitoring data indicate that invasive plants are currently the greatest threat to MSP rare plants monitored through the IMG program. New invasive species are detected in the region often. While some may never impact rare plants, others may have an adverse effect immediately, after a lag period, or in response to an event (e.g., wildfire) that allows their numbers to increase rapidly.

Loss of Connectivity

Loss of connectivity occurs when habitat is fragmented into small, isolated patches. Fragmentation that limits seed dispersal or pollinators may reduce or prevent gene flow among populations. Over time, this may result in lower genetic diversity or an increase in inbreeding in a population that reduces its fitness or adaptive potential. While local adaptations may not be problematic over the short-term, they may be maladaptive over the long-term because of rapidly changing environmental conditions.

Loss of Genetic Diversity

Rare plants may face adverse genetic consequences that affect long-term persistence as a result of isolation, small population size, or hybridization. Isolation and small population size may both lead to a loss of genetic diversity and decreased fitness (Section 3.4). Effects of hybridization are negative if rare species are replaced by hybrids or reproduction is inhibited by maladapted genes (e.g., Todesco et al. 2016, Levin et al. 1996, Ellstrand 1992).

One of the primary evolutionary-based mechanisms to slow or stop the decline of small populations is *genetic rescue*, which improves gene flow by introducing new genetic material into a population (Whiteley et al. 2015). This process tends to increase heterozygosity, mask deleterious alleles, and improve long-term evolutionary potential (Hedrick and Garcia-Dorado 2016, Frankham 2015). However, genetic rescue may be harmful if there is a significant risk of outbreeding depression (e.g., unresolved taxonomy, fixed chromosomal differences, and/or local adaptation).

Conversely, *evolutionary rescue* is the process of adaptation that allows local populations to recover from environmentally induced demographic effects that would have otherwise caused extinction (Carlson et al 2014). However, the effectiveness of selection may be limited in small populations. In other words, relying solely on adaptation from existing genetic variation may not benefit small, isolated populations over the long-term (Lopez et al. 2009).

Urban Development

Urban development may impact rare plants directly or indirectly by degrading habitat, killing or damaging individuals, or altering abiotic conditions (e.g., soil, hydrology). Examples include dumping trash, clearing vegetation, and introducing nonnative species (including horticultural plantings). Small habitat patches are particularly vulnerable to impacts near the urban-preserve interface (edge effects), including altered physical conditions (Pickett et al. 2001, Saunders et al. 1991) and fire regimes (Keeley and Fotheringham 2001), increased invasions by invasive species (Mount and Pickering 2009, Wichmann et al. 2009, Suarez et al. 1998, Brothers and Spingarn 1992), and recreational impacts (e.g., Pickering et al. 2010, Esby et al. 2011, Pickering et al. 2010).

Nitrogen Deposition

Nitrogen deposition can degrade sensitive ecosystems (Weiss 2006). Impacts may be direct or indirect, and include decreased plant function, altered plant community composition, nonnative species invasions, toxicity to freshwater species, eutrophication of water bodies, and loss of biodiversity (e.g., Weiss 2006, Fenn et al. 2005, Fenn et al. 2003, Allen et al. 1998). Impacts most relevant to rare plants include an increase in nonnative annual species (particularly, invasive grasses) and subsequent alteration of fire regimes (grass-fire cycle), and a decrease in native plant species (Ochoa-Hueso et al. 2011, Fenn et al. 2010, Rao et al. 2010, D'Antonio and Vitousek 1992).

3.4 Genetics

Genetic studies provide critical information for managing the genetic structure of MSP rare plant species to improve their potential to persist and adapt to changing climatic conditions. Key metrics include genetic differentiation among occurrences, genetic diversity within occurrences, inbreeding and relatedness among individuals, and differences in ploidy levels that may influence breeding and survivorship. We can use results to develop management strategies to improve gene flow among and within occurrences (as appropriate), increase genetic diversity, and identify genetically appropriate sources of plant material (e.g., seed) to conserve or restore species.

Genetic studies have been conducted for a number of MSP priority rare plants, including three MSP target plants. These studies used different methodologies, but all provided information and recommendations to conserve and manage species. Recent genetic studies for MSP target plants are summarized below. Table 9 summarizes genetic parameters measured in these studies. Table 10 lists representative regional and species-specific studies (including but not limited to genetic studies) related to the four MSP target plants within the MSPA.

Genetic Terms

Allele: One of a pair of genes on a chromosome.

Allelic Diversity: Average number of alleles per locus in a population; a measure of genetic diversity.

Flow Cytometry: Lab technique to measure physical, chemical characteristics of cells.

Gene Flow: Movement of genetic material (e.g., seed, pollen) within or between occurrences.

Genetic Bottleneck: A reduction in population size that results in loss of genetic variation.

Genetic Differentiation: Difference in allele frequencies from one location to another.

Genetic Diversity: Amount and variability of genetic information within and among individuals.

Inbreeding: Mating between relatives.

Inbreeding Depression: Reduced population fitness due to inbreeding, which may genetic diversity.

Isozymes: Variants of the same enzyme; differences allow them to be used as molecular markers to identify low levels of genetic variation.

Ploidy: Number of sets of chromosomes in a cell.

Population Genomic Surveys for Six Rare Plant Species

The U.S. Geological Survey (USGS), in partnership with the San Diego Natural History Museum (SDNHM), conducted a region-wide study to measure the current status of genetic diversity for six MSP rare plant species (Milano and Vandergast 2018):

- San Diego thornmint
- Encinitas baccharis (*Baccharis vanessae*)
- Salt marsh bird's-beak
- Otay tarplant
- Orcutt's bird's-beak (*Dicranostegia orcuttiana*)
- Willowy monardella (*Monardella viminea*)

Table 9. Genetic Parameters Assessed in Key Genetic Studies.[1]

Genetic Parameter[2]	Scale	Metrics[3]	Cause(s)	Potential Negative Consequence(s)[4]	Management Trigger
Genetic Differentiation	Among occurrences	F_{ST}, IBD, genetic clustering	Loss of connectivity, isolation by distance, different ploidy levels, locally adapted traits.	Reduced ability to adapt to changing conditions or stochastic events.	**High** Genetic Differentiation
Genetic Diversity	Within occurrences	H_e, number of private alleles	Small founder size; genetic bottlenecks.	Increased extinction risk; low adaptive potential.	**Low** Genetic Diversity
Inbreeding & Relatedness	Among individuals	F_{IS}, r	Small population size.	Reduced fitness of offspring.	**High** Inbreeding & Relatedness
Ploidy level	Among individuals	Peak ratio	Cellular mutation; hybridization.	Reduced compatibility, fitness, and survivorship.	**Multiple** Ploidy Levels

[1] Refer to Milano and Vandergast (2018), DeWoody et al. (2018), and CNLM (2014) for detailed descriptions of genetic terms, testing methods, results, and recommendations summarized in this document.
[2] Genetic Parameter: indicates parameter tested in genetic studies.
[3] Metrics (per Milano and Vandergast 2018, DeWoody et al. 2018, and CNLM 2014):
Genetic Differentiation: $\boldsymbol{F_{ST}}$ = pairwise genetic differentiation; **IBD** = Isolation by distance.
Genetic Diversity: $\boldsymbol{H_e}$ = expected heterozygosity.
Inbreeding & Relatedness: $\boldsymbol{F_{IS}}$ = inbreeding; $\boldsymbol{r}$ = relatedness.
[4] Potential Negative Consequences: indicates consequence(s) that may require management actions. For some parameters (e.g., ploidy levels), consequences may be negative, neutral, or beneficial, depending on circumstance.

This study estimated the amount of genetic differentiation across each species' range. In addition, it identified occurrences with low genetic diversity and isolated occurrences potentially subject to inbreeding or genetic bottlenecks, as well as areas that are rich sources of allelic diversity (Milano and Vandergast 2018).

The USGS and SDNHM also worked with genetic and species experts to identify a framework and strategies and actions to manage these species, based on study results and cumulative knowledge about the species' distribution, biology, and threats in the region (Milano and Vandergast 2018). We incorporate results and recommendations from this study into species' chapters (Section 4) and the SCBBP.

Table 10. Relevant Studies of MSP Target Plants.

Target Species[1]	Research or Study	Source[2]
Genetics		
ACIL	Genetic studies of San Diego thornmint (*Acanthomintha ilicifolia*) to inform restoration practices	CNLM 2014
ACIL	Spatially explicit and multi-sourced genetic information is critical for conservation of an endangered plant species, San Diego thornmint (*Acanthomintha ilicifolia*)	DeWoody et al. 2018
ACIL, COMAM, DECO	A report of genetic sample collections and curation for six rare plants within the San Diego MSPA	SDNHM 2018
ACIL, COMAM, DECO	Population genomic surveys for six rare plant species in San Diego County, California	Milano and Vandergast 2018
COMAM	Genetic variation and the reintroduction of *Cordylanthus maritimus* ssp. *maritimus* to Sweetwater Marsh, California	Helenurm and Parsons 1997
DECO	A comparison of *Hemizonia conjugens* (Otay tarplant) with two closely related tarplant species using enzyme electrophoresis and soil textural analysis	Bauder and Truesdale 2000
Hydrology		
COMAM	Adaptive management assists reintroduction as higher tides threaten an endangered salt marsh plant	Noe et al. 2019
COMAM	Factors affecting reestablishment of an endangered annual plant at a California salt marsh	Parsons and Zedler 1997
COMAM	Impact of sea level rise on plant species: a threat assessment for the central California Coast	Berlin et al. 2012
COMAM	Salt marsh bird's-beak soil and hydrology assessment, Naval Base Ventura County Point Mugu, California	Tetra Tech 2017
Invasive Plants		
ACIL	*Brachypodium* control, phases I and II	CBI 2014b, 2017a
ACIL	Direct and indirect effects of precipitation, nitrogen, and management on *Acanthomintha ilicifolia*	Rice 2017
ACPR	Nuttall's lotus: final report	Redfern and Flaherty 2018
COMAM	Effects of the non-native grass, *Parapholis incurva* (Poaceae), on the rare and endangered hemiparasite, *Cordylanthus maritimus* subsp. *maritimus* (Scrophulariaceae)	Fellows and Zedler 2005
Pollinators		
ACIL	Autecology of San Diego thornmint (*Acanthomintha ilicifolia*)	Bauder and Sakrison 1997
ACIL	Pollinator study of Lakeside ceanothus (*Ceanothus cyaneus*) and San Diego thornmint (*Acanthomintha ilicifolia*)	Klein 2009

Table 10. Relevant Studies of MSP Target Plants.

Target Species[1]	Research or Study	Source[2]
ACIL, DECO	Arthropod ecosystem services as indicators of ecosystem health and resiliency for conservation management and climate change planning	Marschalek and Deutschman 2016
COMAM	Conservation of salt marsh bird's beak (*Chloropyron maritimum* subsp. *maritimum*)	Knapp and Schneider 2017
COMAM	Pollinator effectiveness and ecology of seed set in *Cordylanthus maritimus* subsp. *maritimus* at Point Mugu, California	Lincoln 1985
COMAM	Factors affecting reestablishment of an endangered annual plant at a California salt marsh	Parsons and Zedler 1997
Modeling		
ACIL	Adaptive management framework for the endangered San Diego thornmint, *Acanthomintha ilicifolia*, San Diego, California	CBI in collaboration with SDMMP 2014
ACIL	Uncertainty in assessing the impacts of global change with coupled dynamic species distribution and population models	Conlisk et al. 2013
ACIL, DECO	Enhancing the resilience of edaphic endemic plants	CBI 2018
COMAM	Impact of sea level rise on plant species: a threat assessment for the central California coast	Berlin et al. 2012
DECO	A conceptual model for Otay tarplant (*Deinandra conjugens*)	Strahm 2012
Restoration Experiments		
ACIL	*Brachypodium* control, phases I and II	CBI 2014b, 2017a
ACIL, DECO	Year 3 final annual report for the Central City Preserve Otay tarplant and San Diego thornmint restoration and enhancement program	RECON 2014
ACPR	Nuttall's lotus: final report	Redfern and Flaherty 2018
COMAM	Genetic variation and the reintroduction of *Cordylanthus maritimus* ssp. *maritimus* to Sweetwater Marsh, California	Helenurm and Parsons 1997
COMAM	Adaptive management assists reintroduction as higher tides threaten an endangered salt marsh plant	Noe et al. 2019
COMAM	Factors affecting reestablishment of an endangered annual plant at a California salt marsh	Parsons and Zedler 1997
DECO	Sweetwater Reservoir vernal pool and Otay tarplant restoration status report	RECON 2008, 2009
DECO	Otay tarplant habitat experimental project	CBI 2017b
DECO	South County grasslands project, phase II	Land IQ and CBI 2015

Table 10. Relevant Studies of MSP Target Plants.

Target Species[1]	Research or Study	Source[2]
Seed Biology		
ACIL	Autecology of San Diego thornmint (*Acanthomintha ilicifolia*)	Bauder and Sakrison 1997
ACIL	Mechanisms of persistence of San Diego thornmint (*Acanthomintha ilicifolia*)	Bauder and Sakrison 1999
ACIL	San Diego thornmint seed and common garden study	Lippett et al. no date
ACIL	San Diego thornmint: propagation, cultivation provides clues to ecology of endangered species (California)	Mistretta and Burkhart 1990
ACIL, DECO	Year 3 final annual report for the Central City Preserve Otay tarplant and San Diego thornmint restoration and enhancement program	RECON 2014
COMAM	Genetic variation and the reintroduction of *Cordylanthus maritimus* ssp. *maritimus* to Sweetwater Marsh, California	Helenurm and Parsons 1997
COMAM	Factors affecting reestablishment of an endangered annual plant at a California salt marsh	Parsons and Zedler 1997
COMAM	Salt marsh bird's-beak outplanting work plan: Huntington Beach wetlands – Magnolia Marsh	Zahn 2015
DECO	Otay tarplant habitat experimental project	CBI 2017b
Soil		
ACIL, DECO	Enhancing the resilience of edaphic endemic plants	CBI 2018
COMAM	Adaptive management assists reintroduction as higher tides threaten an endangered salt marsh plant	Noe et al. 2019
COMAM	Factors affecting reestablishment of an endangered annual plant at a California salt marsh	Parsons and Zedler 1997
COMAM	Salt marsh bird's-beak soil and hydrology assessment, Naval Base Ventura County Point Mugu, California	Tetra Tech 2017
DECO	A comparison of *Hemizonia conjugens* (Otay tarplant) with two closely related tarplant species using enzyme electrophoresis and soil textural analysis	Bauder and Truesdale 2000

[1] Target species: ACIL = *Acanthomintha ilicifolia* (San Diego thornmint), ACPR = *Acmispon prostratus* (Nuttall's acmispon), COMAM = *Chloropyron maritimum* ssp. *maritimum* (salt marsh bird's-beak; formerly *Cordylanthus maritimus* ssp. *maritimus*), DECO = *Deinandra conjugens* (Otay tarplant).
[2] Refer to reference section for full citation.

Genetic Studies of San Diego Thornmint

In a separate genetic study, CNLM studied genetic variation using isozyme markers, flow cytometry, and a common-garden study, and developed guidelines to manage the genetic structure of San Diego thornmint, including seed transfer among occurrences (DeWoody et al. 2018, CNLM 2014). They identified occurrences with local adaptations and/or differing ploidy levels where improving gene flow or introducing genetically incompatible plant material could be detrimental. We incorporate results and recommendations from this study into species chapters (Section 4) and the SCBBP.

Summary of Genetic Studies for MSP Rare Plants

Table 11 summarizes potential strategies to manage genetic parameters assessed in the above-mentioned genetic studies. These strategies are derived from a genetic assessment framework for prioritizing plant conservation at the population level (Ottewell et al. 2016) and tailored for MSP rare plants (Milano and Vandergast 2018). Refer to these peer-reviewed documents for more detailed information and to Section 4 for species- and occurrence-specific priorities and actions to manage genetic resources.

We emphasize that genetic studies are a tool to improve, direct, or prioritize specific management actions. For example, while genetic studies identify occurrences with low genetic diversity, not all occurrences with low diversity will necessarily require genetic rescue. Where improving diversity is appropriate, genetic studies provide a roadmap to proceed in a way that minimizes potential harm to the species or occurrence and maximizes long-term success of the effort. In the context of this document, genetic rescue is most appropriate for small, declining occurrences that do not respond favorably to other management actions and where site conditions are still suitable to support the target species.

3.5 Other Relevant Studies

In this section, we describe additional, key studies that are relevant to the MSP target plants and inform management strategies and actions. Refer to Table 10 for a more complete list of studies related to the four MSP target plants. Results are incorporated into species chapters and the SCBBP, as appropriate.

Table 11. Potential Strategies to Manage Genetic Structure for MSP Rare Plants.[1]

Genetic Structure[2]	Potential Management Strategies
Low Genetic Differentiation	
High Diversity/Low Inbreeding	• Manage threats to maintain or increase size. • Maintain/enhance gene flow among occurrences.
High Diversity/High Inbreeding	• Manage threats and habitat for pollinators or seed dispersers to promote movement of genetic material among and within occurrences. • Introduce/reintroduce plant material (e.g., seed, pollen) from genetically compatible source to reduce inbreeding.
Low Diversity/Low Inbreeding	• Manage threats; manipulate disturbance regimes to increase recruitment from soil seed bank. • Introduce/reintroduce genetically compatible seed to increase size and diversity.
Low Diversity/High Inbreeding	• Manage threats and habitat for pollinators or seed dispersers to promote movement of genetic material within occurrences. • Introduce/reintroduce plant material (e.g., seed) from genetically compatible source to increase size/diversity and reduce inbreeding. If inbreeding appears to be recent, recover diversity from soil seed bank.
High Genetic Differentiation	
High Diversity/Low Inbreeding	• Manage threats; maintain as many occurrences across the species range as possible.
High Diversity/High Inbreeding	• Manage threats to maintain or enhance gene flow within occurrence. • Introduce/reintroduce plant material (e.g., seed, pollen) from genetically compatible source to add new genetic diversity and reduce inbreeding. Collect seed for conservation and propagation (bulking).
Low Diversity/Low Inbreeding	• Manage threats to increase recruitment from soil seed bank. • Introduce/reintroduce genetically compatible plant material (e.g., seed) to increase genetic diversity. In the absence of adequate genetic information, source material from multiple occurrences in proximity (composite provenancing) to reduce risk from outbreeding depression.
Low Diversity/High Inbreeding	• Manage threats to recover diversity from soil seed bank. • Introduce/reintroduce seed from genetically compatible source if risks from outbreeding depression are managed. • May require multiple (potentially long-term) seed introductions/reintroductions to restore occurrence. • Assess whether threats are sufficiently managed and site conditions are suitable to support occurrence in the future <u>before</u> engaging in sustained, long-term introduction efforts.

[1] Table modified from Ottewell et al. 2016, with input from Milano and Vandergast 2018, DeWoody et al. 2018, and CNLM 2014.

[2] Genetic structure: categories from Ottewell et al. 2016. Note that not all may apply to MSP rare plants.

[3] Potential management strategies: not all strategies will apply to a species or occurrence in that genetic structure category. Additional considerations may include occurrence size and status of threats (controlled or not controlled), among others.

Hydrology

For species that occur in or near wetlands, studies that elucidate hydrological relationships are important, particularly in the context of a changing climate. We can use this information to assess (1) whether a decline in occurrence size is due to changing conditions and (2) identify suitable habitat to restore an MSP target plant, if needed.

Hydrology is a key factor in the presence and persistence of salt marsh bird's-beak. In San Diego County, a number of studies have focused on hydrological (and other) conditions that influence this species (see Noe et al. 2019, Parsons and Zedler 1997, Tetra Tech 2017). Berlin et al. (2012) projected that sea level rise will exacerbate inundation, flooding, and erosion in coastal areas in California and along the Pacific coast (Thorne et al. 2016, Thorne et al. 2018), and species at low elevations (including salt marsh bird's-beak) will be most at-risk (Berlin et al. 2012).

Invasive Plants

Invasive plants are one of the primary threats to MSP priority plants within the MSPA. For many of these invasives, particularly those that are widespread and/or long-established in the region, BMPs for treatment are available (e.g., DiTomaso and Healy 2007, Bossard et al. 2000, and others). For species that are relatively new to the region or that behave differently than elsewhere in their range, we often need additional information to develop effective management methods. For these species, information on species biology or ecology can provide insights into potential control methods, while management experiments can refine those methods.

We use PAFs to collate information on invasive plant biology and impacts, and prioritize invasive plants for management. As part of the IPSP, CBI et al. (2012) developed or refined PAFs for 55 invasive plants species in the MSPA. These PAFs are tailored to San Diego County, and reflect regional versus statewide impacts. Regional PAFs are available in the SDMMP library at:

> https://sdmmp.com/library.php?Search=Invasive+plants&Author=&PreparedFor=&PublisherID=&Year=&ArticleType=&submit=Submit

In addition, the County addresses new invasive plants through their EDRR program (Giessow 2019:

https://sdmmp.com/view_article.php?cid=SDMMP_CID_187_5cfe79926f7b1

Regional studies of the invasive grass, purple falsebrome (*Brachypodium distachyon*), found that this species produces a copious amount of highly viable seeds that exhibit minimal dormancy. In addition, purple falsebrome forms dense, nearly monotypic stands on clay soils in San Diego County (CBI 2014b), where it threatens many of our edaphic endemic rare plants. This species also has a short life cycle and the potential for multiple germination events in a given season, depending on climatic conditions. Using this information, CBI (2014b, 2017a) tested multiple control methods and developed BMPs for control. Subsequent research has refined our understanding of this invasive plant and its interactions with rare plant species (e.g., Aronson et al. 2017, Rice 2017).

Pollinators

Many MSP rare plants rely on animals (often insects) to move pollen between flowers or plants to produce viable seed. Pollinators also facilitate gene flow by transferring pollen beyond the immediate parental plant. Long-term persistence of rare plants that rely on animals to transfer pollen requires suitable habitat for pollinators near an occurrence and possibly, between occurrences. One goal of pollinator studies is to identify *effective* pollinators for a target species. This information allows us to (1) assess whether a decline in size or seed production is due to the absence of key pollinators and (2) identify management strategies to improve pollinator visitation.

Pollinator studies are generally time-intensive and require expertise to identify pollinator species. Relatively few pollinator studies have been done for MSP rare plant species, and some focus only on potential (rather than effective) pollinators.

In San Diego County, researchers and biologists have studied pollinators for San Diego thornmint (Marschalek and Deutschman 2016, Klein 2009, Bauder and Sakrison 1997) and Otay tarplant (Marschalek and Deutschman 2016, Bauder et al. 2002). Elsewhere in California, pollinator studies for salt marsh bird's-beak may have some relevance to management of this species in the MSPA (Knapp and Schneider 2017, Lincoln 1985).

Modeling

We use various types of models to identify (1) potential threats to rare plant species, (2) management strategies that address those threats, and (3) suitable habitat for restoration under future climate scenarios (Table 10). Models that inform management of MSP rare plants include conceptual models, habitat suitability models, and climate scenario models.

Species-specific conceptual models identify environmental covariates, focus field assessments, highlight management needs, and inform spatially explicit statistical models that identify potentially suitable habitat. Conceptual management models have been developed for San Diego thornmint (CBI in collaboration with SDMMP 2014, 2018) and Otay tarplant (Strahm 2012, CBI 2018).

Conlisk et al. (2013) modeled potential thornmint habitat suitability and abundance under various species distribution models and future climate change predictions. As part of the edaphic endemic soil study, the USGS and SDMMP modeled suitable habitat for San Diego thornmint and Otay tarplant under current and future climate scenarios (CBI 2018). They also developed (1) a habitat suitability model for the invasive grass, purple falsebrome, to predict areas of potential invasion and (2) a climate influences model for San Diego thornmint to target management strategies when they would be most effective (CBI in collaboration with SDMMP 2014).

Other predictive modeling efforts with some relevance to MSP target species include the potential effects of sea level rise on coastal plant species, including salt marsh bird's-beak, along the central California coast (Berlin et al. 2012), tidal wetlands along the Pacific Coast (e.g., Thorne et al. 2016, 2018), and current and future distribution of purple falsebrome in California (Cal-IPC 2012).

Restoration Experiments

In this context, we consider restoration experiments to include a range of activities that focus on restoring rare plant species and habitats, and developing BMPs for management. Refer to Section 3.7 for a discussion of terminology used in general restoration practice and in this document.

Falk et al. (1996) embraced the concept that "there are no true failures in ecological research, only unexpected outcomes." For this reason, we consider 'early' restoration projects that may not have been successful in the long-term, but which contributed to our knowledge of species biology or habitat management. Our own experience and that of others in the region indicate that results of restoration experiments can translate into general BMPs, but fine-tuning is often needed to fit site-specific conditions or accommodate yearly fluctuations in climate, invasive plant populations, or herbivores (among other issues). We also recognize that similar experiments replicated under different spatial or temporal conditions build a more comprehensive understanding of BMPs for a species. Finally, the relationship between rare plant species and their environment is complex and there is much we have yet to learn. Incorporating an experimental component into restoration is one way to build the body of knowledge needed for effective, long-term management of MSP rare plants.

There are several important restoration projects in San Diego County that have furthered our knowledge of species biology, habitat requirements, and BMPs for managing MSP rare plants. We list key projects for MSP target plants below and in Table 10. This list does not include all restoration projects in the region. For example, we do not include projects that are narrowly defined in scope, lack an experimental component, use established BMPs, and/or are not sufficiently documented. Nonetheless, we incorporate information from some of these projects in species chapters (Section 4), as appropriate.

San Diego Thornmint

Key restoration efforts for thornmint include reintroducing seed[4] and restoring habitat in the Central City Preserve of Chula Vista (RECON 2014), reintroducing seed and restoring habitat at Wright's Field in Alpine (McMillan pers. comm.), and restoring habitat on the Crestridge Ecological Reserve and South Crest Preserve near Crest (CBI 2014b, 2017a).

Otay Tarplant

Key restoration efforts for tarplant include reintroducing seed and restoring habitat in the Central City Preserve of Chula Vista (RECON 2014), Sweetwater Reservoir (RECON 2009, 2008), and Rancho Jamul Ecological Reserve (CBI 2017b, Land IQ and CBI 2015).

Salt Marsh Bird's-beak

Reintroducing salt marsh bird's-beak at Sweetwater Marsh in the 1990s and subsequent, long-term monitoring furthered our knowledge of this species significantly, including its habitat

[4] In this case, reintroducing seed refers to collecting seed from the occurrence and sowing it back into the site directly or propagating seed in the nursery and then sowing the bulked seed back into the occurrence.

requirements and BMPs for management (Noe et al. 2019, Parsons and Zedler 1997, Helenurm and Parsons 1997).

Nuttall's Acmispon

A recent project to restore habitat for Nuttall's acmispon and reintroduce this species into previously occupied habitat at Mission Bay has improved our understanding of the habitat requirements of this species, its interactions with other species, and BMPs for management (Redfern and Flaherty 2018).

Seed Biology

For management purposes, we focus on seed characteristics that influence species reproduction and persistence (e.g., seed size, dormancy, germination, longevity, viability), and on the soil seed bank. Information on seed biology is incomplete for most of our MSP rare plant species. In these cases, we make assumptions based on related species with similar life cycles. These working assumptions should be verified or refined through laboratory testing and/or field experiments.

An understanding of seed biology is important for assessing monitoring results and informing management actions. Information on seed biology allows us to know (1) when to collect seed, (2) how to analyze seed test results in a laboratory setting and outplanting results in a natural setting, (3) how to pre-treat seed to maximize germination and growth, and (4) how long we might reasonably store seed for future use. The SCBBP provides general and species-specific guidelines on collecting, storing, and growing and outplanting seed.

Photo credit: John MacDonald, RSA

The presence or potential for a persistent soil seed bank at a site can inform management strategies, particularly where the target species appears to be declining or has not been observed recently. Likewise, strategies to reintroduce seed into an occurrence will be shaped by whether or not the species' forms a persistent soil seed bank.

In San Diego County, a number of studies have investigated seed biology characteristics for MSP rare plants. Studies on San Diego thornmint have investigated seed germination factors and methods (Mistretta and Burkhart 1990, Bauder and Sakrison 1997, Lippet et al. no date), preliminary soil seed bank characteristics (Bauder and Sakrison 1999), and propagation techniques (Mistretta and Burkhart 1990, Lippet et al. no date). For Otay tarplant, studies have identified seed dormancy and germination and propagation methods (RECON 2014), and verified the presence of a persistent seed bank (CBI 2017b, USFWS 2011). For salt marsh bird's-beak, germination studies have reported germination rates, identified limiting factors for germination (Zahn 2015, Parsons and Zedler 1997), and verified that this species forms a persistent seed bank (Helernum and Parson 1997). Little information exists on seed biology for Nuttall's acmispon; however, the Institute for Conservation Research, San Diego Zoo Global (SDZG) collected, germinated, and assessed viability of seed of this species in 2016.

Soils

A number of MSP rare plants occur on soil types that are limited in distribution. By understanding soil characteristics that limit these species, we can better manage existing occurrences, locate suitable sites to introduce or translocate species (if needed), and identify areas to survey for new occurrences. Soil characteristics that influence plant distribution include structure, texture, chemistry, and moisture, among others.

In San Diego County, several MSP rare plant species are edaphic endemics, i.e., they are restricted to unique or limited soil types, such as clay or gabbro-derived soils. This includes two MSP target species: San Diego thornmint and Otay tarplant. CBI (2018) identified fine-scale soil attributes that support thornmint and tarplant (Sections 4.1 and 4.4, respectively). Salt marsh bird's-beak is also influenced by soil characteristics, as discussed in Section 4.3 (Tetra Tech 2017, Parsons and Zedler 1997).

3.6 Regional Population Structure

Regional population structure refers to the distribution of a species across the landscape, the relationship between populations of that species, and the proximity of existing populations to suitable habitat to expand or migrate in response to climate change.[5] Within this structure, we can identify populations or population groups important to the long-term resilience of a species based on size, condition, location, or other factors. The regional population structure of an MSP rare plant provides a top-down approach to prioritizing management actions where they would most benefit the species.

[5] In this section, the term 'population' is generally analogous to occurrence, and is used in keeping with relevant literature.

We develop regional population structures for MSP target plants using distribution data, habitat suitability models (if available), genetic principles or, where available, genetic data. In the absence of genetic studies or historical data regarding past relationships, we base regional population structures on a number of assumptions (e.g., Kolb 2008, Ellstrand and Elam 1993, Menges 1991):

- Small populations are more susceptible to extirpation than large populations, especially those with recent reductions in population size.
- Small population size reduces reproductive success, particularly in fragmented landscapes.
- Relatively low levels of gene flow may be sufficient to offset effects of genetic drift in small populations.
- Small populations are more likely to receive gene flow from large populations than from other small ones, even if the latter are closer.

Size Class Distribution

For annual plants, in particular, population size can provide an indication of a species' potential to persist under changing conditions. Large populations are generally more resilient to stochastic events and natural catastrophes, and less affected by demographic and genetic stochasticity than small populations (Menges 1991 and others). While there is debate in the literature regarding the use and validity of a set population size as a conservation target, there is consensus that larger populations are more resistant to extinction or extirpation than smaller populations (e.g., Jamison and Allendorf 2012, Brook et al. 2011, Flather et al. 2011, Traill et al. 2010, Flather et al. 2007). Estimates of total population size needed to buffer against environmental stochasticity range from 10^3-10^6 plants (Shaffer 1987 and others), while estimates of *effective* population size range from 5-30 percent (%) of the total population size (see Espeland and Rice 2010). The presence of a seed (or corm) bank further confounds assessments of population size (Nunney 2002).

Regardless, many rare plants persist in small populations, and it is important to consider both published guidelines and available census data in categorizing populations based on size. Some MSP rare plants have the potential to exist in large populations under certain conditions and form persistent seed banks, while others occur only in relatively small numbers, even in intact habitat.

With these factors in mind, we stratify populations of MSP target species into size classes to assess their potential for long-term resilience. We use size guidelines in the literature as a starting point, but refine these with species-specific monitoring data. Table 12 presents generalized population size classes for different life forms; note that exceptions may occur within each life form group. We use these size classes for MSP target species (Section 4).

Table 12. Generalized Population Size Classes.

Life Form	Population Size Class[1]		
	Large	Medium	Small
Annuals	>10,000	1,000-10,000	<1,000
Herbaceous Perennials[2]	>10,000	1,000-10,000	<1,000
Subshrubs	>500	100-500	<100
Shrubs	>500	100-500	<100

[1] Numbers represent estimated number of above-ground individuals.
[2] Includes geophytes.

For each population, we base the size class on the maximum number of plants observed in the last 5-year monitoring period (2014-2018). Where data are not available in this time period, we use the maximum population size recorded in previous years. If a 5-year monitoring period does not include any years with average or above-average rainfall, we would default to maximum population size recorded previously.[6] For species that experience wide population fluctuations, maximum number may indicate potential carrying capacity (Figure 5). We recognize that some populations may no longer have the ability to reach this potential, based on threats and site history. Nonetheless, it is important to consider the potential of a population in setting management priorities, particularly if threats are controlled.

Figure 5. Otay Tarplant: Annual Population Size Fluctuations (left: 2017 population [3,000 plants]; right: 2018 population [89 plants]). Monitoring occurred during the same week in both years; Otay tarplant is the yellow-flowering plant in foreground of left photo.

In delineating regional population structure, we focus on populations on conserved lands within the MSPA. One or more populations in proximity may constitute a 'population group.' In most cases, we assume there is potential for gene flow between populations within a group. Genetic studies provide data on gene flow that we use to refine population groups (e.g., Milano and Vandergast 2018, DeWoody et al. 2018, CNLM 2014). Figure 6 presents an example of the

[6] The San Diego County Water Authority reported above average rainfall at Lindbergh Field in 2015 and 2017 (https://www.sdcwa.org/annual-rainfall-lindbergh-field).

regional population structure for an MSP priority species; this map also shows predicted suitable habitat under current climatic conditions, as modeled by SDMMP (CBI 2018).

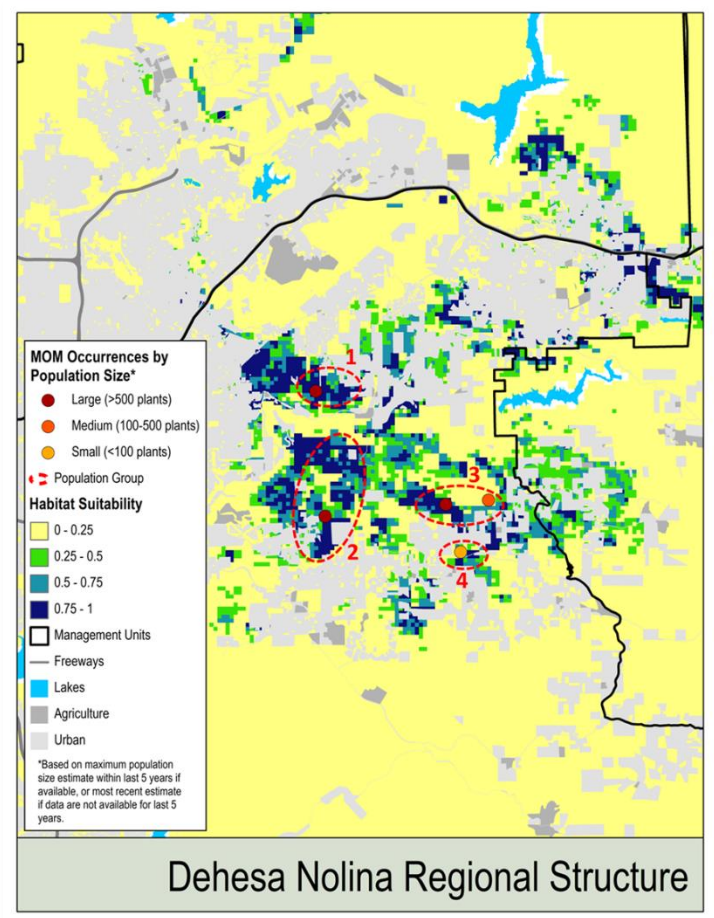


Figure 6. Regional Population Structure: Dehesa nolina (*Nolina interrata*) (from CBI 2018).

Habitat Connectivity

Connectivity of natural open space is essential to maintaining functional landscapes and evolutionary processes (e.g., Taylor et al. 2006, Beier and Noss 1998, Saunders et al. 1991, Noss 1991, 1987). Connected habitat is beneficial to many plant species because it allows pollinators and dispersal agents to move between populations, thereby facilitating gene flow, and provides opportunities for species to expand or migrate under varying climatic conditions (Anacker et al. 2013, Primack 1996). Connectivity may be detrimental where populations exhibit local adaptations and/or contain ploidy levels that differ from noncontiguous populations nearby (DeWoody et al. 2018).

Once we define regional population structure, we can identify gaps in connectivity between populations or population groups. Gaps are most apparent in urbanized areas with high fragmentation and habitat loss (Figure 7). In some cases, populations that were connected historically are now separated completely or subdivided into smaller units.

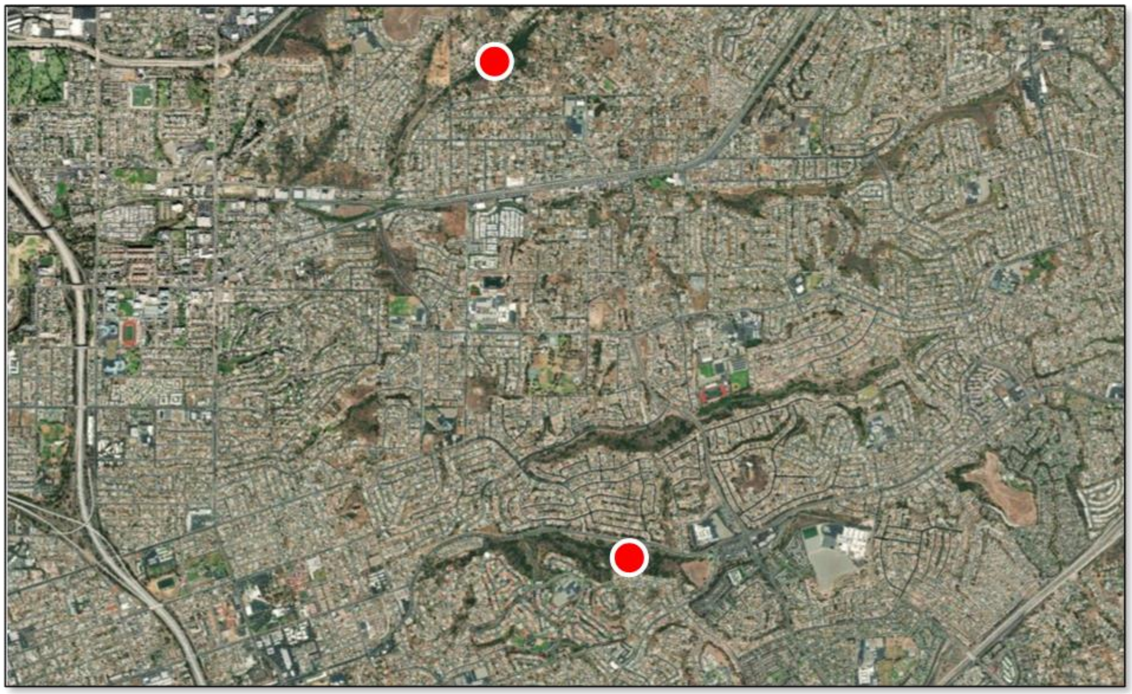


Figure 7. Connectivity Gaps due to Fragmentation (red points represent two discrete populations.

Smaller size and edge effects may affect the persistence of these populations over time. The challenge will be to encourage gene flow across gaps by maintaining, enhancing, or creating steppingstone populations or habitat for pollinators.

Gaps in connectivity may also occur where there are large distances between populations (Figure 8). Where isolated populations appear stable with suitable intervening habitat, gaps may approximate historic conditions in terms of gene flow and may not require efforts to improve connectivity. Isolated populations that are small or declining may benefit by introducing steppingstone populations or enhancing or creating habitat for pollinators in gap areas. Steppingstone habitat for pollinators must account for the dispersal capability of the pollinator, i.e., the pollinator must be able to travel from one population to another to pollinate plants and thus, affect gene flow. In some cases, isolated populations with local adaptations might be compromised by increased connectivity (e.g., San Diego thornmint, DeWoody et al. 2018).

Opportunity Areas

Opportunity areas are conserved lands with the potential to enhance regional population structure by supporting new populations or suitable sites to restore the target species or habitat for pollinators or dispersal agents. Opportunity areas may occur within population groups, in gap areas among groups, or beyond the current species distribution in response to a changing climate. We use species-specific habitat suitability models, if available, to identify opportunity areas.

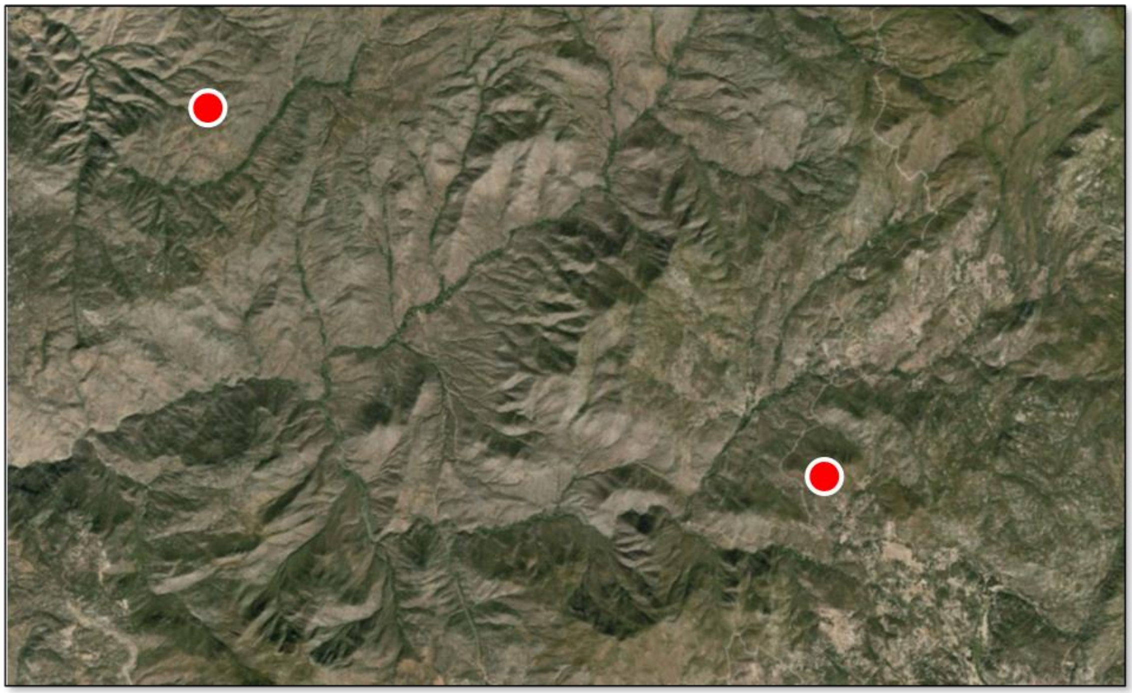
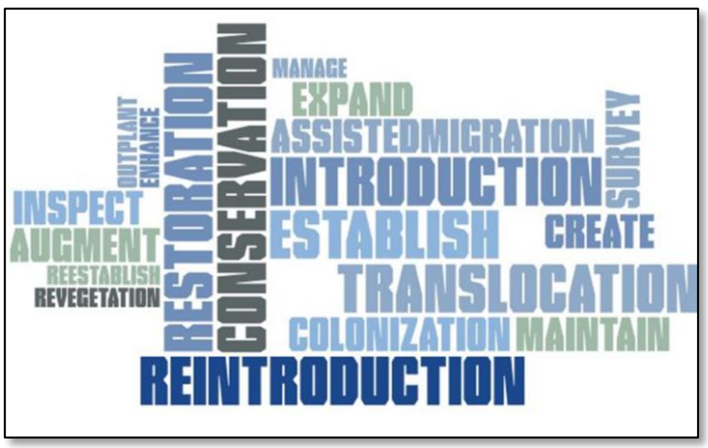


Figure 8. Connectivity Gaps due to Distance (red points indicate two populations separated by undeveloped habitat).

Where models do not exist, we use GIS map layers (e.g., species occurrences, vegetation, conserved lands) to identify these areas.

3.7 Management Strategies

Terminology



To discuss management strategies for MSP rare plants, we need a consistent set of terminology. A review of literature on rare plant conservation and management illustrates the problem, i.e., a variety of terms are used interchangeably. For example, *translocation* is the overarching term used internationally for any action that moves plants from one area to another, with nested categories of restoration (including reinforcement and reintroduction) and introduction (including assisted colonization or migration) (IUCN/SSC 2013). In the U.S., the terms reintroduction, introduction, and translocation are generally equivalent when used for managing rare plants (e.g., Guerrant 2013, Guerrant and Kaye 2007, Falk et al. 1996), with subcategories used inconsistently (e.g., enhance, establish, create, expand, augment).

For this document, we use the hierarchy in Figure 9 when discussing management strategies. Refer to Table 13 for a definition of each term (as used in this document), along with common and accepted synonyms. We acknowledge that the use of certain terms requires perspective. As Falk et al. (1996) point out, the difference between a species reintroduction or introduction may be a matter of spatial or temporal scale. Nonetheless, the terms selected consider both common usages in conservation practice and in the MSPA, including the MSP Roadmap (SDMMP and TNC 2017).

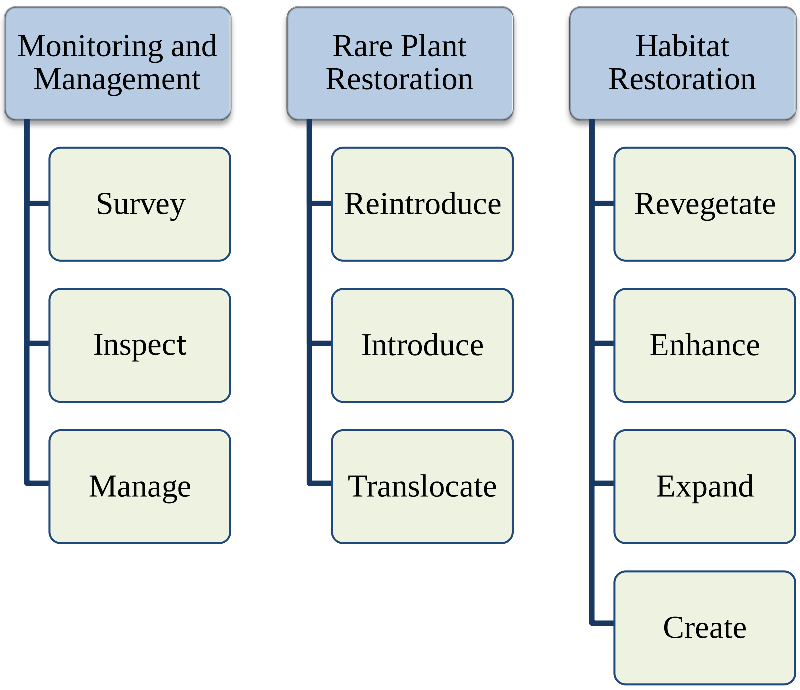


Figure 9. Management Strategies for MSP Rare Plants.

Seed banking is not explicitly stated in Figure 9 or Table 13, but is an important strategy for restoring rare plant occurrences, and is discussed in detail in the SCBBP. Likewise, land acquisition for long-term conservation is another important management strategy for MSP rare plants, but is beyond the scope of this document.

Table 13. Key Terms used for Management Strategies for MSP Rare Plants.

Term[1]	Definition	Synonyms[2]	Scale[3]
Rare Plant Monitoring and Management			
Survey	Assess potential habitat systematically to identify new occurrences, map the spatial extent of known occurrences, or identify suitable habitat for restoration.	Baseline surveys	Regional, Preserve
Inspect	Monitor MSP rare plants periodically (e.g., annually, biannually) using the IMG rare plant monitoring protocol to assess status and threats.	Monitor	Regional, Preserve
Manage	Conduct routine management to control threats identified through IMG monitoring or land stewardship activities.	Routine management, enhance	Preserve
Rare Plant Restoration			
Reintroduce	Add genetically compatible plant material (e.g., seed) of target species to an existing occurrence <u>or</u> an historic but extirpated occurrence to increase population size and/or manage genetic diversity.	Augment, enrich, establish, reinforce, replenish, restock, restore, translocate	Regional, Preserve
Introduce	Introduce target species into suitable habitat in a new location within its current or historic range to strengthen genetic and/or regional population structures.	Augment, create, establish, translocate	Regional
Translocate	Introduce (move) target species into suitable habitat in a new location outside its current or historic range in response to changing climatic conditions.	Assisted colonization, assisted migration, introduction, managed relocation	Regional
Habitat Restoration			
Revegetate	Establish habitat for target species or pollinators on degraded site (little to no vegetation) that previously supported target species or habitat for target species.	Restore	Regional, Preserve
Enhance	Improve the quality of existing habitat for target species or pollinators by reducing threats (e.g., invasive plants).	Restore	Preserve
Expand	Increase the spatial extent of existing habitat for target species into adjacent habitat of a different type with similar functions and values.	Establish, revegetate, restore	Preserve
Create	Convert one habitat type into another type to support target species where the latter did not previously exist at that location.	Reclaim	Regional, Preserve

[1] Indicates the term used in this F-RPMP for the defined management strategy.
[2] Indicates other commonly used terms for the defined management strategy.
[3] Indicates the scale at which the defined management strategy is typically applied.

Regional versus Preserve-level Management Strategies

Regional management strategies are identified through a 'top-down' approach to ensure the target species persists in the MSPA. Examples include baseline surveys, regional rare plant monitoring, regional seed collecting and banking, landscape-level restoration experiments or research studies where results can be applied widely, and measures to maintain or restore occurrences or habitat strategically to strengthen both genetic structure and regional population structure. While some regional management strategies are specific to the regional level, others can be used at multiple scales (Table 13). For example, baseline surveys can detect new occurrences (regional) or extend the maximum extent of an existing occurrence (preserve-level).

Regional management strategies can be implemented by regional entities or partners working across the region, by a land manager on one or multiple preserves, or by multiple land managers working together on multiple preserves.

Preserve-level management strategies can be identified through either top-down or bottom-up approaches, but are generally specific to a single preserve. Preserve-level management strategies focus on managing an existing MSP rare plant occurrence (e.g., by reducing threats) or restoring an occurrence through various species or habitat restoration methods. Examples include reintroducing a species into an historic occurrence or restoring degraded habitat at an existing occurrence. Preserve-level management strategies are generally carried out by a land manager as part of routine management.

3.8 BEST MANAGEMENT PRACTICES

Refer to Appendix B for BMPs to address general threats at MSP rare plant occurrences. These include altered hydrology, brush management, dumping/trash, encampments, erosion, fuel modification, nonnative woody plants, ORVs and mountain bikes, recent fire, road construction, slope movement, soil compaction, trails, trampling, vandalism, and vegetation clearing, and others. Refer to species chapters for BMPs related to habitat or species restoration.

3.9 POTENTIAL FUNDING SOURCES

Table 14 lists potential funding sources that may be available to assist with rare plant management activities identified as regional priorities in this document (Section 4). This list is not comprehensive, but focuses on sources that have funded activities in the region in the past and that are currently available. In general, funding agencies suggest that land managers contact local offices prior to submitting an application to verify that their entity/group and project are eligible for funding.

Refer to the SDMMP website for regularly updated information on grant opportunities: https://sdmmp.com/events.php?type=Grants.

Table 14. Potential Funding Sources.

Funding Source	Program	Focus	Eligible Organizations	Cycle
Preserve-specific Programs				
Land owner/manager	Annual budget allocation	Routine management, contingency funds.	Preserve-specific	Annual
Land owner/manager	Endowments	Routine management, contingency funds.	Preserve-specific	Annual
Regional Programs				
San Diego Association of Governments (SANDAG)	Transnet Environmental Mitigation Program – land management grants https://www.sandag.org/index.asp?projectid=447&fuseaction=projects.detail	Projects on conserved lands within MSPA; MSP species, habitats, threats.	Landowner/manager or representative.	Variable
San Diego Association of Governments (SANDAG)	Transnet Environmental Mitigation Program – land acquisition grants https://www.sandag.org/index.asp?projectid=447&fuseaction=projects.detail	Land acquisition that promotes regional habitat conservation plans.	Local jurisdictions, nonprofit organization, private land owners, consultants.	Variable
The San Diego Foundation	San Diego Foundation grants https://www.sdfoundation.org/grantseekers/	Variable; support for local or regional projects that benefit local residents (particularly, disadvantaged communities).	Any 501(c)(3) organization located in or providing services to San Diego County.	Throughout the year
Federal and State Programs				
California Natural Resource Agency	Environmental enhancement mitigation grants http://resources.ca.gov/grants/environmental-enhancement-and-mitigation-eem/	Projects that mitigate the environmental impacts from public transportation facilities.	Local, state and federal governmental agencies and nonprofit organizations.	Annual
California State Coastal Conservancy	Coastal Conservancy grants https://scc.ca.gov/grants/	Biological diversity, water quality, habitat, and other natural resources within coastal watersheds.	Public agencies, federally-recognized tribes, nonprofit organizations.	Ongoing
California Department of Fish and Wildlife (CDFW)	Local assistance grants https://www.wildlife.ca.gov/Conservation/Planning/NCCP/Grants	High priority NCCP actions (identified in conjunction with the Wildlife Agencies).	Local jurisdictions or other entities implementing a CDFW-approved NCCP, public agencies, tribes, non-profit organizations.	Annual

Table 14. Potential Funding Sources.

Funding Source	Program	Focus	Eligible Organizations	Cycle
California Department of Fish and Wildlife (CDFW)	Prop 1: Watershed Restoration Grant Program (Water Bond 2014) https://www.wildlife.ca.gov/Conservation/Watersheds/Restoration-Grants	Reliable water supplies; resilient, sustainably managed water resources system; important species and habitat.	Public agencies, non-profit organizations, public utilities, Indian tribes,[1] and mutual water companies.	Annual
California Department of Fish and Wildlife (CDFW)	Prop 68: State of California Parks & Water Bond 2018 https://www.wildlife.ca.gov/Conservation/Watersheds/Prop-68	Climate change adaptation; economic development & protection, connectivity, recreation, drought tolerance, landscape resilience, water retention.	Public agencies, non-profit organizations, public utilities, Indian tribes,[1] and mutual water companies.	Annual
Natural Resource Conservation Service	Environmental Quality Incentives Program (EQIP) conservation innovation grants https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/	Natural resource concerns, environmental benefits.	Agriculture and forestry producers.[2]	Annual
San Diego River Conservancy	Prop 1: Watershed Protection and Restoration Program (Water Bond 2014) http://sdrc.ca.gov/prop-1/	Shovel-ready, capital improvement projects in the San Diego River Watershed.	Public agencies, nonprofit organizations, Indian tribes.[1.]	Variable
San Diego River Conservancy	San Diego River Conservancy Proposition 68: The California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for all Act of 2018 http://sdrc.ca.gov/wp-content/uploads/2019/01/SDRC_prop-68-draft-guidelines-draft-012219-COMPLETE.pdf	Shovel-ready projects in the San Diego River Watershed; climate change adaptation; economic development/ & protection, connectivity, recreation, drought tolerance, landscape resilience, water retention.	Public agencies, nonprofit organizations, Indian tribes.[1.]	Variable
Southern California Wetlands Recovery Project (SCWRP)	Community wetland restoration grant program https://scwrp.org/community-wetland-restoration-grant-program/	Community-based restoration projects with an educational component; coastal areas in southern California.	Nonprofit organizations, universities, agencies.	Annual
U.S. Fish and Wildlife Service (USFWS)	Coastal Program https://www.fws.gov/coastal/	Native habitat restoration and acquisition (protection).	Local, state, and federal governmental agencies, Indian tribes,[1] nonprofit organizations, consultants, landowners/managers	Annual

Table 14. Potential Funding Sources.

Funding Source	Program	Focus	Eligible Organizations	Cycle
U.S. Fish and Wildlife Service (USFWS)	Cost-sharing program (e.g., Partners for Fish and Wildlife grants) https://www.fws.gov/cno/conservation/Partners.html	Restore, protect habitat for native fish and wildlife species	Private landowners or individuals or groups engaged in voluntary conservation efforts on private lands.	Annual
U.S. Fish and Wildlife Service (USFWS)	National Coastal Wetlands Conservation Grant https://www.fws.gov/coastal/CoastalGrants/	Native habitat restoration and acquisition (protection).	State agencies.	Annual
U.S. Fish and Wildlife Service (USFWS)	National Wildlife Refuge System Cooperative Recovery Initiative https://www.fws.gov/refuges/whm/cri/get-started/	Restore, recover federally or state-endangered species on National Wildlife Refuges and lands with a Refuge nexus.[3]	Internal grant program. Partners are encouraged to contact local or regional USFWS contacts.	Annual
U.S. Fish and Wildlife Service (USFWS)	Recovery Challenge http://www.federalgrants.com/FY-2018-Recovery-Challenge-72571.html	Enhance, increase partnerships to implement highest priority recovery actions identified in recovery plans (particular for breeding, rearing, and reintroduction programs).	State and local jurisdictions, public or private universities, Indian tribes,[1] nonprofit organizations, for-profit organizations and small businesses.	Annual
USFWS (funder), CDFW (administrator)	State Wildlife Grant program https://wsfrprograms.fws.gov/Subpages/GrantPrograms/SWG/SWG.htm https://www.wildlife.ca.gov/Grants/State-Wildlife-Grants	Programs that benefit wildlife and their habitats as identified in State Wildlife Action Plans.	Nonprofit organizations, local government agencies, colleges and universities, and state departments.	Annual
USFWS (funder), CDFW (administrator)	Cooperative Endangered Species Conservation Fund/Section 6 grants https://www.fws.gov/endangered/grants/index.html https://www.wildlife.ca.gov/Conservation/Planning/NCCP/Grants	Endangered species conservation, recovery; habitat acquisition for listed species per approved, draft species recovery plans.	Public agencies, state departments, colleges and universities, tribal governments, and nonprofit entities working with resource agencies.	Annual
Wildlife Conservation Board (WCB), CDFW	Monarch butterfly and pollinator rescue program https://wcb.ca.gov/Programs/Pollinators	Monarch butterflies and other pollinators.	Private landowners, nonprofit organizations, resource conservation districts, public agencies.	Annual

[1] Including federally recognized Indian tribes, and state Indian tribes listed on the Native American Heritage Commission's California Tribal Consultation List.
[2] Including nonprofit organizations, indigenous tribes, private land owners, or individuals or groups engaged in conservation efforts on private lands.
[3] Program funds on-the-ground projects with high likelihood of success.

4.0 SPECIES-SPECIFIC MANAGEMENT

4.1 San Diego Thornmint (*Acanthomintha ilicifolia*)

MSP Goals and Objectives

The MSP Roadmap identifies the following goal for San Diego thornmint:

> *Maintain large populations, enhance small populations, and establish new populations of San Diego thornmint or pollinator habitat to buffer against environmental stochasticity, maintain genetic diversity, and promote connectivity, thereby enhancing resilience within and among MUs over the long-term (>100 years) in native habitats.*

Refer to Table 15 for objectives and actions for this species per the MSP Roadmap (SDMMP and TNC 2017). In this chapter, we present species life history and ecological requirements, status and trends on conserved lands in the MSPA, genetics, and regional population structure, and recommend management priorities and actions to achieve goals and objectives.

Life History and Ecological Information

Species Description

San Diego thornmint is an annual species in the Mint family (Lamiaceae). This low-growing, aromatic herb is typically 5-15 centimeters (cm) (2-6 inches [in]) high, and stems are single or branched. The white to lavender- or rose-colored flowers occur in head-like terminal and axillary clusters, and flower clusters are subtended by distinctive spine-tipped bracts. Each flower produces up to four smooth, ovoid seeds (Miller and Jokerst 2012).

Distribution and Status

San Diego thornmint is restricted to San Diego County and northern Baja California, Mexico (CNDDB 2019a, SDNHM 2018). Within San Diego County, the species is known from MUs 2, 3, 4, 5, 6, and 10. Historically, there were many more occurrences in the MSPA. Currently, the species is found from Otay Lakes in the south and Poser Mountain in the east to Oceanside in the north and Encinitas in the west (Figure 10). Although San Diego thornmint occurs at a relatively large number of locations for a rare species; many of these occurrences face multiple challenges. The species is listed as federally threatened and state endangered.

Table 15. San Diego Thornmint: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
Monitoring				
MON-IMP-IMG: ACAILI-2	Conduct IMG monitoring annually	IMP-1	Determine management needs (routine versus intensive).	IP
		IMP-2	Submit monitoring data to MSP Web Portal.	IP
MON-RES-GEN: ACAILI-5	Conduct genetic studies	RES-1	Collect plant material for genetic samples.	C
		RES-2	Evaluate the long-term genetic trajectory of San Diego thornmint in the MSPA.	C
		RES-3	Hold a workshop to develop management recommendations based on genetic analyses.	C
		RES-4	Submit project data, report to MSP Web Portal.	C
MON-IMP-MGTPL: ACAILI-8	Monitor management effectiveness	IMP-1	Submit data, report to MSP Web Portal.	NS
MON-RES-SPEC: ACAILI-11	Conduct soils study; develop habitat suitability and climate change models	RES-1	Test soils to determine key edaphic parameters for thornmint occupation.	C
		RES-2	Prepare habitat suitability models.	C
		RES-3	Collect covariate data for selected occurrences.	C
		RES-4	Prioritize locations for conservation, management, surveys.	C
		RES-5	Submit project data, report to MSP Web Portal.	C
Management				
MGT-IMP-FMGT: ACAILI-1	Reduce fire risk at large occurrences	IMP-1	Manage thatch and invasive annuals every 3-5 years at occurrences most at risk from fire.	IP
		IMP-2	Submit data and report to MSP Web Portal.	IP
MGT-IMP-IMG: ACAILI-3	Conduct routine management identified through IMG monitoring.	IMP-1	Perform routine management as needed (e.g., access control, weed control).	IP
		IMP-2	Submit data to MSP Web Portal.	IP
MGT-DEV-BMP: ACAILI-4	Refine BMPs through continued research and experiments	DEV-1	Incorporate results from management experiments and research studies.	IP
		DEV-2	Submit data and reports to MSP web portal.	IP

Table 15. San Diego Thornmint: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
MGT-PRP-MGTPL: ACAILI-6	Prepare a section for San Diego thornmint in the F-RPMP.	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Develop a conceptual model for management.	C
		PRP-3	Prioritize occurrences for management.	C
		PRP-4	Develop an implementation plan that prioritizes management actions for the next 5 years.	C
		PRP-5	Submit data and plan to the MSP Web Portal.	C
MGT-IMP-MGTPL: ACAILI-7	Implement highest priority management actions in the F-RPMP	IMP-1	Submit project data and report to MSP Web Portal.	NS
MGT-PRP-SBPL: ACAILI-9	Prepare a section for San Diego thornmint in the SCBBP	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Prepare a seed collection plan for occurrences on conserved lands in the MSPA.	C
		PRP-3	Include guidelines for collecting seeds on (1) conserved lands based on genetic studies and (2) unconserved occurrences that may be developed.	C
		PRP-4	Include protocols and guidelines for collecting and submitting voucher specimens.	C
		PRP-5	Include guidelines for seed testing.	C
		PRP-6	Submit data and plans to MSP Web Portal.	C
MGT-IMP-SBPL: ACAILI-10	Collect and store seeds at a permanent seed bank; provide propagules for research and management actions	IMP-1	Bulk seed at a qualified facility using seed from genetically appropriate donor accessions in the propagation seed bank collection.	IP
		IMP-2	Maintain records for collected seed to document donor and receptor sites, collection dates, and amounts. Submit data to MSP Web Portal.	IP

[1] Objective Codes: **MGT** = Management, **MON** = Monitoring; **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare; **RES** = Research; **BMP** = Best Management Practices, **FMGT** = Fire Management, **GEN** = Genetics, **IMG** = Inspect and Manage, **MGTPL** = Management Plan, **SPEC** = Species, **SBPL** = Seed Banking Plan.
[2] Descriptions: Refer to MSP Roadmap for complete descriptions (SDMMP and TNC 2017).
[3] Action Codes: **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare, **RES** = Research.
[4] Status: **C** = Completed, **IP** = In-progress (refers to some or all occurrences), **NS** = Not started.

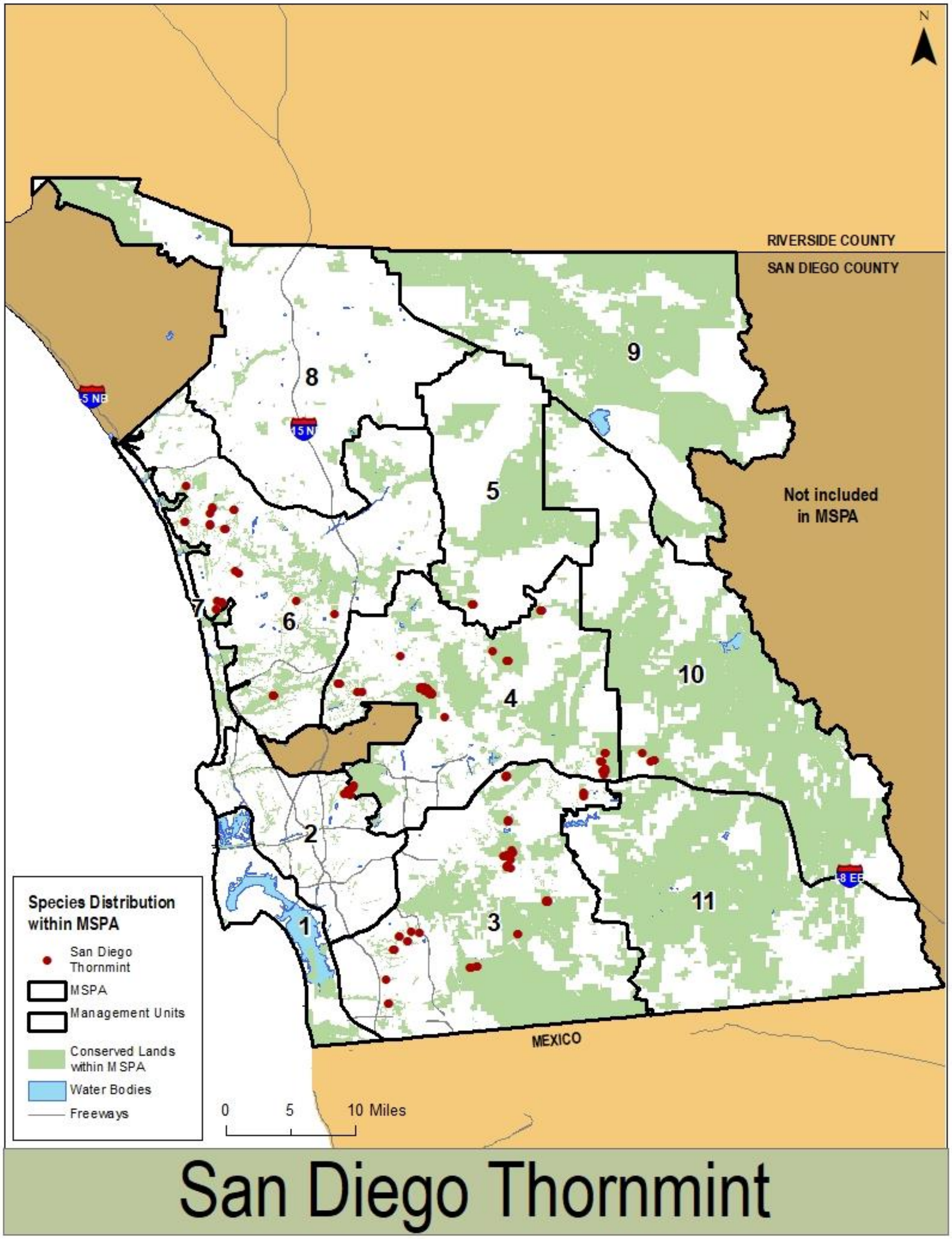


Figure 10. San Diego Thornmint: Distribution within the MSPA.

Table 16 lists 48 occurrences of San Diego thornmint on conserved lands in the MSPA, including population size(s) recorded during the 5-year monitoring period (2014-2018). Table 17 presents recent and historic maximum population size recorded for each of these occurrences, and categorizes occurrences into size classes (per Table 12) based on recent population size.

Ecological Requirements

San Diego thornmint germinates in late winter to early spring and flowers from March through July. It experiences wide fluctuations in annual population size that are driven primarily by growing season precipitation and winter temperatures (SDMMP *in* CBI 2014a). The SDMMP identified growing season, precipitation (January through April), and average maximum temperature from November to January as the most important variables in predicting low and high population sizes (CBI 2014a).

The SDMMP also developed habitat suitability models for San Diego thornmint under current and future climate scenarios in southern California (SDMMP *in* CBI 2018). Future conditions models predict that thornmint habitat suitability declines under all emission scenarios for all future time periods, although there are differences between models. For the high emission scenario, 62% of current suitable habitat remains in 2010-2039, with large reductions in suitable habitat predicted from 2040-2099 (SDMMP *in* CBI 2018).

San Diego thornmint is associated with chaparral, scrub, and grasslands, where it occurs on clay soils or clay lenses (SANDAG 2012, Oberbauer and Vanderwier 1991). CBI (2018) found that thornmint is specifically restricted to clay soils with low sand content relative to other clay-loving species, and has a low tolerance to metals. Even on gabbroic soils, which are typically metal-rich, thornmint is found in microsites with lower metal content. Gabbro weathers readily into silt and clay (Medeiros et al. 2015), and the occurrence of thornmint on gabbroic clays is likely due to the weathering properties (rather than chemical content) of the parent material. Significant soil variables for thornmint include clay (42-52%), low sand (25-35%), and low metal content (3.5-6 parts per million [ppm] iron, 0.5-1.1 ppm copper, and 0.25-0.55 ppm zinc).

CBI (2018) also found that soil color at thornmint-occupied sites was variable, and while the species was always associated with soil cracks, these cracks often occurred in adjacent, unoccupied habitat, as well. Within appropriate soils, thornmint occurs most frequently in concave hollows rather than undulating terrain, possibly because these landscape features fill up with fine grain sediment (e.g., clay) over time (CBI 2018).

Table 16. San Diego Thornmint: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
Management Unit 2									
ACIL_2EDHI001	El Dorado Hills	El Dorado Hills	San Diego	San Diego PRD	---	---	50	---	---
ACIL_2EDHI002	El Dorado Hills	El Dorado Hills	San Diego	San Diego PRD	---	---	0	---	---
Management Unit 3									
ACIL_3BOME003	Bonita Meadows	Bonita Meadows	Caltrans	Caltrans	---	---	300	1,200	0
ACIL_3CERE004	Crestridge ER	Crestridge ER	CDFW	EHC	0	0	0	0	1
ACIL_3DREA005	Dennery Ranch East	Dennery Ranch	San Diego	San Diego PRD	0	150	16	24	0
ACIL_3HCWA006	Hollenbeck WA	Hollenbeck Canyon WA	CDFW	CDFW	4	338	192	803	1,722
ACIL_3LONC007	Long Canyon (PMA 4-2b)	Central City Preserve	Chula Vista	Chula Vista	---	---	67	92	180
ACIL_3MGMT008	McGinty Mountain	San Diego NWR	USFWS	USFWS	136	---	15	100[6]	5
ACIL_3MGMT009	McGinty Mountain (southwest slope)	Flying Dolphin Trust	TNC	TNC	---	---	276	756	195
ACIL_3MGMT010	McGinty Mountain (summit and ridgeline)	San Diego NWR	USFWS	USFWS	---	866	172	230	488
ACIL_3OTLA011[7]	Lower Otay Reservoir	Otay Mountain ER	CDFW	CDFW	---	---	0	0	0
ACIL_3OTLA012	Otay Lakes (south side)	Otay Lakes Cornerstone Lands	San Diego PUD	San Diego PRD	0	0	0	0	0
ACIL_3PMA1013	PMA1 (Rice Canyon)	Central City Preserve	Chula Vista	Chula Vista	168	6,240	2,408	10,091	341
ACIL_3PMA3014[7]	PMA3 (Poggi Canyon)	Central City Preserve	Chula Vista	Chula Vista	---	---	0	---	0
ACIL_3RJER015	Rancho Jamul ER	Rancho Jamul ER	CDFW	CDFW	---	---	0	0	0
ACIL_3SOCR016	South Crest (Suncrest)	South Coast Properties	EHC	EHC	64	474	352	620	1,375
ACIL_3WHRI017	Bonita, Wheeler Ridge (Long Canyon PMA 4-1cW)	Central City Preserve	Chula Vista	Chula Vista	---	81	358	965	6

Table 16. San Diego Thornmint: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
ACIL_3WRFI018	Wright's Field (north & south)	Wright's Field	BCLT	BCLT	0	14	250	2,750	2,150
Management Unit 4									
ACIL_4CSVI019[7]	Canada San Vicente-Daney Canyon	Canada de San Vicente	CDFW	CDFW	---	---	0	---	0
ACIL_4CSVI020	Canada San Vicente--Monte Vista (Long's Gulch)	Canada de San Vicente	CDFW	CDFW	---	---	0	0	0
ACIL_4MTRP021	MTRP	MTRP	San Diego	San Diego PRD	21	510	105	360	77
ACIL_4MTRP022	MTRP (southwest Tierra Santa parcel, northwest of Mission Gorge)	MTRP	San Diego	San Diego PRD	---	---	0	---	---
ACIL_4POGR023[7]	Poway Grade	RAAN LLC	RAAN LLC	Unknown	---	---	---	---	0
ACIL_4POMT048	Poser Mountain	Cleveland NF	USFS	USFS	---	---	---	---	---
ACIL_4POMT049	Poser Mountain 35	Cleveland NF	USFS	USFS	---	---	---	7	1
ACIL_4POMT050	Poser Mountain	Cleveland NF	USFS	USFS	---	---	---	---	0
ACIL_4SASP024	Saber Springs (east)	City of Poway OS	Poway	Poway	---	---	0	---	0
ACIL_4SASP025	Sabre Springs (east, subpopulation 1)	Sabre Springs	San Diego	San Diego PRD	5	20	11	85	0
ACIL_4SIPR026	Simon Preserve	Simon Preserve	County DPR	County DPR	---	---	965	6,000	1,600
ACIL_4SYCA027	Sycamore Canyon	Sycamore Canyon and Goodan Ranch Preserves	County DPR	County DPR	---	---	1,000	777,300	5,525
ACIL_4VIMT0028	Viejas Mountain (northwest slope)	Cleveland NF	USFS	USFS	---	---	0	0	0
ACIL_4VIMT0029	Viejas Mountain (southwest slope)	Viejas Hills Partners, LLC	Viejas Hills Partners, LLC & USFS	USFS (on USFS-owned portion)	---	---	---	2,245[8]	859
ACIL_4VIMT0030	Viejas Mountain (west-southwest flank)	Cleveland NF	USFS	USFS	---	---	113	233	80

Table 16. San Diego Thornmint: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
Management Unit 5									
ACIL_5RAGR031	Ramona Grasslands, Hobbes Property	Ramona Grasslands Preserve	Ramona MWD & WRI	County DPR & WRI	---	---	0	0	0
Management Unit 6									
ACIL_6BLMO032	Black Mountain	Black Mountain OS Park	San Diego	San Diego PRD	0	10	5	1	0
ACIL_6CAHI033	Calavera Hills	Calavera Hills Phase 2 & Robertson Ranch	Calavera Hills HOA	CNLM	---	---	---	---	---
ACIL_6CARA034	Carlsbad Racetrack (south)	Carlsbad Raceway	Fenton Raceway LLC	Fenton Raceway LLC	---	---	---	3	9
ACIL_6CARL035	Southeast Carlsbad (east)	Santa Fe Trails HOA	Santa Fe Trails HOA	Santa Fe Trails HOA	---	---	---	---	---
ACIL_6CARL036	Southeast Carlsbad (west)	Ranch Carlsbad HOA	Ranch Carlsbad HOA	La Costa HOAs	---	---	---	---	---
ACIL_6EMPO037	Emerald Pointe	Emerald Point OS	SDHC	SDHC	6	22	39	17	22
ACIL_6LCGR038	La Costa Greens	Rancho La Costa HCA	CNLM	CNLM	652	378	237	966	278
ACIL_6LPCA039	Los Peñasquitos Canyon	Los Peñasquitos Canyon Preserve	San Diego	San Diego PRD	100	57	38	91	241
ACIL_6LUCA040	Lux Canyon (west)	Pacific Pines Racquet Club HOA	Viejas Hills Partners, LLC	Pacific Pines Racquet Club HOA	---	---	---	0	---
ACIL_6MAMI041	Lux Canyon (east), Manchester Avenue Mitigation Bank	Manchester Mitigation Bank	CNLM	CNLM	236	1,086	318	4,722	80
ACIL_6LUCA042	Lux Canyon (west of Manchester Avenue Mitigation Bank)	Calle Ryan HOA	Calle Ryan HOA	Calle Ryan HOA	---	---	---	0	---
ACIL_6PARO043	Palomar Airport Road	Carlsbad Oaks North HCA	County PWD	County PWD & CNLM	327[6]	420[6]	15,586	36,533	1,922
ACIL_6RACA044	El Fuerte Street (Rancho Carrillo)	Rancho Carrillo HOA	Rancho Carrillo Master HOA	Rancho Carrillo Master HOA	---	---	---	23	3
ACIL_6RSFE045	Rancho Santa Fe	MS Rialto to the Lakes CA LLC	MS Rialto to the Lakes CA LLC	MS Rialto to the Lakes CA LLC	---	---	---	---	---

Table 16. San Diego Thornmint: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
ACIL_6THCO046	Thornmint Court	4-S Ranch	4S Ranch HOA	4S Ranch HOA	---	---	---	---	---

[1] Table lists only occurrences in the SDMMP's Master Occurrence Matrix (MOM) database on conserved lands.
[2] Occurrence Identification (ID) per the SDMMP's MOM database.
[3] Occurrence/preserve abbreviations: **ER** = Ecological Reserve, **HCA** = Habitat Conservation Area, **HOA** = Homeowner's Association, **MTRP** = Mission Trails Regional Park, **LLC** = Limited Liability Company, **OS** = Open Space, **PMA** = Preserve Management Area, **NF** = National Forest, **NWR** = National Wildlife Refuge, **WA** = Wildlife Area.
[4] Land owner/land manager: **BCLT** = Back Country Land Trust, **Caltrans** = California Department of Transportation, **CDFW** = California Department of Fish and Wildlife, **CNLM** = Center for Natural Lands Management, **Chula Vista** = City of Chula Vista, **County DPR** = County of San Diego Department of Parks and Recreation, **County PWD** = County of San Diego Public Works Department, **EHC** = Endangered Habitats Conservancy, **HOA** = Homeowner's Association, **LLC** = Limited Liability Company, **Poway** = City of Poway, **Ramona MWD** = Ramona Municipal Water District, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **San Diego PUD** = City of San Diego Public Utilities Department, **SDHC** = San Diego Habitat Conservancy, **TNC** = The Nature Conservancy, **USFS** = U.S. Forest Service, **USFWS** = U.S. Fish and Wildlife Service.
[5] Population size information from IMG monitoring data, land manager data, and report and research data; (---) = not surveyed or data not available or not provided, 0 = surveyed, no plants detected.
[6] Surveyors did not have access to the largest populations of this occurrence in 2014 and 2015, resulting in incomplete population numbers.
[7] Occurrence location is questionable (possibly mapped incorrectly) based on monitoring data that indicate an absence of both plants and suitable habitat.
[8] The largest population of this occurrence is on private land adjacent to the Cleveland National Forest.

Table 17. San Diego Thornmint: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
Management Unit 2						
Small Populations						
ACIL_2EDHI001	El Dorado Hills	El Dorado Hills	San Diego	San Diego PRD	50 (2016)	50 (2016)
ACIL_2EDHI002	El Dorado Hills	El Dorado Hills	San Diego	San Diego PRD	200 (1986)	0 (2016)
Management Unit 3						
Large Populations						
ACIL_3PMA1013	PMA1 (Rice Canyon)	Central City Preserve	Chula Vista	Chula Vista	32,000 (2012)	10,091 (2017)
Medium Populations						
ACIL_3BOME003	Bonita Meadows	Bonita Meadows	Caltrans	Caltrans	1,200 (2017)	1,200 (2017)
ACIL_3HCWA006	Hollenbeck WA	Hollenbeck Canyon WA	CDFW	CDFW	32,000 (2003)	1,722 (2018)
ACIL_3SOCR016	South Crest (Suncrest)	South Coast Properties	EHC	EHC	1,375 (2018)	1,375 (2018)
ACIL_3WRFI018	Wright's Field (north & south)	Wright's Field	BCLT	BCLT	2,750 (2017)	2,750 (2017)
Small Populations						
ACIL_3CERE004	Crestridge ER	Crestridge ER	CDFW	EHC	505 (2000)	1 (2018)
ACIL_3DREA005	Dennery Ranch East	Dennery Ranch	San Diego	San Diego PRD	536 (2012)	150 (2015)
ACIL_3LONC007	Long Canyon (PMA 4-2b)	Central City Preserve	Chula Vista	Chula Vista	180 (2018)	180 (2018)
ACIL_3MGMT008	McGinty Mountain	San Diego NWR	USFWS	USFWS	6,500 (2011)	136 (2014)
ACIL_3MGMT010	McGinty Mountain (summit, ridgeline)	San Diego NWR	USFWS	USFWS	2,559 (2010)	866 (2015)
ACIL_3MGMT009	McGinty Mountain (southwest slope)	Flying Dolphin Trust	TNC	TNC	1,000 (2011)	756 (2017)
ACIL_3OTLA011	Lower Otay Reservoir	Otay Mountain ER	CDFW	CDFW	0 (2016)	0 (2018)

Table 17. San Diego Thornmint: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
ACIL_3OTLA012	Otay Lakes (south side)	Otay Lakes Cornerstone Lands	San Diego PUD	San Diego PRD	61 (2003)	0 (2018)
ACIL_3PMA3014	PMA 3 (Poggi Canyon)	Central City Preserve	Chula Vista	Chula Vista	Unknown (2001)	0 (2017)
ACIL_3RJER015	Rancho Jamul ER	Rancho Jamul ER	CDFW	CDFW	125 (2010)	0 (2018)
ACIL_3WHRI017	Bonita, Wheeler Ridge (Long Canyon PMA 4-1cW)	Central City Preserve	Chula Vista	Chula Vista	965 (2017)	965 (2017)
Management Unit 4						
Large Populations						
ACIL_4SYCA027	Sycamore Canyon	Sycamore Canyon and Goodan Ranch Preserves	County DPR	County DPR	777,300 (2017)	777,300 (2017)
Medium Populations						
ACIL_4SIPR026	Simon Preserve	Simon Preserve	County DPR	County DPR	7,500 (2009)	6,000 (2017)
ACIL_4VIMT0029	Viejas Mountain (southwest slope)	Viejas Hills Partners, LLC	Viejas Hills Partners, LLC	---	21,015 (2010)	2,245 (2017)
Small Populations						
ACIL_4CSVI019	Canada San Vicente-Daney Canyon	Canada de San Vicente	CDFW	CDFW	100 (1995)	0 (2018)
ACIL_4CSVI020	Canada San Vicente--Monte Vista (Long's Gulch)	Canada de San Vicente	CDFW	CDFW	26 (2006)	0 (2018)
ACIL_4MTRP021	MTRP	MTRP	San Diego	San Diego PRD	737 (2013)	510 (2015)
ACIL_4MTRP022[7]	MTRP (southwest Tierra Santa parcel, northwest of Mission Gorge)	MTRP	San Diego	San Diego PRD	250 (1994)	0 (2016)
ACIL_4POGR023[8]	Poway Grade	RAAN LLC	RAAN LLC	Unknown	Unknown (2001)	Unknown (2001)
ACIL_4POMT048	Poser Mountain	Cleveland NF	USFS	USFS	2,000 (2000)	65 (2010)

Table 17. San Diego Thornmint: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
ACIL_4POMT049[9]	Poser Mountain 35	Cleveland NF	USFS	USFS	7 (2017)	7 (2017)
ACIL_4POMT050	Poser Mountain	Cleveland NF	USFS	USFS	6,650 (1991)	0 (2018)
ACIL_4SASP024	Saber Springs (east)	City of Poway OS	Poway	Poway	Unknown (2001)	0 (2018)
ACIL_4SASP025	Sabre Springs (east, subpopulation 1)	Sabre Springs	San Diego	San Diego PRD	19,721 (2003)	85 (2017)
ACIL_4VIMT0028	Viejas Mountain (northwest slope)	Cleveland NF	USFS	USFS	44 (2010)	0 (2018)
ACIL_4VIMT0030	Viejas Mountain (west-southwest flank)	Cleveland NF	USFS	USFS	1,638 (2010)	233 (2017)
Management Unit 5						
Small Populations						
ACIL_5RAGR031	Ramona Grasslands, Hobbes Property	Ramona Grasslands Preserve	Ramona MWD	County DPR	58 (2010)	0 (2018)
Management Unit 6						
Large Populations						
ACIL_6PARO043	Palomar Airport Road	Carlsbad Oaks North HCA	County PWD	CNLM	36,533 (2017)	36,533 (2017)
Medium Populations						
ACIL_6MAMI041	Lux Canyon (east), Manchester Avenue Mitigation Bank	Manchester Mitigation Bank	CNLM	CNLM	11,400 (1989)	4,722 (2017)
Small Populations						
ACIL_6BLMO032	Black Mountain	Black Mountain OS Park	San Diego	San Diego PRD	1,115 (2000)	10 (2015)
ACIL_6CAHI033	Calavera Hills	Calavera Hills Phase 2 & Robertson Ranch	Calavera Hills HOA	CNLM	4 (2009)	0 (2013)
ACIL_6CARA034	Carlsbad Racetrack (south)	Carlsbad Raceway	Fenton Raceway LLC	Fenton Raceway LLC	1,000 (1986)	9 (2018)
ACIL_6CARL035	Southeast Carlsbad (east)	Santa Fe Trails HOA	Santa Fe Trails HOA	Santa Fe Trails HOA	2,000 (1994)	200 (2010)

Table 17. San Diego Thornmint: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
ACIL_6CARL036	Southeast Carlsbad (west)	Ranch Carlsbad HOA	Ranch Carlsbad HOA	La Costa HOAs	1,000 (1994)	500 (2010)
ACIL_6EMPO037	Emerald Pointe	Emerald Point OS	SDHC	SDHC	110 (2009)	39 (2016)
ACIL_6LCGR038	La Costa Greens	Rancho La Costa HCA	CNLM	CNLM	1,000 (2003)	996 (2017)
ACIL_6LPCA039	Los Peñasquitos Canyon	Los Peñasquitos Canyon Preserve	San Diego	San Diego PRD	2,091 (2005)	241 (2018)
ACIL_6LUCA040	Lux Canyon (west)	Pacific Pines Racquet Club HOA	Viejas Hills Partners, LLC	Pacific Pines Racquet Club HOA	30 (1986)	0 (2017)
ACIL_6LUCA042	Lux Canyon (west of Manchester Avenue Mitigation Bank)	Calle Ryan HOA	Calle Ryan HOA	Calle Ryan HOA	500 (1994)	0 (2017)
ACIL_6RACA044	El Fuerte Street (Rancho Carrillo)	Rancho Carrillo HOA	Rancho Carrillo Master HOA	Rancho Carrillo Master HOA	170 (1991)	23 (2017)
ACIL_6RSFE045	Rancho Santa Fe	MS Rialto to the Lakes CA LLC	MS Rialto to the Lakes CA LLC	MS Rialto to the Lakes CA LLC	500 (1991)	0 (2001)
ACIL_6THCO046	Thornmint Court	4-S Ranch	4S Ranch HOA	4S Ranch HOA	1,000 (1983)	0 (2011)

1 Table lists only occurrences in the SDMMP's MOM database on conserved lands.
2 Occurrence Identification (ID) per the SDMMP MOM database.
3 Occurrence name/preserve abbreviations: **ER** = Ecological Reserve, **HCA** = Habitat Conservation Area, **HOA** = Homeowner's Association, **MTRP** = Mission Trails Regional Park, **LLC** = Limited Liability Company, **OS** = Open Space, **PMA** = Preserve Management Area, **NF** = National Forest, **NWR** = National Wildlife Refuge, **WA** = Wildlife Area.
4 Land owner/land manager: **BCLT** = Back Country Land Trust, **Caltrans** = California Department of Transportation, **CDFW** = California Department of Fish and Wildlife, **CNLM** = Center for Natural Lands Management, **Chula Vista** = City of Chula Vista, **County DPR** = County of San Diego Department of Parks and Recreation, **County PWD** = County of San Diego Public Works Department, **EHC** = Endangered Habitats Conservancy, **HOA** = Homeowner's Association, **LLC** = Limited Liability Company, **Poway** = City of Poway, **Ramona MWD** = Ramona Municipal Water District, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **San Diego PUD** = City of San Diego Public Utilities Department, **SDHC** = San Diego Habitat Conservancy, **TNC** = The Nature Conservancy, **USFS** = U.S. Forest Service, **USFWS** = U.S. Fish and Wildlife Service.
5 Indicates maximum recorded population size.
6 Indicates maximum recorded population size from 2014 - 2018, or most recent year overall if 2014-2018 data are not available.
7 CBI surveyed this location in 2016 as part of the soils assessment for this project; we did not find any plants.
8 Occurrence not depicted on Figure 10.
9 The SDMMP designates separate occurrences on Poser Mountain for -049 and -050, while CNDDB considers these the same occurrence. At this time, we are retaining the two occurrences pending additional information.

Pollinators

Marschalek and Deutschman (2016) investigated potential pollinators of San Diego thornmint, and assessed visitation rates of each species. Although they found few insect visitors on thornmint flowers during their observation periods, they noted bees and flies as the most common visitors. They also found that some insect visitors (e.g., bees: mason bee [*Osmia* sp.], European honey bee [*Apis mellifera*]) tended to move between flowers more quickly than other species present in very large numbers (e.g., soft-winged flower beetles [Melyridae], long-horned fly [*Exiliscelis californiensis*]), and hypothesized that both groups could be important thornmint pollinators. DeWoody et al. (2018) suggested that beetles that moved among flowers on a single plant could facilitate self-fertilization. Earlier research suggested that bees (Apidae, Halicidae families) were dominant visitors to thornmint flowers (Klein 2009, Bauder and Sakrison 1997).

Floral display is important to attract insects to thornmint patches. A buildup of nonnative grass thatch that inhibits germination or plant size may reduce pollinator visits and reduce or eliminate bare ground for ground-nesting bees (CBI 2018, Dodero pers. comm., Rogers 2014, Klein 2009).

Reproductive Biology

San Diego thornmint reproduces sexually from seed. The mating system is unknown; however, evidence suggests there may be some self-compatibility, with the species exhibiting both inbreeding and outcrossing modes of reproduction. There is also evidence of polyploidy in some occurrences (DeWoody et al. 2018, CNLM 2014).

Seed Biology

The number of seeds produced by a thornmint plant is highly variable, with recent estimates ranging from 10-200 seeds per plant (DeWoody et al. 2018, Lippett et al. no date). Bauder and Sakrison (1999) reported higher seed production in experimentally-grown plants, including one individual that produced over 3,000 seeds. Lippett et al. (no date) found that dark-colored seed had both a higher percentage of filled seed and a higher germination rate than lighter-colored seed, and suggested that the latter might not be fully mature.

Several studies found that thornmint seed germinates readily in the presence of adequate moisture and has few physical dormancy mechanisms (e.g., Lippett et al. no date, Rancho Santa Ana Botanic Garden [RSA] 2018, Mistretta and Burkhart 1990). However, Bauder and Sakrison (1997) suggested there is some light-mediated dormancy that is relieved with age. They found that fresh seed had the lowest germination rates and narrowest range of suitable germination conditions, cool temperatures promoted germination, and warm temperatures inhibited germination. Mistretta and Burkhart (1990) found that germination in a nursery setting was about 2x higher in wild-collected seed (95% germination rate) compared to the first generation of seed produced in the nursery (45% germination rate).

Seed production increases with plant size and flower production. Seeds mature from spring through summer and remain on the plants presumably until they desiccate completely or are released from the parental plant by weather (wind, rain), usually within one year. Although dry plants may be present from the previous year, they do not usually contain seeds. Lippett et al. (no date) found that seed from inland or high elevation occurrences had a higher germination percentage than seed from coastal plants, and plants grown from inland seed took longer to flower and produced more viable seed than plants grown from coastal seed.

Thornmint seed appears to be primarily gravity-dispersed, with most seed falling near the parental plant. Other dispersal mechanisms may act at a local scale (e.g., animal dispersal). Seeds do not possess any obvious structures to facilitate dispersal by wind or water.

Bauder and Sakrison (1999) indicated that the species may not form a persistent soil seed bank; however, others have suggested that the soil seed bank may be an important strategy for long-term persistence of this species (e.g., DeWoody et al. 2018 and others), particularly given the fluctuations in population size across years and presence in fire-adapted communities. Seed longevity is unknown; however, RSA will test long-term seed collections in the future, which may shed light on seed longevity in controlled settings.

Status and Trends

We can compare population size and extent over time to determine trends. In Table 17, we presented maximum recent and historic population sizes for each occurrence. Although these data are incomplete, they provide a preliminary indication of status and trends. Recent monitoring (2014-2018) data indicate the following:

- The majority of occurrences on conserved lands in the MSPA (38 of 48 occurrences; 79% of occurrences) support fewer than 1,000 plants. Of the remaining occurrences, 7 (15%) support 1,000-10,000 plants and 3 (6%) support >10,000 plants (Figure 11). We have no recent or historic size data for one occurrence, and it is not included in these totals.
- For the 38 occurrences with <1,000 plants, 26 occurrences (68% of all occurrences in this size category) had ≤100 plants recorded in any year from 2014-2018. This included 17 occurrences with 0 plants, which represents 45% of all occurrences with <1,000 plants and 35% of all occurrences on conserved lands in the MSPA (Figure 12).

Comparing recent (2014-2018) and historic population size data suggest the following:

- Of the 49 occurrences on conserved lands, 35 (71%) appear relatively stable with respect to size based on available data, while 14 (29%) appear to have declined over time so that they are now categorized into a smaller size category (Table 18). We placed occurrences with no plants detected during the last monitoring period (2014-2018), or that were not monitored or population numbers not collected, into the small category (see Table 18).

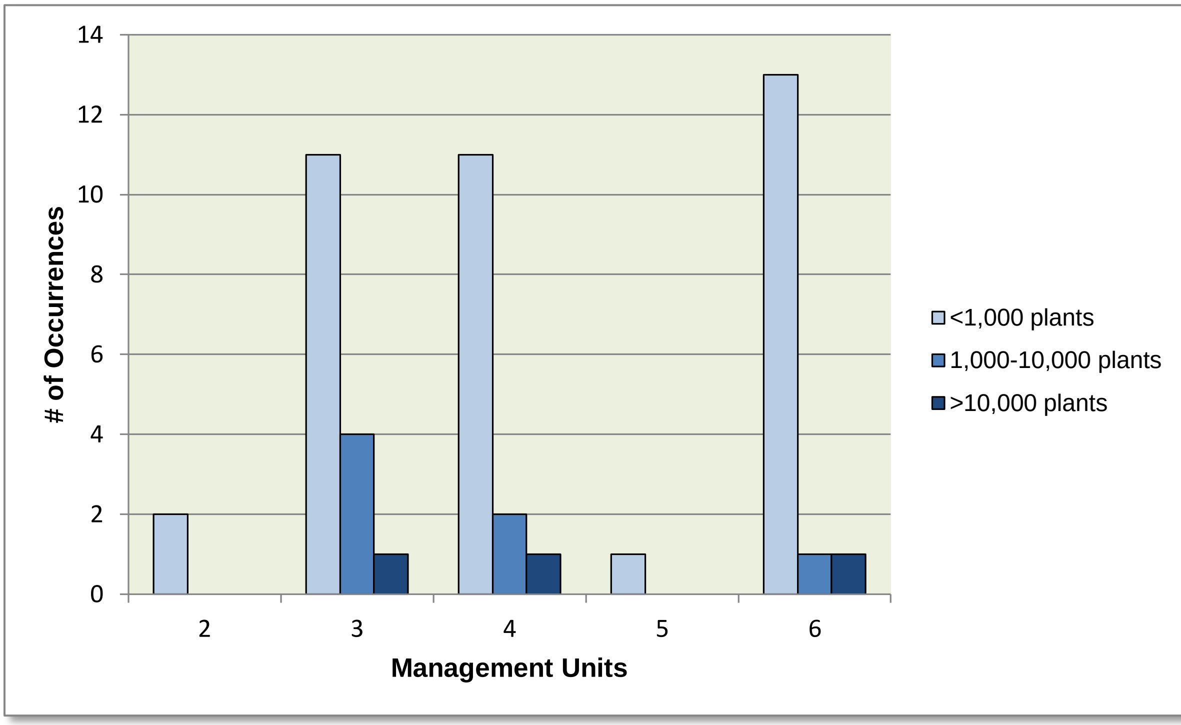


Figure 11. San Diego Thornmint: Distribution by Population Size and MU (2014-2018).

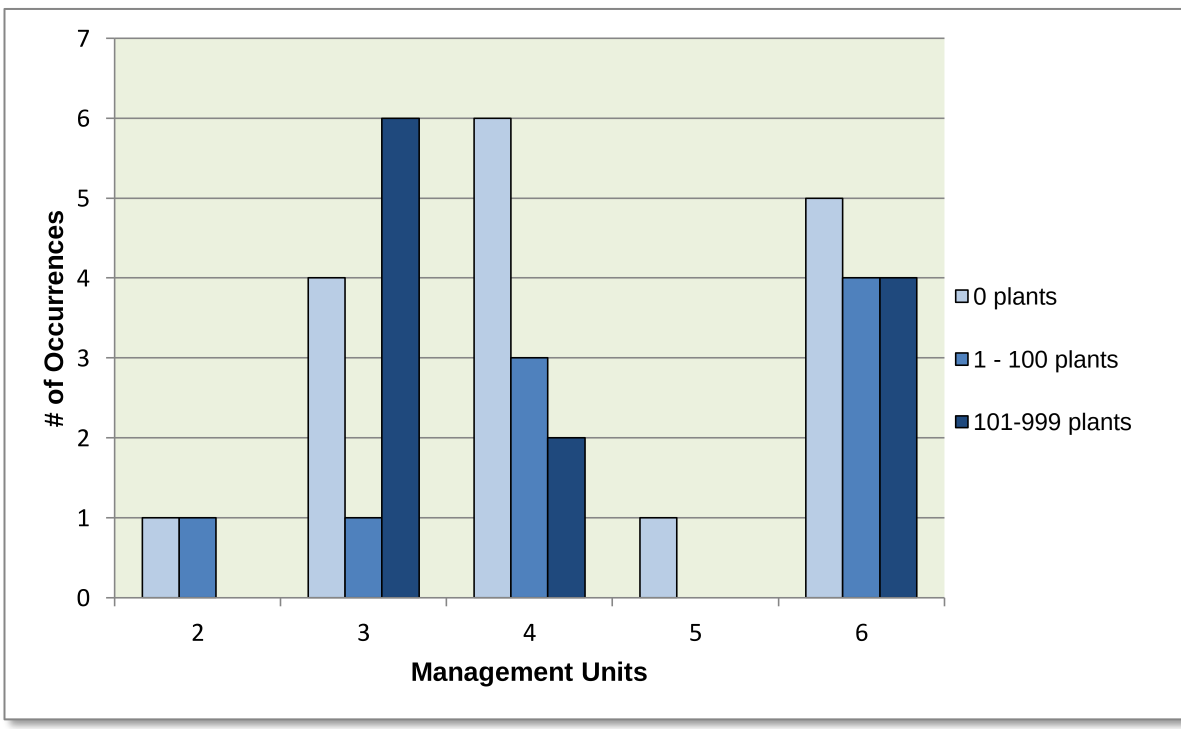


Figure 12. San Diego Thornmint: Distribution by Population Size and MU for Occurrences with <1,000 Plants (2014-2018).

Table 18. San Diego Thornmint Occurrences by Recent and Historic Population Size Category.

Occurrence ID[1]	MU[2]	Recent Population Size Category[3,4]	Historic Population Size Category[3,5,6]
ACIL_2EDHI001	2	Small	Small
ACIL_2EDHI002	2	Small[7]	Small
ACIL_3PMA1013	3	Large	Large
ACIL_3BOME003	3	Medium	Medium
ACIL_3HCWA006	3	Medium	Large
ACIL_3SOCR016	3	Medium	Medium
ACIL_3WRFI018	3	Medium	Medium
ACIL_3CERE004	3	Small	Small
ACIL_3DREA005	3	Small	Small
ACIL_3LONC007	3	Small	Small
ACIL_3MGMT008	3	Small	Medium
ACIL_3MGMT010	3	Small	Medium
ACIL_3MGMT009	3	Small	Medium
ACIL_3OTLA011	3	Small[7]	Small
ACIL_3OTLA012	3	Small[7]	Small
ACIL_3PMA3014	3	Small[7]	Small
ACIL_3RJER015	3	Small[7]	Small
ACIL_3WHRI017	3	Small	Small
ACIL_4SYCA027	4	Large	Large
ACIL_4SIPR026	4	Medium	Medium
ACIL_4VIMT0029	4	Medium	Large
ACIL_4CSVI019	4	Small[7]	Small
ACIL_4CSVI020	4	Small[7]	Small
ACIL_4MTRP021	4	Small	Small
ACIL_4MTRP022	4	Small[7]	Small
ACIL_4POGR023[9]	4	Small[7]	Small
ACIL_4POMT048	4	Small[8]	Medium
ACIL_4POMT049[10]	4	Small	Small
ACIL_4POMT050	4	Small[7]	Medium
ACIL_4SASP024	4	Small[7]	Small
ACIL_4SASP025	4	Small	Large
ACIL_4VIMT0028	4	Small[7]	Small
ACIL_4VIMT0030	4	Small	Small
ACIL_5RAGR031	5	Small[7]	Small
ACIL_6PARO043	6	Large	Large
ACIL_6MAMI041	6	Medium	Large
ACIL_6BLMO032	6	Small	Medium
ACIL_6CAHI033	6	Small[8]	Small

Table 18. San Diego Thornmint Occurrences by Recent and Historic Population Size Category.

Occurrence ID[1]	MU[2]	Recent Population Size Category [3,4]	Historic Population Size Category[3,5,6]
ACIL_6CARA034	6	Small	Medium
ACIL_6CARL035	6	Small[8]	Small
ACIL_6CARL036	6	Small[8]	Small
ACIL_6EMPO037	6	Small	Small
ACIL_6LCGR038	6	Small	Medium
ACIL_6LPCA039	6	Small	Medium
ACIL_6LUCA040	6	Small[7]	Small
ACIL_6LUCA042	6	Small[7]	Small
ACIL_6RACA044	6	Small	Small
ACIL_6RSFE045	6	Small[8]	Small
ACIL_6THCO046	6	Small[8]	Medium

1 Occurrence ID = Occurrence identification code per the SDMMP's MOM database.
2 MU = Management Unit.
3 Population size categories: **Small** = <1,000 plants**, Medium** = 1,000-10,000 plants**, Large** = >10,000 plants.
4 Recent population size category is based on maximum size recorded at occurrence from 2014-2018.
5 Historic population size category is based on maximum size recorded at occurrence; may include data from 2014-2018 or earlier.
6 Cells highlighted with green shading indicate a change between historic and recent size categories.
7 Indicates occurrences with at least one IMG monitoring event during the 5-year period from 2014-2018, but 0 plants detected.
8 Indicates occurrences with no IMG monitoring events during the 5-year period from 2014-2018. For the purpose of analysis, we placed these occurrences into the small population size category.
9 No historic population size data available for this occurrence.
10 This occurrence is recognized as distinct by SDMMP and part of ACIL_4POMT050 by the CNDDB.

Note that (1) the monitoring record is incomplete for many occurrences and (2) the time scale is insufficient to detect some trends, such as those related to genetic factors that may affect long-term persistence (e.g., isolation, inbreeding depression).

Threats and Stressors

At a regional scale, San Diego thornmint may be affected directly or indirectly by altered fire regimes, climate change, and possibly, nitrogen deposition (CBI 2014a, 2018, Tonnesen et al. 2007). At the preserve-level, biologists and land managers have recorded 21 categories of threats at thornmint occurrences through the IMG monitoring process (Figure 13). The most common threats are invasive species (nonnative grasses and forbs).

Threats at each occurrence are recorded as a continuum from no threat (threat level 0-1) to a threat that affects ≥75% of the maximum area occupied by thornmint (threat level 7). When reporting threats, we use a color-coded system to allow land managers to easily identify low versus high threat levels. In most cases, management costs and labor will increase with

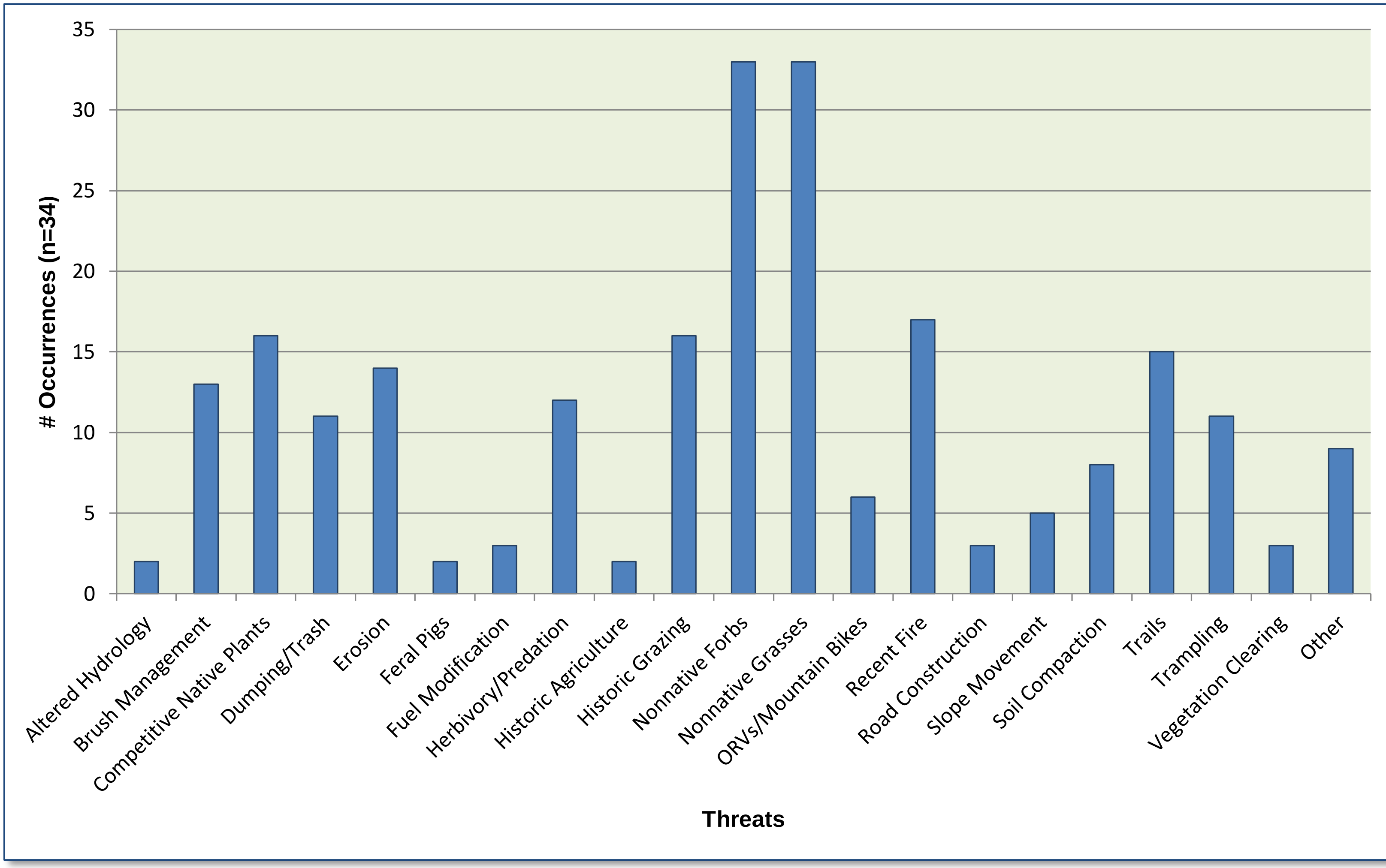


Figure 13. San Diego Thornmint: Threats Recorded during IMG Monitoring, 2014-2018 (note: data indicate the number of occurrences at which a threat was recorded).

increasing threat level. Thus, addressing threats before they become a problem is a cost-effective strategy for managing occurrences.

We further stratify the color-coded system by different shades of the same color to (1) indicate magnitude of threat and (2) allow land managers to track threats over time (taking into account annual variability due to climate). Table 19 defines threat levels per the IMG monitoring protocol (SDMMP 2019), while Figure 14 depicts the color-coded system used to display threats.

Table 19. Descriptions of Threat Levels.[1]

Threat Level	Description	Priority for Management
1	Threat not recorded at occurrence or in 10-m buffer	None
2	Threat not recorded at occurrence, but recorded in adjacent buffer	Low
3	Threat occurs over 0-10% of area within maximum extent	Low
4	Threat occurs in 10% to <25% of area within maximum extent	Medium
5	Threat occurs in 25% to <50% of area within maximum extent	Medium
6	Threat occurs in 50% to <75% of area within maximum extent	High
7	Threat occurs in ≥75% of area within maximum extent	High

[1] Threat level descriptions per IMG monitoring protocol (SDMMP 2019).

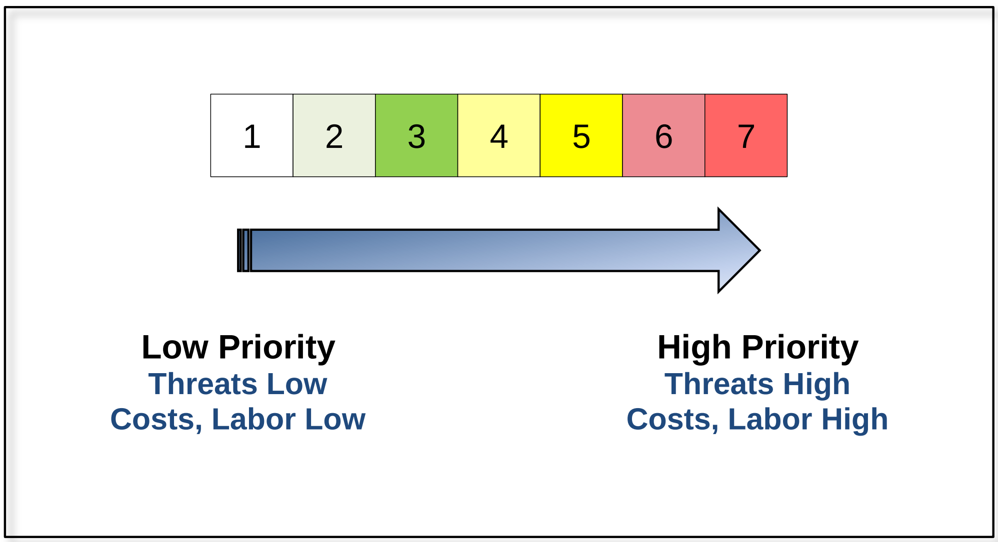


Figure 14. San Diego Thornmint: Color-coded Threat Levels.

Table 20 presents threats and threat levels by year for those occurrences where IMG data were collected. We include occurrences that were not monitored as a placeholder for future data, and also indicate where occurrences were visited but not monitored due to an absence of plants, or not visited at all. All IMG data are available on the SDMMP website:

> https://sdmmp.com/view_project.php?sdid=SDID_sarah.mccutcheon%40aecom.com_57cf0196dff76.

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_2EDHI001	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_2EDHI002	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_3BOME003	2016	1	1	1	3	1	1	1	1	1	1	6	7	1	1	1	1	1	---	1	1	1
ACIL_3BOME003	2017	1	1	1	1	3	1	1	1	1	1	3	6	1	1	1	1	3	4	3	1	1
ACIL_3BOME003	2018	1	1	1	2	1	1	1	1	1	1	3	7	4	1	1	1	3	4	5	1	1
ACIL_3CERE004	2014	1	---	1	1	1	1	1	1	1	---	3	3	1	6	1	1	1	1	1	1	---
ACIL_3CERE004	2015	1	3	3	1	1	1	1	1	1	1	3	4	1	7	1	1	1	1	1	1	7
ACIL_3CERE004	2016	1	7	1	1	6	1	1	1	1	1	7	7	1	7	1	1	1	---	1	1	1
ACIL_3CERE004	2018	1	4	1	1	3	1	3	1	1	1	3	5	1	1	1	1	1	1	1	1	1
ACIL_3DREA005	2014	1	---	1	1	1	1	1	1	1	1	6	6	1	1	1	1	1	1	1	1	---
ACIL_3DREA005	2015	1	1	1	1	1	1	1	1	1	7	5	5	1	1	1	1	6	2	1	1	---
ACIL_3DREA005	2016	1	1	1	1	1	1	1	1	1	7	3	3	1	1	1	1	1	1	1	1	1
ACIL_3DREA005	2017	1	7	1	1	1	1	1	1	1	1	5	3	1	1	1	1	1	1	1	1	1
ACIL_3DREA005	2018	1	7	1	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1
ACIL_3HCWA006	2014	1	---	1	1	1	1	1	1	1	1	2	2	3	1	1	1	1	2	2	1	---
ACIL_3HCWA006	2015	1	1	1	1	1	1	1	1	1	1	3	3	3	1	1	1	1	3	3	1	---
ACIL_3HCWA006	2016	1	7	3	3	1	1	1	1	1	1	7	7	1	1	1	1	1	---	3	1	---
ACIL_3HCWA006	2017	1	7	5	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	3	1	1
ACIL_3HCWA006	2018	1	7	7	1	1	1	1	1	1	1	7	5	1	1	1	1	1	1	3	1	---
ACIL_3LONC007	2016	1	1	1	1	1	1	1	1	1	7	2	2	1	1	1	1	1	---	2	1	2
ACIL_3LONC007	2017	1	1	1	1	1	1	1	1	1	7	3	3	1	1	1	1	1	---	3	1	2
ACIL_3LONC007	2018	1	1	1	1	1	1	1	1	1	6	3	3	1	1	1	1	1	3	3	1	1
ACIL_3MGMT008	2016	1	1	1	1	1	1	1	1	1	1	5	7	1	1	1	1	1	---	3	1	---
ACIL_3MGMT008	2017	1	1	4	1	1	1	1	1	1	7	2	4	1	1	1	1	2	2	1	1	1
ACIL_3MGMT008	2018	1	1	1	1	1	1	1	3	1	1	7	7	1	1	1	1	1	2	1	1	1

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_3MGMT009	2016	1	1	---	---	2	1	5	1	1	1	---	---	1	1	1	1	1	---	2	2	1
ACIL_3MGMT009	2017	1	1	3	1	4	1	1	3	1	1	7	7	1	1	1	1	1	2	1	1	1
ACIL_3MGMT009	2018	1	1	1	1	3	1	1	1	1	1	7	3	1	1	1	1	1	2	1	1	1
ACIL_3MGMT010	2015	3	---	3	1	3	1	1	1	1	1	3	3	1	7	1	3	1	---	3	1	2
ACIL_3MGMT010	2016	1	1	1	1	3	1	1	2	1	1	6	6	1	1	3	1	1	---	1	3	---
ACIL_3MGMT010	2017	3	1	3	1	3	1	1	5	1	3	3	3	1	7	1	3	3	2	1	1	7
ACIL_3MGMT010	2018	1	1	1	1	1	1	1	2	6	6	5	3	2	1	1	1	1	2	1	1	1
ACIL_3OTLA011	2016	1	1	1	3	1	1	1	1	1	7	6	3	1	7	3	1	1	---	1	1	---
ACIL_3OTLA012	2014	1	---	1	1	1	1	1	1	1	6	3	2	1	6	1	1	1	1	1	1	---
ACIL_3OTLA012	2015	1	1	1	1	1	1	1	1	6	1	5	3	1	1	1	1	1	1	1	1	1
ACIL_3OTLA012	2016	1	1	1	1	1	1	1	1	1	7	6	3	1	7	1	1	1	1	1	1	1
ACIL_3OTLA012	2017	1	1	1	1	1	1	1	1	1	1	6	3	1	1	1	1	1	---	1	1	---
ACIL_3OTLA012	2018	1	1	1	1	1	1	1	1	1	1	6	3	1	1	1	1	1	1	1	1	1
ACIL_3PMA1013	2015	1	1	1	1	3	1	1	1	1	3	3	4	1	1	1	3	1	---	3	1	---
ACIL_3PMA1013	2016	1	7	1	2	2	1	1	1	---	7	7	7	1	1	1	1	2	---	3	1	---
ACIL_3PMA1013	2017	1	1	1	2	3	1	1	2	1	7	6	7	1	1	1	1	2	---	3	3	---
ACIL_3PMA1013	2018	1	1	1	3	1	1	1	1	1	1	3	7	1	1	1	1	1	3	1	1	1
ACIL_3PMA3014	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_3PMA3014	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_3RJER015	2016	1	1	1	1	1	1	1	1	1	7	3	7	1	7	1	1	1	---	1	1	---
ACIL_3RJER015	2017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_3SOCR016	2014	1	---	3	1	3	2	1	1	1	1	3	3	1	3	1	1	1	1	2	1	---
ACIL_3SOCR016	2015	1	1	1	1	1	3	1	1	1	1	3	3	3	7	1	1	1	3	3	1	3
ACIL_3SOCR016	2016	1	1	1	1	3	1	1	1	1	1	7	7	2	7	1	1	1	---	1	1	---
ACIL_3SOCR016	2017	1	1	1	1	5	1	1	1	1	1	3	3	1	7	1	7	1	1	1	1	---

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_3SOCR016	2018	1	1	3	1	3	1	1	1	1	1	3	3	1	6	1	7	2	2	1	1	1
ACIL_3WHRI017	2016	1	1	1	1	1	1	1	1	1	7	2	2	1	1	1	1	1	---	2	1	1
ACIL_3WHRI017	2017	1	1	1	1	1	1	1	1	1	3	4	3	1	1	1	1	1	3	3	1	---
ACIL_3WHRI017	2018	1	1	1	1	1	1	1	1	1	1	4	3	1	1	1	1	1	4	4	1	1
ACIL_3WRFI018	2016	1	1	4	1	1	1	1	1	1	6	3	3	1	1	1	1	1	---	2	1	1
ACIL_3WRFI018	2017	1	7	6	1	1	1	1	1	1	7	5	3	1	7	1	1	1	1	2	1	1
ACIL_3WRFI018	2018	1	7	1	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1
ACIL_4CSVI019	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4CSVI019	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4CSVI020	2016	1	7	1	1	2	1	1	1	1	7	7	6	1	7	1	1	1	---	1	1	---
ACIL_4MTRP021	2014	1	---	1	1	1	1	1	1	1	1	3	5	1	1	1	1	1	2	1	---	---
ACIL_4MTRP021	2015	1	1	1	3	1	1	1	1	1	7	3	6	1	1	1	1	3	2	1	1	1
ACIL_4MTRP021	2016	1	1	1	1	1	1	1	1	1	7	3	4	1	7	1	1	1	2	1	1	1
ACIL_4MTRP021	2017	1	7	4	1	1	1	1	1	1	1	3	4	1	1	1	1	1	1	1	1	1
ACIL_4MTRP021	2018	1	7	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	2	1	7	4
ACIL_4MTRP022	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4POGR023	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4POMT048	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4POMT049	2017	1	2	3	1	1	1	1	1	1	1	2	2	1	7	1	1	1	1	1	1	1
ACIL_4POMT049	2018	1	1	1	1	1	1	1	1	1	1	3	4	1	1	1	1	1	1	1	1	1
ACIL_4POMT050	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4SASP024	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_4SASP024	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_4SASP025	2014	1	---	1	1	1	1	1	1	1	---	4	4	1	1	1	1	1	1	1	1	---
ACIL_4SASP025	2015	1	6	1	2	1	1	1	2	1	6	5	5	1	1	1	1	1	3	1	1	1
ACIL_4SASP025	2016	1	1	1	1	1	1	1	1	1	7	5	3	1	7	1	1	1	1	1	1	1
ACIL_4SASP025	2017	1	6	1	1	1	1	1	1	1	1	7	5	1	1	1	1	1	1	1	1	1
ACIL_4SASP025	2018	1	7	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	1	1	1	1
ACIL_4SIPR026	2016	1	1	1	1	1	1	1	1	1	---	7	7	1	7	1	1	1	---	1	1	7
ACIL_4SIPR026	2017	1	1	1	3	1	1	1	1	1	1	7	7	1	7	1	1	1	1	1	1	1
ACIL_4SIPR026	2018	1	1	1	3	1	1	1	2	1	1	7	5	1	6	1	1	1	1	1	1	1
ACIL_4SYCA027	2016	1	1	1	1	1	1	1	1	1	1	6	6	1	1	1	3	1	1	1	1	1
ACIL_4SYCA027	2017	1	1	2	2	3	1	1	2	1	1	7	7	1	7	1	1	1	1	1	1	3
ACIL_4SYCA027	2018	1	1	1	1	1	1	1	2	1	1	3	5	1	1	1	1	1	1	1	1	1
ACIL_4VIMT0028	2016	1	1	1	1	1	1	1	1	1	1	7	7	1	7	1	1	1	---	1	1	1
ACIL_4VIMT0029	2017	1	1	1	1	2	1	1	3	1	1	3	7	2	7	1	1	1	1	1	1	1
ACIL_4VIMT0029	2018	1	1	1	1	2	1	1	2	1	1	6	7	1	1	1	1	1	1	1	1	1
ACIL_4VIMT0030	2016	1	1	1	1	1	1	1	2	1	1	3	3	1	7	1	1	1	---	1	1	1
ACIL_4VIMT0030	2017	1	1	1	3	1	1	1	1	1	1	7	7	1	7	1	1	1	1	1	1	1
ACIL_4VIMT0030	2018	1	1	1	1	1	1	1	2	1	1	3	3	1	6	1	1	1	1	1	1	1
ACIL_5RAGR031	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_5RAGR031	2017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_5RAGR031	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6BLMO032	2014	1	---	1	1	1	1	1	1	1	6	3	3	1	1	1	1	1	1	1	1	---
ACIL_6BLMO032	2015	1	6	1	1	1	1	1	1	1	7	4	4	1	7	1	1	1	1	1	1	1
ACIL_6BLMO032	2016	1	1	1	1	1	1	1	1	1	7	5	4	1	7	1	1	1	1	1	1	1
ACIL_6BLMO032	2017	1	6	1	1	1	1	1	1	1	1	5	6	1	7	1	1	1	1	1	1	1
ACIL_6BLMO032	2018	1	7	1	1	1	1	1	1	1	1	4	6	1	1	1	1	1	1	1	1	1

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_6CAHI033	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6CARA034	2017	1	1	1	1	1	1	1	1	1	1	7	2	1	1	1	1	1	1	1	1	1
ACIL_6CARA034	2018	1	1	4	1	1	1	1	1	1	1	4	3	1	1	1	1	1	1	3	1	1
ACIL_6CARL035	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6CARL036	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6EMPO037	2015	1	1	3	1	4	1	1	1	1	1	3	3	1	1	1	3	1	3	1	1	---
ACIL_6EMPO037	2016	1	2	1	1	3	1	1	4	1	7	7	7	1	1	1	1	1	---	1	1	---
ACIL_6EMPO037	2017	1	2	1	1	7	1	1	3	1	1	7	2	1	1	1	1	1	1	1	1	1
ACIL_6EMPO037	2018	1	4	4	1	3	1	1	4	1	1	4	3	1	1	1	1	3	1	1	1	1
ACIL_6LCGR038	2016	1	1	3	1	1	1	1	1	1	1	3	3	1	1	1	1	1	---	1	1	---
ACIL_6LCGR038	2017	1	1	4	1	1	1	1	1	1	1	4	1	1	1	1	1	1	---	1	1	---
ACIL_6LCGR038	2018	---	---	---	---	---	---	---	1	1	1	---	---	---	1	---	---	---	---	---	---	---
ACIL_6LPCA039	2014	1	---	1	1	1	1	1	1	1	6	3	3	2	1	1	1	1	2	1	1	---
ACIL_6LPCA039	2015	1	7	1	1	1	1	1	1	1	7	3	4	1	1	1	1	1	2	1	1	1
ACIL_6LPCA039	2016	1	1	1	1	1	1	1	1	1	7	3	3	1	1	1	1	1	2	1	1	1
ACIL_6LPCA039	2017	1	7	1	1	1	1	1	1	1	1	3	5	1	1	1	1	1	2	1	1	1
ACIL_6LPCA039	2018	1	7	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	2	1	1	1
ACIL_6LUCA040	2017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6LUCA042	2017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6MAMI041	2016	2	1	4	1	3	1	2	1	1	1	3	3	1	1	1	1	1	---	1	1	---
ACIL_6MAMI041	2017	2	1	4	1	3	1	2	1	1	1	3	1	1	1	1	1	1	---	1	1	---
ACIL_6MAMI041	2018	---	---	---	---	---	---	---	1	1	1	---	---	---	1	---	---	---	---	---	---	---
ACIL_6PARO043	2016	1	2	3	2	5	1	1	2	---	---	3	3	1	1	1	1	1	---	1	1	3
ACIL_6PARO043	2017	1	1	1	2	3	1	1	2	1	1	7	6	1	1	1	1	1	2	1	2	3
ACIL_6PARO043	2018	1	1	3	2	1	1	1	3	1	1	7	4	1	1	1	1	1	1	1	1	1

Table 20. San Diego Thornmint: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]																				
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT
ACIL_6RACA044	2017	1	1	1	1	7	1	1	3	1	1	7	7	1	1	1	1	1	1	1	1	1
ACIL_6RACA044	2018	1	1	1	2	1	1	1	1	1	1	3	2	1	1	1	1	1	1	1	1	1
ACIL_6RSFE045	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACIL_6THCO046	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

[1] Table includes only occurrences on conserved lands within the MSPA.

[2] Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **ER** = Erosion, **FP** = Feral Pigs, **FM** = Fuel Modification, **HE** = Herbivory, **HA** = Historic Agriculture, **HG** = Historic Grazing, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **O/M** = Off-road Vehicles/Mountain Bikes, **RF** = Recent Fire, **RC** = Road Construction, **SM** = Slope Movement, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **VC** = Vegetation Clearing, **OT** = Other (refer to full IMG data for description of other threats at each occurrence).

[3] Threat Levels (exclusive of herbivory; numbers represent percent (%) of maximum extent disturbed by threat):
1 = 0% in maximum extent or adjacent 10 m buffer; **2** = 0% in maximum extent but threat detected in surrounding 10 m buffer; **3** = >0-<10% of maximum extent; **4** = 10-<25% of maximum extent; **5** = 25-<50% of maximum extent; **6** = 50-<75% of maximum extent; **7** = ≥75% of maximum extent; **---** = data not collected or not available.

[4] Threats Levels (herbivory only; numbers represent % of plants in sampling area that show signs of herbivory):
1 (0%), **2** (>0-<10%), **3** (10-<25%, **4** (25-<50%), **5** (≥50-<75%), **6** (≥75%).

Genetic Considerations

Genetic studies of San Diego thornmint in San Diego County indicate that this species has high genetic differentiation (divergence) across the region, low genetic diversity within occurrences, and low or mixed levels of inbreeding (Milano and Vandergast 2018; Table 21). Both the USGS and CNLM studies found significant isolation by distance (Milano and Vandergast 2018, DeWoody et al. 2018, CNLM 2014). The USGS study identified five spatially distinct genetic clusters: North, East, South, and Central-west and Central-east (Milano and Vandergast 2018).

Table 21. San Diego Thornmint: Genetic Structure within the MSPA.[1]

Genetic Parameter	Status[2]	Management Trigger[3]	Management Strategy[4,5]
Genetic Differentiation	High (3-5 genetic clusters)	**Yes**	(1) Maintain or restore connectivity among geographically proximate occurrences. (2) Source seed from within genetic cluster (if needed to restore connectivity).
Genetic Diversity	Low (particularly, North and East clusters)	**Yes** (north and east clusters)	(1) Manage threats to increase size and recruitment from soil seed bank. (2) For reintroductions, bulk seed from either occurrence or larger, genetically compatible occurrences within genetic cluster.
Inbreeding & Relatedness	Inbreeding: Low Relatedness: Some High (North and East clusters only)	**Yes** (north and east clusters)	(1) Manage threats to increase size and recruitment from soil seed bank. (2) For reintroductions, bulk seed from either occurrence or larger, genetically compatible occurrences within genetic cluster.
Ploidy level	No differences (Milano and Vandergast 2018) Mixed ploidy (DeWoody et al. 2018)	**Possible** (mixed ploidy)	(1) For small occurrences with mixed ploidy levels, reintroduce seed only from material collected onsite.

1 Results and recommendations from Milano and Vandergast 2018, DeWoody et al. 2018, and CNLM 2014.
2 Status: results of genetic testing per Milano and Vandergast 2018 and Woody et al. 2018
3 Management Trigger: **Yes** = genetic testing indicates that some or all occurrences require specific actions to manage genetic parameter for this species, **Possible** = genetic testing (to date) is not conclusive; further genetic testing or specific actions required to manage genetic parameter for this species.
4 Management Strategy: refers only to strategies to manage genetic parameter. Additional strategies may be needed to manage other threats; management of multiple threats should be coordinated.
5 Strategies to improve connectivity are warranted except where there are local adaptations within populations or differing ploidy levels between populations in proximity (DeWoody et al. 2018).

Figure 15 depicts the five distinct genetic clusters within this species (Milano and Vandergast 2018, DeWoody et al. 2018, CNLM 2014). Table 22 presents the actual or presumed genetic structure of thornmint occurrences. We use the term ‘actual’ structure for occurrences tested genetically, and ‘presumed’ structure for occurrences not yet tested. The latter may be refined in the future.

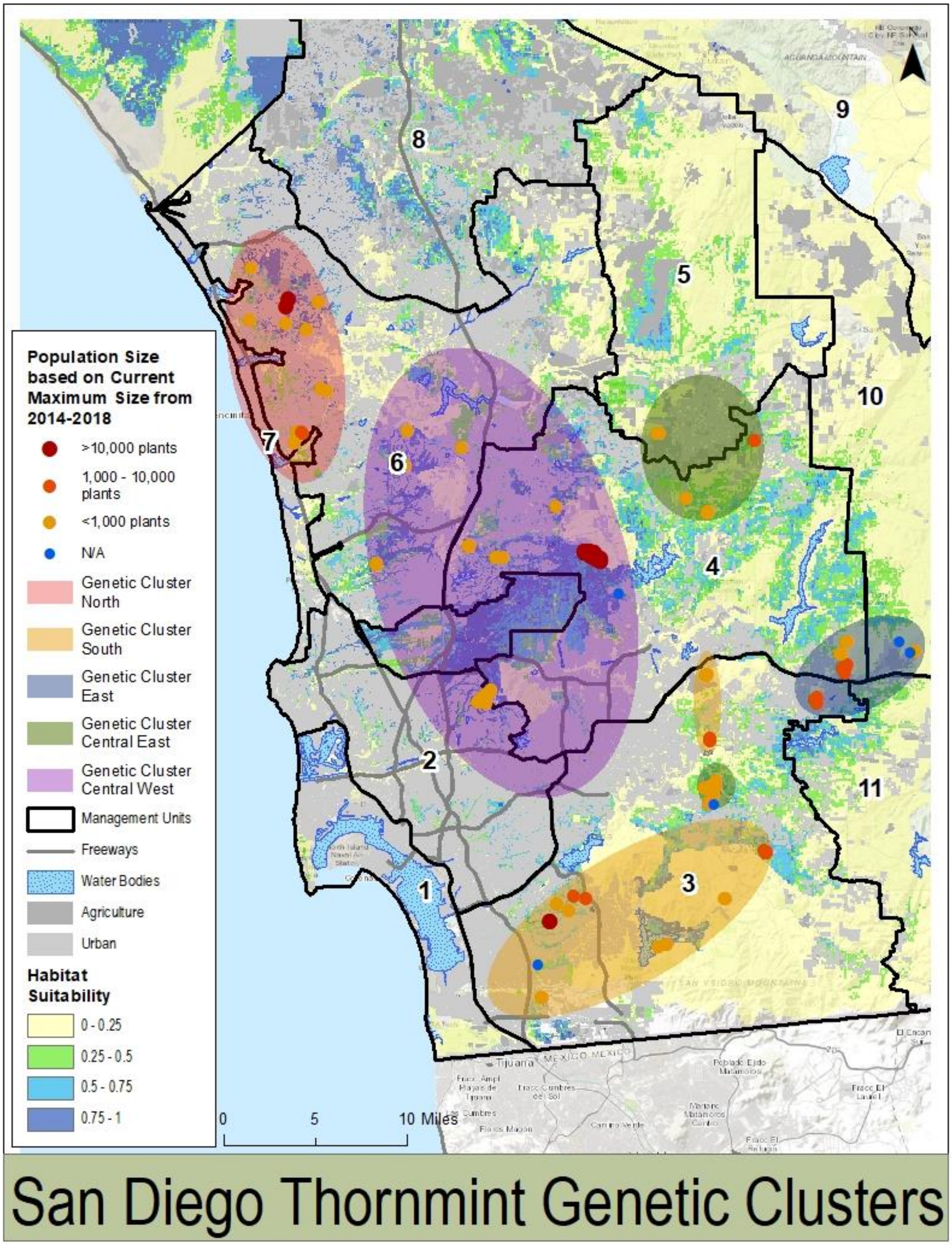


Figure 15. San Diego Thornmint: Genetic Clusters within the MSPA.

Table 22. San Diego Thornmint: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster[1]	Genetic Structure	Potential Management Actions[2]
Management Unit 2			
ACIL_2EDHI001	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_2EDHI002	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
Management Unit 3			
ACIL_3BOME003	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_3CERE004	(South)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3DREA005	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3HCWA006	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats
ACIL_3LONC007	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3MGMT008	Central-east	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_3MGMT009	Central-east	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_3MGMT010	Central-east	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_3OTLA011	(South)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3OTLA012	(South)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3PMA1013	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats
ACIL_3PMA3014	(South)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats
ACIL_3RJER015	(South)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size

Table 22. San Diego Thornmint: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster[1]	Genetic Structure	Potential Management Actions[2]
ACIL_3SOCR016	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_3WHRI017	South	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_3WRFI018	East	High Differentiation + Low Diversity + Low Inbreeding, Some Relatedness	• Manage threats • Consider introducing seed to increase genetic diversity and reduce relatedness[1]
Management Unit 4			
ACIL_4CSVI019	(Central-west, -east)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4CSVI020	(Central-west, -east)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4MTRP021	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4MTRP022	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4POGR023	(Central-west)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4POMT048	(East)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4POMT049	(East)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4POMT050	(East)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4SASP024	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4SASP025	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_4SIPR026	Central-east	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_4SYCA027	Central-west*	High Differentiation + Low Diversity + Low Inbreeding, Some Relatedness	• Manage threats

Table 22. San Diego Thornmint: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster[1]	Genetic Structure	Potential Management Actions[2]
ACIL_4VIMT0028	East	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size; consider introducing seed to increase genetic diversity and reduce relatedness[1]
ACIL_4VIMT0029	East	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
ACIL_4VIMT0030	East	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
Management Unit 5			
ACIL_5RAGR031	(Central-east)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
Management Unit 6			
ACIL_6BLMO032	(East, Central-west)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6CAHI033	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6CARA034	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6CARL035	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6CARL036	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6EMPO037	North	High Differentiation + Low Diversity + Low Inbreeding, Some Relatedness	• Manage threats • Reintroduce/introduce seed to increase occurrence size and genetic diversity and reduce relatedness[1]
ACIL_6LCGR038	North	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6LPCA039	Central-west	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6LUCA040	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size

Table 22. San Diego Thornmint: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster[1]	Genetic Structure	Potential Management Actions[2]
ACIL_6LUCA042	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6MAMI041	North	High Differentiation + Low Diversity + Low Inbreeding, Some Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size; consider introducing seed to increase genetic diversity and reduce relatedness[1]
ACIL_6PARO043	North	High Differentiation + Low Diversity + Low Inbreeding, Some Relatedness, Mixed Ploidy	• Manage threats • Consider introducing seed to increase genetic diversity and reduce relatedness[1]
ACIL_6RACA044	(North)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6RSFE045	(North, Central-west)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
ACIL_6THCO046	(Central-west)	High Differentiation + Low Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size

[1] Placement in a genetic cluster is per genetic testing results (Milano and Vandergast 2018 and others). Occurrences not included in genetic testing are placed in closest genetic cluster, with parentheses around cluster name.

[2] Reintroduce/introduce seed from genetically compatible occurrence(s) within genetic cluster to increase genetic diversity and decrease inbreeding if common garden studies indicate no local adaptation within the target occurrence.

The primary strategies to manage genetic resources within this species include:

- Manage threats at all occurrences to increase population size, maintain or increase genetic diversity, replenish the soil seed bank, and encourage pollinator activity.
- Reintroduce seed into consistently small (<1,000 individuals) occurrences to increase population size and diversity *if determined necessary after managing threats*. Follow guidelines in the SCBBP on seed collecting and bulking. Collect seed from the target occurrence or from genetically similar, higher diversity occurrences *within the genetic cluster*.

  Not all small occurrences will require seed reintroduction. This strategy is most appropriate under the following conditions: (1) occurrence is small *and* declining, even with management, (2) suitable habitat persists, and (3) adequate funding is available for both the reintroduction effort and long-term management. Occurrences with fewer than 100 plants are the highest priority for reintroduction (if the conditions above are met), because they are particularly susceptible to extirpation. We recognize that some small occurrences are stable and will not require additional seed.

- For occurrences with very low genetic diversity and/or high relatedness, consider reintroducing genetically compatible propagules from *within the genetic cluster* to increase genetic diversity and decrease inbreeding regardless of occurrence size, unless common garden experiments indicate local adaptations. This includes the following occurrences:
  - ACIL_3WRFI018 (medium occurrence)
  - ACIL_4VIMT0028 (small occurrence)
  - ACIL_6EMPO037 (small occurrence)
  - ACIL_6MAMI041 (medium occurrence)
  - ACIL_6PARO043 (large occurrence)
- Improve connectivity among occurrences *within genetic clusters* by reintroducing/introducing the species into suitable, unoccupied habitat or enhancing/creating habitat for pollinators, unless common garden experiments indicate that mixing would be detrimental to reproductive success (i.e., outbreeding depression). Genetic data supported genetic isolation by distance, which suggests that natural gene flow among populations occurred in a steppingstone fashion (Milano and Vandergast 2018).

  Note that enhancing or creating habitat for pollinators to improve connectivity should occur only between occurrences within the dispersal capability of a pollinator. This will allow the pollinator to transfer pollen from one occurrence to another, thereby promoting gene flow. These actions will not be effective if the distance between occurrences exceeds the distance that a pollinator can travel.

Regional Population Structure

Size Class Distribution

For San Diego thornmint, we used the population size classes for annual plant species from Table 12. Table 23 presents the distribution of size classes for thornmint across MUs. Where recent monitoring data were not available or no plants were detected at an occurrence during IMG monitoring (2014-2018), we used historic data (pre-2014) to assign size class. Although this method is imprecise, it highlights the need for comprehensive monitoring data.

Table 23. San Diego Thornmint: Size Class Distribution by MU.

Management Unit	Occurrence Size Class[1]			Total[2]
	Large	Medium	Small	
2	0 (0%)	0 (0%)	2 (100%)	2
3	1 (6%)	4 (25%)	11 (69%)	16
4	1 (7%)	2 (14%)	11 (79%)	14
5	0 (0%)	0 (0%)	1 (100%)	1
6	1 (6.5%)	1 (6.5%)	13 (87%)	15
Total	3	7	38	48

[1] Refer to text and Table 12 for description of size classes. Number = number of occurrences in size class; percent (%) = percent of occurrences in size class for management unit (note: numbers rounded to sum to total).

[2] We do not have population size data for one occurrence; thus, we show size class for only 48 of the 49 occurrences on conserved lands in the MSPA.

We identified five population groups across the MSPA, based on population size, location, and actual or presumed levels of connectivity and genetic differentiation (Figure 16). Population groups correspond to genetic clusters (Milano and Vandergast 2018 and others; Table 22).

Occurrences within population groups are currently genetically compatible. However, fragmentation and subsequent isolation are relatively recent events that could increase genetic differentiation and/or decrease genetic diversity within some groups over time. For that reason, we also identified population subgroups within population groups based on proximity and/or the presence of suitable habitat to potentially allow for gene flow, population expansion, or movement of pollinators between occurrences. We refer to the groups or subgroups by their population codes (Table 24), with the group abbreviation (North = N, East = E, South = S, Central-west = Cw, and Central-east = Ce) followed by the subgroup number. For example, subgroup 3 in the North population group is N-3. Population groups and subgroups are depicted in Figures 17-21. Group and subgroup designations refine earlier regional population structures developed for this species in the absence of genetic data (CBI 2018, 2014a).

We assigned occurrences not included in the genetic studies to the nearest population group. We assigned occurrences that had been studied, but placed in more than one genetic cluster, to the population group that was both closest and had suitable intervening habitat. Finally, the large occurrence at Sycamore Canyon has a mixed genetic assignment and high diversity, with potential implications as a seed source beyond its population group.

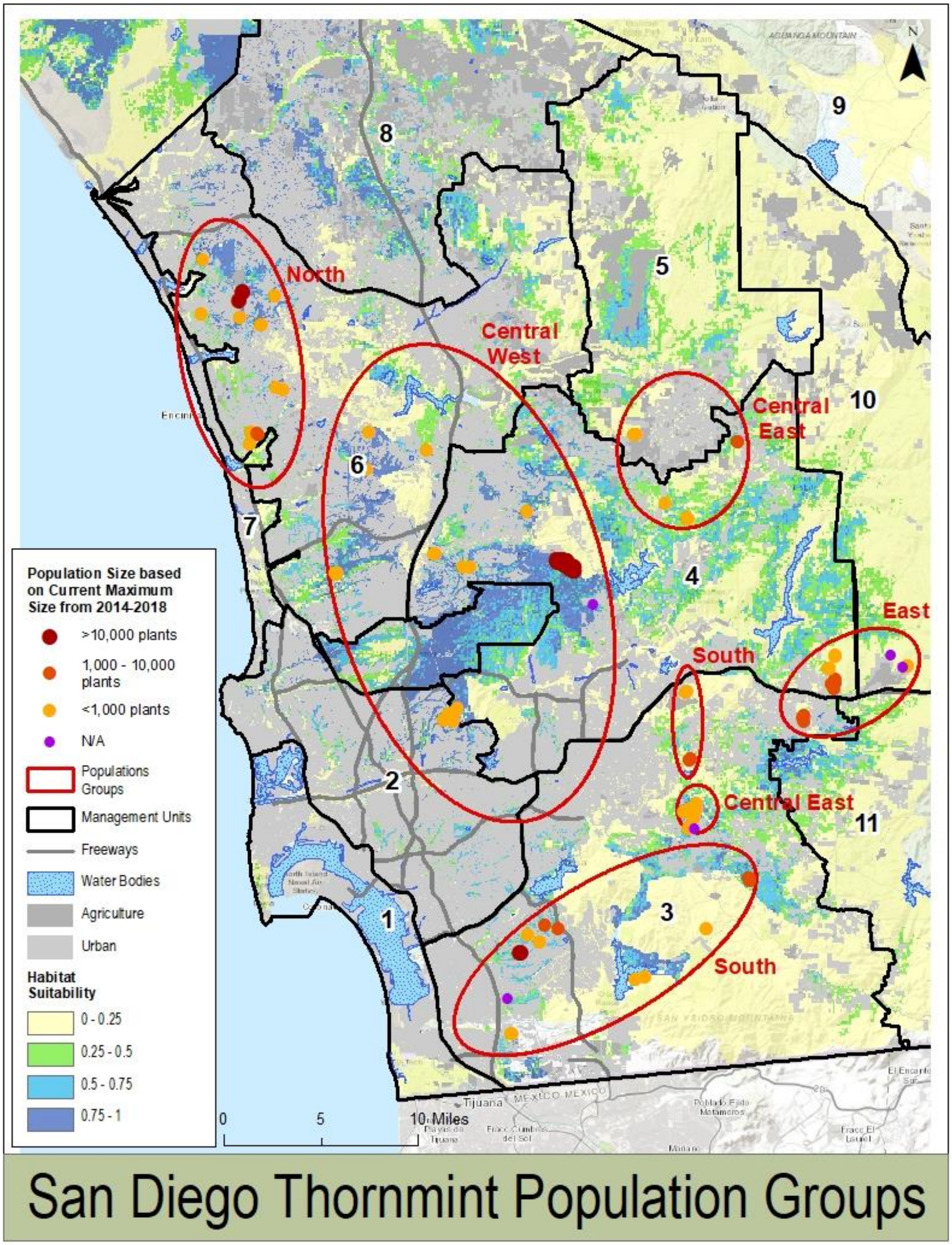


Figure 16. San Diego Thornmint: Population Groups within the MSPA.

Table 24. San Diego Thornmint: Population Groups and Subgroups.

Population Group[1]	Population Subgroup	Population Code	Occurrence ID	Population Size[2]	Group Characterization[3]
North Group					
(North)	1	N-1	ACIL_6CAHI033	Small	Large
(North)	1	N-1	ACIL_6CARA034	Small	
North	1	N-1	ACIL_6EMPO037	Small	
North	1	N-1	ACIL_6LCGR038	Small	
North	1	N-1	ACIL_6PARO043	Large	
(North)	1	N-1	ACIL_6RACA044	Small	
(North)	2	N-2	ACIL_6CARL035	Small	Small
(North)	2	N-2	ACIL_6CARL036	Small	
(North)	3	N-3	ACIL_6LUCA040	Small	Mixed
(North)	3	N-3	ACIL_6LUCA042	Small	
North	3	N-3	ACIL_6MAMI041	Medium	
East Group					
East	1	E-1	ACIL_3WRFI018	Medium	Mixed
(East)	1	E-1	ACIL_4POMT048	Small	
(East)	1	E-1	ACIL_4POMT049	Small	
(East)	1	E-1	ACIL_4POMT050	Small	
East	1	E-1	ACIL_4VIMT0028	Small	
East	1	E-1	ACIL_4VIMT0029	Medium	
East	1	E-1	ACIL_4VIMT0030	Small	
South Group					
South	1	S-1	ACIL_3BOME003	Medium	Large
South	1	S-1	ACIL_3DREA005	Small	
South	1	S-1	ACIL_3LONC007	Small	
(South)	1	S-1	ACIL_3OTLA012	Small	
South	1	S-1	ACIL_3PMA1013	Large	
(South)	1	S-1	ACIL_3PMA3014	Small	
South	1	S-1	ACIL_3WHRI017	Small	
South	2	S-2	ACIL_3HCWA006	Medium	Mixed
(South)	2	S-2	ACIL_3OTLA011	Small	
(South)	2	S-2	ACIL_3RJER015	Small	
(South)	3	S-3	ACIL_3CERE004	Small	Mixed
South	3	S-3	ACIL_3SOCR016	Medium	

Table 24. San Diego Thornmint: Population Groups and Subgroups.

Population Group[1]	Population Subgroup	Population Code	Occurrence ID	Population Size[2]	Group Characterization[3]
Central-west Group					
Central-west	1	Cw-1	ACIL_2EDHI001	Small	Small
Central-west	1	Cw-1	ACIL_2EDHI002	Small	
Central-west	1	Cw-1	ACIL_4MTRP021	Small	
Central-west	1	Cw-1	ACIL_4MTRP022	Small	
(Central-west)	2	Cw-2	ACIL_4POGR023	Small	Large
Central-west	2	Cw-2	ACIL_4SASP024	Small	
Central-west	2	Cw-2	ACIL_4SASP025	Small	
Central-west[4]	2	Cw-2	ACIL_4SYCA027	Large	
Central-west	2	Cw-2	ACIL_6LPCA039	Small	
(Central-west)[5]	3	Cw-3	ACIL_6BLMO032	Small	Small
(Central-west)[5]	3	Cw-3	ACIL_6RSFE045	Small	
(Central-west)	3	Cw-3	ACIL_6THCO046	Small	
Central-east Group					
Central-east	1	Ce-1	ACIL_3MGMT008	Small	Small
Central-east	1	Ce-1	ACIL_3MGMT009	Small	
Central-east	1	Ce-1	ACIL_3MGMT010	Small	
Central-east	2	Ce-2	ACIL_4SIPR026	Medium	Mixed
(Central-east)	2	Ce-2	ACIL_5RAGR031	Small	
(Central-east)[6]	2	Ce-2	ACIL_4CSVI019	Small	
(Central-east)[6]	2	Ce-2	ACIL_4CSVI020	Small	

[1] Population Groups correspond to genetic clusters (see Table 22; Milano and Vandergast 2018). Where the group is in parentheses, the occurrence was not included in genetic testing and is placed in the group based on proximity to tested occurrences.
[2] Population size categories: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.
[3] Group characterization: **large** = group has at least one large occurrence; **medium** = group has medium occurrences only; **small** = group has small occurrences only; **mixed** = group has medium and small occurrences.
[4] Occurrence has a mixed genetic structure.
[5] Genetic studies indicate that the occurrence also includes elements of the Central-east genetic cluster; we have tentatively placed it in the Central-west subgroup due to geographic location and proximity to other occurrences in this subgroup.
[6] Genetic studies indicate that occurrence also includes elements of the Central-west genetic cluster; we have tentatively placed it in the Central-east subgroup due to geographic location and proximity to other occurrences in this subgroup.

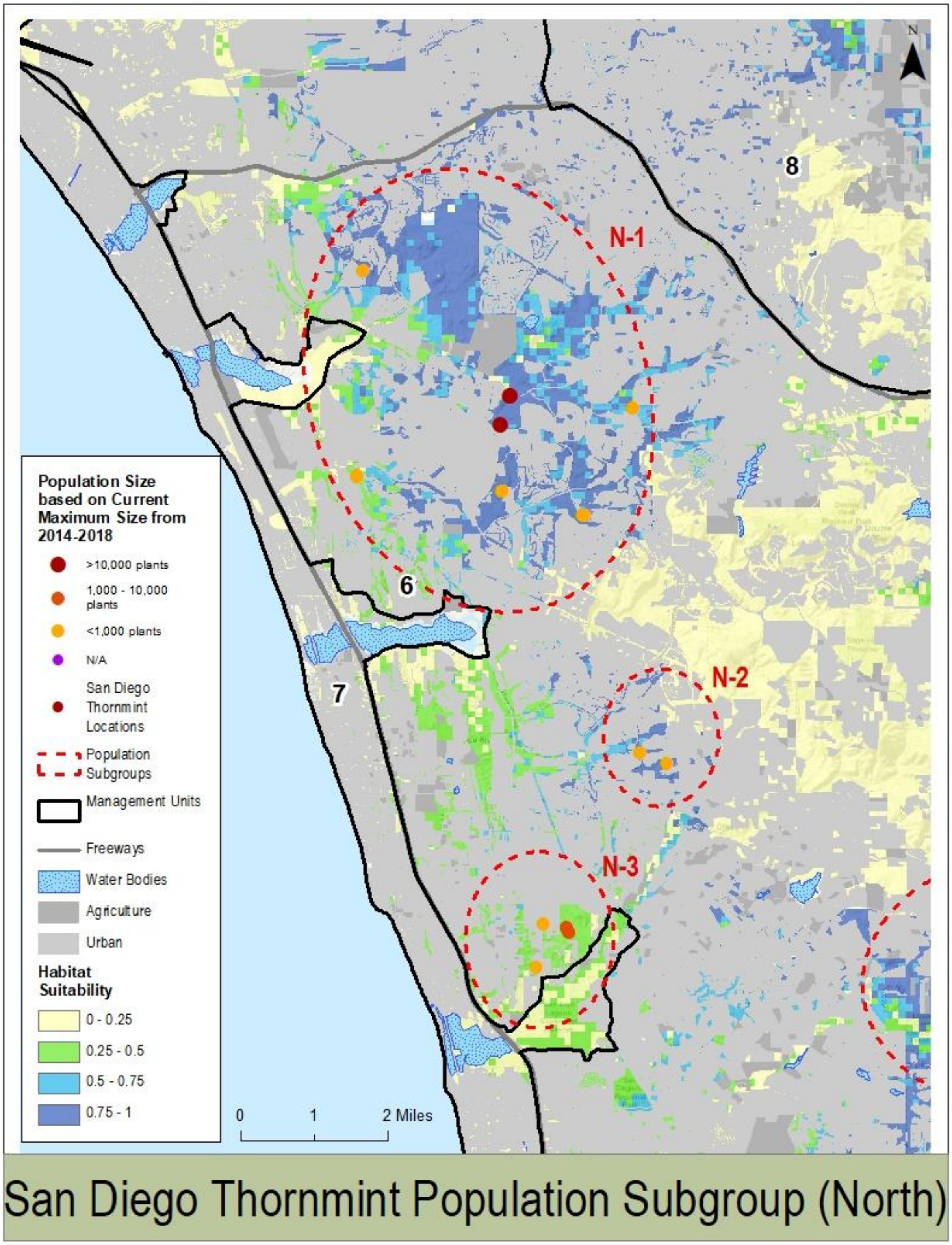


Figure 17. San Diego Thornmint: North Population Subgroup.

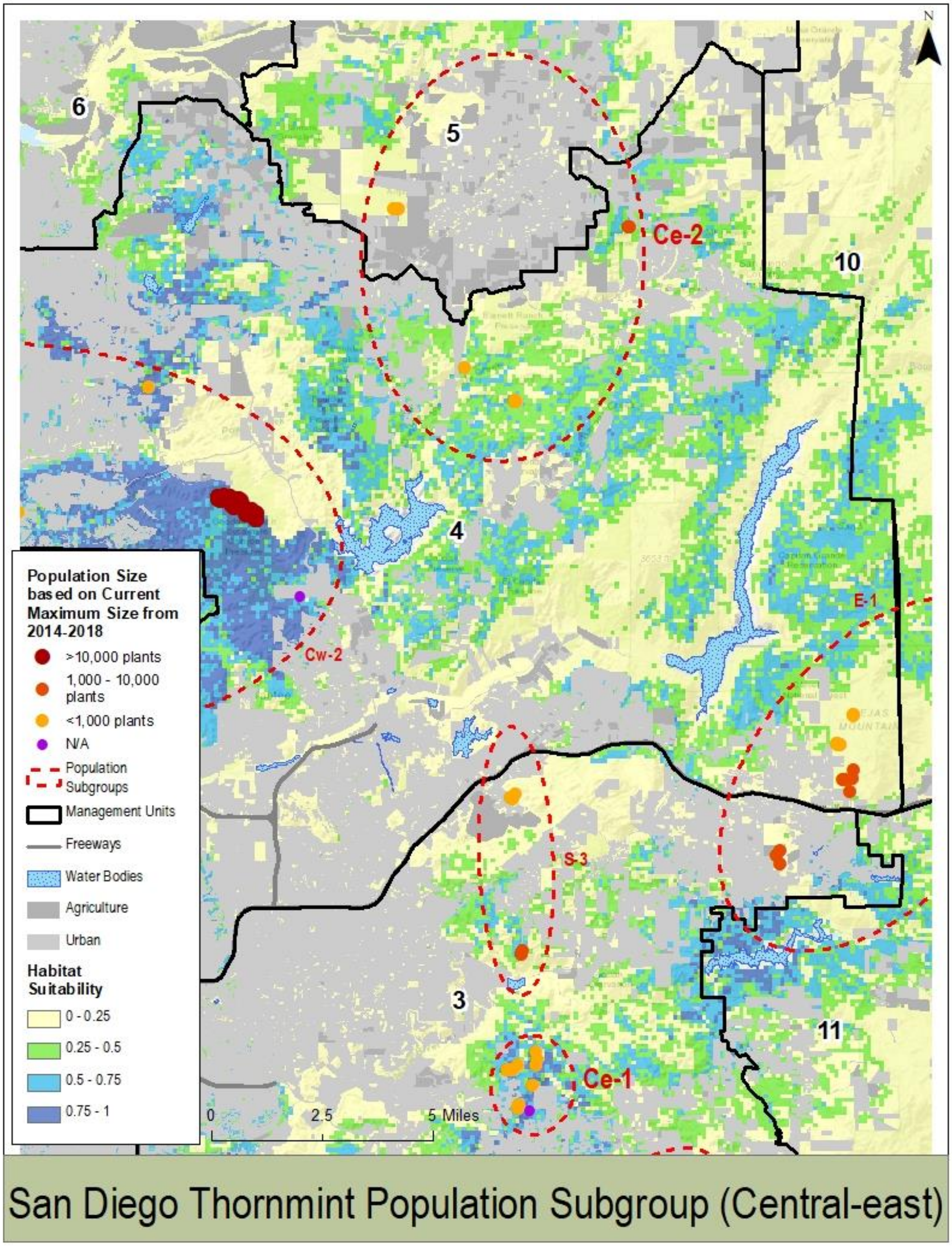


Figure 18. San Diego Thornmint: Central-east Population Subgroup.

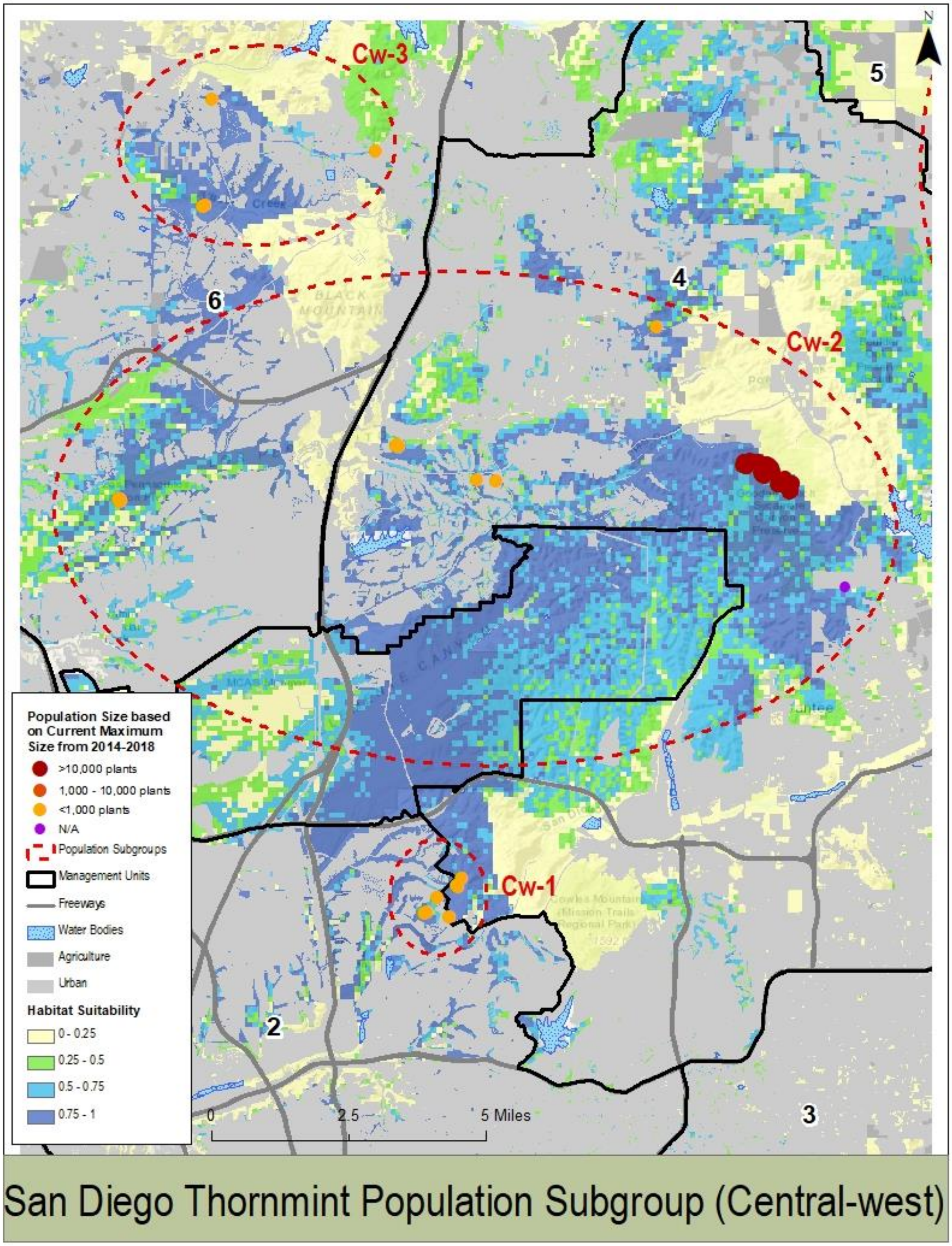


Figure 19. San Diego Thornmint: Central-west Population Subgroup.

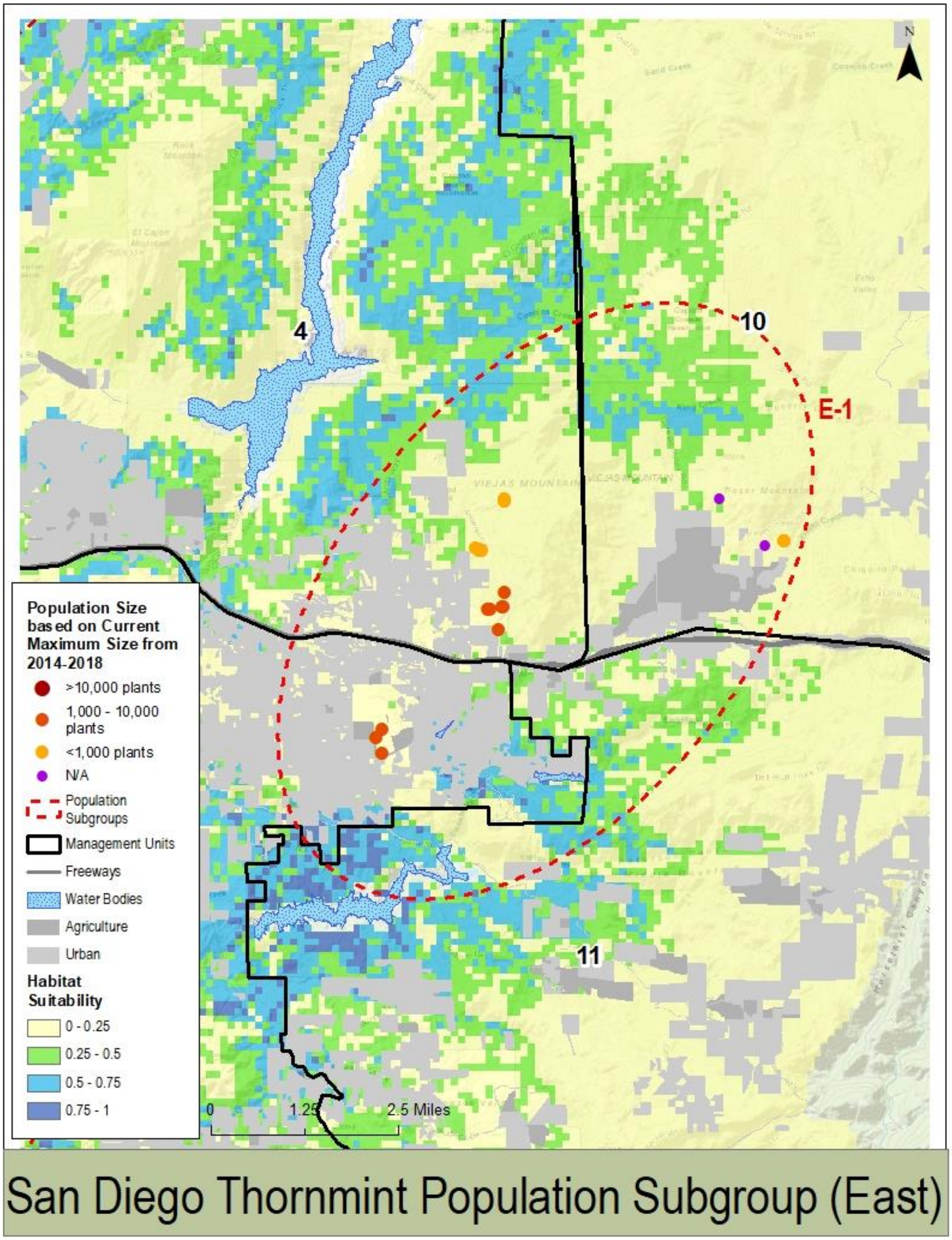


Figure 20. San Diego Thornmint: East Population Subgroup.

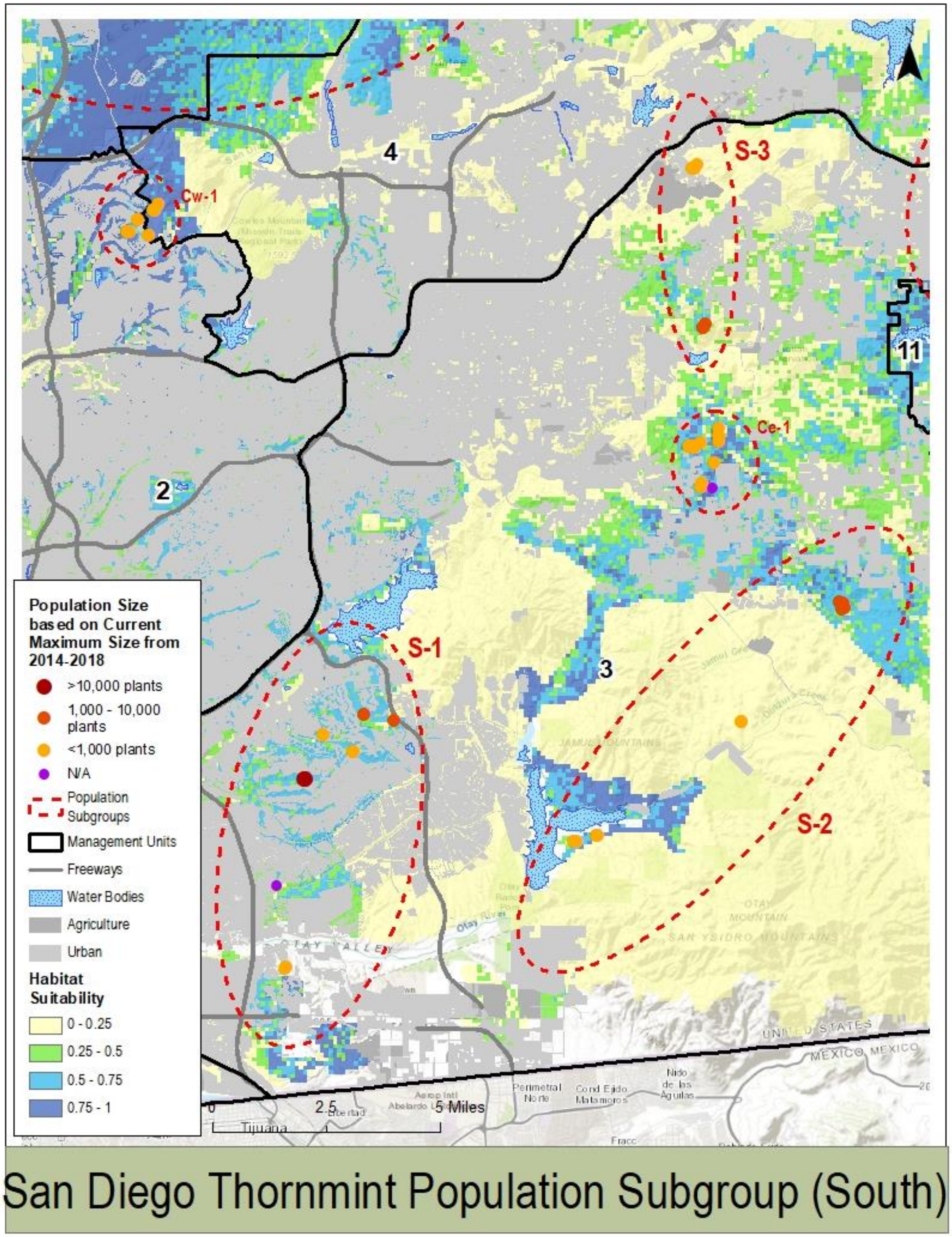


Figure 21. San Diego Thornmint: South Population Subgroup.

Habitat Connectivity

Habitat fragmentation and loss of connectivity are particular concerns for thornmint population groups in the north and west portions of the MSPA, where gaps occur within and among groups (Figure 16). While a network of conserved lands connects many population groups (at least tenuously), population group N-3 and possibly, the Ramona Grasslands occurrence in group Ce-2, are isolated and likely to remain so because there is little suitable habitat in gap areas. Population group S-1 also occurs on fragmented lands; however, occurrences within this group are in proximity and likely benefit in terms of gene flow from the presence of a large occurrence. Conversely, population groups Ce-1, Ce-2, and E-1 contain high suitability habitat that may support additional occurrences.

Regional Management Strategies for Opportunity Areas

Management actions will occur within *Opportunity Areas* identified through the regional population structure process. Opportunity Areas are conserved lands within the MSPA that have the potential to enhance regional population structure and long-term resilience of the target species through various conservation and management actions. Opportunity Areas occur within population groups or subgroups, in gap areas between population subgroups, or beyond the current species' distribution in response to a changing climate (SDMMP in CBI 2018).

We recommend the following strategies to maintain or improve regional population structure and long-term resilience of San Diego thornmint within opportunity areas across the MSPA:

- **Survey** high suitability habitat within and among population groups to determine whether additional occurrences exist.
- **Manage** all occurrences through site-specific actions (e.g., invasive plant control), as determined necessary through monitoring.
- **Reintroduce** the species into selected small occurrences that do not respond positively to management by adding seed from the target occurrence (if adequate seed is available) or from a genetically compatible source population within the same population group (genetic cluster). A positive response to management is an increase in occurrence size under favorable climatic conditions. Small occurrences are present in all identified population groups and subgroups (Table 24).

  For small occurrences that supported no plants in recent monitoring periods, test soil to ensure it is still suitable to support San Diego thornmint and control threats prior to reintroducing seed.
- **Restore** habitat at selected small occurrences by enhancing existing habitat or expanding adjacent habitat and/or introducing or reintroducing genetically compatible thornmint seed from within the same population group (genetic cluster; Table 22). Test soil first to

ensure it is suitable to support San Diego thornmint. Restore habitat (if necessary) only after controlling threats and monitoring for response of thornmint and associated species.

- **Introduce** new occurrences into high suitability habitat between population groups *if* surveys fail to locate new occurrences in these gap areas.
- **Translocate** the species experimentally into future suitable habitat outside the current species' range if population declines are potentially attributable to changing climatic conditions rather than lack of management.

Management Priorities and Recommendations

Management priorities and recommendations are based on IMG monitoring data, and genetic and regional population structures, and informed by management strategies outlined in previous sections. The current focus is managing thornmint under existing (versus future) conditions.

Table 25 presents criteria to prioritize management actions; priorities are assigned for each management category. For example, an occurrence may be a high priority for all categories, or a high priority in one category and a lower priority in other categories. For threats, prioritize large occurrences with high or moderate threats over small occurrences with high threats.

Table 25. San Diego Thornmint: Criteria for Prioritizing Management Actions.

Management Category	Priority Level[1,2]			
	Not A Priority	Low Priority	Medium Priority	High Priority
Threats	Threat level 1	Threat levels 2-3	Threat levels 4-5	Threat levels 6-7
Genetic Structure	Large occurrence, low genetic diversity and/or inbreeding	Medium occurrence, low genetic diversity and/or inbreeding	Small occurrence in south or central clusters, low genetic diversity and/or inbreeding	Small occurrence in north and east clusters, low genetic diversity, and/or inbreeding
Regional Population Structure	Large population group, intact habitat within group	Large population group, fragmented habitat within group	Mixed or medium population group	Small population group

[1] Priority levels may differ for each management category within an occurrence.
[2] For threats, prioritize large occurrences with high or medium threats over small occurrences with high threats.

Although the focus is on managing high priority levels within a management category, land managers may address lower priority levels, as well. For each priority level, refer to companion tables in this document for relevant information, including appropriate management strategies:

- Threats (Table 20)
- Genetic Structure (Tables 21, 22)
- Regional Population Structure (Table 24)

For some proposed actions, management may be a one-time event (e.g., removing trash). For others, management may be a long-term effort that requires multiple years and considerable expense (e.g., controlling invasive plants). Land managers can reduce management costs by addressing threats at an early stage (e.g., threat levels of 3, 4, 5). This is particularly important for large occurrences to maintain their status and prevent decline. Where early intervention is not possible, land managers should have adequate funding or other resources available before starting a large-scale or expensive management program, unless these actions can be phased. As an example, invasive plant control may require an initial and intensive 3-5 year treatment program, but if this is not followed by long-term maintenance, the site may revert quickly to its pre-treatment condition. In all cases, continue IMG monitoring to assess status, threats, and effectiveness of management actions.

We recommend an adaptive approach to managing thornmint occurrences, as outlined in the steps below and presented in Figure 22:

1. Monitor occurrence using IMG rare plant monitoring protocol
2. If threats are identified, manage to reduce impacts to rare plant occurrence.
3. Continue monitoring to assess management effectiveness.
4. If threats are not controlled, continue management actions or manage adaptively.
5. If there are no threats or if threats are controlled through management actions, and occurrence is small and declining, reintroduce seed per species-specific BMPs in this document and in the SCBBP.
6. Continue monitoring to assess success of seeding effort.
7. If seeding is unsuccessful, reintroduce additional seed (per flow chart) or reassess seeding effort and site conditions to determine if continued seeding is worthwhile.
8. If seeding is successful, continue monitoring per IMG rare plant monitoring protocol to assess occurrence status and threats.

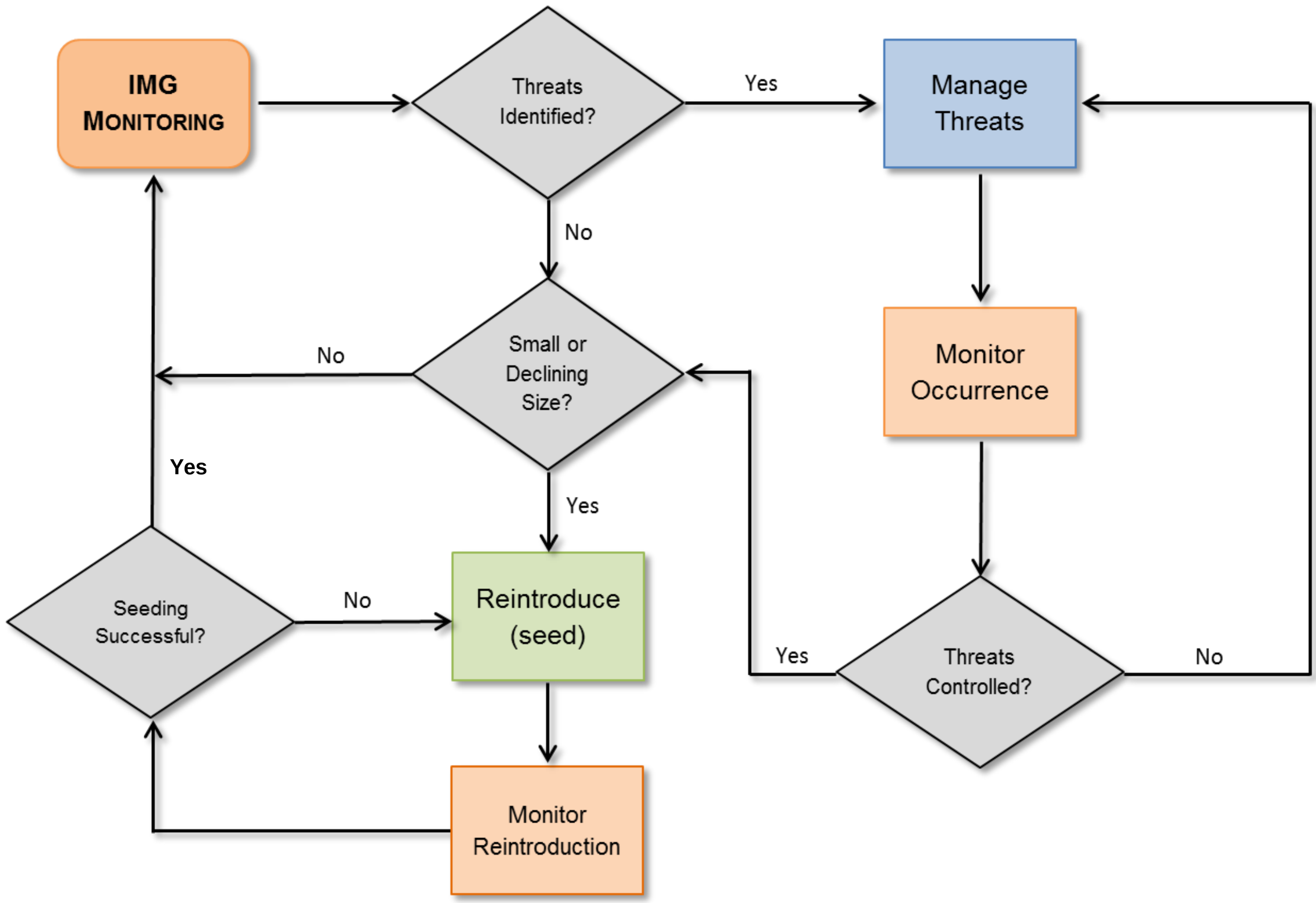


Figure 22. San Diego Thornmint: Adaptive Management Flow Chart.

Regional Priorities and Recommendations

Regional priorities focus first on actions that would benefit the species within its current range (e.g., regional monitoring, baseline surveys, possibly species introductions). At this time, actions that would occur outside the current range of the species (e.g., species translocations) are a lower priority for management. Regional management actions identified for thornmint include:

- Continue monitoring all thornmint occurrences on conserved lands in the MSPA.
- Monitor newly conserved occurrences or occurrences that are conserved but have not yet been monitored per the IMG monitoring protocol.
- Prioritize large occurrences with high or moderate threats for management over small occurrences with high threats. This will ensure that large populations remain large and genetically diverse to help rescue smaller populations.
- Survey high suitability habitat *within* population groups Cw-2, Ce-2, E-1, and S-2, and *between* population groups Cw-2 and Ce-2, Ce-2 and E-1 (Figures 18-21) to determine if additional occurrences exist. Monitor newly discovered occurrences per the IMG monitoring protocol.
- Introduce new occurrences into high suitability habitat on conserved lands between population groups Cw-2 and Ce-2, Ce-2 and E-1, and possibly, within group S-2 (Figures 18-21) *if* (1) surveys fail to locate new occurrences in gap areas, (2) funding is available, and (3) existing occurrences decline despite management.
- Translocate the species into future suitable habitat outside the current species range *if* existing occurrences in one or more MUs decline steadily over time and this decline is potentially attributable to changing climate rather than lack of management. All translocations should be considered experimental and controlled carefully. Refer to habitat suitability maps under future climatic scenarios for potential translocation locations (SDMMP *in* CBI 2018). At this time, managing existing occurrences is a higher priority than translocating occurrences.

Preserve-level Priorities and Recommendations

Preserve-level priorities and recommendations are informed primarily by IMG monitoring, although they also address those aspects of genetic structure or regional population structure that are specific to an occurrence. We did not assign priorities or recommendations to occurrences where monitoring data were lacking, unless those data were available through other sources.

For most occurrences on conserved lands, surveys have already been conducted. For occurrences where locational information appears to be incorrect or incomplete, the first step will be to conduct baseline surveys. For occurrences with accurate locational information but no monitoring data, the first step will be IMG monitoring to determine status and threats, unless it has been determined that suitable habitat no longer exists. For all occurrences, *manage threats prior to reintroducing seed*. Managing threats may be sufficient to restore habitat from the soil seed bank, particularly on clay lenses that support thornmint.

We use a variation of our earlier color-coded threats scheme to allow land managers to quickly identify priority levels for management (Figure 23). We assigned priority levels for threats at each occurrence using the highest threat level recorded for any sample during the monitoring period. This accommodates different levels of threats between years that may be due to annual climatic variation or surveyor variability. In some cases, land managers may have already controlled threats effectively (e.g., trash removal). In other cases, threat levels may fluctuate between years (e.g., invasive plants).

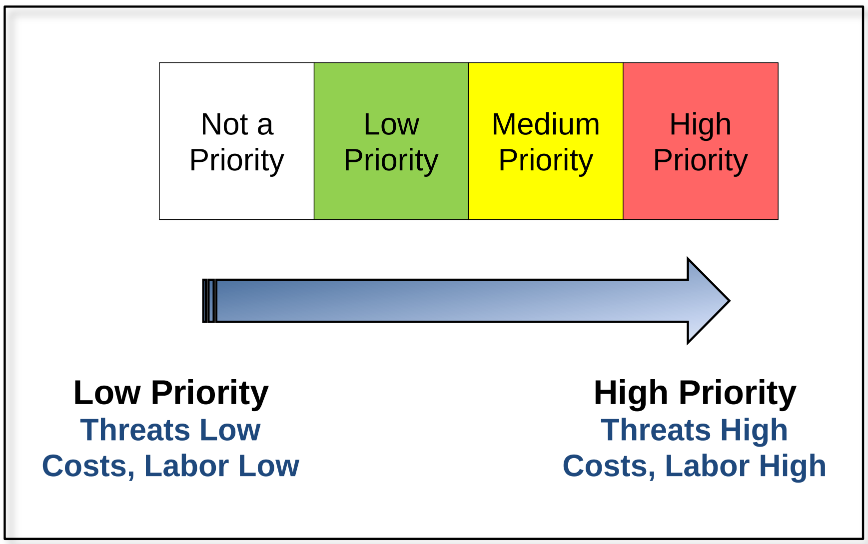


Figure 23. San Diego Thornmint: Color-coded Management Priority Levels.

Table 26 presents management priorities for San Diego thornmint occurrences. The steps below outline how to use Table 26 and other information in this document to identify and implement management priorities. Refer to Appendix B for general BMPs; species-specific BMPs are included in this chapter.

Steps to Identifying and Implementing Management Priorities
San Diego Thornmint:
1. Locate the occurrence in **Table 26**.
2. Determine which threats occur at the target occurrence.
3. Determine which threats are most important to manage. In general, manage higher priority threats first and then move on to lower priority threats. If budgets are limited, manage smaller portions of the high priority threat each year. Increase management efforts once budgets improve or if endowment or grant funding becomes available. Refer to **Table 20** for detailed threat levels.
4. Refer to general and species-specific BMPs to manage the identified threat(s). For example, if erosion and altered hydrology are high priority threats, refer to **general BMPs (Appendix B)** for control methods or other recommendations. If nonnative grasses and forbs are high priority threats, refer to **species-specific BMPs** in this chapter for control methods.
5. Once threats are controlled, refer to the genetics and regional population structure columns in **Table 26** to determine if the occurrence would benefit from reintroducing seed or restoring habitat. To reintroduce seed, identify appropriate seed source (**Figures 17-19**, **Table 24)**, collect seed per the **SCBBP**, and outplant seed per **species-specific BMPs** in this chapter. To restore habitat, determine extent and location of restoration effort after threats are controlled, and restore habitat following **species-specific BMPs** in this chapter.
6. After implementing the appropriate management action(s), monitor the occurrence using the IMG monitoring protocol to determine if actions are successful and manage adaptively per the Adaptive Management flow chart (**Figure 22**).

Table 26. San Diego Thornmint: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																					GN[5]	RP[6]
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT	RE	RS
ACIL_2EDHI001	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_2EDHI002	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_3BOME003	Medium				L	L						H	H	M				L	M	M			M	L
ACIL_3CERE004	Small		H	L		H		L				H	H		H								H	M
ACIL_3DREA005	Small		H								H	H	H					H	L				H	L
ACIL_3HCWA006	Medium		H	H	L							H	H	L					L	L			M	M
ACIL_3LONC007	Small										H	L	L						L	L		L	H	L
ACIL_3MGMT008	Small			M					L		H	H	H					L	L	L			H	H
ACIL_3MGMT009	Small			L		M		M	L			H	H						L	L	L		H	H
ACIL_3MGMT010	Small	L		L		L			M	H	H	H	H	L	H	L	L	L	L	L	L	H	H	H
ACIL_3OTLA011	Small				L						H	H	L		H	L							H	M
ACIL_3OTLA012	Small									H	H	H	L		H								H	L
ACIL_3PMA1013	Large		H		L	L			L		H	H	H				L	L	L	L	L		L	
ACIL_3PMA3014	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_3RJER015	Small										H	L	H		H								H	M
ACIL_3SOCR016	Medium			L		M	L					H	H	L	H		H	L	L	L		H	H	M
ACIL_3WHRI017	Small										H	M	L						M	M			H	L
ACIL_3WRFI018	Medium		H	H							H	M	L		H					L			M	M
ACIL_4CSVI019	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_4CSVI020	Small		H			L					H	H	H		H								H	M
ACIL_4MTRP021	Small		H	M	L						H	M	H		H			L	L		H	M	H	H
ACIL_4MTRP022	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_4POGR023	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		L
ACIL_4POMT048	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		

Table 26. San Diego Thornmint: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																					GN[5]	RP[6]
		AH	BR	CNP	D/T	ER	FP	FM	HE	HA	HG	NNF	NNG	O/M	RF	RC	SM	SC	TR	TP	VC	OT	RE	RS
ACIL_4POMT049	Small		L	L								L	M		H								H	M
ACIL_4POMT050	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_4SASP024	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_4SASP025	Small		H		L				L		H	H	M		H				L				H	L
ACIL_4SIPR026	Medium				L				L			H	H		H							H	M	M
ACIL_4SYCA027	Large			L	L	L			L			H	H		H		L					L		
ACIL_4VIMT0028	Small											H	H		H								H	M
ACIL_4VIMT0029	Medium					L			L			H	H	L	H								M	M
ACIL_4VIMT0030	Small				L				L			H	H		H								H	M
ACIL_5RAGR031	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6BLMO032	Small		H								H	M	H		H								H	H
ACIL_6CAHI033	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6CARA034	Small			M								H	L							L			H	L
ACIL_6CARL035	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6CARL036	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6EMPO037	Small		M	M		H			M		H	H	H				L	L	L				H	L
ACIL_6LCGR038	Small			M								M	L										H	L
ACIL_6LPCA039	Small		H								H	M	M	L					L				H	L
ACIL_6LUCA040	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6MAMI041	Small	L		M		L		L				L	L										M	M
ACIL_6LUCA042	Medium	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6PARO043	Large		L		L	M			L			H	H						L		L	L	L	
ACIL_6RACA044	Small				L	H			L			H	H										H	L
ACIL_6RSFE045	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
ACIL_6THCO046	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		

[1] Management Priorities: **L** = Low Priority, **M** = Medium Priority, **H** = High Priority. If no priority level is indicated, then no management action is recommended at this time. Monitor occurrences with no data (**---**) per the IMG protocol to identify and recommend appropriate management actions.
[2] Size = population size category: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.
[3] Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **ER** = Erosion, **FP** = Feral Pigs, **FM** = Fuel Modification, **HE** = Herbivory, **HA** = Historic Agriculture, **HG** = Historic Grazing, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **O/M** = Off-road Vehicles/Mountain Bikes, **RF** = Recent Fire, **RC** = Road Construction, **SM** = Slope Movement, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **VC** = Vegetation Clearing, **OT** = Other (refer to full IMG data for description of other threats at each occurrence).
[4] Threats per IMG monitoring protocol. **---** = no data (occurrence not monitored per IMG monitoring protocol).
[5] **GN** = Genetics; **RE** = Reintroduce seed using seed from the target occurrence (if an adequate amount of seed is available) or from a genetically compatible seed source within the same population group (genetic cluster). We do not include recommendations for occurrences with no monitoring data.
[6] **RP** = Regional Population Structure; **RS** = Restore habitat (enhance, expand). We do not include recommendations for occurrences with no monitoring data.

Best Management Practices

We define a BMP as a tested, effective practice to accomplish management goals or objectives. Land managers, biologists, restoration contractors, or ecologists (*practitioners*) typically implement BMPs. In this section, we outline BMPs to restore thornmint habitat (*habitat restoration*) and occurrences (*species restoration*). These BMPs have been used successfully in San Diego County and represent the current state of management knowledge for this species (Dodero pers. comm., Ekhoff pers. comm., McMillan pers. comm., Spiegelberg pers. comm.).

The BMPs for restoring thornmint habitat include dethatching and invasive plant control. The use of herbicides to control invasive plants in thornmint habitat is based on many factors, including (but not limited to) goals and objectives, management approach, occurrence history, proximity of target invasive species to thornmint, practitioner experience, restoration timeline, budget, and herbicide restrictions. Currently, herbicide is the preferred method to control invasive plants in thornmint habitat, especially for larger occurrences, and has been tested by multiple land managers in San Diego County. Nonetheless, we also provide mechanical methods in case herbicide is unnecessary, inadvisable, or restricted.

The BMPs for herbicide use in this section focus only on synthetic herbicides. We do not provide BMPs for non-synthetic herbicide use at this time due to (1) a lack of research regarding their effectiveness in thornmint habitat or (2) existing research that indicates variable and/or marginally effective results (i.e., Suppress®) in controlling primary invaders in thornmint habitat (i.e., *Brachypodium distachyon*, *Centaurea melitensis*) (Natural Communities Coalition 2018). We acknowledge that using non-synthetic herbicides alone or in combination with mechanical methods may be appropriate to control specific invasive species in some situations.

Refer to Natural Communities Coalition (NCC 2018) for additional information and guidelines on the selection and use of manual and chemical control methods on conserved lands. The NCC document is specific to Orange County; however, the *general* recommendations on invasive plant control methods apply broadly to San Diego County and have the support of both the USFWS and CDFW. Refer to BMPs in this section for invasive plant control methods developed and tested specifically for San Diego thornmint.

The BMPs for restoring thornmint occurrences include reintroducing, introducing, or translocating seed, and are used primarily to increase small and medium occurrences. Although we identify seed collecting and bulking needs in this document, we refer the reader to the SCBBP for specific guidelines and BMPs that address these practices. Finally, we provide a flow chart to assist practitioners with implementing BMPs (Figure 24). All BMPs may be refined in the future based on results from management actions or experimental studies.

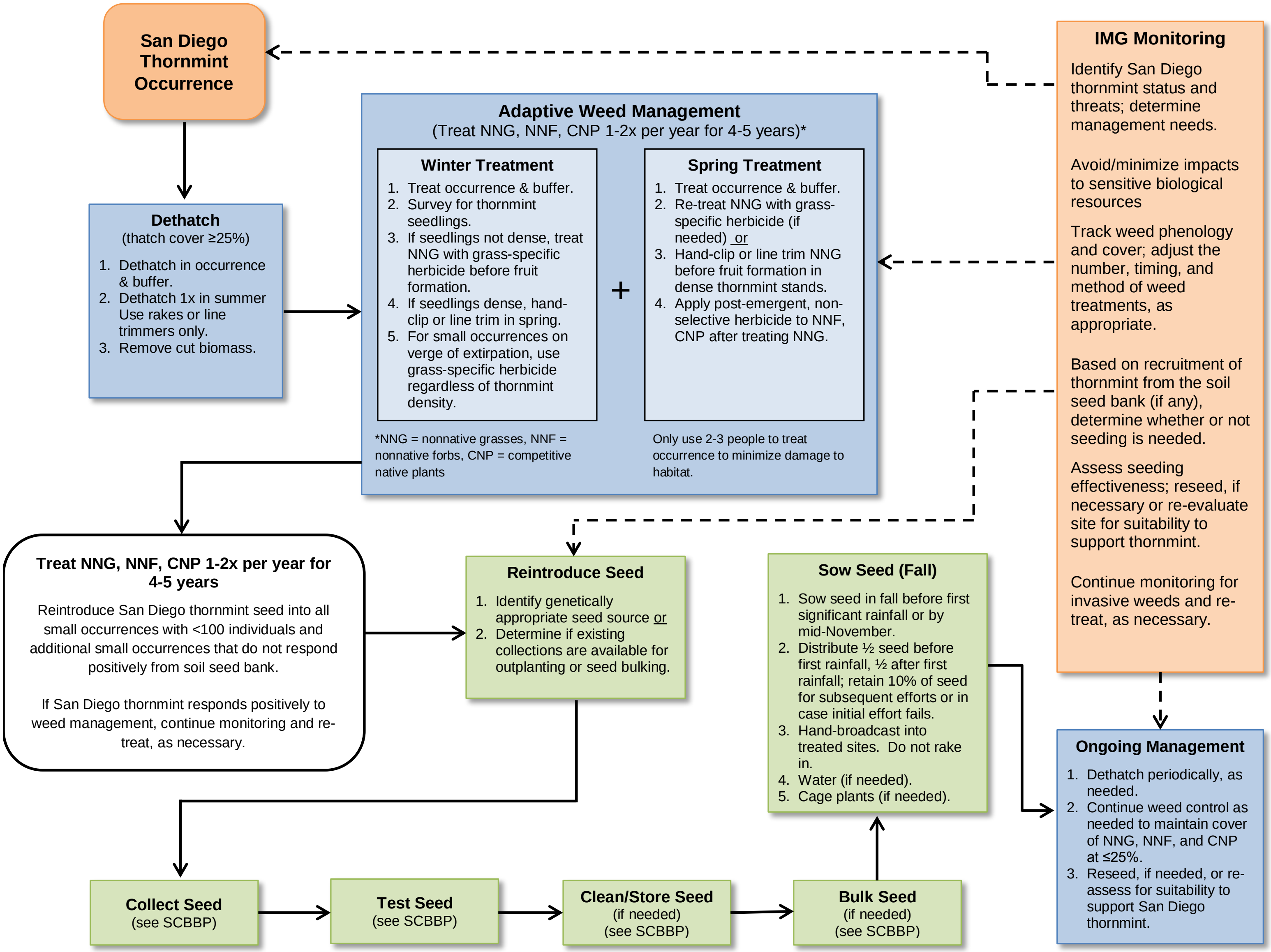


Figure 24. San Diego Thornmint: Best Management Practices (BMP) Flow Chart.

As outlined in earlier sections of this chapter, occurrences of different sizes or with different genetic structures or threats will require different types and/or levels of management. For example, the primary management action for large occurrences will be managing threats to ensure that thornmint continues to germinate, reproduce, and replenish the soil seed bank during favorable years. Managing threats is also critical for small and medium occurrences. However, these occurrences may require the addition of seed to increase size and ultimately, potential for long-term persistence. In these cases, we recommend controlling threats before adding seed.

Practitioners have found that they can successfully restore small populations of San Diego thornmint and native forb habitats using a process that includes all of the following elements implemented in the order shown (Dodero pers. comm., Ekhoff, pers. comm., McMillan pers. comm., Spiegelberg pers. comm., CBI 2014b):

Step 1: Dethatch (prepare) the site

Step 2: Control nonnative grasses

Step 3: Control nonnative forbs and competitive native plants

Step 4: Reintroduce thornmint seed (if warranted)

Step 5: Continue weed control

We discuss each of these steps below. It is important to stress that to successfully restore a thornmint occurrence, land managers must complete *each* step in the order indicated, unless one of the threats addressed in a step is not present at the occurrence.

Habitat Restoration

Monitoring data show that invasive plants[7] are the primary threat to San Diego thornmint. Therefore, removing thatch buildup from nonnative grasses and controlling invasive plants are key factors to ensure persistence of large and many medium occurrences, and necessary initial steps for small and medium occurrences where reintroducing seed is appropriate.

Practitioners should tailor invasive plant control actions to the specific thornmint occurrence and its unique complement of invasive plants and habitat conditions. In addition, not all invasive plants will necessarily require management. Practitioners should prioritize management of invasive species known or strongly suspected to result in thornmint population declines and habitat degradation (i.e., *Brachypodium distachyon*).

Invasive plant control methods described below have the potential to cause soil disturbance and in some cases, thornmint mortality, particularly in large, dense occurrences. However, the net

[7] For the purpose of this discussion, invasive plants are primarily nonnative species, but may include a few native species that out-compete San Diego thornmint for resources.

benefit to the occurrence is expected to outweigh any adverse consequences, and potential impacts can be avoided or minimized with care and experience.

Once the restoration process begins, practitioners should expect some level of perpetual management to maintain habitat conditions because of the extensive weed seed bank at many sites, and continual input of weed seeds from surrounding, untreated areas via wind, animal, or human dispersal. However, regular management should decrease management frequency, intensity, and cost over time. Conversely, if management is discontinued, even for a few years, some sites may revert quickly to pre-treatment conditions.

Timing is critical for treating nonnative grasses and forbs in San Diego thornmint habitat. For example, if herbicide is applied too early in the season, then additional treatments may be required to treat late-germinating plants. Conversely, applying herbicide too late in the season will be ineffective if fruit has already hardened into viable seed. Finally, the phenology of both thornmint and the target invasive plants differs by site based on geographic location, site topography, slope aspect, microclimate weather patterns, vegetation association, and cover and depth of thatch. For these reasons, experienced practitioners should visit an occurrence several times per season to ensure correct timing to apply herbicide(s).

In any given year, the extent of invasive plant control will depend on weather conditions. Practitioners can expect treatments to be more intensive during years of average- and above-average rainfall because of increased germination of invasive plants and possibly, the need for multiple treatments. Treatments will be less expensive during drought years. To accommodate variations in treatment level, practitioners should include contingency funds in annual budgets and/or allow these funds to carry over to years where they are most needed.

<u>Step 1: Dethatch</u>

Determine if dethatching is necessary by either reviewing IMG monitoring data or estimating the cover of nonnative grass thatch. Dethatch if thatch cover is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Dethatch in the occurrence(s) and in the buffer. Dethatch only once in the summer using dethatch rakes or line trimmers and remove all cut biomass.

<u>Step 2: Control Nonnative Grasses</u>

Control nonnative grass if IMG monitoring data indicate that cover of nonnative grass is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative grass in the occurrence(s) and in the buffer.

> *Herbicide*. Before applying a grass-specific herbicide (e.g., Fusilade® DX), survey extant occurrences to ensure that no thornmint seedlings are present. If thornmint seedlings are dense, do not apply a grass-specific herbicide directly over the dense patches and instead

hand-clip or line-trim to control nonnative grasses in these dense patches. If thornmint seedlings are not dense, apply a grass-specific herbicide over nonnative grass and thornmint seedlings. Research has shown that Fusilade® DX can delay flower production and produce dieback of thornmint leaves; however, most thornmint plants will recover, grow larger, and will produce more flowers after removing the nonnative grass (Rice pers. comm.).

Mature bunchgrasses will not die from Fusilade® DX application. Nonnative, annual grasses will die from Fusilade® DX application with the exception rat-tail fescue (*Festuca myuros*), which is unaffected by this herbicide. Fusilade® DX kills native, annual grasses and native, perennial grass seedlings.

Follow herbicide label directions to determine application rates, timing, and limitations/restrictions, and proper personal protection equipment. Apply a grass-specific herbicide over the top of nonnative grasses in the winter, when grasses are between 4-6 inches tall and before (or just after) grasses produce fruit. If fruit is hardened and seed is beginning to form, do not apply herbicide since seed will continue to mature and the treatment will be ineffective.

Apply herbicide at least once, and possibly a second time if grasses germinate again after a late winter or early spring rain. Apply herbicide annually for 4-5 years. The herbicide applicator(s) should be experienced and possess a Qualified Applicator License (QAL). Use caution when walking on the clay soils that support San Diego thornmint soil and avoid using more than 2-3 people to apply herbicide to minimize damage to the habitat.

For small occurrences on the verge of extirpation, practitioners should control nonnative grasses with Fusilade® DX, despite adverse effects to thornmint (Rice pers. comm.). Refer to the SCBBP for guidelines on collecting and banking seed from these occurrences prior to management.

Hand-clipping or Line Trimming. Hand-clip or line trim nonnative grasses as soon as they produce soft fruit and before seeds harden and set if not using herbicides or if surveys indicate that San Diego thornmint seedling are growing densely. Hand-clip or line-trim for 4-5 years. Use caution when walking on the clay soils that support San Diego thornmint soil and avoid using more than 2-3 people to cut or line-trim to minimize damage to the habitat.

<u>Step 3: Control Nonnative Forbs and Competitive Native Plants</u>

Control nonnative forbs and competitive native plants if IMG monitoring data indicate that cover of either group is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative forbs and competitive native plants in the occurrence(s) and in the buffer.

Herbicide or Hand-clipping. In the spring, after applying a grass-specific herbicide or cutting nonnative grass, apply a post-emergent, non-selective herbicide to nonnative forbs and competitive native plants, if necessary. Choose the appropriate herbicide based on the target nonnative or competitive native plant(s). Follow herbicide label directions to determine application rates, timing, and limitations/restrictions, and use proper personal protection equipment. Ensure that the applicator(s) is experienced and possesses a QAL.

Apply herbicide using a backpack sprayer (e.g., battery-operated Birchmeier) or weed wand. Use a backpack sprayer if San Diego thornmint plants do not grow densely with nonnative forbs and competitive native plants (i.e., greater than several inches of distance between San Diego thornmint and the target species). Where thornmint does grow densely with these species, use a weed wand filled with herbicide or hand clip (if not using herbicide) the nonnative forbs and competitive native plants.

Manage nonnative forbs and competitive native plants at least once a year for 4-5 years and avoid using more than 2-3 people to apply herbicide or cut plants to minimize damage to habitat.

Species Restoration

In this section, we discuss seeding to restore occurrences. The BMPs in this section and the BMP flowchart (Figure 24) refer primarily to reintroducing seed into small and medium occurrences. Since large occurrences presumably support a stable soil seed bank, we do not recommend adding seed unless (1) there is a decline in occurrence size category when monitored over at least five years (including one or more years with favorable climatic conditions) or (2) there is evidence of low genetic diversity and/or inbreeding within the occurrence. In the latter case, use seed only from the target occurrence unless common greenhouse studies show no local adaptations.

We recommend *reintroducing* seed into small, declining occurrences if threats are controlled, habitat is likely to support this species in the future, and funding is available for short- and long-term management. Potential seed sources for reintroduction include (1) seed collection and *ex situ* bulking in a nursery setting (as needed) or (2) *in situ* management of existing plants (e.g., watering) to maximize seed production (‘bulking onsite’) and increase the soil seed bank. Practitioners may choose to reintroduce seed into medium occurrences to increase size and/or genetic diversity, or reduce the effects of inbreeding. Refer to Step 4 for guidelines on reintroducing seed.

We recommend *introducing* seed into suitable habitat within Opportunity Areas (e.g., gaps) to create steppingstone occurrences that improve gene flow, if warranted by genetic or regional population structure, and following BMPs in Step 4 (below) for reintroducing seed into extirpated occurrences.

We recommend *translocating* seed only in the event of climatic changes that render existing occurrences unsuitable to support thornmint, unless conducted for experimental purposes. Where translocations are warranted, move seed into suitable habitat outside the current species' distribution following BMPs in Step 4 (below) for reintroducing seed into extirpated occurrences.

Refer to the genetic structure of the thornmint occurrence (Table 22), appropriate management strategies to improve genetic structure (Table 21), and genetic clusters (Figure 15) to identify genetically appropriate seed source(s) for reintroduction. The SCBBP also designates seed zones to identify appropriate seed sources. In general, we recommend sourcing seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a genetically compatible occurrence (as addressed in this document).

Refer to the SCBBP for BMPs for collecting, banking, and bulking thornmint seed for restoration. The BMPs address timing of collections, amount of seed to collect, maximizing diversity in a collection, and transporting, storing, and processing seeds. We recommend that only experienced seed collectors collect thornmint seed per the SCBBP. The BMPs for bulking thornmint seed address potential nurseries, bulking methods, and maximizing genetic diversity in bulked samples.

At this time, species experts do not recommend growing thornmint in a nursery and outplanting individual plants.

Finally, consider climatic conditions when assessing the success of any seeding effort. For example, drought may prevent sufficient germination, but seed may persist in the soil seed bank.

<u>Step 4: Reintroduce Seed</u>

Small, Extant Occurrences. We recommend the following guidelines to reintroduce seed into small, extant occurrences of San Diego thornmint:

- Reintroduce thornmint seed into all extant occurrences that support fewer than 100 plants *and* meet the reintroduction criteria outlined in the previous section. In these cases, seed reintroduction is critical to the long-term persistence of the occurrence.

- Reintroduce thornmint seed into small occurrences that support more than 100 plants if these occurrences do not respond positively to dethatching and control of nonnative or competitive native plants.

- For all seed reintroductions into small occurrences, refer to the genetics section of this chapter or seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive plants after reintroducing seed, as necessary.

- For all seed reintroductions into small occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
    - Where small occurrences have increased in size, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
    - Where small occurrences have not increased in size or have decreased, even under favorable climatic conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

The objective of reintroducing seed in an existing occurrence is to increase population size to a level that reduces the potential for extirpation or adverse effects from inbreeding. For very small occurrences (<100 individuals), it may take time, multiple reintroductions, and intensive management to achieve this objective. In these cases, success of a single reintroduction may be measured by a two- or three-fold increase in occurrence size.

Medium, Extant Occurrences. We recommend the following guidelines to reintroduce seed into medium occurrences of San Diego thornmint:

- Reintroduce seed of San Diego thornmint into medium occurrences that appear to be declining and that do not respond positively to dethatching and control of nonnative or competitive native plants.
- For all seed reintroductions into medium occurrences, refer to the genetics section of this chapter or seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive plants after reintroducing seed, as necessary.
- For all seed reintroductions into medium occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
    - Where medium occurrences appear stable under favorable conditions, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
    - Where medium occurrences are declining even under favorable conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

Extirpated Occurrences. We recommend the following steps to reintroduce seed into confirmed historic but extirpated occurrences *unless* suitable habitat is no longer present, the occurrence location is incorrect, or existing information is unclear as to where to reintroduce seed:

- Prior to reintroducing seed, restore habitat by dethatching (if necessary) and controlling invasive plants for three years (see Steps 1-3, above).
- Prior to reintroducing seed, test the soil to ensure that it falls within identified soil parameters known to support this species (e.g., texture, chemical composition, cracks).
- Identify a genetically appropriate seed source of suitable size from the nearest genetic cluster or consider composite provenancing from within the genetic cluster to develop a genetically appropriate seed source. Follow guidelines in the SCBBP to collect and bulk seed (if necessary). Refer to guidelines on outplanting (sowing) seeds in this section.
- Proceed with seed reintroduction steps outlined above for small, extant occurrences.

Outplanting (Sowing) Seed. Based on input from species experts, we provide the following guidelines for outplanting (sowing) thornmint seed into prepared sites:

- Sow seed in the fall before the first significant rainfall event; however, if it has not rained by mid-November, sow seed anyway. Consider (1) distributing one half of the bulked or collected seed before the first rainfall event and the second half after the second rainfall event and (2) retaining approximately 10% of the seed to use in subsequent seeding efforts if the first effort fails (McMillan pers. comm.).
- Hand-broadcast seed only into sites where thatch has been removed and/or invasive plants controlled. Removing cover prior to sowing will promote germination through increased seed-to-soil contact and reduce competition for thornmint seedlings. For extirpated occurrences, reintroduce seed into habitat that has been treated (if necessary) and soils tested for suitability to support thornmint. Where the reintroduction site is located on a slope, apply seed to the top of the clay lens habitat and work down toward the bottom of the lens. After hand-broadcasting, do not rake or scarify the soil since the clay soils are friable and contain cracks and crevices.
- After thornmint plants germinate, apply water (1) if plants appear stressed (e.g., seedlings emerge but start to dry out), (2) if weather conditions will not support the full life cycle of the plants, or (3) if bulking thornmint seed onsite (see below). Monitor the weather conditions and water seedlings to maintain soil moisture during prolonged dry and warm periods and between rainfall events, if necessary. Do not water to germinate seed. Discontinue watering during rainfall events and if there is an increase in herbivory (i.e., slugs, snails, rabbits).

  Onsite seed bulking consists of watering plants throughout their life cycle to maximize seed production and increase the soil seed bank. The watering regime and amount of time needed to effectively bulk the onsite soil seed bank will vary by occurrence, depending on thornmint density, phenology, and fecundity. This approach may be best suited to occurrences that are relatively easy to access because of the number of visits potentially required per season and the logistics and cost of delivering adequate water to allow plants to thrive. Onsite seed bulking has been used successfully at Wright's Field in Alpine (McMillan pers. comm.).

- Consider constructing and installing small wire cages over seeded areas to exclude small mammals if herbivory is a known or anticipated threat or if the occurrence is small.

Step 5: Continue Weed Control

After reintroducing seed, continue to manage nonnative grasses and forbs and competitive native plants as outlined in Steps 2 and 3, at a frequency to maintain cover of these species at ≤25% cover in the maximum extent at an occurrence.

Additional Research Needs

The list of additional research needs is derived from a number of sources, including planning documents, research studies, and identified gaps in relevant information about San Diego thornmint.

Genetics

- Conduct common garden studies to assess adaptive genetic diversity and outcomes of mixing among occurrences and genetic clusters.
- Evaluate offspring fitness by examining crosses within populations, among populations in the same genetic cluster (for example, northern cluster), and among populations in different genetic clusters. These studies should also account for environmental gradients across the species range.

Pollinators

- Determine *effective* pollinators and their host plants, maximum pollinator migration/travel distance, pollinator abundance threshold for reproductive success, and potential effects of climate change on pollinator communities in relation to thornmint phenology.
- Study the effect of nonnative plants on pollination and seed production and viability.

Seed Biology

- Determine seed bank dynamics (including presence, longevity, and susceptibility to fire).
- Refine our understanding of seed dormancy factors, germination cues and timing, and viability rates.
- Examine germination rates in wild-collected seed versus F1 and F2 nursery-grown generations (e.g., per Mistretta and Burkhart 1990).

- Determine dispersal agents and dispersal capabilities of thornmint seed.

Soils

- Test whether the establishment of thornmint links to the abundance of base cations (sodium, magnesium), direct effects of soil pH, or effects of clay on soil moisture, structure, or porosity.
- Test the performance of thornmint in response to soil variables (soil type, clay content, pH, and other variables) both in monoculture and in competition with nonnative, invasive plants.
- Examine the bulk physical properties (structure, density, friability) of soils in clay lenses that support thornmint. For example, further explore the importance of sand, the sand to clay ratio, porosity, and bulk density of soils that support thornmint, and examine the vertical soil structure in a careful, fine-scale fashion.

4.2 Nuttall's Acmispon (*Acmispon prostratus*)

MSP Goals and Objectives

The MSP Roadmap identifies the following goal for Nuttall's acmispon:

> *Maintain or enhance existing Nuttall's acmispon occurrences to ensure multiple conserved occurrences with self-sustaining populations to increase resilience to environmental and demographic stochasticity, maintain genetic diversity, and ensure persistence over the long-term (>100 years) in coastal bluff and coastal dune habitats.*

Refer to Table 27 for objectives and actions for this species, per the MSP Roadmap (SDMMP and TNC 2017). In this chapter, we present species life history and ecological requirements, status and trends on conserved lands in the MSPA, and regional population structure, and recommend management priorities and actions to achieve goals and objectives.

Life History and Ecological Information

Species Description

Nuttall's acmispon is a spring-blooming annual herb in the Legume family (Fabaceae). The pea-shaped flowers are yellow, tinged with red, and individual plants are 1-10 decimeters (dm) (ca. 4-40 in) high. The characters that distinguish it from other members of the genus in San Diego County include its prostrate (flat) habit, indehiscent fruits, and peduncled flowers (Baldwin et al. 2012).

Distribution and Status

Nuttall's acmispon is restricted to coastal areas in San Diego County and northern Baja California, Mexico (CNDDB 2019b, SDNHM 2018). Within San Diego County, the species occurs in MUs 1 and 7, with extant occurrences ranging from Border Field State Park in the south to Mission Bay in the east and Camp Pendleton in the north (Figure 25). The species is on CNPS List 1B.1 (rare or endangered in California and elsewhere, seriously endangered in California).

Table 28 lists 22 occurrences of Nuttall's acmispon on conserved lands in the MSPA, including population size(s) recorded during the 5-year monitoring period (2014-2018). Table 29 presents recent and historic maximum population sizes for each of these occurrences, and categorizes occurrences into size classes (per Table 12) based on recent population size.

Table 27. Nuttall's Acmispon: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
Monitoring				
MON-IMP-IMG: ACMPRO-1	Conduct IMG monitoring annually	IMP-1	Determine management needs (routine versus intensive).	IP
		IMP-2	Submit monitoring data to MSP Web Portal.	IP
MON-IMP-MGTPL: ACMPRO-8	Monitor management effectiveness	IMP-1	Submit data, report to MSP Web Portal.	NS
Management				
MGT-IMP-IMG: ACMPRO-2	Conduct routine management identified through IMG monitoring.	IMP-1	Perform routine management as needed (e.g., access control, weed control).	IP
		IMP-2	Submit project data to MSP Web Portal.	IP
MGT-IMP-IEX: ACMPRO-3[5]	Restore (enhance, expand) four occurrences and create one new occurrence; use BMPs to control invasive plants.	IMP-1	Control invasive plants within each occurrence	IP
		IMP-2	Collect, bulk, and redistribute seed following recommendations in SCBBP.	IP
		IMP-3	Submit project data to the MSP Web Portal.	IP
MGT-PRP-MGTPL: ACMPRO-6	Prepare a section for Nuttall's acmispon in the F-RPMP.	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Develop a conceptual model for management.	C
		PRP-3	Prioritize occurrences for management.	C
		PRP-4	Develop an implementation plan that prioritizes management actions for the next 5 years.	C
		PRP-5	Submit data and plan to the MSP Web Portal.	C
MGT-IMP-MGTPL: ACMPRO-7	Implement highest priority management actions in F-RPMP	IMP-1	Submit project data and report to MSP Web Portal.	NS
MGT-PRP-SBPL: ACMPRO-9	Prepare a section for Nuttall's acmispon in the SCBBP	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Prepare a seed collection plan for occurrences on conserved lands in the MSPA.	C
		PRP-3	Include guidelines for collecting seeds on conserved lands based on genetic studies. Include provisions for collecting seed from unconserved occurrences that may be lost to development.	C

Table 27. Nuttall's Acmispon: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
		PRP-4	Include protocols and guidelines for collecting and submitting voucher specimens.	C
		PRP-5	Include guidelines for seed testing.	C
		PRP-6	Submit data and plan to MSP Web Portal.	C
MGT-IMP-SBPL: ACMPRO-5	Collect and store seeds at a permanent seed bank (conservation collection) and provide propagules for research and management actions (propagation collection).	IMP-1	Bulk seed at a qualified facility using seed from genetically appropriate donor accessions in the propagation seed bank collection.	IP
		IMP-2	Maintain records for collected seed to document donor and receptor sites, collection dates, and amounts. Submit data to MSP Web Portal.	IP

[1] Objective Codes: **MGT** = Management, **MON** = Monitoring; **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare; **RES** = Research; **BMP** = Best Management Practices, **FMGT** = Fire Management, **GEN** = Genetics, **IMG** = Inspect and Manage, **MGTPL** = Management Plan, **SPEC** = Species, **SBPL** = Seed Banking Plan.
[2] Descriptions: Refer to MSP Roadmap for complete descriptions (SDMMP and TNC 2017).
[3] Action Codes: **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare, **RES** = Research.
[4] Status: **C** = Completed, **IP** = In-progress (refers to some or all occurrences), **NS** = Not started.
[5] Note that ACMPRO-3 is specific to MU 1 only.

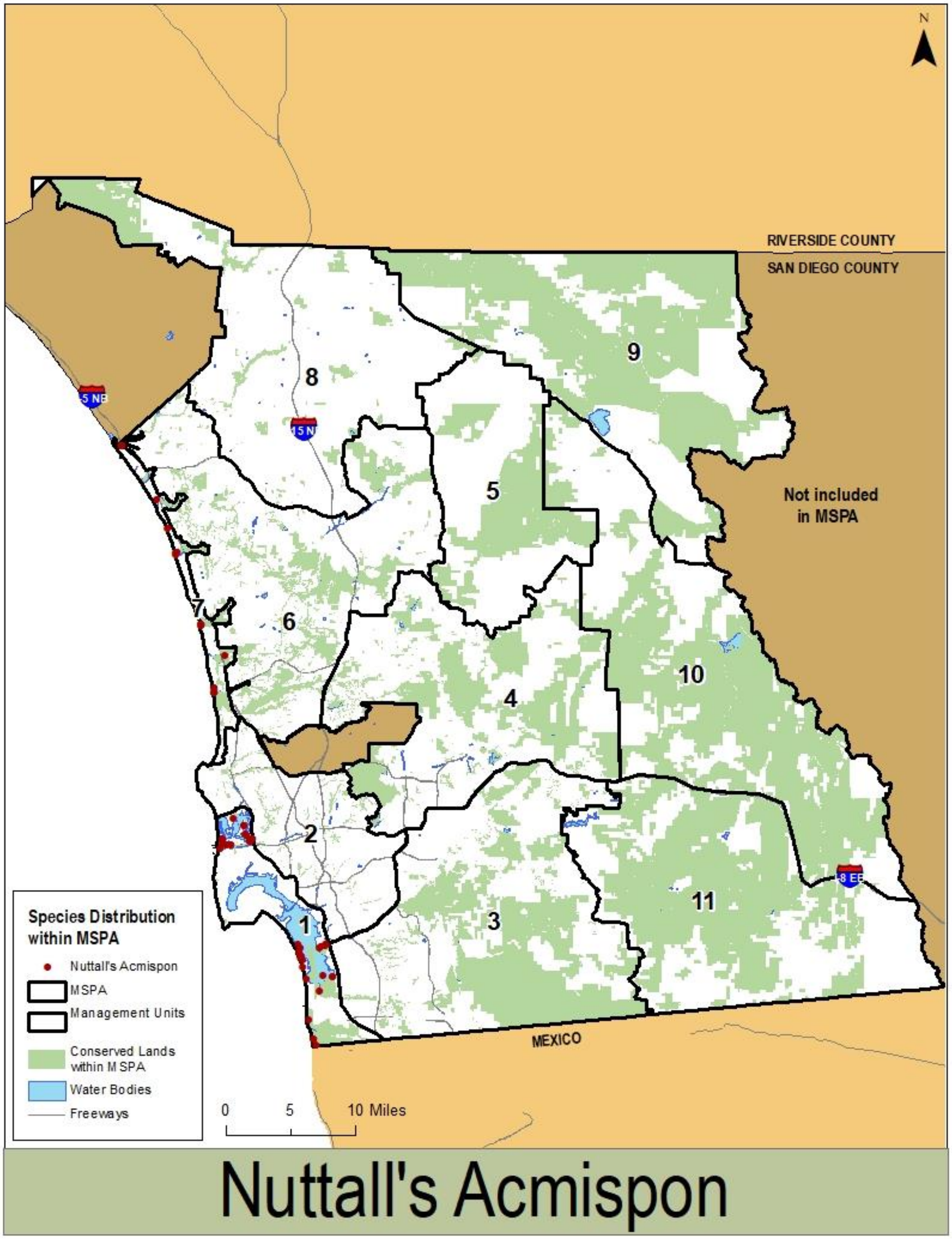


Figure 25. Nuttall's Acmispon: Distribution within the MSPA.

Table 28. Nuttall's Acmispon: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
Management Unit 1									
ACPR_1BFSP014	Border Field SP	Border Field SP	CDPR	CDPR	---	---	---	300	517
ACPR_1DSTR010	D Street Fill	San Diego Bay NWR	USFWS	USFWS	---	---	---	110	685
ACPR_1DUTR005	Dune Triangle	Mission Bay Park	San Diego	San Diego PRD	0	0	0	2	0
ACPR_1FIIS007	Mission Bay (Fiesta Island)	Mission Bay Park	San Diego	San Diego PRD	---	---	---	---	793
ACPR_1FIIS029	Fiesta Island	Fiesta Island	San Diego	San Diego PRD	---	---	---	---	20
ACPR_1HOPO002	Mission Bay (Hospitality Point)	Mission Bay Park	San Diego	San Diego PRD	63	2,026	797	7,292	5,788
ACPR_1MAPO004	Mission Bay (Mariner's Point)	Mission Bay Park	San Diego	San Diego PRD	---	---	12,000	10,000	---
ACPR_1NMLA001	Mission Bay (No Man's Land)	Mission Bay Park	San Diego	San Diego PRD	1	2	68	30	236
ACPR_1NOBE015	North Ocean Beach (Dog Beach)	Flood Control Channel Southern Wildlife Preserve	San Diego	San Diego	---	---	---	---	915
ACPR_1RRSO003	Mission Bay (Rip Rap)	Flood Control Channel Southern Wildlife Preserve	San Diego	San Diego PRD	17	188	171	551	152
ACPR_1SBSA013	South Bay Salt Works Nuttall's Acmispon	San Diego Bay NWR	CLC	USFWS	---	---	---	1,200	3,000
ACPR_1SOSH006	Mission Bay (east of South Shores)	Mission Bay (east of South Shores)	San Diego	San Diego PRD	19	431	139	1,355	100
ACPR_1SSSB012	Silver Strand SB	Silver Strand SB, Navy Bayside	CDPR, Navy	CDPR, Navy	70,100[6]	719,800[6]	296,400[6]	9,500[7]	35,972[7]
ACPR_1SSSB027	Silver Strand SB	Silver Strand SB	CDPR	CDPR	---	---	---	---	626[8]

Table 28. Nuttall's Acmispon: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
ACPR_1SSSB028	Silver Strand SB	Silver Strand SB	CDPR	CDPR	---	---	---	---	8
Management Unit 7									
ACPR_7AGHE024	Agua Hedionda	Agua Hedionda	NRG Energy	NRG Energy	---	23	---	7	0
ACPR_7BALA020	Batiquitos Lagoon	Batiquitos Lagoon EP	CDFW, CDPR	CDFW, CDPR	44	678	116	277	48
ACPR_7CSPA018	San Elijo Lagoon	San Elijo Lagoon, Cardiff SB	CDFW, CDPR	CDPR, Nature Collective	47,700	62,000	1,200	1,200	5,472
ACPR_7SCSB025	South Carlsbad SB	South Carlsbad SB	CDPR	CDPR	---	100	---	7	22
ACPR_7SLRR017	San Luis Rey River	San Luis Rey River	Oceanside	Oceanside	---	91	26	46	135
ACPR_7TPSR019	Torrey Pines SR (south)	Torrey Pines SNR	CDPR	CDPR	335	180	250	163	400
ACPR_7TPSR023	Torrey Pines SR (north)	Torrey Pines SNR	County DPR	CDPR	---	117	75	75	38

1 Table lists only occurrences in the SDMMP's MOM database on conserved lands.
2 Occurrence Identification (ID) per the SDMMP's MOM database.
3 Occurrence name/preserve abbreviations: **EP** = Ecological Preserve, **NWR** = National Wildlife Refuge, **SB** = State Beach, **SNR** = State Natural Reserve, **SP** = State Park, **SR** = State Reserve.
4 Land owner/land manager: **CDFW** = California Department of Fish and Wildlife, **CDPR** = California Department of Parks and Recreation, **CLC** = California Lands Commission, **Navy** = U.S. Navy, **Oceanside** = City of Oceanside, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **County DPR** = County of San Diego Department of Parks and Recreation, **USFWS** = U.S. Fish and Wildlife Service.
5 Population size information from IMG monitoring data, land manager data, and report and research data (CNDDB 2019b); (---) = not surveyed or data not available or not provided, 0 = surveyed, no plants detected.
6 Data collected with a different monitoring method than IMG rare plant protocol.
7 Surveyors did not have access to Navy property in 2017, but did have access in 2018 which significantly increased the maximum extent size between years.
8 These occurrences were unknown until 2018. Surveyors mapped the occurrences, but didn't collect IMG data.

Table 29. Nuttall's Acmispon: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
Management Unit 1						
Large Populations						
ACPR_1MAPO004	Mission Bay (Mariner's Point)	Mission Bay Park	San Diego	San Diego PRD	12,000 (2016)	12,000 (2016)
ACPR_1SSSB012	Silver Strand SB	Silver Strand SB, Navy Bayside	CDPR, Navy	CDPR, Navy	934,400 (2011)	35,972 (2018)
Medium Populations						
ACPR_1HOPO002	Mission Bay (Hospitality Point)	Mission Bay Park	San Diego	San Diego PRD	7,292 (2017)	7,292 (2017)
ACPR_1SBSA013	South Bay Salt Works Nuttall's Acmispon	San Diego Bay NWR	CLC	USFWS	3,000 (2018)	3,000 (2018)
ACPR_1SOSH006	Mission Bay (east of South Shores)	Mission Bay (east of South Shores)	San Diego	San Diego PRD	1,355 (2017)[7]	1,355 (2017)
Small Populations						
ACPR_1BFSP014	Border Field SP	Border Field SP	CDPR	CDPR	517 (2018)	517 (2018)
ACPR_1DSTR010	D Street Fill	San Diego Bay NWR	USFWS	USFWS	685 (2018)	685 (2018)
ACPR_1DUTR005	Dune Triangle	Mission Bay Park	San Diego	San Diego PRD	2 (2017)[7]	2 (2017)
ACPR_1FIIS007	Mission Bay (Fiesta Island)	Mission Bay Park	San Diego	San Diego PRD	793 (2018)	793 (2018)
ACPR_1FIIS029	Fiesta Island	Fiesta Island	San Diego	San Diego PRD	20 (2018)	20 (2018)
ACPR_1NMLA001	Mission Bay (No Man's Land)	Mission Bay Park	San Diego	San Diego PRD	236 (2018)[7]	236 (2018)
ACPR_1NOBE015	North Ocean Beach (Dog Beach)	Flood Control Channel Southern Wildlife Preserve	San Diego	San Diego	915 (2018)	915 (2018)
ACPR_1RRSO003	Mission Bay (Rip Rap)	Flood Control Channel Southern Wildlife Preserve	San Diego	San Diego PRD	551 (2017)	551 (2017)

Table 29. Nuttall's Acmispon: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
ACPR_1SSSB027	Silver Strand SB	Silver Strand SB	CDPR	CDPR	626 (2018)	626 (2018)
ACPR_1SSSB028	Silver Strand SB	Silver Strand SB	CDPR	CDPR	8 (2018)	8 (2018)
Management Unit 7						
Large Populations						
ACPR_7CSPA018	San Elijo Lagoon	San Elijo Lagoon, Cardiff SB	CDFW, CDPR	Nature Collective, CDPR	62,000 (2015)	62,000 (2015)
Small Populations						
ACPR_7AGHE024	Agua Hedionda	Agua Hedionda	NRG Energy	NRG Energy	23 (2015)	23 (2015)
ACPR_7BALA020	Batiquitos Lagoon	Batiquitos Lagoon EP	CDFW, CDPR	CDFW, CDPR	678 (2015)	678 (2015)
ACPR_7SCSB025	South Carlsbad SB	South Carlsbad SB	CDPR	CDPR	100 (2015)	100 (2015)
ACPR_7SLRR017	San Luis Rey River	San Luis Rey River	Oceanside	Oceanside	200 (1991)	135 (2018)
ACPR_7TPSR019	Torrey Pines SR (south)	Torrey Pines SNR	CDPR	CDPR	400 (2018)	400 (2018)
ACPR_7TPSR023	Torrey Pines SR (north)	Torrey Pines SNR	County DPR	CDPR	117 (2015)	117 (2015)

1 Table lists only occurrences in the SDMMP's MOM database on conserved lands.
2 Occurrence Identification (ID) per the SDMMP MOM database.
3 Occurrence name/preserve abbreviations: **EP** = Ecological Preserve, **NWR** = National Wildlife Refuge, **SB** = State Beach, **SNR** = State Natural Reserve, **SP** = State Park, **SR** = State Reserve.
4 Land owner/land manager: **CDFW** = California Department of Fish and Wildlife, **CDPR** = California Department of Parks and Recreation, **CLC** = California Lands Commission, **Navy** = U.S. Navy, **Oceanside** = City of Oceanside, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **County DPR** = County of San Diego Department of Parks and Recreation, **USFWS** = U.S. Fish and Wildlife Service.
5 IMG monitoring data; land manager data; report and research data; CNDDB 2019b.
6 Surveyors did not have access to US Navy property in 2017, but did have access in 2018 which significantly increased the maximum extent size between years.
7 CNDDB combines historic data for these three occurrences; thus, we used IMG monitoring data to determine maximum population size.

Ecological Requirements

Nuttall's acmispon is an annual species that germinates in early spring and typically flowers from March through July. It experiences wide fluctuations in annual population size that are driven primarily by annual climatic conditions (Landis 2014-2017). Biologists report large numbers of seedlings during years of average to above-average rainfall, and higher mortality and lower numbers of seedlings in drought years (Landis 2014). At some locations, it appears that robust Nuttall's acmispon plants survive through summer and winter suggesting that the species can act as a short-lived, herbaceous perennial when weather conditions are favorable (Landis 2015, 2016, Smith pers. comm.).

In San Diego County, Nuttall's acmispon occurs on beaches, coastal strands, bluffs, dunes, and disturbed areas. The species is restricted to sandy soils in coastal areas and may favor finer sand (Smith pers. comm.). Nuttall's acmispon does not generally grow in areas with direct exposure to wind and ocean conditions. Rather, it prefers uncompacted sand in hummocks between active dunes, in back dunes, and in sandy locations where soils are more stable (Smith pers. comm.).

Pollinators

We do not have definitive pollinator information for Nuttall's acmispon. Buchmann et al. (2010) identified over 40 insect visitors on Marine Corps Base Camp Pendleton and Coronado Naval Amphibious Base that might serve as pollinators of Nuttall's acmispon. This study, however, was based primarily on a literature search, interviews with experts, and an assessment of flower morphology and related pollinator syndrome, and included no field verification. However, bees are known to be important insect visitors and pollinators to flowers with the distinctive corolla shape (banner and wings) of this species. In a related species of *Acmispon* (*A. glaber*), native bees are the primary flower visitors and pollinators, although butterflies and the nonnative European honeybee are also floral visitors (Montalvo and Beyers 2010).

Reproductive Biology

We do not have any information on the reproductive biology of Nuttall's acmispon, although it is presumably insect-pollinated and outcrossing. Other species of *Acmispon* are known to be self-compatible (Montalvo and Ellstrand 2001).

Seed Biology

Nuttall's acmispon seed matures in late spring through summer. Each Nuttall's acmispon flower can produce two indehiscent seeds that are 2-3 millimeters (mm) (0.08-1.2 in) long. The seeds are linear, bean-shaped, and slightly curved. Germination tests indicate that seeds likely possess physical dormancy that can be relieved with a hot water soak to soften the seed coat (RSA 2018).

Seed appears to be primarily gravity-dispersed, with most of the seed falling near the parental plant. The seed is smooth, with no apparent modifications for wind, water, or animal dispersal.

The presence or longevity of a soil seed bank is unknown for this species (Smith pers. comm.).

Status and Trends

We can compare population size and extent over time to determine trends. In Table 29, we presented maximum recent and historic population sizes for each occurrence. Although these data are incomplete, they provide a preliminary indication of status and trends. Recent monitoring data (2014-2018) indicate the following:

- The majority of occurrences on conserved lands in the MSPA (16 of 22 occurrences; 73% of occurrences) support fewer than 1,000 plants. Of the remaining occurrences, 3 (<14%) support 1,000-10,000 plants and 3 (<14%) support >10,000 plants (Figure 26).

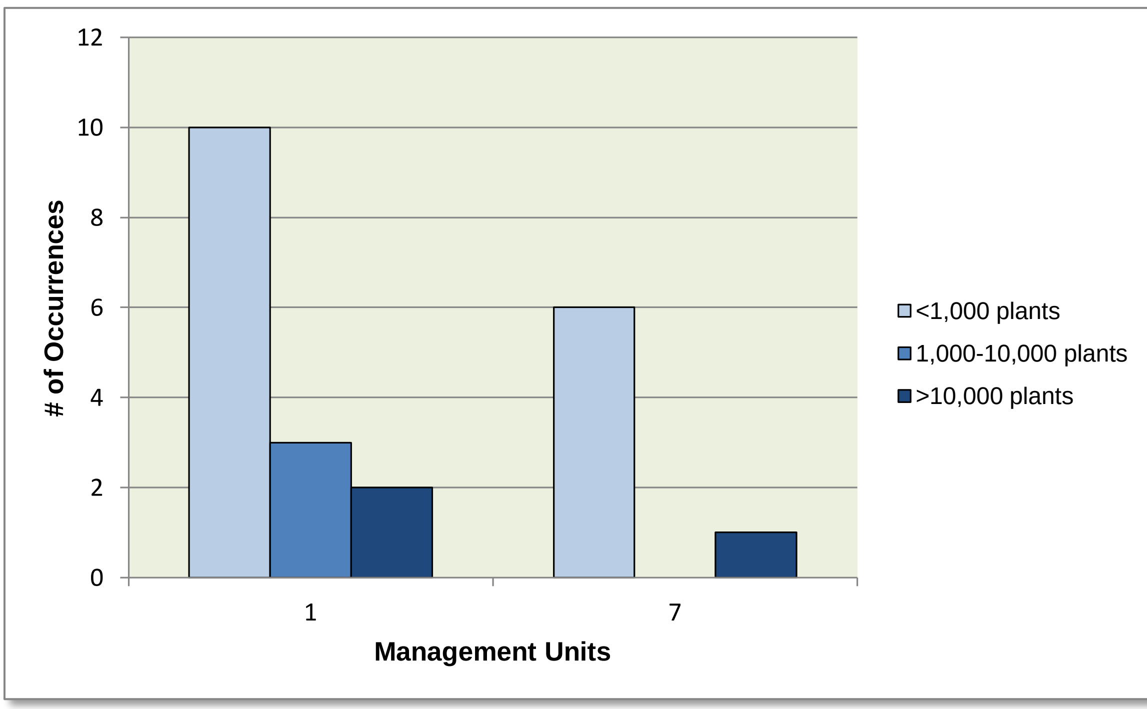


Figure 26. Nuttall's Acmispon: Distribution by Population Size and MU (2014-2018).

- For the 16 occurrences with <1,000 plants, 5 occurrences (31% of all occurrences in this size category) had ≤100 plants recorded in any year from 2014-2018 (Figure 27).

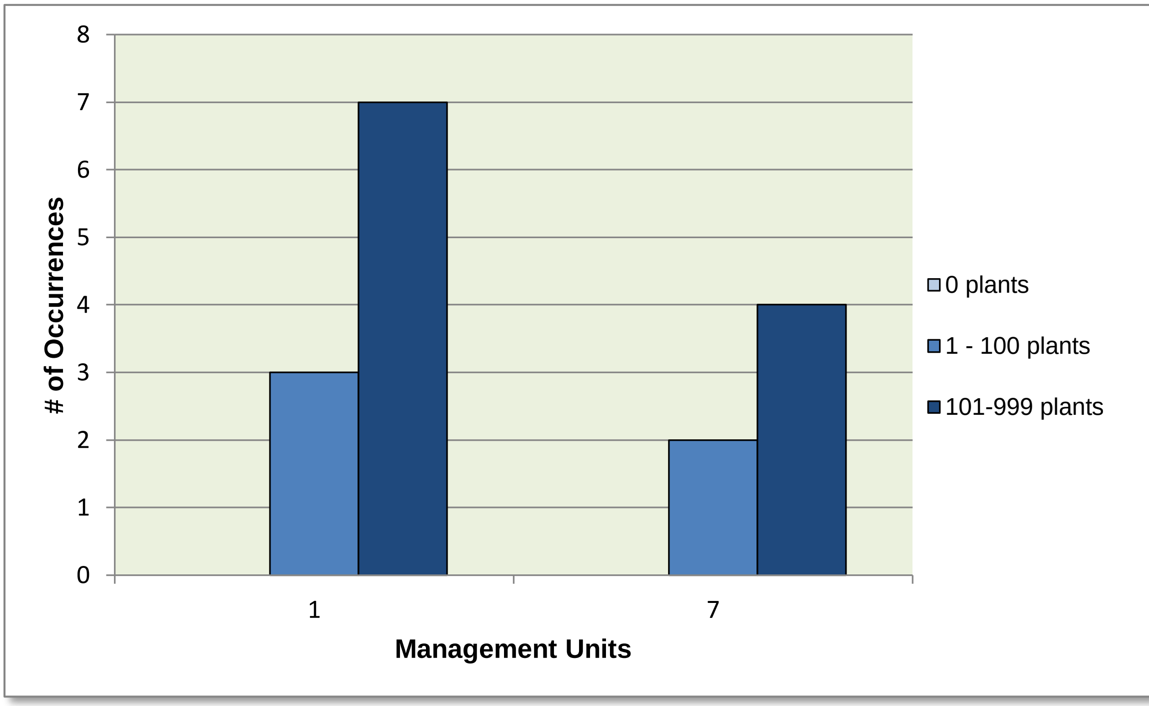


Figure 27. Nuttall's Acmispon: Distribution by Population Size and MU for Occurrences with <1,000 plants (2014-2018).

Comparing recent (2014-2018) and historic population size data suggest the following:

- Of the 22 occurrences on conserved lands, all appear relatively stable with respect to size based on available data (Table 30). In other words, populations remain consistent with respect to size category. It should be noted that (1) the monitoring record is incomplete for many occurrences and (2) the time scale is insufficient to detect some trends.

Threats and Stressors

At a regional scale, Nuttall's acmispon may be affected directly or indirectly by climate change. At the preserve-level, biologists and land managers have recorded 18 categories of threats at acmispon occurrences through the IMG monitoring process (Figure 28). The most common threats are invasive species (nonnative grasses and forbs), although dumping/trash, trails, brush management, and competitive native plants also threaten at least half of all occurrences.

Threats at each occurrence are recorded as a continuum from no threat (threat level 0-1) to a threat that affects ≥75% of the maximum area occupied by Nuttall's acmispon (threat level 7). When reporting threats, we use a color-coded system to allow land managers to easily identify threat levels that are low versus high. In most cases, management costs and labor will increase with increasing threat level. Thus, addressing threats before they become a problem is a cost-effective strategy for managing occurrences.

Table 30. Nuttall's Acmispon: Occurrences by Recent and Historic Population Size Category.

Occurrence ID[1]	MU[2]	Recent Population Size Category[3,4]	Historic Population Size Category[3,5,6]
ACPR_1MAPO004	1	Large	Large
ACPR_1SSSB012	1	Large	Large
ACPR_1HOPO002	1	Medium	Medium
ACPR_1SBSA013	1	Medium	Medium
ACPR_1SOSH006	1	Medium	Medium
ACPR_1BFSP014	1	Small	Small
ACPR_1DSTR010	1	Small	Small
ACPR_1DUTR005	1	Small	Small
ACPR_1FIIS007	1	Small	Small
ACPR_1FIIS029	1	Small	Small
ACPR_1NMLA001	1	Small	Small
ACPR_1NOBE015	1	Small	Small
ACPR_1RRSO003	1	Small	Small
ACPR_1SSSB027	1	Small	Small
ACPR_1SSSB028	1	Small	Small
ACPR_7CSPA018	7	Large	Large
ACPR_7AGHE024	7	Small	Small
ACPR_7BALA020	7	Small	Small
ACPR_7SCSB025	7	Small	Small
ACPR_7SLRR017	7	Small	Small
ACPR_7TPSR019	7	Small	Small
ACPR_7TPSR023	7	Small	Small

[1] Occurrence ID = Occurrence identification code per the SDMMP's MOM database.
[2] MU = Management Unit.
[3] Population size categories: **Small** = <1,000 plants**, Medium** = 1,000-10,000 plants**, Large** = >10,000 plants.
[4] Recent population size category is based on maximum size recorded at occurrence from 2014-2018.
[5] Historic population size category is based on maximum size recorded at occurrence; may include data from 2014-2018 or earlier.

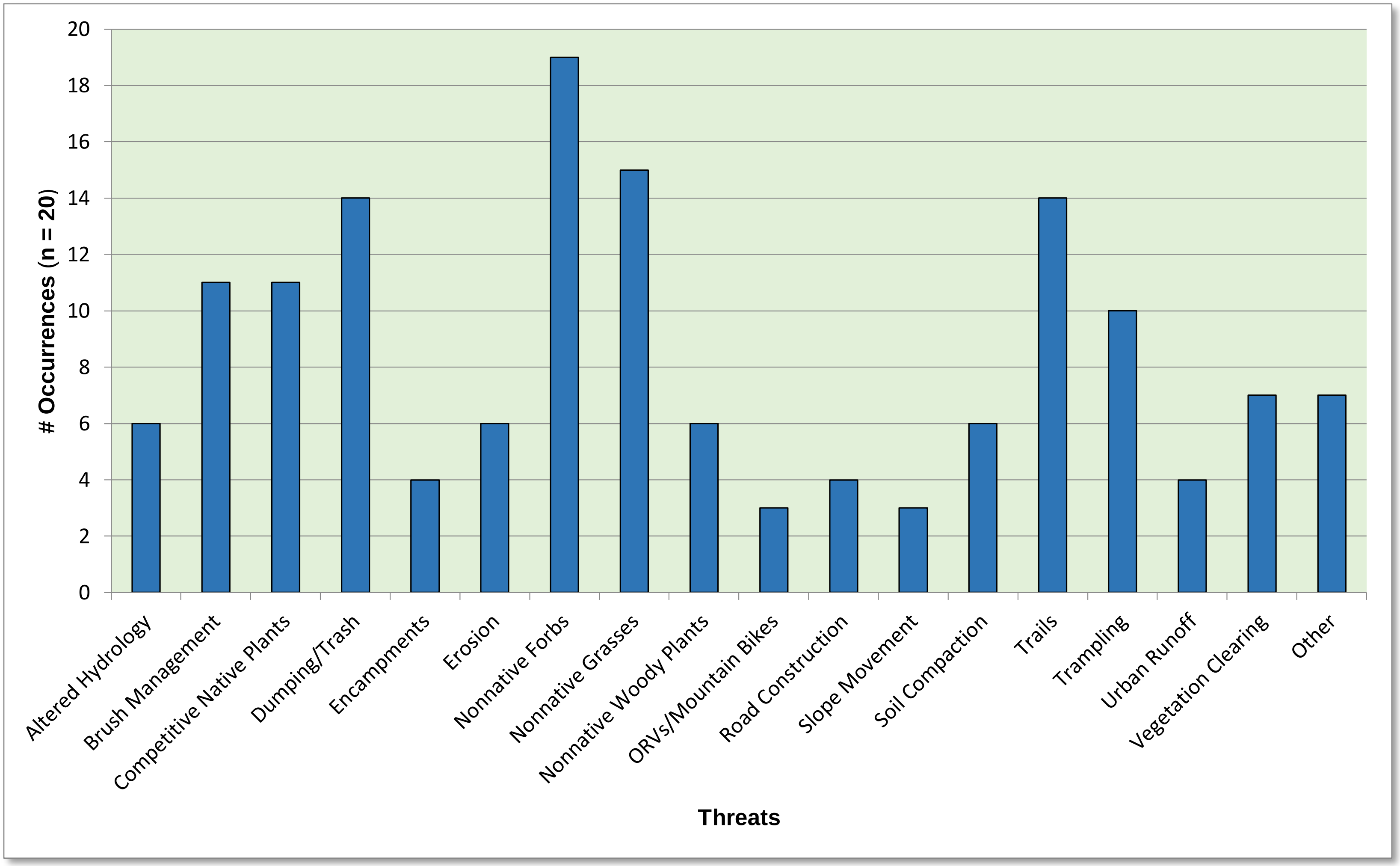


Figure 28. Nuttall's Acmispon: Threats Recorded during IMG Monitoring (2014-2018) (note: data indicate the number of occurrences at which a threat was recorded).

We further stratify the color-coded system by different shades of the same color to (1) indicate magnitude of threat and (2) allow land managers to track whether threats are increasing or decreasing over time (taking into account annual variability due to climate). Table 31 defines threat levels per the IMG monitoring protocol (SDMMP 2019), while Figure 29 depicts the color-coded system used to display threats.

Table 31. Descriptions of Threat Levels.[1]

Threat Level	Description	Priority for Management
1	Threat not recorded at occurrence or in 10-m buffer	None
2	Threat not recorded at occurrence, but recorded in adjacent buffer	Low
3	Threat occurs over 0-10% of area within maximum extent	Low
4	Threat occurs in 10% to <25% of area within maximum extent	Medium
5	Threat occurs in 25% to <50% of area within maximum extent	Medium
6	Threat occurs in 50% to <75% of area within maximum extent	High
7	Threat occurs in ≥75% of area within maximum extent	High

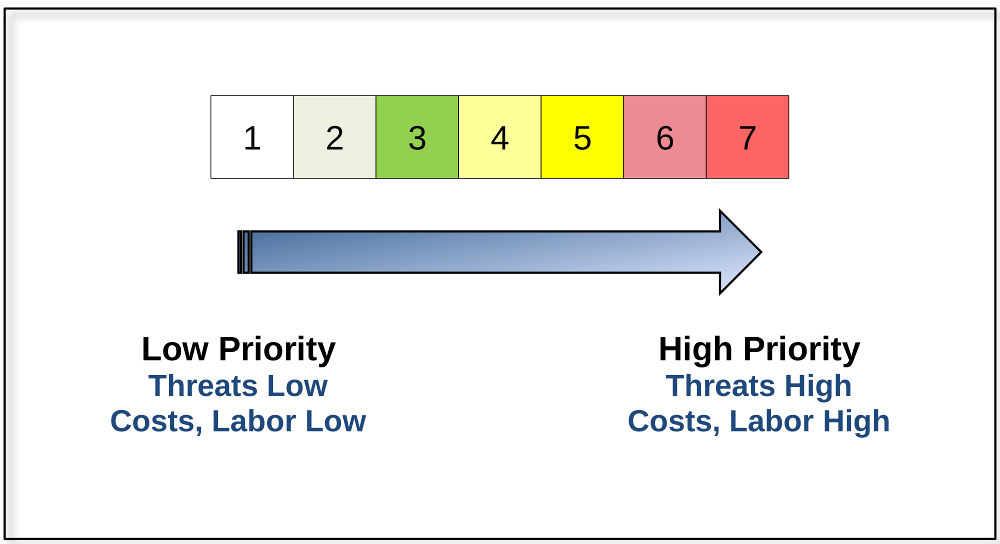


Figure 29. Nuttall's Acmispon: Color-coded Threat Levels.

Table 32 presents threats and threat levels by year for those occurrences where IMG data were collected. We include occurrences that were not monitored as a placeholder for future data. This includes occurrences that were visited but not monitored due to an absence of plants or where plants were counted but other IMG data were not collected. All IMG data are available on the SDMMP website:

https://sdmmp.com/view_project.php?sdid=SDID_sarah.mccutcheon%40aecom.com_57cf0196dff76.

Table 32. Nuttall's Acmispon: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]															
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT
ACPR_1BFSP014	2017	1	1	4	1	1	1	4	3	1	1	1	1	1	1	1	1
ACPR_1BFSP014	2018	1	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1
ACPR_1DSTR010	2017	1	7	1	1	1	3	3	3	1	1	3	1	1	1	3	1
ACPR_1DSTR010	2018	1	1	1	1	1	1	3	3	1	1	3	1	6	1	1	1
ACPR_1DUTR005	2014	6	---	1	1	3	1	4	1	1	1	1	4	1	1	3	---
ACPR_1DUTR005	2015	1	1	1	1	1	1	4	1	1	1	1	1	1	1	2	1
ACPR_1DUTR005	2016	1	7	1	3	1	1	3	1	2	1	1	1	1	1	2	1
ACPR_1DUTR005	2017	1	7	1	1	1	1	4	1	1	1	1	1	1	1	1	1
ACPR_1DUTR005	2018	1	1	1	1	1	1	3	2	2	1	1	1	1	1	3	1
ACPR_1FIIS007	2018	1	1	1	3	2	1	7	3	2	1	1	3	4	1	4	1
ACPR_1FIIS029	2018	1	1	1	3	1	1	7	1	2	1	1	1	1	1	2	1
ACPR_1HOPO002	2014	1	---	1	1	1	1	4	5	3	1	1	1	1	1	4	---
ACPR_1HOPO002	2015	1	7	1	1	1	1	3	4	3	1	1	1	1	1	3	1
ACPR_1HOPO002	2016	1	1	1	3	1	1	3	5	3	1	1	1	1	1	3	1
ACPR_1HOPO002	2017	1	4	1	1	1	1	4	7	3	1	1	1	1	1	3	1
ACPR_1HOPO002	2018	1	7	1	1	1	1	3	5	1	1	1	1	1	1	4	1

Table 32. Nuttall's Acmispon: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]															
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT
ACPR_1MAPO004	2014	---	---	1	1	1	1	3	3	1	1	1	1	1	1	1	---
ACPR_1MAPO004	2015	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACPR_1MAPO004	2016	1	7	1	2	2	1	3	3	1	1	2	1	1	1	---	1
ACPR_1MAPO004	2017	1	7	6	1	1	1	3	3	1	1	1	1	1	1	3	1
ACPR_1MAPO004	2018	1	7	1	1	1	1	3	3	1	1	1	1	1	1	1	1
ACPR_1NMLA001	2014	1	---	1	1	3	1	6	3	3	1	1	1	1	1	3	---
ACPR_1NMLA001	2015	1	1	1	1	1	1	5	3	1	1	1	1	2	1	3	1
ACPR_1NMLA001	2016	---	1	1	4	3	1	6	4	3	1	1	1	1	1	1	1
ACPR_1NMLA001	2017	1	7	1	4	2	1	6	3	1	1	1	1	1	1	3	1
ACPR_1NMLA001	2018	1	5	1	3	1	1	5	3	3	1	1	1	1	1	2	1
ACPR_1NOBE015	2018	1	1	1	5	2	1	3	4	1	1	1	1	1	2	4	6
ACPR_1RRSO003	2014	6	---	1	1	1	1	3	6	1	1	1	1	1	1	2	---
ACPR_1RRSO003	2015	1	1	1	3	1	1	4	5	1	1	1	1	1	1	2	1
ACPR_1RRSO003	2016	7	1	1	4	1	1	5	3	3	1	1	1	1	1	1	2
ACPR_1RRSO003	2017	1	1	1	3	1	1	4	6	1	1	1	1	1	1	3	1
ACPR_1RRSO003	2018	7	1	1	3	1	1	3	5	2	1	4	1	1	3	2	1

Table 32. Nuttall's Acmispon: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]															
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT
ACPR_1SBSA013	2017	1	7	3	1	1	1	5	1	1	1	3	7	1	3	4	1
ACPR_1SBSA013	2018	1	1	1	1	1	1	2	1	1	4	1	1	1	1	1	1
ACPR_1SOSH006	2014	1	---	1	1	1	1	6	1	1	1	1	1	6	1	1	---
ACPR_1SOSH006	2015	1	7	1	1	1	1	5	3	1	1	1	1	1	1	1	1
ACPR_1SOSH006	2016	1	1	1	1	1	1	7	4	1	1	1	1	1	1	2	1
ACPR_1SOSH006	2017	1	5	1	4	3	1	7	3	1	1	1	1	1	1	2	1
ACPR_1SOSH006	2018	1	5	1	1	2	1	6	3	2	1	1	1	1	1	2	1
ACPR_1SSSB012	2017	3	3	3	1	1	1	7	5	3	1	3	1	3	3	3	1
ACPR_1SSSB012	2018	7	7	1	3	1	4	7	3	2	1	2	1	1	3	3	7
ACPR_1SSSB027	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACPR_1SSSB028	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
ACPR_7AGHE024	2015	1	1	1	1	1	1	6	6	1	1	1	1	1	3	3	---
ACPR_7AGHE024	2017	1	1	5	1	1	1	7	3	1	1	1	7	1	7	2	1
ACPR_7AGHE024	2018	1	1	1	1	1	1	3	2	1	1	1	1	1	5	5	1
ACPR_7BALA020	2015	1	---	1	3	1	3	4	3	3	3	2	1	1	3	1	3
ACPR_7BALA020	2016	3	---	3	1	1	4	4	4	3	---	1	1	1	3	---	5
ACPR_7BALA020	2017	3	1	3	31	1	4	3	1	1	1	1	1	7	3	1	1

Table 32. Nuttall's Acmispon: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]															
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT
ACPR_7BALA020	2018	3	7	1	1	1	4	3	1	1	1	1	1	1	3	---	---
ACPR_7CSPA018	2014	1	---	1	2	1	1	1	1	1	1	2	1	4	1	1	---
ACPR_7CSPA018	2015	1	1	2	2	1	1	4	3	3	4	1	1	1	6	4	3
ACPR_7CSPA018	2016	7	1	5	2	1	1	3	1	1	1	1	1	1	4	---	3
ACPR_7CSPA018	2017	7	7	1	2	2	3	4	1	1	2	1	3	1	3	4	3
ACPR_7CSPA018	2018	2	2	3	3	1	2	7	2	1	2	2	3	2	3	3	---
ACPR_7SCSB025	2015	1	1	6	2	1	3	6	1	1	1	1	1	1	4	3	---
ACPR_7SCSB025	2017	7	1	1	3	1	7	2	1	1	1	1	1	1	3	1	7
ACPR_7SCSB025	2018	1	1	2	2	1	7	4	1	1	1	2	2	1	2	2	4
ACPR_7SLRR017	2015	1	7	6	3	1	1	6	6	2	1	1	1	1	1	2	7
ACPR_7SLRR017	2016	1	7	1	4	2	1	3	4	1	1	1	1	3	6	---	7
ACPR_7SLRR017	2017	2	7	1	3	3	1	3	3	1	1	1	1	1	1	1	3
ACPR_7SLRR017	2018	1	1	7	3	4	1	1	3	1	1	1	1	1	1	1	7
ACPR_7TPSR019	2015	1	1	3	2	1	1	6	6	2	1	1	5	1	6	6	---
ACPR_7TPSR019	2016	1	1	3	1	1	1	6	6	1	1	1	1	1	6	---	1
ACPR_7TPSR019	2017	1	1	1	3	1	4	4	4	1	1	2	7	1	7	7	3
ACPR_7TPSR019	2018	1	1	3	3	1	3	3	3	1	1	1	5	1	5	5	1

Table 32. Nuttall's Acmispon: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year		Threats[2,3]														
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT
ACPR_7TPSR023	2015	1	1	1	1	1	1	2	2	2	1	1	1	1	2	---	---
ACPR_7TPSR023	2016	1	1	1	1	1	1	1	1	1	1	1	1	1	1	---	1
ACPR_7TPSR023	2017	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ACPR_7TPSR023	2018	1	1	4	1	1	1	1	1	1	1	1	1	1	1	1	1

1 Table includes only occurrences on conserved lands within the MSPA.

2 Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **EN** = Encampments, **ER** = Erosion, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **NWP** = Nonnative Woody Plants, **O/M** = Off-road Vehicles, Mountain Bikes, **RC** = Road Construction, **SC** = Soil Compaction, **TP** = Trampling, **TR** = Trails, **VC** = Vegetation Clearing, **OT** = Other (see detailed IMG data for description of other threats).

3 Threats Ranking (exclusive of herbivory; numbers represent percent (%) of maximum extent disturbed by threat):
1 = 0% in maximum extent or adjacent 10 m buffer; **2** = 0% in maximum extent but threat detected in surrounding 10 m buffer; **3** = >0-<10% of maximum extent; **4** = 10-<25% of maximum extent; **5** = 25-<50% of maximum extent; **6** = 50-<75% of maximum extent; **7** = ≥75% of maximum extent; **---** = data not collected or not available.

Genetic Considerations

There are no genetic data available for Nuttall's acmispon. Thus, we recommend a conservative approach to managing genetic resources within this species that includes the following strategies:

- Manage threats at all occurrences to increase population size, maintain or increase genetic diversity, replenish the soil seed bank, and encourage pollinator activity.
- Reintroduce seed into consistently small (<1,000 individuals) occurrences to increase population size and diversity, *if determined necessary after managing threats.* Follow guidelines in the SCBBP on seed collecting and bulking. Collect seed from the target occurrence or from nearby large or medium occurrences.

  Not all small occurrences will require seed reintroduction. This strategy is most appropriate under the following conditions: (1) occurrence is small *and* declining, even with management, (2) suitable habitat persists, and (3) adequate funding is available for both the reintroduction effort and long-term management. Occurrences with fewer than 100 plants are the highest priority for reintroduction (if the conditions above are met), because they are particularly susceptible to extirpation. We recognize that some small occurrences are stable and will not require additional seed.
- Although acmispon habitat is limited within the region, improve connectivity among occurrences by reintroducing/introducing the species into suitable, unoccupied habitat.

Figure 30 depicts population groups that represent *potential* genetic clusters for this species, based on geographic location and distance. We include this information only to inform seed collection; however, clusters should be refined in the future if genetic studies are conducted.

Regional Population Structure

Size Class Distribution

For Nuttall's acmispon, we used the population size classes for annual plant species from Table 12. Table 33 presents the distribution of size classes for Nuttall's acmispon across MUs. Although this method is imprecise, it highlights the need for comprehensive monitoring data.

Table 33. Nuttall's Acmispon: Size Class Distribution by MU.

Management Unit	Occurrence Size Class[1]			Total
	Large	Medium	Small	
1	2 (13%)	3 (20%)	10 (67%)	15
7	1 (14%)	0 (0%)	6 (86%)	7
Total	3	3	16	22

[1] Refer to text and Table 12 for description of size classes. Number = number of occurrences in size class; percent (%) = percent of occurrences in size class for management unit.

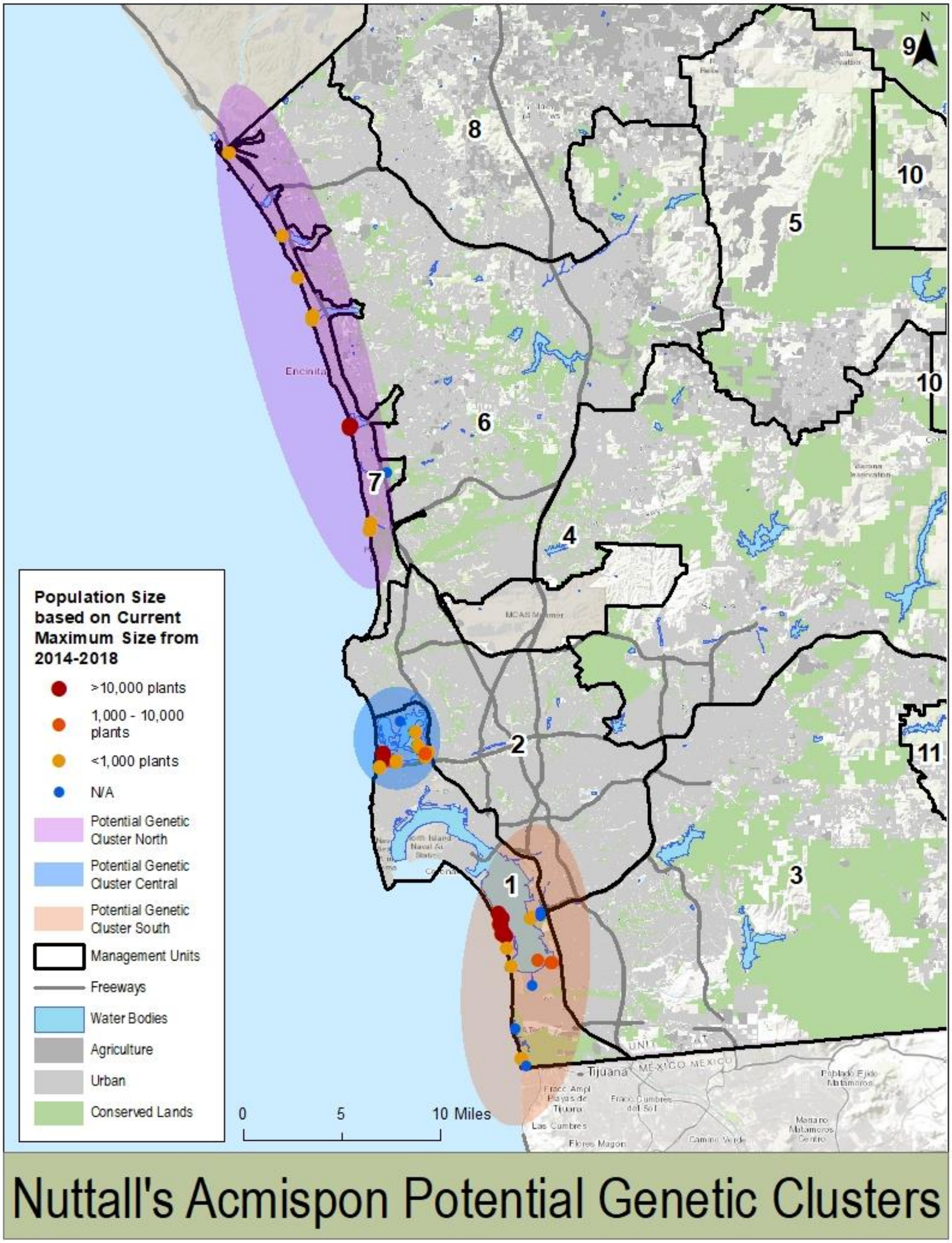


Figure 30. Nuttall's Acmispon: *Potential* Genetic Clusters Based on Proximity of Occurrences.

We identified three population groups across the MSPA, based on population size, location, and presumed levels of connectivity: North, Central, and South (Figure 31). The North group occurs in MU 7, while the other two groups occur in MU 1. For the remainder of this section, we refer to the groups by their population codes, as presented in Table 34, with the group abbreviation (North = N, Central = C, and South = S). Figures 32-34 show these groups in greater detail.

Habitat Connectivity

Habitat fragmentation and loss of connectivity are particular concerns for Nuttall's acmispon, which occurs in the highly developed coastal region of San Diego County (Figure 31). Most occurrences are in habitat fragments, often around bays or lagoons with little intervening suitable habitat, and all occurrences face a multitude of threats.

Regional Management Strategies for Opportunity Areas

Management actions will occur within *Opportunity Areas*, which are conserved lands within the MSPA that have the potential to enhance regional population structure and long-term resilience of this species. Opportunity Areas typically occur within or among population groups, or beyond the current species' distribution in response to a changing climate. For Nuttall's acmispon, management actions are expected to occur primarily in or near existing occurrences.

We recommend the following strategies to maintain or improve regional population structure and long-term resilience of Nuttall's acmispon within opportunity areas across the MSPA:

- **Manage** all occurrences through site-specific actions (e.g., invasive plant control), as determined necessary through monitoring.
- **Reintroduce** the species into selected small occurrences that do not respond positively to management by adding seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a nearby large source occurrence within the population group. A positive response to management is an increase in occurrence size under favorable climatic conditions. Small occurrences are present in all identified population groups and subgroups (Table 34).
- **Restore** habitat at small occurrences by enhancing existing habitat or expanding adjacent habitat and/or reintroducing acmispon seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a large source occurrence within the same population group.
- **Introduce** Nuttall's acmispon seed into high suitability habitat (if available) within population groups to increase the number of occurrences and potentially, promote gene flow.

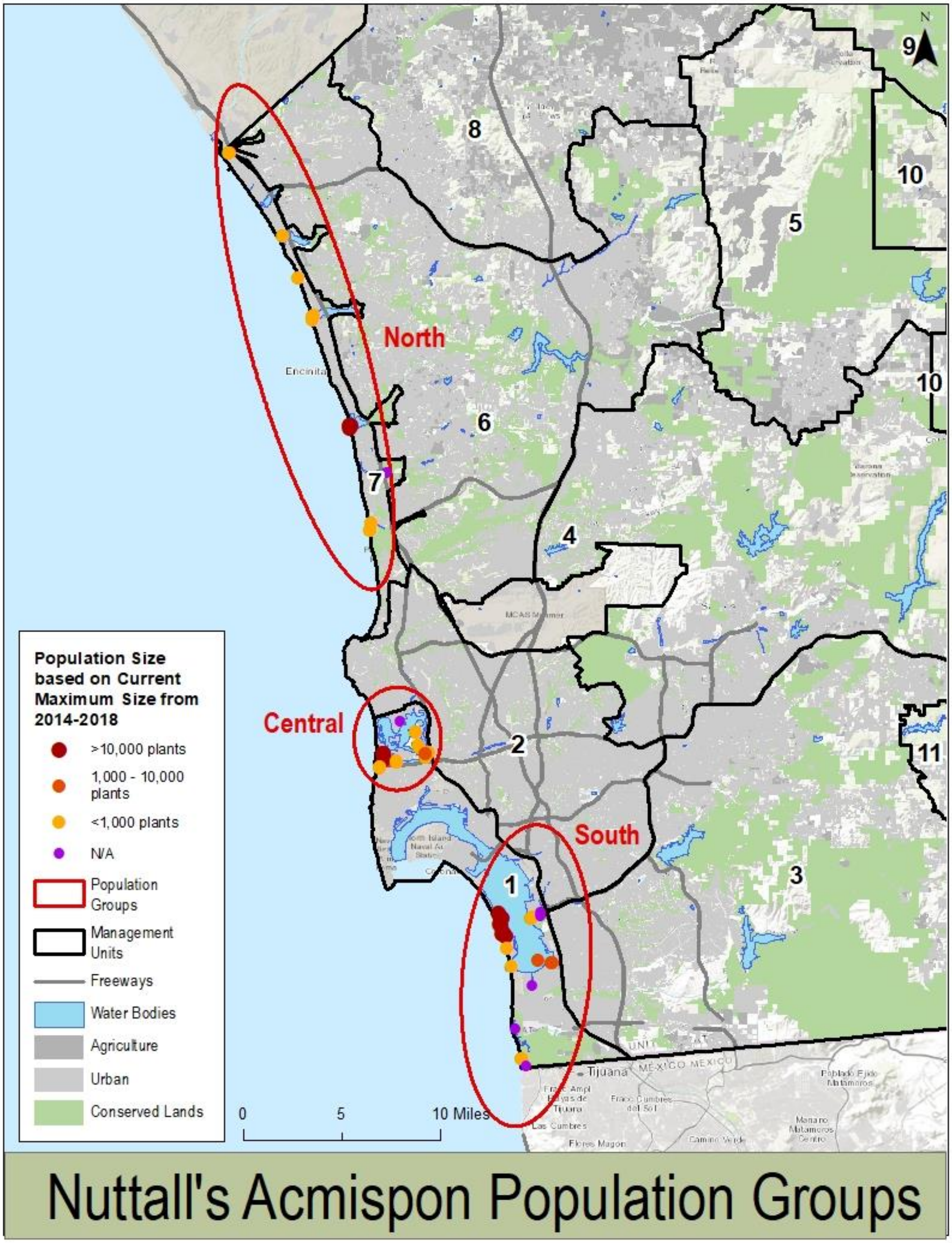


Figure 31. Nuttall's Acmispon: Population Groups within the MSPA.

Table 34. Nuttall's Acmispon: Population Groups.

Population Group[1]	Population Code	Occurrence ID	Population Size[2]	Group Characterization
North Group				
North	N	ACPR_7AGHE024	Small	Large
North	N	ACPR_7BALA020	Small	
North	N	ACPR_7CSPA018	Large	
North	N	ACPR_7SCSB025	Small	
North	N	ACPR_7SLRR017	Small	
North	N	ACPR_7TPSR019	Small	
North	N	ACPR_7TPSR023	Small	
Central Group				
Central	C	ACPR_1DUTR005	Small	Large
Central	C	ACPR_1FIIS007	Small	
Central	C	ACPR_1FIIS029	Small	
Central	C	ACPR_1HOPO002	Medium	
Central	C	ACPR_1MAPO004	Large	
Central	C	ACPR_1NMLA001	Small	
Central	C	ACPR_1NOBE015	Small	
Central	C	ACPR_1RRSO003	Small	
Central	C	ACPR_1SOSH006	Medium	
South Group				
South	S	ACPR_1BFSP014	Small	Large
South	S	ACPR_1DSTR010	Small	
South	S	ACPR_1SBSA013	Medium	
South	S	ACPR_1SSSB012	Large	
South	S	ACPR_1SSSB027	Small	
South	S	ACPR_1SSSB028	Small	

1 Population Group based primarily on geographic location (no genetic data available).
2 Population size categories: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.
3 Group characterization: large = group has at least one large occurrence.

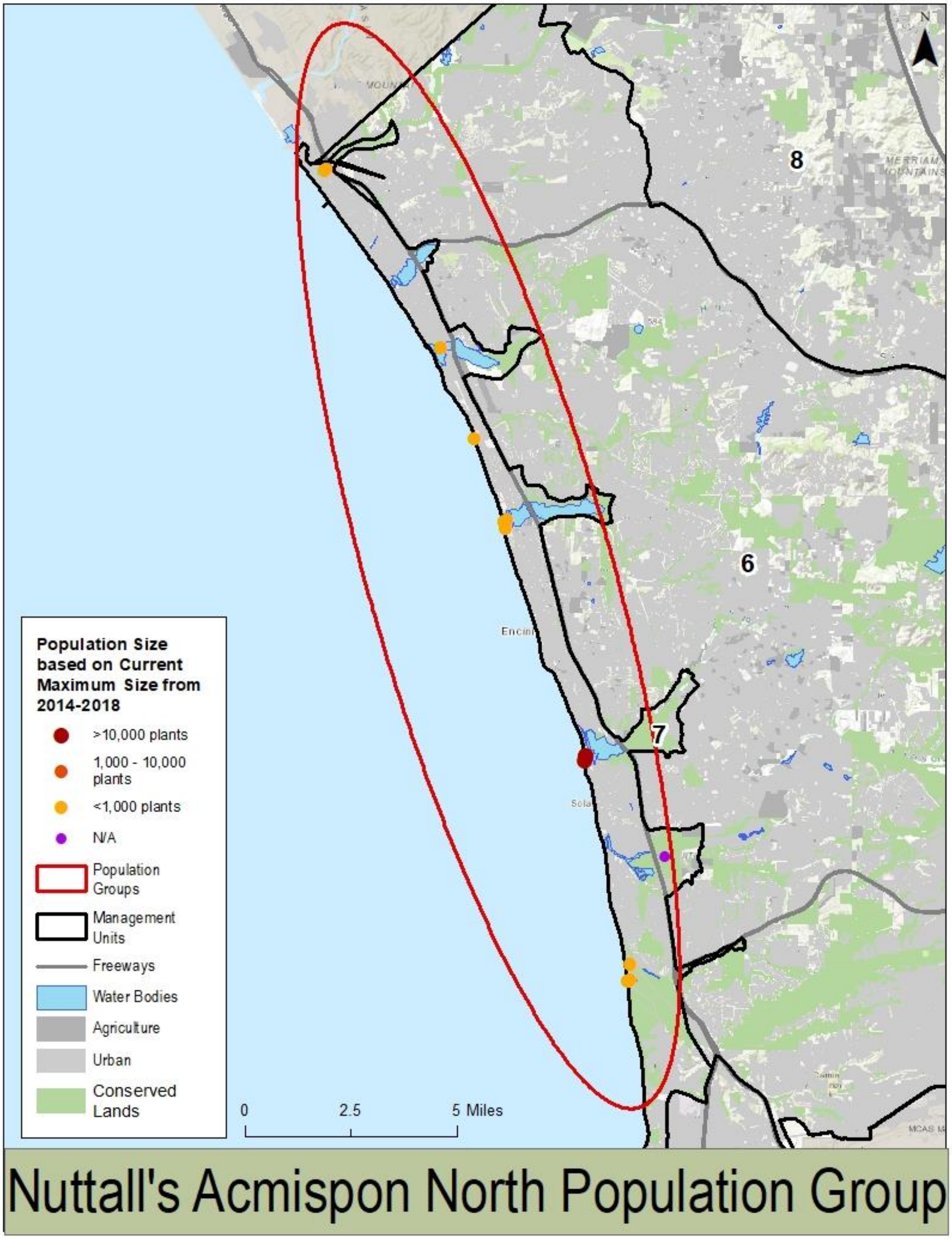


Figure 32. Nuttall's Acmispon: North Population Group.

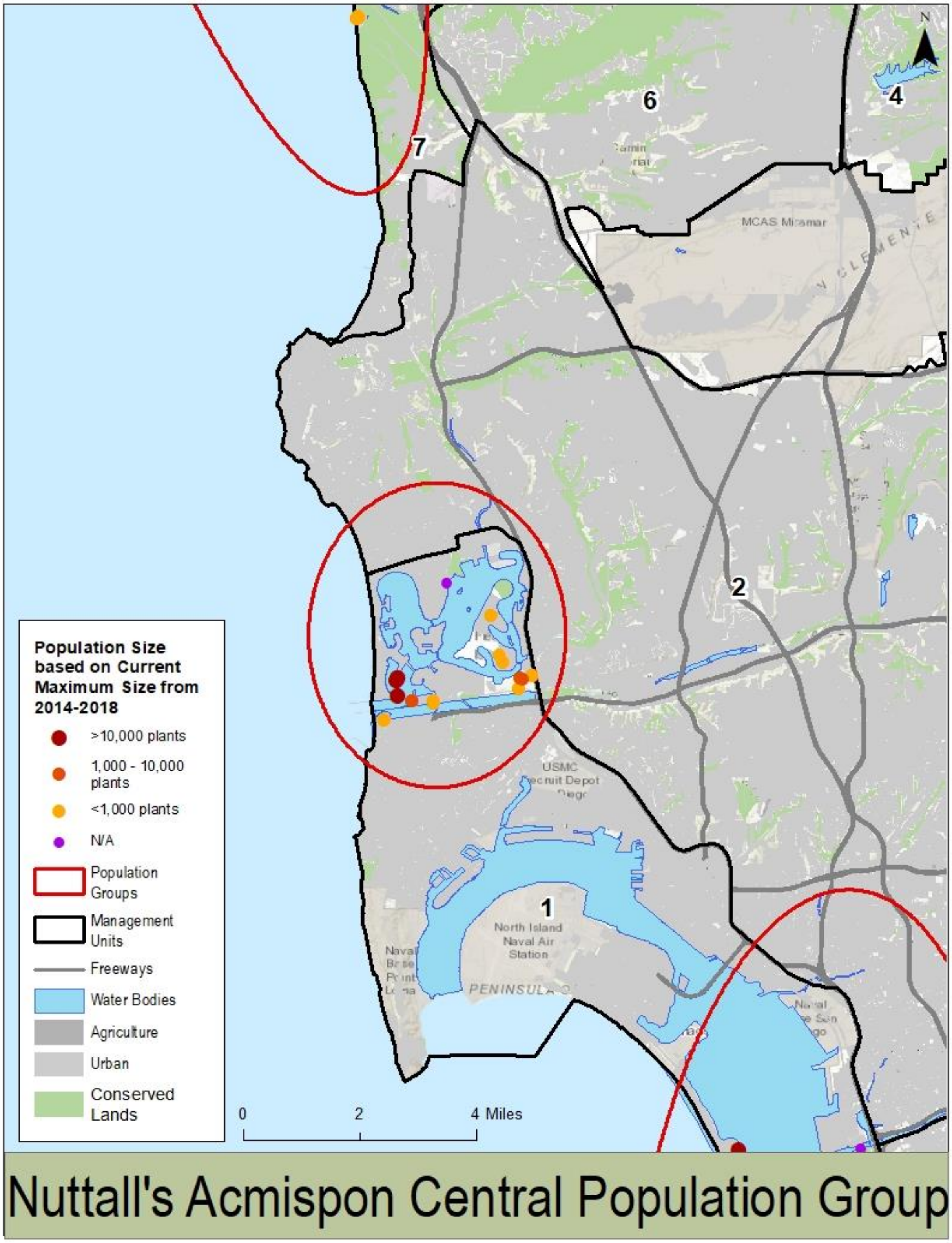


Figure 33. Nuttall's Acmispon: Central Population Group.

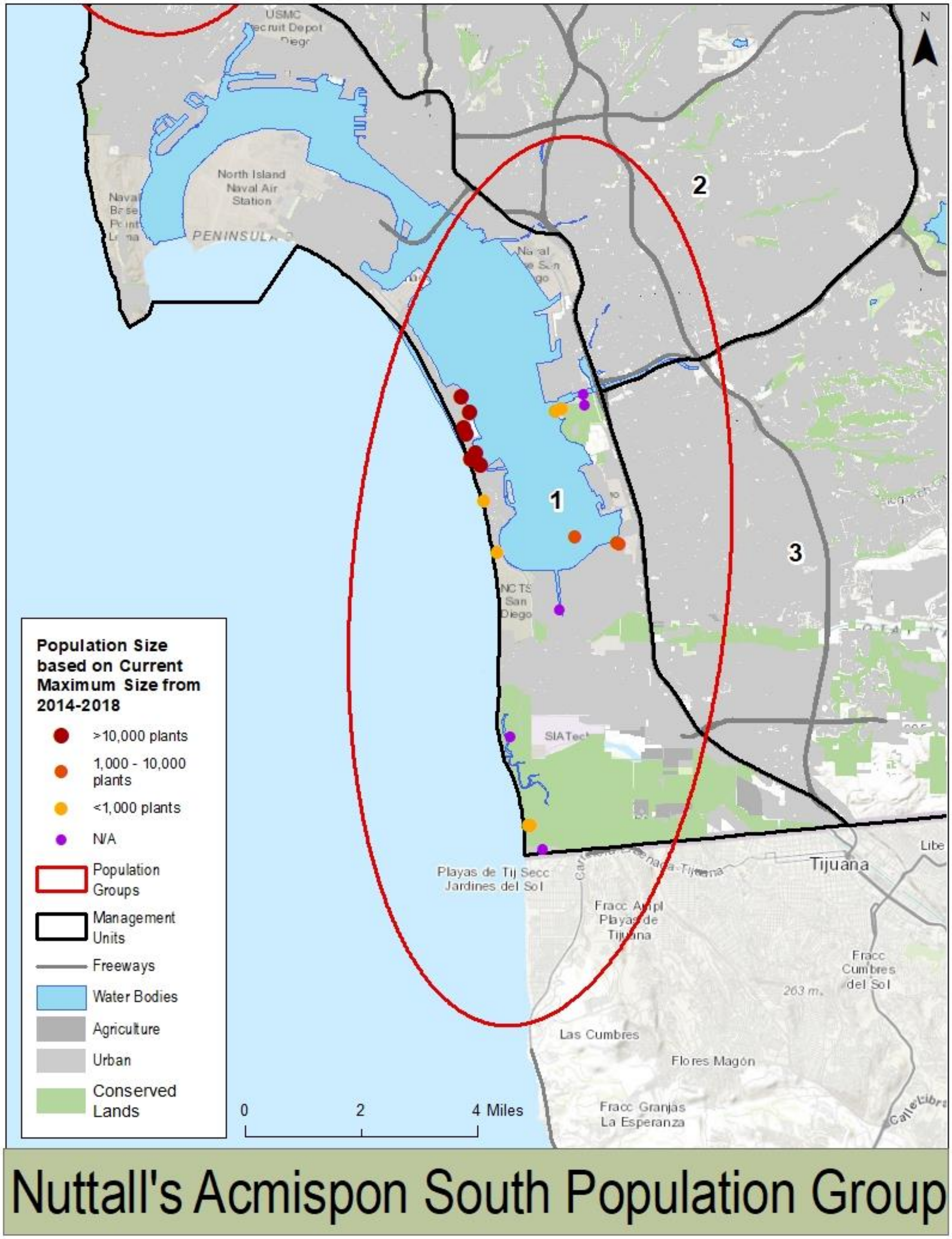


Figure 34. Nuttall's Acmispon: South Population Group.

Management Priorities and Recommendations

Management priorities and recommendations are based on IMG monitoring data, genetic principles, and regional population structure, and informed by strategies outlined in previous sections. Results of genetic studies (if conducted) should be factored into future priorities and recommendations. The current focus is managing acmispon under existing (versus future) conditions.

Table 35 presents criteria for prioritizing management actions; priorities are assigned for each management category. For example, an occurrence may be a high priority for all categories, or a high priority in one category and a lower priority in other categories. For threats, prioritize large occurrences with high or moderate threats over small occurrences with high threats.

Table 35. Nuttall's Acmispon: Criteria for Prioritizing Management Actions.

Management Category	Priority Level[1,2]			
	Not A Priority	Low Priority	Medium Priority	High Priority
Threats	Threat level 1	Threat levels 2-3	Threat levels 4-5	Threat levels 6-7
Genetic Structure	Large occurrence	Medium occurrence	Small occurrence (>100 plants)	Small occurrence (<100 plants)
Regional Population Structure	Large population group, intact habitat within group	Large population group, fragmented habitat within group	Medium population or population group	Small population or population group

[1] Priority levels may differ for each management category within an occurrence.
[2] For threats, prioritize large occurrences with high or medium threats over small occurrences with high threats.

Although the focus is on managing high priority levels within a management category, land managers may address lower priority levels, as well. For each priority level, refer to companion tables in this document for relevant information needed to manage the occurrence, including appropriate management strategies:

- Threats (Table 32)
- Regional Population Structure (Table 34)

For some proposed actions, management may be a one-time event (e.g., removing trash). For others, management may be a long-term effort that requires multiple years and considerable expense (e.g., controlling invasive plants). In many cases, land managers can reduce management costs by addressing threats at an early stage (e.g., threat levels of 3, 4, 5). This is particularly important for large occurrences to maintain their status and prevent decline. Where early intervention is not possible, land managers should have adequate funding or other resources available before starting a large-scale or expensive management program, unless these actions can be phased. As an example, invasive plant control may require an initial and intensive 3-5 year treatment program, but if this is not followed by long-term maintenance, then the site may revert quickly to its pre-treatment condition. In all cases, continue IMG monitoring to assess status and threats, as well as effectiveness of management actions.

We recommend an adaptive approach to managing Nuttall's acmispon occurrences, as outlined in the steps below and presented in Figure 35:

1. Monitor occurrence using IMG rare plant monitoring protocol
2. If threats are identified, manage to reduce impacts to rare plant occurrence.
3. Continue monitoring to assess management effectiveness.
4. If threats are not controlled, continue management actions or manage adaptively.
5. If there are no threats or if threats are controlled through management actions, and occurrence is small or declining, reintroduce seed per species-specific BMPs in this document and in the SCBBP.
6. Continue monitoring to assess success of seeding effort.
7. If seeding is unsuccessful, reintroduce additional seed (per flow chart) or reassess seeding effort and site conditions to determine if continued seeding is worthwhile. Note that Nuttall's acmispon has a hard seed coat, so there may be a delay of a season or more between seeding and optimal seed germination (Flaherty pers. obs.).
8. If seeding is successful, continue monitoring per IMG rare plant monitoring protocol to assess occurrence status and threats.

Regional Priorities and Recommendations

Regional priorities focus first on actions that would benefit the species within its current range (e.g., regional monitoring, possibly species introductions). At this time, actions that would occur outside the current range of the species (e.g., species translocations) are a lower priority for management. Regional management actions identified to date for Nuttall's acmispon include:

- Continue monitoring all acmispon occurrences on conserved lands in the MSPA.
- Monitor newly conserved occurrences (e.g., occurrences currently on private lands that become conserved in the future) or occurrences that are conserved but have not yet been monitored per the IMG monitoring protocol.
- Prioritize large occurrences with high or moderate threats for management over small occurrences with high threats. This will ensure that large populations remain large and genetically diverse to help rescue smaller populations.

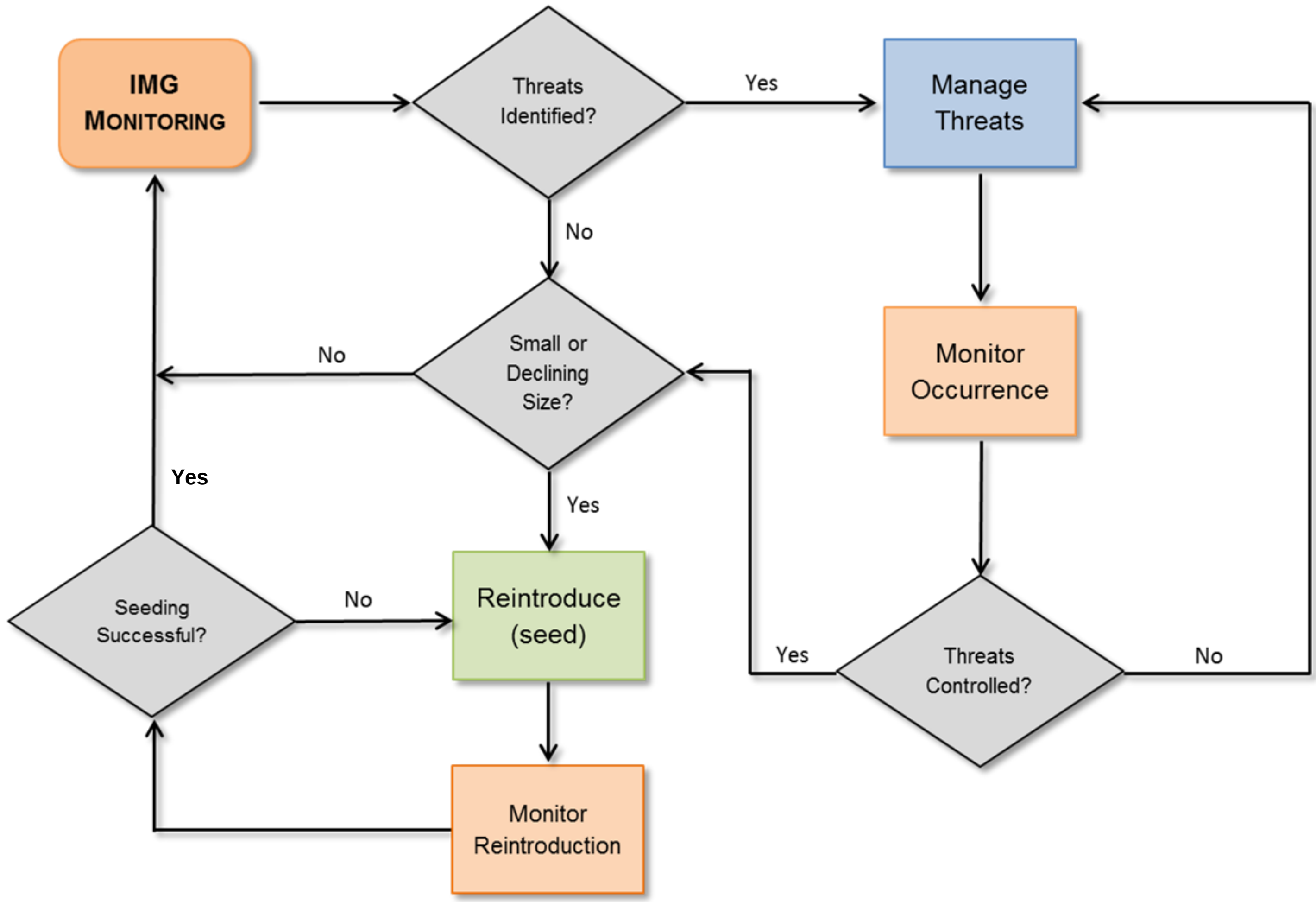


Figure 35. Nuttall's Acmispon: Adaptive Management Flow Chart.

- Introduce new occurrences into high suitability habitat on conserved lands within population groups *if* funding exists. Prior to an introduction, procure seed from an appropriate seed source within the population group and control threats (if any). If necessary, enhance habitat for pollinators. Monitor and adaptively manage the site.

Preserve-level Priorities and Recommendations

Preserve-level priorities and recommendations are informed primarily by IMG monitoring, although they also address those aspects of regional population structure that are specific to an occurrence. For some occurrences, recommendations are incomplete or not provided at all due to a lack of monitoring data.

For most occurrences on conserved lands, surveys have already been conducted. For occurrences where locational information appears to be incorrect or incomplete, the first step will be to conduct baseline surveys. For occurrences with accurate locational information but no monitoring data, the first step will be IMG monitoring to determine status and threats. For all occurrences, *manage threats prior to reintroducing seed*. Managing threats may be sufficient to restore habitat from the soil seed bank.

We use a variation of our earlier color-coded threats scheme to allow land managers to quickly identify priority levels for management (Figure 36). We assigned priority levels for threats at each occurrence using the highest threat level recorded for any sample during the monitoring period. This accommodates different levels of threats between years that may be due to annual climatic variation or surveyor variability. In some cases, land managers may have already controlled threats effectively (e.g., trash removal). In other cases, threat levels may fluctuate between years (e.g., invasive plants).

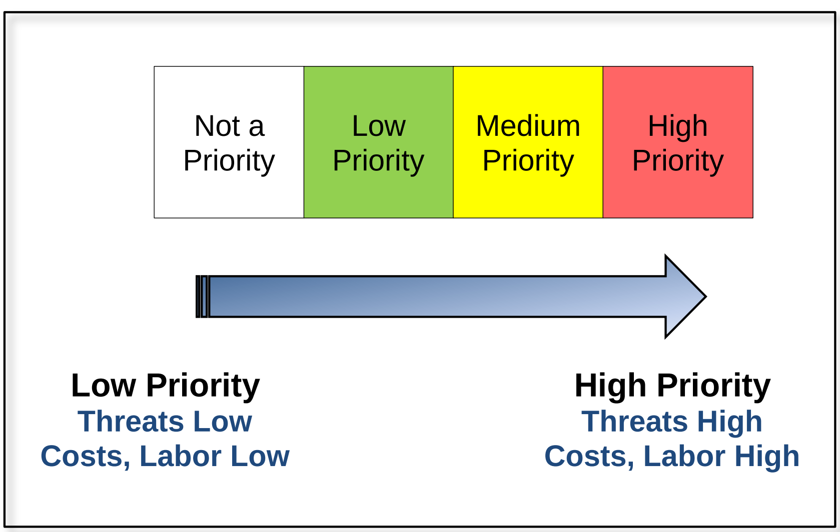


Figure 36. Nuttall's Acmispon: Color-coded Management Priority Levels.

Table 36 presents management priorities for Nuttall's acmispon occurrences. The steps below outline how to use Table 36 and other information in this document to identify and implement management priorities. Refer to Appendix B for general BMPs; species-specific BMPs are included in this chapter.

Steps to Identifying and Implementing Management Priorities
Nuttall's Acmispon:
1. Locate the occurrence in **Table 36**.
2. Determine which threats occur at the target occurrence.
3. Determine which threats are most important to manage. In general, manage higher priority threats first and then move on to lower priority threats. If budgets are limited, manage smaller portions of the high priority threat(s) each year. Increase management efforts once budgets improve or if endowment or grant funding becomes available. Refer to **Table 32** for detailed threat levels.
4. Refer to general and species-specific BMPs to manage the identified threat(s). For example, if erosion and altered hydrology are high priority threats, refer to **general BMPs (Appendix B)** for control methods or other recommendations. If nonnative grasses and forbs are high priority threats, refer to **species-specific BMPs** in this chapter for control methods.
5. Once threats are controlled, refer to the genetics and regional population structure columns in **Table 36** to determine if the occurrence would benefit from reintroducing seed or restoring habitat. To reintroduce seed, identify appropriate seed source (**Figures X or Y**, **Table 34)**, collect seed per the **SCBBP**, and outplant seed per **species-specific BMPs** in this chapter. To restore habitat, determine extent and location of restoration effort after threats are controlled, and restore habitat following **species-specific BMPs** in this chapter.
6. After implementing the appropriate management action(s), monitor the occurrence using the IMG monitoring protocol to determine if actions are successful and manage adaptively per the Adaptive Management flow chart (**Figure 35**).

Table 36. Nuttall's Acmispon: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																GN[5]	RP[6]
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT	RE	RS
ACPR_1BFSP014	Small			M				M	L									M	H
ACPR_1DSTR010	Small		H				L	L	L			L		H		L		M	H
ACPR_1DUTR005	Small	H	H		L	L		M	L	L	L	L	M			L		H	H
ACPR_1FIIS007	Small				L	L		H	L	L			L	M	H	M		M	H
ACPR_1FIIS029	Small				L			H		L						L		H	H
ACPR_1HOPO002	Medium		H		L			M	H	L						M		L	M
ACPR_1MAPO004	Large		H	H	L	L		L	L			L				L			
ACPR_1NMLA001	Small		H		M	L		H	M	L				L		L		M	H
ACPR_1NOBE015	Small				M	L		L	M							M	H	M	H
ACPR_1RRSO003	Small	H			M			M	H	L		M			L	L	L	M	H
ACPR_1SBSA013	Medium		H	L				M			M	L	H		L	M		L	M
ACPR_1SOSH006	Medium		H		M	L		H	M	L				H		L		L	M
ACPR_1SSSB012	Large	H	H	L	L		M	H	M	L		L		L	L	L	H		
ACPR_1SSSB027	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	M	H
ACPR_1SSSB028	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	M	H
ACPR_7AGHE024	Small			M				H	H				H		H	M		H	H
ACPR_7BALA020	Small	L	H	L	L		M	M	M	L	L	L		H	L		M	M	H
ACPR_7CSPA018	Large	H	H	M	L	L	L	H	L	L	M	L	L	M	H	M	L		L
ACPR_7SCSB025	Small	H		H	L		H	H				L	L		M	L	H	H	H
ACPR_7SLRR017	Small	L	H	H	M	M		H	H	L				L	H	L	H	M	H
ACPR_7TPSR019	Small			L	L		M	H	H	L		L	M		H	H	L	M	H

Table 36. Nuttall's Acmispon: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																GN[5]	RP[6]
		AH	BR	CNP	D/T	EN	ER	NNF	NNG	NWP	O/M	RC	SC	VC	TP	TR	OT	RE	RS
ACPR_7TPSR023	Small			M				L	L	L								M	H

[1] Management Priorities: **L** = Low Priority, **M** = Medium Priority, **H** = High Priority. If no priority level is indicated, then no management action is recommended at this time. Occurrences with no data (**---**) should be monitored per the IMG protocol to assess status and threats prior to identifying and recommending appropriate management actions.

[2] Size = population size category: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.

[3] Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **EN** = Encampments, **ER** = Erosion, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **NWP** = Nonnative Woody Plants, **O/M** = Off-road Vehicles/Mountain Bikes, **RC** = Road Construction, **SC** = Soil Compaction, **TP** = Trampling, **TR** = Trails, **VC** = Vegetation Clearing, **OT** = Other (refer to full IMG data for description of other threats at each occurrence).

[4] Threats per IMG monitoring protocol. --- = no data (occurrence not monitored per IMG monitoring protocol).

[5] **GN** = Genetics; **RE** = Reintroduce seed using seed from the target occurrence (if an adequate amount of seed is available) or from a large seed source within the same population group. For occurrences with no data, assess status and threats and refine recommendation.

[6] **RP** = Regional Population Structure; **RS** = Restore habitat (enhance, expand). For occurrences with no data, assess status and threats and refine recommendation.

Best Management Practices (BMPs)

We define a BMP as a tested, effective practice to accomplish management goals or objectives. Land managers, biologists, restoration contractors, or ecologists (*practitioners*) typically implement BMPs. In this section, we outline BMPs to restore Nuttall's acmispon habitat (*habitat restoration*) and occurrences (*species restoration*). These BMPs have been implemented successfully in San Diego County and represent the current state of management knowledge for this species (Redfern and Flaherty 2018, Smith pers. comm.).

The BMPs for restoring Nuttall's acmispon habitat focus on invasive plant control. The use of herbicides to control invasive plants in acmispon habitat is based on many factors, including (but not limited to) goals and objectives, management approach, occurrence history, proximity of target invasive species to acmispon, practitioner experience, restoration timeline, budget, and herbicide restrictions. Currently, herbicide is the preferred method of invasive plant control in acmispon habitat, especially for larger occurrences, and has been tested by land managers in San Diego County. Nonetheless, we also provide mechanical methods in case herbicide is unnecessary, inadvisable, or restricted.

The BMPs for herbicide use in this section focus only on synthetic herbicides. We do not provide BMPs for non-synthetic herbicide use at this time due to a lack of research regarding their effectiveness in controlling invasive plants in acmispon habitat. We acknowledge that using non-synthetic herbicides alone or in combination with mechanical methods may be appropriate to control specific invasive species in some situations.

Refer to Natural Communities Coalition (NCC 2018) for additional information and guidelines on the selection and use of manual and chemical control methods on conserved lands. The NCC document is specific to Orange County; however, the *general* recommendations on invasive plant control methods apply broadly to San Diego County and have the support of both the USFWS and CDFW. Refer to BMPs in this section for invasive plant control methods developed and tested specifically for Nuttall's acmispon.

The BMPs for restoring acmispon occurrences include reintroducing, introducing, or translocating seed, and are used primarily to increase small and medium occurrences. Although we identify seed collecting and bulking needs in this document, we refer the reader to the SCBBP for specific guidelines and BMPs that address these practices. Finally, we provide a flow chart to assist practitioners with implementing BMPs (Figure 37). All BMPs may be refined in the future based on adaptive management or experimental studies.

As outlined in earlier sections of this chapter, occurrences of different sizes or threats will require different types and/or levels of management. For example, the primary management action for large occurrences will be managing threats to ensure that Nuttall's acmispon continues to germinate, reproduce, and replenish the soil seed bank during favorable years. Managing

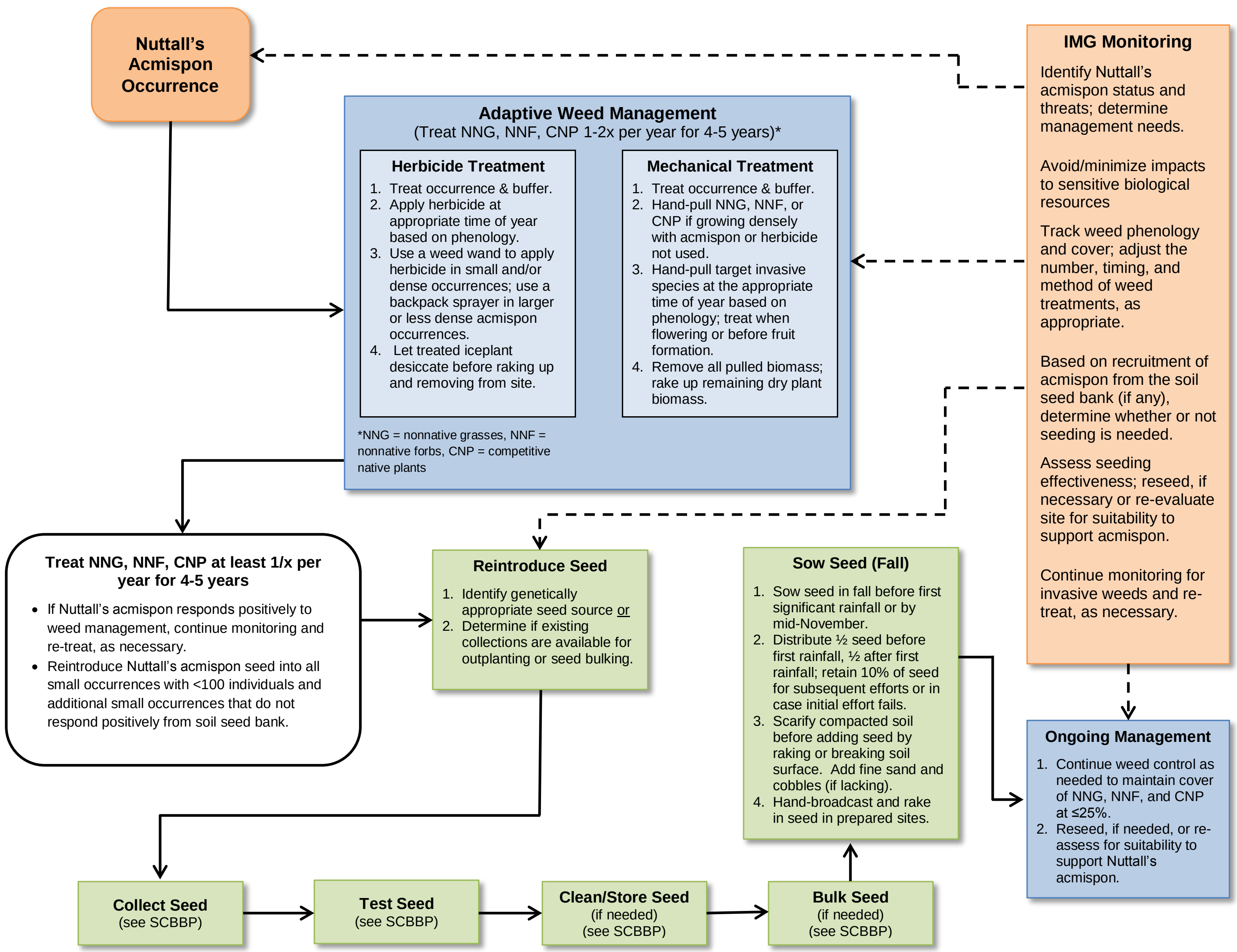


Figure 37. Nuttall's Acmispon: Best Management Practices (BMP) Flow Chart.

threats is also critical for small and medium occurrences. However, these occurrences may require the addition of seed to increase size and potential for long-term persistence. In these cases, we recommend controlling threats before adding seed.

Based on input from experts, we recommend the following steps to restore Nuttall's acmispon occurrences and habitat, and discuss each of these below:

Step 1: Control nonnative grasses, forbs, and competitive native plants

Step 2: Reintroduce Nuttall's acmispon seed (if warranted)

Step 3: Continue weed control

It is important to stress that to successfully restore an acmispon occurrence, land managers must complete *each* step in the order indicated, unless one of the threats addressed in the steps is not present at the occurrence.

Habitat Restoration

Monitoring data show that invasive plants[8] are the most common threat to Nuttall's acmispon. Therefore, controlling invasive plants is a key factor in ensuring the persistence of large and many medium occurrences, and a necessary first step for small and medium occurrences where reintroducing seed is appropriate.

Practitioners should tailor invasive plant control actions to the specific Nuttall's acmispon occurrence and its unique complement of invasive plants and habitat conditions. In addition, not all invasive plants will necessarily require management. Practitioners should prioritize management of invasive species known or strongly suspected to result in acmispon population declines and habitat degradation.

Invasive plant control methods described below have the potential to cause soil disturbance and in some cases, acmispon mortality, particularly in large, dense occurrences. However, the net benefit to the occurrence is expected to outweigh any adverse consequences, and potential impacts can be avoided or minimized with care and experience. Nonetheless, the practitioner should evaluate each method carefully to determine the best management approach for a particular occurrence.

Practitioners have found that by controlling weeds (nonnative grasses, forbs, and competitive native plants) with herbicides and hand-pulling, they can successfully restore Nuttall's acmispon and native dune and coastal habitats (Redfern and Flaherty 2018, Smith pers. comm.). Reintroducing seed can also restore occurrences successfully, but should not be necessary if there is an extant soil seed bank. Practitioners should consider reintroducing seed if the species

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[8] For the purpose of this discussion, invasive plants are primarily nonnative species, but may include a few native species that out-compete Nuttall's acmispon for resources.

does not respond positively to at least three years of invasive plant control (including at least one year with favorable climatic conditions for Nuttall's acmispon germination and growth).

Once the restoration process begins, practitioners should expect some level of perpetual management to maintain habitat conditions because of the extensive weed seed bank at many sites, and continual input of weed seeds from surrounding, untreated areas via wind, animal, or human dispersal. However, regular management should decrease management frequency, intensity, and cost over time. Conversely, if management is discontinued, even for a few years, some sites may revert quickly to pre-treatment conditions.

Timing is critical for treating invasive plants in Nuttall's acmispon habitat. For example, if herbicide is applied too early in the season, then additional treatments may be required to treat late-germinating plants. Conversely, applying herbicide too late in the season will be ineffective if fruit has already hardened into viable seed. Finally, the phenology of both Nuttall's acmispon and the target invasive plants differ by site based on geographic location, site topography, slope aspect, microclimate weather patterns, and vegetation association. For these reasons, experienced practitioners should visit an occurrence several times per season to ensure correct timing to apply herbicide(s).

In any given year, the extent of invasive plant control will depend on weather conditions. Practitioners can expect treatments to be more intensive during years of average- and above-average rainfall because of increased germination of invasive plants and possibly, the need for multiple treatments. Treatments will be less expensive during drought years. To accommodate variations in treatment level, practitioners should include contingency funds in annual budgets and/or allow these funds to carry over to years where they are most needed.

<u>Step 1: Control Nonnative Forbs, Grasses, and Competitive Native Plants</u>

Control nonnative forbs, grasses, and competitive native plants if IMG monitoring data indicate that cover of any of these groups is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative forbs, grasses, and competitive native plants in the occurrence(s) and in the buffer using a combination of herbicides and hand-pulling (Redfern and Flaherty 2018).

Herbicide. Follow herbicide label directions to determine application rates, timing, and limitations/restrictions and proper personal protection equipment. Treat target species at the appropriate time of year. For example, treat Saharan mustard (*Brassica tournefortii*) and nonnative grasses in winter, treat most nonnative forbs and competitive native plants in early spring (March-April), or treat iceplant (*Carpobrotus* spp.) year-round. Treat each species with an appropriate non-selective post-emergent herbicide and ensure that the applicator(s) is experienced and possesses a QAL.

Apply herbicide to basal rosettes and bolting and flowering target species using a backpack sprayer or weed wand. Use a backpack sprayer if Nuttall's acmispon does not grow densely with nonnative forbs and competitive native plants (i.e., greater than several inches of distance between Nuttall's acmispon and the target species). Expect some collateral damage to Nuttall's acmispon where it co-occurs densely with the target species. Use a weed wand for small populations and where Nuttall's acmispon grows densely with nonnative forbs, grasses, and competitive native plants. Treat iceplant with herbicide, let it desiccate and then rake up the dry biomass and remove it (Smith pers. comm.). Manage target plants at least one time a year for 4-5 years.

When using herbicide, avoid or minimize impacts to other sensitive plants that co-occur with Nuttall's acmispon, such as Brand's phacelia (*Phacelia stellaris*) and coast woolly heads (*Nemacaulis denudata* var. *denudata*).

Hand-pull. Use hand-pulling when Nuttall's acmispon and the target invasive species grow densely together and/or if not using herbicides. Hand-pull the target invasive species based on phenology. Practitioners can hand-pull iceplant throughout the year, but some species, such as Saharan mustard and nonnative grasses, are ready for hand-pulling in mid-winter before the majority of other nonnative annual forbs. Hand-pull all target invasive or competitive native species when flowering or just after producing fruit. Remove all pulled biomass and rake up any remaining dry plant biomass (i.e., underneath patches of iceplant) from the site.

When hand-pulling invasive plants, avoid or minimize impacts to other sensitive plants that co-occur with Nuttall's acmispon, such as Brand's phacelia and coast woolly heads.

Monitor the effectiveness of invasive plant control, including the response of Nuttall's acmispon. Per Figure 35, re-treat invasive plants (if necessary) before reintroducing seed, as described under species restoration (below).

Species Restoration

In this section, we discuss seeding to restore occurrences. The BMPs in this section and the BMP flowchart (Figure 37) refer primarily to small and medium occurrences. Since large occurrences presumably support a stable soil seed bank, we do not recommend adding seed unless there is a decline in occurrence size category when monitored over at least five years (including one or more years with favorable climatic conditions).

We recommend *reintroducing* seed into small, declining occurrences if threats are controlled, habitat is likely to support this species in the future, and funding is available for short- and long-term management. Potential seed sources for reintroduction include (1) seed collection and *ex situ* bulking in a nursery setting (as needed) or (2) *in situ* management of existing plants (e.g., watering) to maximize seed production ('bulking onsite') and increase the soil seed bank.

Practitioners may choose to reintroduce seed into medium occurrences to increase size. Refer to Step 2 for guidelines on reintroducing seed.

We recommend *introducing* seed into suitable habitat within Opportunity Areas (e.g., gaps) to create steppingstone occurrences that maintain or improve gene flow, if warranted by regional population structure, following BMPs in Step 2 (below) for reintroducing seed into extirpated occurrences.

At this time, we do not recommend translocating seed outside of the species' current range, pending development of models that predict suitable habitat under future climate scenarios. At that time, we recommend *translocating* seed only in the event of climatic changes that render existing occurrences unsuitable to support acmispon, unless conducted for experimental purposes. Where translocations are warranted, move seed into suitable habitat outside the current species' distribution following BMPs in Step 2 (below) for reintroducing seed into extirpated occurrences.

In the absence of genetic data, refer to *potential* genetic clusters (Figure 30) and population groups (Figures 31-34, Table 34) for appropriate seed sources for reintroduction. The SCBBP also designates seed zones to identify appropriate seed sources. In general, we recommend sourcing seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a large population within the same population group (as addressed in this document and the SCBBP).

Refer to the SCBBP for BMPs for collecting, banking, and bulking acmispon seed for restoration. The BMPs address timing of collections, amount of seed to collect, maximizing diversity in a collection, and transporting, storing, and processing seeds. We recommend that only experienced seed collectors collect acmispon seed per the SCBBP. The BMPs for bulking acmispon seed address potential nurseries, bulking methods, and maximizing genetic diversity in bulked samples.

At this time, species experts do not recommend growing Nuttall's acmispon in a nursery and outplanting individual plants.

Finally, consider climatic conditions when assessing the success of any seeding effort. For example, drought may prevent sufficient germination, but seed may persist in the soil seed bank.

<u>Step 2: Reintroduce Seed</u>

Small, Extant Occurrences. We recommend the following guidelines to reintroduce seed into small, extant occurrences of Nuttall's acmispon where threats have been controlled:

- Reintroduce acmispon seed into all extant occurrences that support fewer than 100 plants *and* meet the reintroduction criteria outlined in the previous section. In these cases, seed reintroduction is critical to the long-term persistence of the occurrence.

- Reintroduce acmispon seed into small occurrences that support more than 100 plants if these occurrences do not respond positively to control of nonnative or competitive native plants.
- For all seed reintroductions into small occurrences, refer to the population groups in this chapter and seed zones in the SCBBP for appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for Nuttall's acmispon. Guidelines of particular importance for this species include:
    - Collect mature seed in the summer or fall after acmispon plants have senesced and fruits are dry.
    - Collect seed directly from senesced plants or collect the soil and duff directly beneath senesced Nuttall's acmispon plants (Redfern and Flaherty 2018, Flaherty pers. comm.).
    - Depending on the site, collect seed outside of the nesting season for the California least tern (*Sternula antillarum*) and avoid any other existing conflicts between collecting seed and sensitive resources.
- Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive or competitive native plants after reintroducing seed, as necessary.
- For all seed reintroductions into small occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
    - Where small occurrences have increased in size, continue weed control at a frequency sufficient to maintain cover of target invasive or competitive native plants at ≤25% cover within the maximum extent area.
    - Where small occurrences have not increased in size or have decreased, even under favorable climatic conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

The objective of reintroducing seed is to increase population size to a level that reduces the potential for extirpation or adverse effects from inbreeding. For very small occurrences (<100 individuals), it may take time, multiple reintroductions, and intensive management to achieve this objective. In these cases, success of a single reintroduction may be measured by a two- or three-fold increase in occurrence size.

Medium, Extant Occurrences. We recommend the following guidelines to reintroduce seed into medium occurrences of Nuttall's acmispon:

- Reintroduce seed of Nuttall's acmispon into medium occurrences that appear to be declining and that do not respond positively to control of nonnative or competitive native plants.

- For all seed reintroductions into medium occurrences, refer to the SCBBP for guidelines on seed collection, banking, and bulking for this species. Guidelines of particular importance for this species include:
  - Collect mature seed in the summer or fall after acmispon plants have senesced.
  - Collect seed directly from senesced plants or collect the soil and duff directly beneath senesced Nuttall's acmispon plants (Redfern and Flaherty 2018, Flaherty pers. comm.).
  - Depending on the site, collect seed outside of the nesting season for the California least tern and avoid any other existing conflicts between collecting seed and sensitive resources.
- Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive or competitive native plants after reintroducing seed, as necessary.
- For all seed reintroductions into medium occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
  - Where medium occurrences appear stable under favorable conditions, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
  - Where medium occurrences are declining even under favorable conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

Extirpated Occurrences. We recommend the following guidelines to reintroduce seed into confirmed historic but extirpated occurrences:

- Reintroduced acmispon occurrences will likely require management in perpetuity. Thus, when assessing an extirpated occurrence for seed reintroduction, consider other sensitive species or resources at that location and potential management conflicts. For example, large-scale herbicide use or mechanized scraping would not be appropriate management actions once Nuttall's acmispon is established.
- Prior to reintroducing seed, restore habitat by controlling invasive or competitive native plants for three years (see Steps 1-3, above).
- Identify an appropriate seed source, preferably from a large occurrence within the same population group or consider composite provenancing from multiple occurrences within the population group to develop an appropriate seed source. Follow guidelines in the SCBBP to collect and bulk seed (if necessary). Guidelines of particular importance for this species include:
  - Collect mature seed in the summer or fall after acmispon plants have senesced.

- Collect seed directly from senesced plants or collect the soil and duff directly beneath senesced Nuttall's acmispon plants (Redfern and Flaherty 2018, Flaherty pers. comm.).
- Depending on the site, collect seed outside of the nesting season for the California least tern and avoid any other existing conflicts between collecting seed and sensitive resources.

- Refer to guidelines on outplanting (sowing) seeds in this section.
- Proceed with seed reintroduction steps outlined above for small, extant occurrences.

Outplanting (Sowing) Seed. Based on input from species experts, we provide the following guidelines for outplanting (sowing) thornmint seed into prepared sites:

- Sow seed in the fall before the first significant rainfall event; however, if it has not rained by mid-November, sow seed anyway. Consider (1) distributing one half of the bulked or collected seed before the first rainfall event and the second half after the second rainfall event and (2) retaining approximately 10% of the seed to use in subsequent seeding efforts if the first effort fails.
- If soils are compact, scarify the soil before adding seed by raking or breaking the soil surface. After breaking up the soil, consider importing and adding fine sand and cobbles if they are lacking or absent. Adding cobbles provides microtopography (Smith pers. comm.).
- Hand-broadcast and then rake seed into sites where target species have been controlled and soils have been scarified (if needed). Removing cover prior to sowing seed will promote germination through increased seed-to-soil contact and reduce competition for Nuttall's acmispon seedlings. Add seed to hummocks between dunes, back dune areas, or flat sites comprised of fine sand that are stable as opposed to active or disturbed (i.e., foredunes, highly trafficked areas) (Redfern and Flaherty 2018, Smith pers. comm.).

<u>Step 3: Continue Weed Control</u>

After reintroducing seed, continue to manage nonnative grasses and forbs and competitive native plants as outlined in Step 1, at a frequency to maintain cover of these species at ≤25% cover in the maximum extent at an occurrence.

Additional Research Needs

The list of additional research needs is derived from a number of sources, including planning documents, research studies, and identified gaps in relevant information about Nuttall's acmispon.

Genetics

- Conduct studies to identify the genetic structure of Nuttall's acmispon within San Diego County.
- Conduct common garden studies to evaluate offspring fitness in crosses within or between populations, if warranted by results of genetic studies.

Habitat Requirements

- Conduct studies to better define optimal restoration locations for Nuttall's acmispon, including habitat, topographic, and edaphic affinities (e.g., back dunes versus foredunes, hummocks between dunes, soil characteristics such as soil chemistry texture and sand density). Refer to Stafford and Smith (2014) for baseline soil chemistry testing in occupied Nuttall's acmispon habitat.
- Conduct studies to refine types and levels of habitat disturbance necessary for species germination and persistence. Refer to Stafford and Smith (2014) for information on disturbance methods and frequency.
- Model suitable habitat based on future climate scenarios.

Reproductive Biology

- Conduct studies to determine the reproductive biology of Nuttall's acmispon (e.g., obligate outcrosser versus some self-compatibility). Identify factors associated with the amount and quality of seed production and whether second year plants are more productive than first year plants.
- Conduct studies to determine longevity of small and large Nuttall's acmispon plants.

Pollinators

- Determine *effective* pollinators and their host plants, maximum pollinator migration/travel distance, and potential effects of climate change on pollinator communities in relation to acmispon phenology.

Seed Biology

- Determine seed bank dynamics (including presence and longevity).
- Determine seed dormancy factors, germination cues, and viability rates.
- Determine dispersal agents of acmispon seed.

4.3 SALT MARSH BIRD'S-BEAK (*CHLOROPYRON MARITIMUM* SSP. *MARITIMUM*)

MSP Goals and Objectives

The MSP Roadmap identifies the following goal for salt marsh bird's-beak:

> *Maintain or enhance existing salt marsh bird's-beak occurrences and create salt marsh to establish new occurrences to reduce risk of population loss to rising sea levels and to ensure multiple conserved occurrences with self-sustaining populations to increase resilience to environmental and demographic stochasticity, maintain genetic diversity, and ensure persistence over the long-term (>100 years) in salt marsh vegetation communities.*

Refer to Table 37 for objectives and actions for this species, per the MSP Roadmap (SDMMP and TNC 2017). In this chapter, we present species life history and ecological requirements, status and trends on conserved lands in the MSPA, genetics, and regional population structure, and recommend management priorities and actions to achieve goals and objectives.

Life History and Ecological Information

Species Description

Salt marsh bird's-beak is a low-growing (10-40 cm [ca. 4-16 in]), typically branched annual herb in the Broomrape family (Orobanchaceae). Foliage is gray-green, often tinged purple and salt-encrusted (Wetherwax and Tank 2012). Flowers are white to cream with lips that are pale-colored or brownish to purple-red. This species is distinguished from other subspecies by geographic location and from other members of the genus by the presence of four fertile stamens (Baldwin et al. 2012, Zedler et al. 1992).

Distribution and Status

Salt marsh bird's-beak occurs from northern Baja California, Mexico north to Morro Bay (SDNHM 2017, CNDDB 2019c). Within San Diego County, the species is known from MUs 1 and 7, with extant occurrences ranging from the Tijuana Slough in the south to Dog Beach in the north (Figure 38). The Border Fields State Park occurrence may be extirpated based on recent

Table 37. Salt Marsh Bird's-beak: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
Monitoring				
MON-IMP-IMG: CHLMAR-1	Conduct IMG monitoring annually	IMP-1	Determine management needs (routine versus intensive).	IP
		IMP-2	Submit monitoring data to MSP Web Portal.	IP
MON-RES-GEN: CHLMAR-3	Conduct genetic studies	RES-1	Collect plant material for genetic samples.	C
		RES-2	Hold a workshop to develop management recommendations based on genetic analyses.	C
		RES-3	Evaluate the long-term genetic trajectory of salt marsh bird's-beak in the MSPA.	C
		RES-4	Submit project data, report to MSP Web Portal.	C
MON-DEV-MODL CHLMAR	Develop models to evaluate/prioritize sites for new occurrences and manage existing occurrences	DEV-1	Identify opportunities to manage salt marsh bird's-beak under changing climate and land use conditions.	NS
		DEV-2	Submit project data, report to MSP Web Portal.	NS
MON-IMP-MGTPL: CHLMAR-9	Monitor management effectiveness	IMP-1	Submit data, report to MSP Web Portal.	NS
Management				
MGT-IMP-IMG: CHLMAR-2	Conduct routine management identified through IMG monitoring.	IMP-1	Perform routine management as needed (e.g., access control, weed control).	IP
		IMP-2	Submit project data to MSP Web Portal.	IP
MGT-PRP-MGTPL: CHLMAR-7	Prepare a section for salt marsh bird's-beak in the F-RPMP.	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Develop a conceptual model for management.	C
		PRP-3	Prioritize occurrences for management.	C
		PRP-4	Develop an implementation plan that prioritizes management actions for the next 5 years.	C
		PRP-5	Submit data and plan to the MSP Web Portal.	C
MGT-IMP-MGTPL: CHLMAR-8	Implement highest priority management actions in F-RPMP	IMP-1	Submit project data and report to MSP Web Portal.	NS

Table 37. Salt Marsh Bird's-beak: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
MGT-PRP-SBPL: CHLMAR-5	Prepare a section for salt marsh bird's-beak in the SCBBP	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Prepare a seed collection plan for occurrences on conserved lands in the MSPA.	C
		PRP-3	Include guidelines for collecting seeds on conserved lands based on genetic studies. Include provisions for collecting seed from unconserved occurrences that may be lost to development.	C
		PRP-4	Include protocols and guidelines for collecting and submitting voucher specimens.	C
		PRP-5	Include guidelines for seed testing.	C
		PRP-6	Submit data and plan to MSP Web Portal.	C
MGT-IMP-SBPL: CHLMAR-6	Collect and store seeds at a permanent seed bank (conservation collection) and provide propagules for research and management actions (propagation collection).	IMP-1	Bulk seed at a qualified facility using seed from genetically appropriate donor accessions in the propagation seed bank collection.	IP
		IMP-2	Maintain records for collected seed to document donor and receptor sites, collection dates, and amounts. Submit data to MSP Web Portal.	IP

[1] Objective Codes: **MGT** = Management, **MON** = Monitoring; **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare; **RES** = Research; **BMP** = Best Management Practices, **FMGT** = Fire Management, **GEN** = Genetics, **IMG** = Inspect and Manage, **MGTPL** = Management Plan, **SPEC** = Species, **SBPL** = Seed Banking Plan.
[2] Descriptions: Refer to MSP Roadmap for complete descriptions (SDMMP and TNC 2017).
[3] Action Codes: **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare, **RES** = Research.
[4] Status: **C** = Completed, **IP** = In-progress (refers to some or all occurrences), **NS** = Not started.

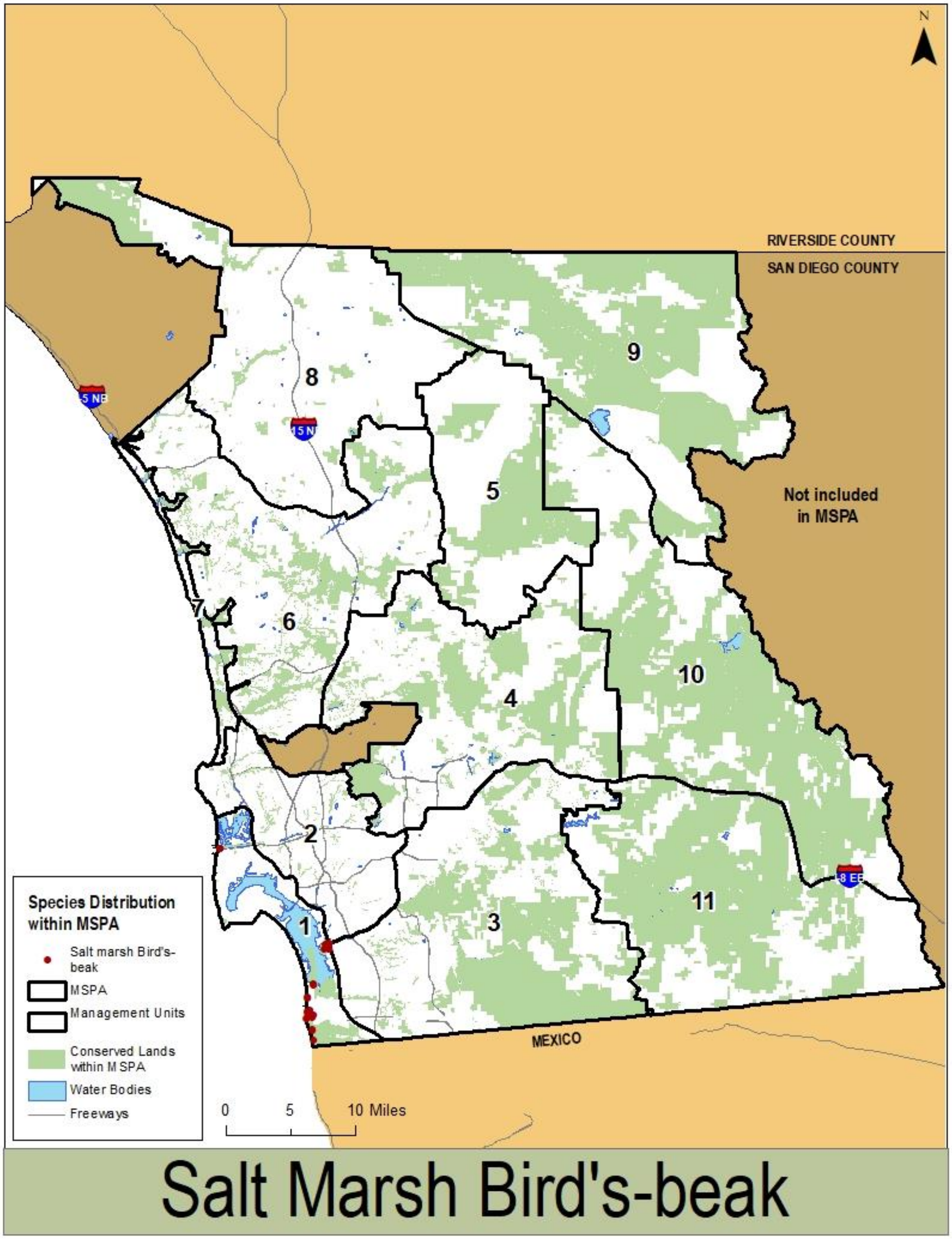

Figure 38. Salt Marsh Bird's-beak: Distribution within the MSPA.

surveys (CNDDB 2019c, SDNHM 2018). Salt marsh bird's-beak is listed as both federally and state endangered.

Table 38 lists 10 occurrences of salt marsh bird's-beak on conserved lands in the MSPA, including population size(s) recorded during the 5-year monitoring period (2014-2018). Table 39 presents recent and historic maximum population sizes for each of these occurrences, and categorizes occurrences into size classes (per Table 12) based on recent population size.

Ecological Requirements

Salt marsh bird's-beak is a late-winter to spring blooming halophytic herb. In San Diego County, this species can flower for up to eight months of the year, depending on weather conditions. Salt marsh bird's-beak experiences large fluctuations in annual population size that are likely tied to timing and levels of precipitation; some occurrences can fail to germinate for several years in a row (Zedler et al. 1992). Noe et al. (2019) report 'boom' populations at Sweetwater Marsh under the following conditions: smaller tidal amplitudes followed by above average rainfall, with moderate temperatures in May. The higher rainfall desalinizes upper tidal soils and stimulates germination, while the moderate temperatures favor growth and reproduction in early summer (June).

There appear to be relatively consistent phenological differences across the species' range, with occurrences in the south flowering before occurrences to the north, and remaining in flower longer than those in the north (USFWS 1985).

Salt marsh bird's-beak is restricted primarily to coastal salt flats and elevated salt marsh habitat. Although this species is a hemiparasite, it is not host-specific and uses a variety of salt marsh species. In a greenhouse setting, biomass was greatest when grown with salt grass (*Distichlis spicata*) (Fink and Zedler 1989). In the same study, researchers cultured salt marsh bird's-beak in the greenhouse without a host, suggesting that it is a facultative parasite, at least in a controlled environment (Fink and Zedler 1989). Some known host species include shore grass (*Distichlis littoralis*), glasswort (*Salicornia pacifica*), alkali heath (*Frankenia salina*), Parish's glasswort (*Arthrocnemum subterminale*), Watson's saltbush (*Atriplex watsonii*), fleshy jaumea (*Jaumea carnosa*), sea lavender (*Limonium californicum*), and alkali weed (*Cressa truxillensis*), among others (Fink and Zedler 1989, USFWS 1985).

Salt marsh bird's-beak prefers to grow in somewhat shaded locations in the upper salt marsh, where it occurs on coarse-textured soils with lower levels of salinity (Tetra Tech 2017, Zedler et al. 1992). Seedlings are sensitive to prolonged periods of inundation and will not survive in areas that hold water for longer than 24 hours (Zedler et al. 1992). Fink and Zedler (1989) found that plants were more tolerant to salt if growing with a host.

Table 38. Salt Marsh Bird's-Beak: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
Management Unit 1									
COMAM3_1DOBE007	Dog Beach	Flood Control Channel Southern Wildlife Preserve	City of San Diego	City San Diego PRD	1,042	17,793	8,130	93,589	7,771
COMAM3_1IMBE008	Camp Surf	Camp Surf	US Navy	US Navy	---	---	200[7]	1,685	4
COMAM3_1SDBA004	San Diego Bay, Naval Radar Receiving Facility, Naval Base Coronado	San Diego Bay, Naval Radar Receiving Facility, Naval Base Coronado	US Navy	USFWS	---	---	0	---	---
COMAM3_1SWMA005	Sweetwater Marsh (west of I-5 and north of Sweetwater River)	San Diego Bay National Wildlife Refuge	USFWS	USFWS	---	---	494	14,900	2,958
COMAM3_1TIES001	Tijuana Estuary Area (at Boundary Monument #258)	Tijuana Slough National Wildlife Refuge	USFWS	USFWS	---	---	0	---	---
COMAM3_1TIES002	Tijuana Estuary Area (between mouth of Tijuana River & Coronado Avenue, Imperial Beach)	Tijuana Slough National Wildlife Refuge	USFWS & US Navy	USFWS & US Navy	---	---	1,100[6]	164,000	1,112
COMAM3_1TIES003	Tijuana Estuary Area (near mouth of Tijuana River and north part of Border Field State Park)	Tijuana Slough National Wildlife Refuge	CDPR	CDPR	---	---	0	---	---
COMAM3_1TIES009	Tijuana Slough	Tijuana Slough National Wildlife Refuge	USFWS	USFWS	---	---	81	---	0
COMAM3_1TISO010	Tijuana Slough National Wildlife Area #2	Tijuana Slough National Wildlife Refuge	USFWS	USFWS	---	---	1,200[7]	---	235
COMAM3_1TISO011	Tijuana Slough National Wildlife Area #3	Tijuana Slough National Wildlife Refuge	USFWS	USFWS	---	---	3,000[7]	14,230	2,795

[1] Table lists only occurrences in the SDMMP's MOM database on conserved lands.
[2] Occurrence Identification (ID) per the SDMMP's MOM database.
[3] Occurrence name/preserve abbreviations: **NWA** = National Wildlife Area, **NWR** = National Wildlife Refuge.

[4] Land owner/land manager: **CDPR** = California Department of Parks and Recreation, **Navy** = U.S. Navy, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **USFWS** = U.S. Fish and Wildlife Service.
[5] Population size information from IMG monitoring data, land manager data, and report and research data; (---) = not surveyed or data not available or not provided, 0 = surveyed, no plants detected.
[6] Surveyors did not have access to Navy property in 2017, but did have access in 2018 which significantly increased the maximum extent size between years.
[7] Data from San Diego Natural History Museum (SDNHM 2018).

Table 39. Salt Marsh Bird's-beak: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
Management Unit 1						
Large Populations						
COMAM3_1DOBE007	Dog Beach	Flood Control Channel Southern Wildlife Preserve	San Diego	San Diego PRD	93,589 (2017)	93,589 (2017)
COMAM3_1SWMA005	Sweetwater Marsh (west of I-5 and north of Sweetwater River)	San Diego Bay NWR	USFWS	USFWS	14,900 (2017)	14,900 (2017)
COMAM3_1TIES002	Tijuana Estuary Area (between mouth of Tijuana River & Coronado Avenue, Imperial Beach)	Tijuana Slough NWR	USFWS, Navy	USFWS, Navy	164,000 (2017)	164,000 (2017
COMAM3_1TISO011	Tijuana Slough NWA #3	Tijuana Slough NWR	USFWS	USFWS	14,230 (2017)	14,230 (2017)
Medium Populations						
COMAM3_1IMBE008	Camp Surf	Camp Surf	Navy	Navy	1,685 (2017)	1,685 (2017)
COMAM3_1TISO010	Tijuana Slough NWA #2	Tijuana Slough NWR	USFWS	USFWS	1,200[9] (2016)	1,200[9] (2016)
Small Populations						
COMAM3_1SDBA004	San Diego Bay, Naval Radar Receiving Facility, Naval Base Coronado	San Diego Bay, Naval Radar Receiving Facility, Naval Base Coronado	Navy	USFWS	0[7] (2016)	0[7] (2016)
COMAM3_1TIES001	Tijuana Estuary Area (at Boundary Monument #258)	Tijuana Slough NWR	USFWS	USFWS	0[8] (2016)	0 (2016)
COMAM3_1TIES003	Tijuana Estuary Area (near mouth of Tijuana River and north part of Border Field State Park)	Tijuana Slough NWR	CDPR	CDPR	2,000 (1979)	0 (2016)
COMAM3_1TIES009	Tijuana Slough	Tijuana Slough NWR	USFWS	USFWS	81 (2016)	81 (2016)

[1] Table lists only occurrences in the SDMMP's MOM database on conserved lands.
[2] Occurrence Identification (ID) per the SDMMP MOM database.
[3] Occurrence name/preserve abbreviations: **NWA** = National Wildlife Area, **NWR** = National Wildlife Refuge.

[4] Land owner/land manager: **CDPR** = California Department of Parks and Recreation, **Navy** = U.S. Navy, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **USFWS** = U.S. Fish and Wildlife Service.
[5] Indicates maximum recorded population size.
[6] Indicates maximum recorded population size from 2014 - 2018 if data are available, or most recent year overall if data are not available.
[7] Occurrence may not be valid; no current or historic data available.
[8] Data from San Diego Natural History Museum (SDNHM 2018).
[9] No historical population data exists for this occurrence (CNDDB 2019c).

Pollinators

Salt marsh bird's-beak is pollinated by solitary bees that nest in the ground in upland habitat adjacent to salt marshes (Lincoln 1985); thus, the presence of suitable upland habitat in proximity to salt marsh bird's-beak occurrences is important for the persistence of this species. At Point Mugu in Ventura County, four bee species were observed visiting salt marsh bird's-beak flowers: American bumblebee (*Bombus pensylvanicus sonorous* [often called *B. sonorous*]), wool carder bee (*Anthidium edwardsii*), long-horned bee (*Melissodes tepida timberlakei*), and an unidentified species (likely a sweat bee [*Lasioglossum* sp.]) (Lincoln 1985). Knapp and Schneider (2017) repeated the study by Lincoln (1985) and reconfirmed that wool carder bees and long-horned bees both visit salt marsh bird's-beak flowers. They also confirmed the presence of sweat bees at Point Mugu, but not with salt marsh bird's-beak, and did not locate American bumblebees (Knapp and Schneider 2017).

Reproductive Biology

Salt marsh bird's-beak reproduces sexually from seed. Insect visitation is required for pollination; however, the species is self-compatible (i.e., plants can be fertilized by pollen from the same plant) and weakly autogamous (i.e., a flower can be fertilized by pollen from the same flower) (Helenurm and Parson 1997, Parsons and Zedler 1997, Lincoln 1985).

Seed Biology

Salt marsh bird's-beak appears to form a soil seed bank. Seed bank longevity is unknown, but seeds have retained viability in a controlled setting for 11 years (Parsons and Zedler 1997, Zedler et al. 1992). Seed dormancy is relieved with after-ripening, scarification, or vernalization (artificially cooling seeds to mimic cold temperatures and induce germination), or by placing seeds in slightly saline water (Zedler et al. 1992, USFWS 1985). Seed is buoyant; thus, floating may be the primary dispersal mechanism, although animals may disperse some seed (USFWS 1985). In one successful restoration project, researchers noted that the larger salt marsh bird's-beak patches produced more seed, but some patches did not produce seed at all, suggesting that the limiting factor may have been pollinators (Zedler et al. 1992).

Seed production is highly variable and many factors affect seed set, including seed predators and fungal diseases (USFWS 1985). Some seed predators may drastically affect seed production in a given year, including larvae of the leaf roller moth (*Platynota stultana*), the geranium plume moth (*Amblyptilia pica*), the salt marsh plume moth (*Liphographus fenestrella),* and the salt marsh leaf roller moth (*Saphenista* sp.) (USFWS 2013, Anderson pers. comm.). Biologists have observed high levels of seed predation at Dog Beach, Sweetwater Marsh, and the Tijuana Slough. Most observations of seed predation occurred in drier versus wetter locations. Reduced tidal flooding (i.e., drier soil conditions) may increase the suitability of a site for the salt marsh leaf roller, which spends part of its life cycle in the ground (USFWS 2013).

Status and Trends

We can compare population size and extent over time to determine trends. In Table 39, we presented maximum recent and historic population sizes for each occurrence. Although these data are incomplete, they provide a preliminary indication of status and trends. Recent monitoring data (2014-2018) indicate the following:

- Of the 10 occurrences of salt marsh bird's-beak on conserved lands in the MSPA, 4 occurrences (40% of occurrences) support <1,000 plants, 2 (20%) support 1,000-10,000 plants and 4 (40%) support >10,000 plants (Figure 39).

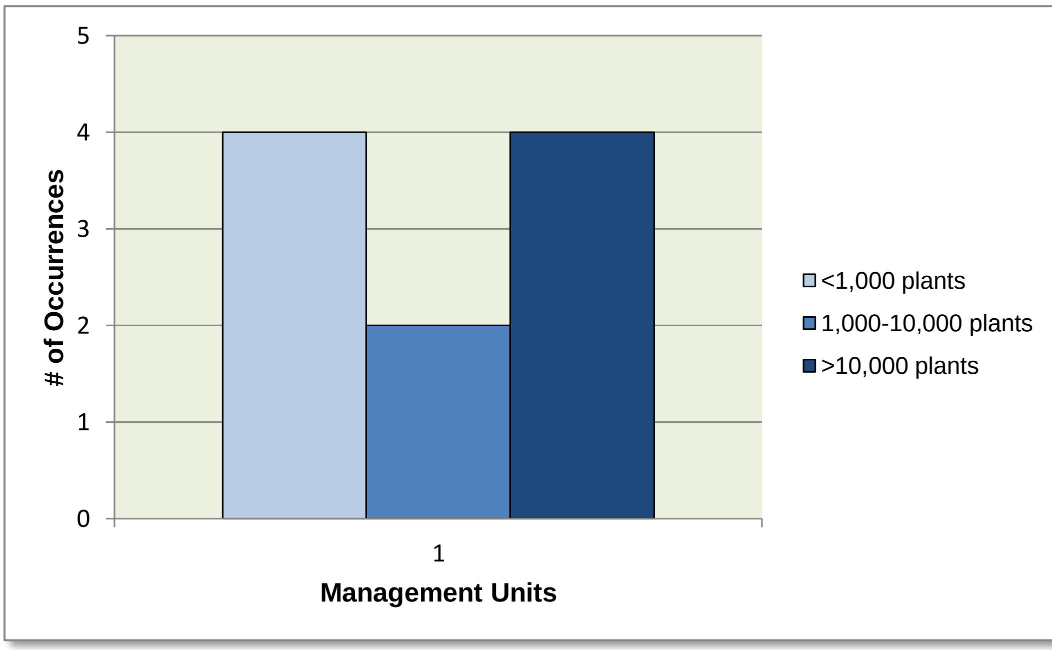

Figure 39. Salt Marsh Bird's-beak: Distribution by Population Size and MU (2014-2018).

- For the 4 occurrences with <1,000 plants, all had ≤100 plants recorded in any year from 2014-2018. This included 3 occurrences with 0 plants (75% of all occurrences in this size category; 30% of all occurrences) (Figure 40).

Comparing recent (2014-2018) and historic population size data suggest the following:

- Of the 10 occurrences on conserved lands, 9 (90%) appear relatively stable with respect to size, while 1 (10%) appears to have declined over time and is now in a smaller size category (Table 40). The monitoring record is incomplete for many occurrences and the time scale is insufficient to detect some trends, such as those related to genetic factors that may affect long-term persistence (e.g., isolation, inbreeding depression).

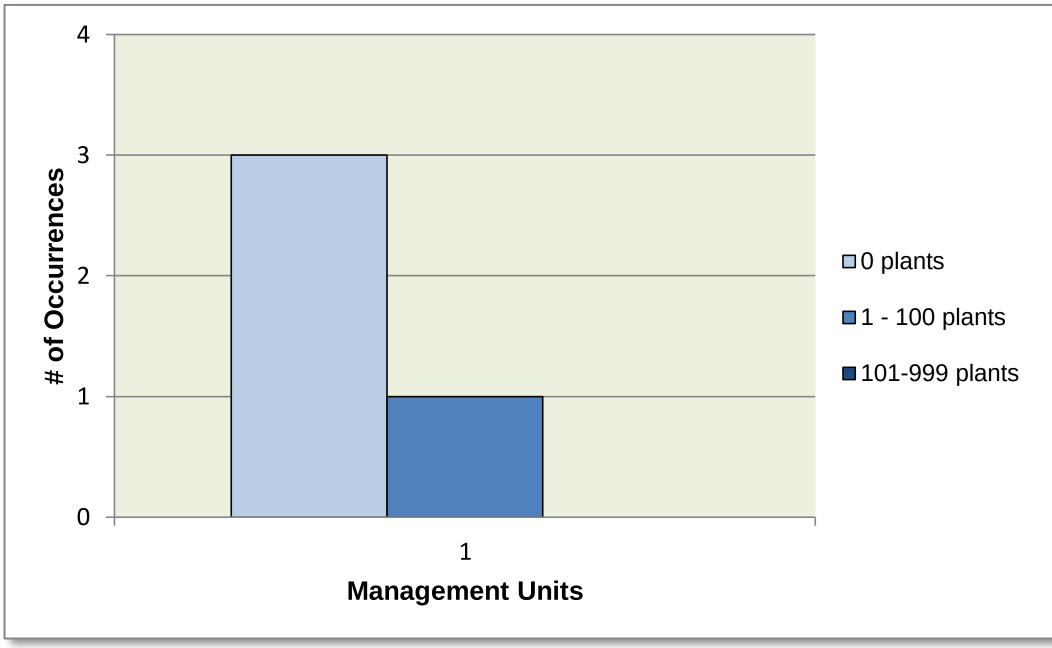

Figure 40. Salt Marsh Bird's-beak: Distribution by Population Size and MU for Occurrences with <1,000 plants (2014-2018).

Table 40. Salt Marsh Bird's-beak: Occurrences by Recent and Historic Population Size Category.

Occurrence ID[1]	MU[2]	Recent Population Size Category [3,4]	Historic Population Size Category[3,5,6]
COMAM3_1DOBE007	1	Large	Large
COMAM3_1SWMA005	1	Large	Large
COMAM3_1TIES002	1	Large	Large
COMAM3_1TISO011	1	Large	Large
COMAM3_1IMBE008	1	Medium	Medium
COMAM3_1TISO010	1	Medium	Medium
COMAM3_1SDBA004	1	Small[7]	Small
COMAM3_1TIES001	1	Small[7]	Small
COMAM3_1TIES003	1	Small[7]	Medium
COMAM3_1TIES009	1	Small	Small

[1] Occurrence ID = Occurrence identification code per the SDMMP's MOM database.
[2] MU = Management Unit.
[3] Population size categories: **Small** = <1,000 plants**, Medium** = 1,000-10,000 plants**, Large** = >10,000 plants.
[4] Recent population size category is based on maximum size recorded at occurrence from 2014-2018.
[5] Historic population size category is based on maximum size recorded from 2014-2018 or earlier.
[6] Cells highlighted with green shading indicate a change between historic and recent size categories.
[7] Indicates occurrences with at least one IMG monitoring event during the 5-year period from 2014-2018, but 0 plants detected.

Threats and Stressors

At a regional scale, salt marsh bird's-beak may be affected directly or indirectly by climate change (Berlin et al. 2012). At the preserve-level, biologists and land managers have recorded 14 categories of threats at bird's-beak occurrences through the IMG monitoring process (Figure 41). The most common threats are dumping/trash, nonnative forbs, altered hydrology, and 'other' threats (e.g., rising sea level).

Threats at each occurrence are recorded as a continuum from no threat (threat level 0-1) to a threat that affects ≥75% of the maximum occupied area by salt marsh bird's-beak (threat level 7). When reporting threats, we use a color-coded system to allow land managers to easily identify threat levels that are low versus high. In most cases, management costs and labor will increase with increasing threat level. Thus, addressing threats before they become a problem is a cost-effective strategy for managing occurrences.

We further stratify the color-coded system by different shades of the same color to (1) indicate magnitude of threat and (2) allow land managers to track whether threats are increasing or decreasing over time (taking into account annual variability due to climate). Table 41 defines threat levels per the IMG monitoring protocol (SDMMP 2019), while Figure 42 depicts the color-coded system used to display threats.

Table 41. Descriptions of Threat Levels.[1]

Threat Level	Description	Priority for Management
0-1	Threat not recorded at occurrence or in 10-m buffer	None
2	Threat not recorded at occurrence, but recorded in adjacent buffer	Low
3	Threat occurs over 0-10% of area within maximum extent	Low
4	Threat occurs in 10% to <25% of area within maximum extent	Medium
5	Threat occurs in 25% to <50% of area within maximum extent	Medium
6	Threat occurs in 50% to <75% of area within maximum extent	High
7	Threat occurs in ≥75% of area within maximum extent	High

[1] Threat level descriptions per IMG monitoring protocol (SDMMP 2019).

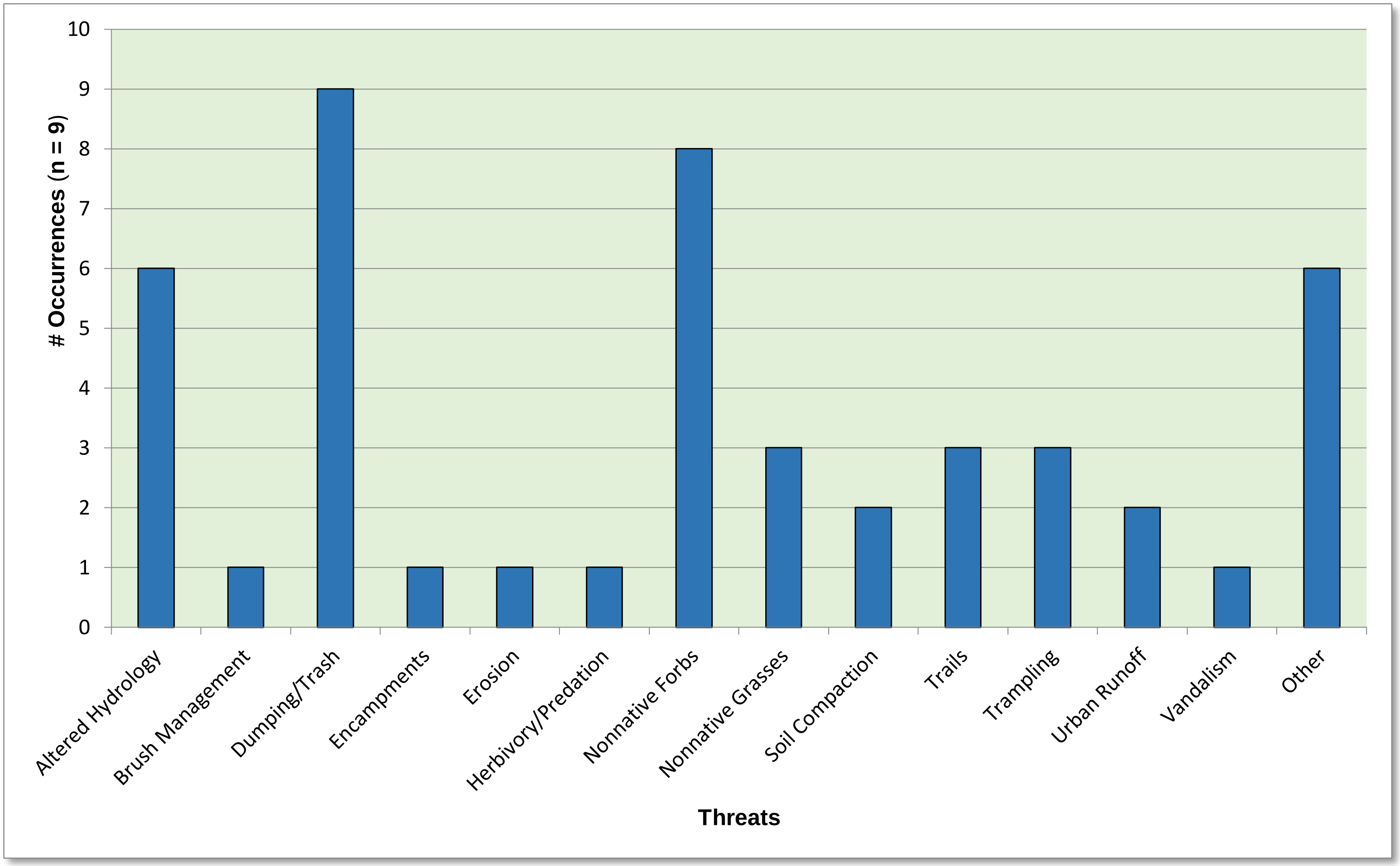

Figure 41. Salt Marsh Bird's-beak: Threats Recorded during IMG Monitoring (2014-2018) (notes: data indicate the number of occurrences at which a threat was recorded; 'Other' category includes threats from sea level rise).

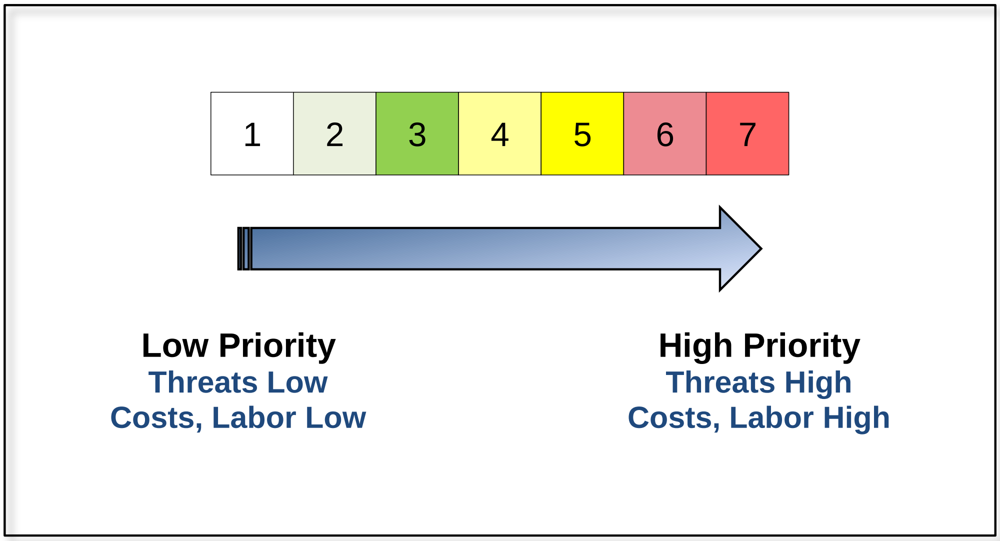

Figure 42. Salt Marsh Bird's-beak: Color-coded Threat Levels.

Table 42 presents threats and threat levels by year for occurrences with IMG data. IMG data are available on the SDMMP website:

> https://sdmmp.com/view_project.php?sdid=SDID_sarah.mccutcheon%40aecom.com_57cf0196dff76.

Genetic Considerations

Genetic studies of salt marsh bird's-beak indicate that this species has high genetic differentiation (divergence) across its range in California, but low genetic differentiation within San Diego County (Milano and Vandergast 2018). San Diego County occurrences also exhibit low genetic diversity within four occurrences and higher genetic diversity within one occurrence, and low inbreeding with some high relatedness (Milano and Vandergast 2018; Table 43). The USGS study identified one genetic cluster in the county (Milano and Vandergast 2018).

Figure 43 depicts the single genetic cluster (South) identified for this species in San Diego County (Milano and Vandergast 2018). Table 44 presents the actual or presumed genetic structure of salt marsh bird's-beak occurrences. We use the term 'actual' structure for occurrences tested genetically, and 'presumed' structure for occurrences not yet tested. The latter may be refined in the future.

The primary strategies to manage genetic resources within this species include:

- Manage threats (e.g., invasive plants) at all occurrences to increase population size, maintain or increase genetic diversity, replenish the soil seed bank, and encourage pollinator activity. In addition, maintain intact upland habitat adjacent to occurrences to support pollinators.

Table 42. Salt Marsh Bird's-beak: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3,4]													
		AH	BR	D/T	EN	ER	HE	NNF	NNG	SC	TR	TP	UR	VA	OT[5]
COMAM3_1DOBE007	2014	6	---	3	2	1	1	6	1	1	2	1	1	1	---
COMAM3_1DOBE007	2015	7	1	1	1	1	1	4	1	1	5	1	1	1	1
COMAM3_1DOBE007	2016	7	1	1	1	1	1	6	1	1	4	1	1	1	1
COMAM3_1DOBE007	2017	1	1	1	1	1	1	5	1	1	2	1	1	1	1
COMAM3_1DOBE007	2018	1	2	3	2	1	1	5	2	1	4	3	3	3	1
COMAM3_1IMBE008	2017	1	1	3	1	1	2	3	7	1	3	1	1	1	1
COMAM3_1IMBE008	2018	2	1	2	1	1	1	2	2	1	1	1	2	1	7
COMAM3_1SDBA004	2016	1	1	4	1	1	0	3	1	1	---	1	1	1	---
COMAM3_1SWMA005	2016	5	5	7	7	1	1	5	4	7	---	7	1	1	7
COMAM3_1SWMA005	2017	7	3	7	1	1	1	4	3	1	1	1	1	1	1
COMAM3_1SWMA005	2018	6	2	6	2	3	1	3	3	2	2	1	1	1	7
COMAM3_1TIES002	2016	7	1	7	1	1	1	5	3	3	---	4	1	1	7
COMAM3_1TIES002	2017	3	1	5	1	1	1	4	4	1	3	3	1	1	7
COMAM3_1TIES002	2018	7	1	3	1	1	1	1	1	1	3	1	1	1	7
COMAM3_1TIES003	2016	1	1	3	1	1	0	7	1	1	---	1	1	1	---
COMAM3_1TIES009	2016	1	1	3	1	1	1	3	1	1	---	1	1	1	7
COMAM3_1TIES009	2018	7	1	3	1	1	1	1	1	1	1	1	1	1	7
COMAM3_1TISO010	2018	7	1	3	1	2	1	2	2	1	1	1	2	1	7
COMAM3_1TISO011	2017	2	1	3	1	1	1	3	2	1	1	1	4	1	6
COMAM3_1TISO011	2018	3	1	3	1	2	1	3	1	1	2	1	3	1	7

[1] Table includes only occurrences on conserved lands within the MSPA.

[2] Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **D/T** = Dumping/Trash, **EN** = Encampments, **HE** = Herbivory, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **UR** = Urban Runoff, **VA** = Vandalism, **OT** = Other (refer to full IMG data for description of other threats at each occurrence).

[3] Threat Levels (exclusive of herbivory; numbers represent percent (%) of maximum extent disturbed by threat): **1** = 0% in maximum extent or adjacent 10 m buffer; **2** = 0% in maximum extent but threat detected in surrounding 10 m buffer; **3** = >0-<10% of maximum extent; **4** = 10-<25% of maximum extent; **5** = 25-<50% of maximum extent; **6** = 50-<75% of maximum extent; **7** = ≥75% of maximum extent; **---** = data not collected or not available.

[4] Threats Levels (herbivory only; numbers represent % of plants in sampling area that show signs of herbivory): **1** (0%), **2** (>0-<10%), **3** (10-<25%, **4** (25-<50%), **5** (≥50-<75%), **6** (≥75%).

[5] Most threats in the ‘Other’ category are related to rising sea level due to climate change.

Table 43. Salt Marsh Bird's-beak: Genetic Structure within the MSPA.[1]

Genetic Parameter	Status[2]	Management Trigger[3]	Management Strategy[4]
Genetic Differentiation	Low (1 genetic cluster in San Diego County)	**No**	(1) Maintain or restore habitat for pollinators or seed dispersers to promote gene flow among occurrences.
Genetic Diversity	Low (4 occurrences) Higher (1 occurrence)	**Yes** (4 occurrences)	(1) Manage threats to maintain or increase occurrence size; (2) reintroduce seed into restored occurrences to increase genetic diversity; (3) source seed from higher diversity occurrence in San Diego County.
Inbreeding & Relatedness	Inbreeding: Low Relatedness: Some High	**Yes** (some occurrences)	(1) Manage threats to maintain or increase gene flow within occurrences; (2) reintroduce seed into small occurrences to increase size; (3) source seed from higher diversity occurrence in San Diego County.
Ploidy level	No differences	**No**	None.

1 Results and recommendations from Milano and Vandergast 2018.
2 Status: results of genetic testing per Milano and Vandergast 2018.
3 Management Trigger: **Yes** = genetic testing indicates that some or all occurrences require specific actions to manage genetic parameter for this species, **No** = genetic testing indicates that no specific actions are required to manage genetic parameter for this species.
4 Management Strategy: refers only to strategies to manage genetic parameter. Additional strategies may be needed to manage threats; management of multiple threats should be coordinated.

- Reintroduce seed into consistently small (<1,000 individuals) occurrences to increase population size and diversity, *if determined necessary after managing threats*. Follow guidelines in the SCBBP on seed collecting and bulking. Collect seed from the larger occurrences in the Tijuana Estuary.

  Not all small occurrences will require seed reintroduction. This strategy is most appropriate under the following conditions: (1) occurrence is small *and* declining, even with management, (2) suitable habitat persists, and (3) adequate funding is available for both the reintroduction effort and long-term management. Occurrences with fewer than 100 plants are the highest priority for reintroduction (if the conditions above are met), because they are particularly susceptible to extirpation. We recognize that some small occurrences are stable and will not require additional seed.

- For occurrences with low genetic, consider reintroducing genetically compatible propagules from higher diversity Tijuana Estuary occurrences.

- For occurrences that are threatened by sea level rise, consider experimental reintroductions at higher elevations within existing habitat.

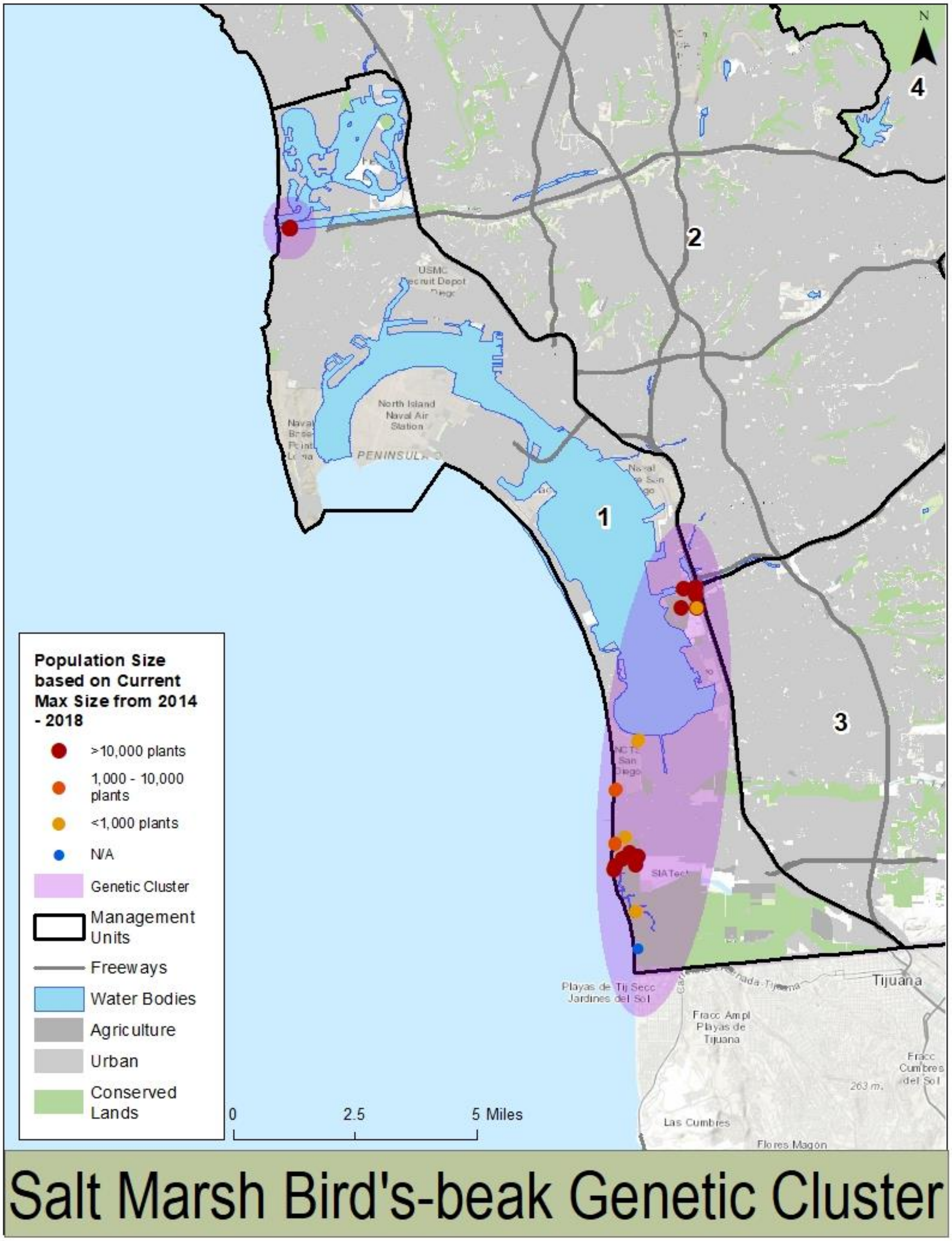

Figure 43. Salt Marsh Bird's-beak: Genetic Cluster.

Table 44. Salt Marsh Bird's-beak: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster[1]	Genetic Structure	Potential Management Actions[2]
Management Unit 1			
COMAM3_1DOBE007	South	Low Differentiation + Low Diversity + Low Inbreeding	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1IMBE008	South	Low Differentiation + Low Diversity + Low Inbreeding	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1SDBA004	(South)	Low Differentiation + High Diversity + Low Inbreeding	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1SWMA005	South	Low Differentiation + Low Diversity + Low Inbreeding	• Manage threats • Reintroduce seed to increase genetic diversity
COMAM3_1TIES001	South	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1TIES002	South	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats
COMAM3_1TIES003	South	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1TIES009	South	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats • Reintroduce seed to increase occurrence size
COMAM3_1TISO010	(South)	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats
COMAM3_1TISO011	(South)	Low Differentiation + Higher Diversity + Low Inbreeding (some high relatedness)	• Manage threats

[1] Placement in a genetic cluster is per genetic testing results (Milano and Vandergast 2018 and others). Occurrences not included in genetic testing are placed in closest genetic cluster, with parentheses around cluster name.

[2] Reintroduce/introduce seed from genetically compatible occurrence(s) within genetic cluster to increase genetic diversity (i.e., larger occurrences in the Tijuana Estuary).

Regional Population Structure

Size Class Distribution

For salt marsh bird's-beak, we used the population size classes for annual plant species from Table 12. Table 45 presents the distribution of size classes for bird's-beak within MU 1. Where recent monitoring data were not available or no plants were detected at an occurrence during IMG monitoring (2014-2018), we used historic data (pre-2014) to assign size class. Although this method is imprecise, it highlights the need for comprehensive monitoring data.

Table 45. Salt Marsh Bird's-beak: Size Class Distribution by MU.

Management Unit	Occurrence Size Class[1]			Total
	Large	Medium	Small	
1	4 (40%)	2 (20%)	4 (40%)	10
Total	4 (40%)	2 (20%)	4 (40%)	10

[1] Refer to text and Table 12 for description of size classes. Number = number of occurrences in size class; percent (%) = percent of occurrences in size class for management unit.

We identified one population group for salt marsh bird's-beak occurrences across the MSPA, based on geographic location, and actual or presumed levels of connectivity and genetic differentiation (Figure 44). This population group corresponds to the genetic cluster identified by Milano and Vandergast (2018). All occurrences within this group are currently genetically compatible. However, fragmentation and subsequent isolation are relatively recent processes within or among some occurrences that could increase genetic differentiation and/or decrease genetic diversity over time. For that reason, we also identified two subgroups within the group based on proximity and/or the presence of suitable habitat to potentially allow for gene flow, population expansion, or movement of pollinators between occurrences (Table 46, Figure 45). We assigned occurrences not included in genetic studies to the nearest subgroup.

For the remainder of this section, we refer to the group or subgroups by their population codes (Table 46), with the group abbreviation (South = S), followed by the subgroup number. For example, Subgroup 1 in the South population group is S-1.

Habitat Connectivity

Habitat fragmentation and loss of connectivity among the two subgroups are a concern for salt marsh bird's-beak (Figure 45). This species likely occurred as a single, nearly continuous population prior to development. Genetic studies indicate no genetic differentiation within the group (Milano and Vandergast 2018). However, we do not know if this will persist over time, since there is little suitable habitat available for salt marsh bird's-beak between the two subgroups. Strategies to prevent differentiation in the future include (1) restoring steppingstone habitat for pollinators or (2) periodically reintroducing seed from one subgroup into the other.

Regional Management Strategies for Opportunity Areas

Management actions will occur within *Opportunity Areas* identified through the regional population structure process. Opportunity Areas are conserved lands within the MSPA that have the potential to enhance regional population structure and long-term resilience of salt marsh bird's-beak through various conservation and management actions. Opportunity Areas occur within population groups or subgroups, in gap areas between population subgroups, or beyond the current species' distribution in response to a changing climate.

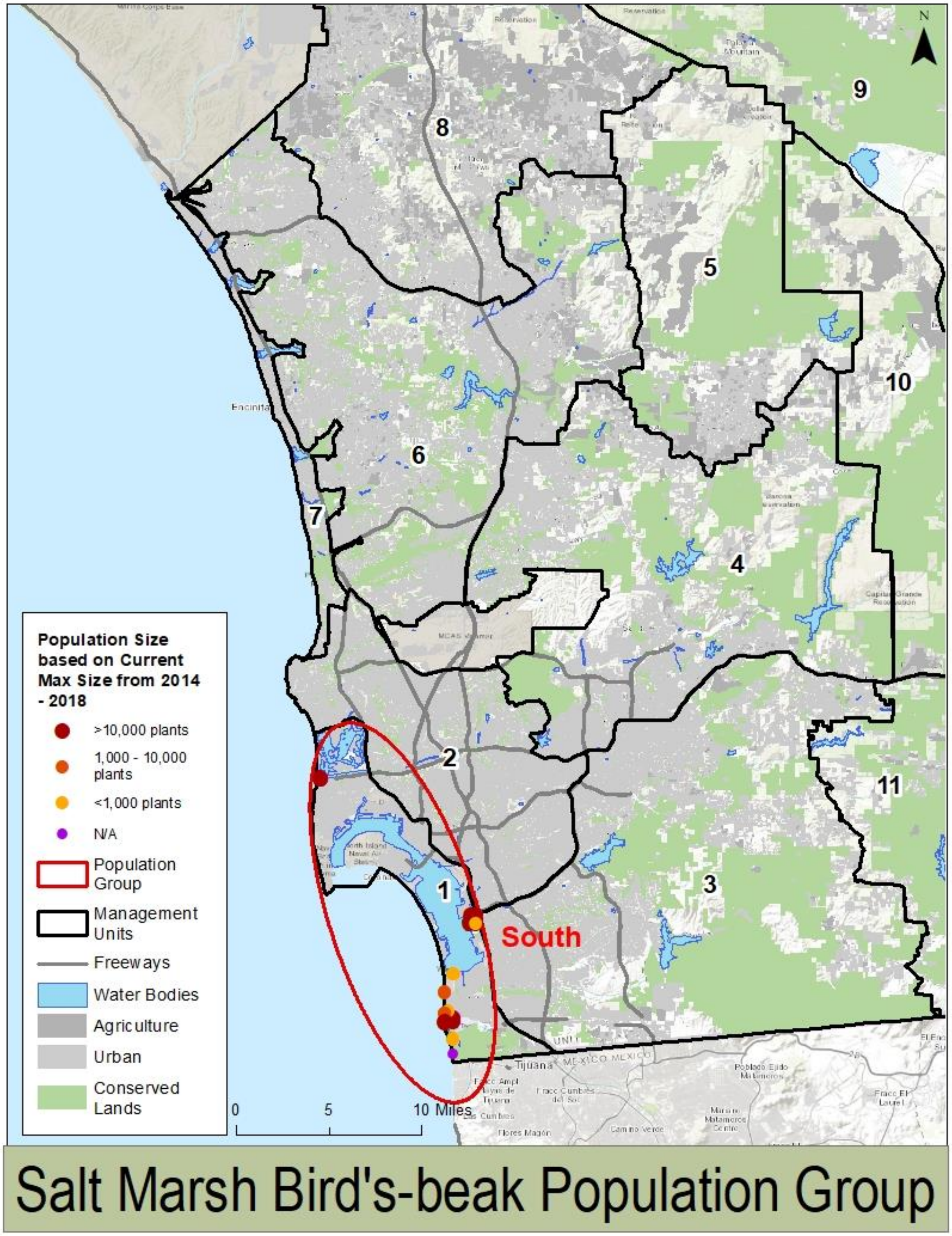

Figure 44. Salt Marsh Bird's-beak: Population Group within the MSPA.

Table 46. Salt Marsh Bird's-beak: Population Group and Subgroups.

Population Group[1]	Population Subgroup	Population Code	Occurrence ID	Population Size[2]	Group Characterization[3]
South	1	S-1	COMAM3_1DOBE007	Large	Large
South	2	S-2	COMAM3_1IMBE008	Medium	Large
(South)	2	S-2	COMAM3_1SDBA004	Small	
South	2	S-2	COMAM3_1SWMA005	Large	
South	2	S-2	COMAM3_1TIES001	Small	
South	2	S-2	COMAM3_1TIES002	Large	
South	2	S-2	COMAM3_1TIES003	Small	
South	2	S-2	COMAM3_1TIES009	Small	
(South)	2	S-2	COMAM3_1TISO010	Medium	
(South)	2	S-2	COMAM3_1TISO011	Large	

[1] The population group corresponds to the genetic cluster (see Table 44; Milano and Vandergast 2018). Where the group is in parentheses, the occurrence was not tested and is placed in the subgroup based on proximity to tested occurrences.
[2] Population size categories: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.
[3] Group characterization: **large** = group has at least one large occurrence.

We recommend the following strategies to maintain or improve regional population structure and long-term resilience of salt marsh bird's-beak within opportunity areas across the MSPA:

- **Survey** occurrences that have not been visited recently and/or where the species has not been detected recently (e.g., Border Field State Park). In addition, conduct baseline surveys throughout the Tijuana Estuary, with a focus on areas that have not been visited.
- **Manage** all occurrences through site-specific actions (e.g., invasive plant control), as determined necessary through monitoring.
- **Reintroduce** the species into small occurrences that do not respond positively to management by adding seed from the target occurrence (if adequate seed is available) or from larger occurrences within the Tijuana Estuary. A positive response to management is an increase in occurrence size under favorable climatic conditions. Small occurrences occur in subgroup S-2.
- **Expand** habitat at selected small occurrences by enhancing adjacent habitat and/or introducing or reintroducing seed.
- **Introduce** new occurrences experimentally into suitable habitat adjacent to occurrences that are threatened by rising sea levels.

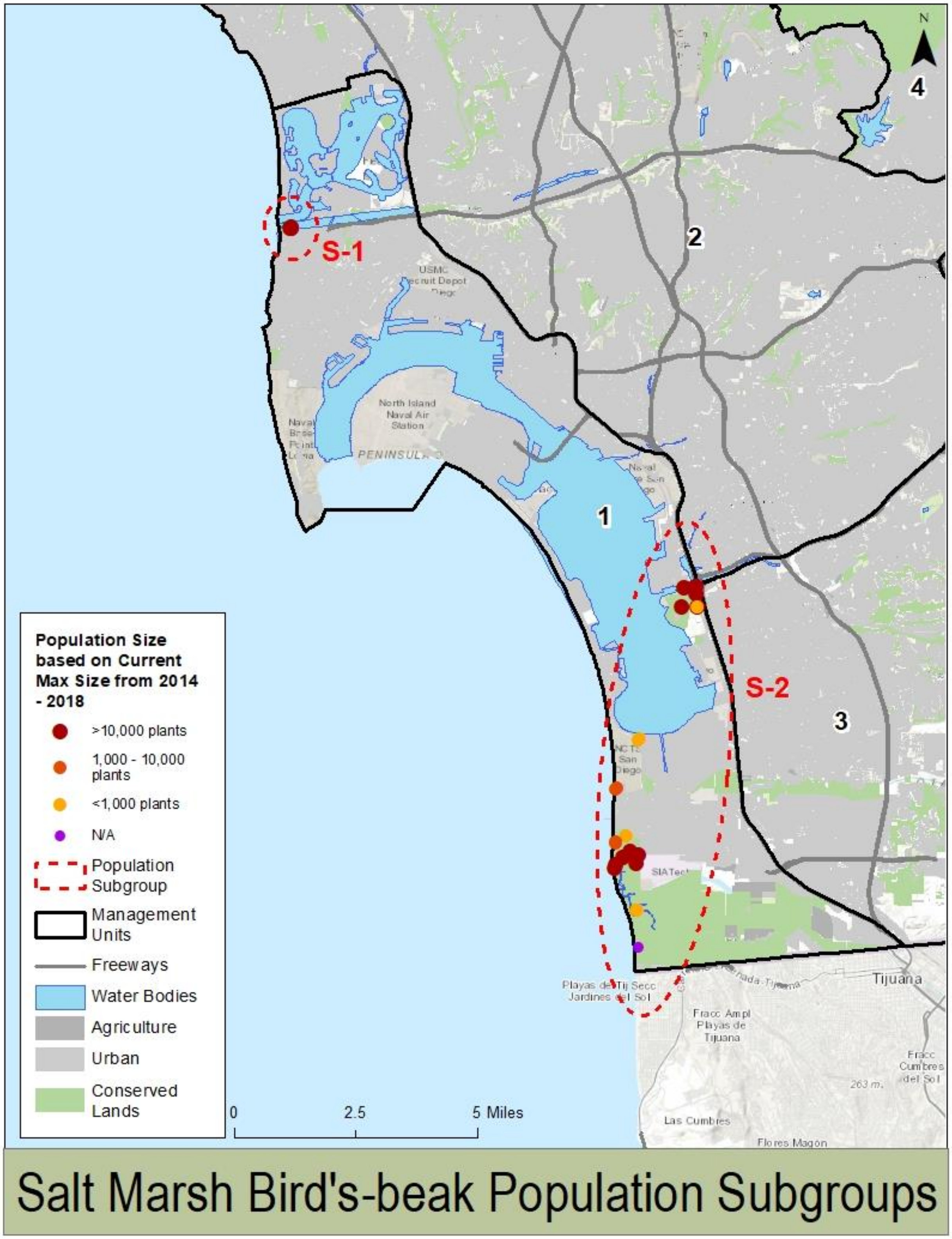

Figure 45. Salt Marsh Bird's-beak: Population Subgroups within the MSPA.

- **Introduce** new occurrences into suitable habitat on conserved lands within the MSPA that is potentially climate-resilient, based on habitat suitability modeling under future climatic scenarios.
- **Maintain or restore** habitat for pollinators among subgroups, where feasible.

Management Priorities and Recommendations

Management priorities and recommendations are based on IMG monitoring data, and genetic and regional population structures, and informed by management strategies outlined in previous sections. Except where noted, the current focus is managing salt marsh bird's-beak under existing (versus future) conditions.

Table 47 presents criteria for prioritizing management actions; priorities are assigned for each management category. For example, an occurrence may be a high priority for all categories, or a high priority in one category and a lower priority in other categories. For threats, prioritize large occurrences with high or moderate threats over small occurrences with high threats.

Table 47. Salt Marsh Bird's-beak: Criteria for Prioritizing Management Actions.

Management Category	Priority Level[1,2]			
	Not A Priority	Low Priority	Medium Priority	High Priority
Threats	Threat level 1	Threat levels 2-3	Threat levels 4-5	Threat levels 6-7
Genetic Structure	Large occurrence	Medium occurrence	Small occurrence (>100 plants)	Small occurrence (<100 plants)
Regional Population Structure	Large population group, intact habitat within group	Large population group, fragmented habitat within group	Mixed or medium population group	Small population group

[1] Priority levels may differ for each management category within an occurrence.
[2] For threats, prioritize large occurrences with high or medium threats over small occurrences with high threats.

Although the focus is on managing high priority levels within a management category, land managers may address lower priority levels, as well. For each priority level, refer to companion tables in this document for relevant information needed to manage the occurrence, including appropriate management strategies:

- Threats (Table 42)
- Genetic Structure (Tables 43, 44)
- Regional Population Structure (Tables 46)

For some proposed actions, management may be a one-time event (e.g., removing trash). For others, management may be a long-term effort that requires multiple years and considerable expense (e.g., controlling invasive plants). In many cases, land managers can reduce management costs by addressing threats at an early stage (e.g., threat levels of 3, 4, 5). This is particularly important for large occurrences to maintain their status and prevent decline. Where early intervention is not possible, land managers should have adequate funding or other resources available before starting a large-scale or expensive management program, unless these actions can be phased. As an example, invasive plant control may require an initial and intensive 3-5 year treatment program, but if this is not followed by long-term maintenance, then the site may revert quickly to its pre-treatment condition. In all cases, continue IMG monitoring to assess status and threats, as well as effectiveness of management actions.

We recommend an adaptive approach to managing salt marsh bird’s-beak occurrences, as outlined in the steps below and presented in Figure 46:

1. Monitor occurrence using IMG rare plant monitoring protocol.
2. If threats are identified, manage to reduce impacts to rare plant occurrence.
3. Continue monitoring to assess management effectiveness.
4. If threats are not controlled, continue management actions or manage adaptively.
5. If there are no threats or if threats are controlled through management actions, and occurrence is small or declining, reintroduce seed per species-specific BMPs in this document and in the SCBBP.
6. Continue monitoring to assess success of seeding effort.
7. If seeding is unsuccessful, reintroduce additional seed (per flow chart) or reassess seeding effort and site conditions to determine if continued seeding is worthwhile.
8. If seeding is successful, continue monitoring per IMG rare plant monitoring protocol to assess occurrence status and threats.

Regional Priorities and Recommendations

Regional priorities focus first on actions that would benefit the species within its current range (e.g., regional monitoring, baseline surveys, possibly species introductions). At this time, actions that would occur outside the current range of the species (e.g., species translocations) are a lower priority for management. Regional management actions identified to date for salt marsh bird’s-beak include the following:

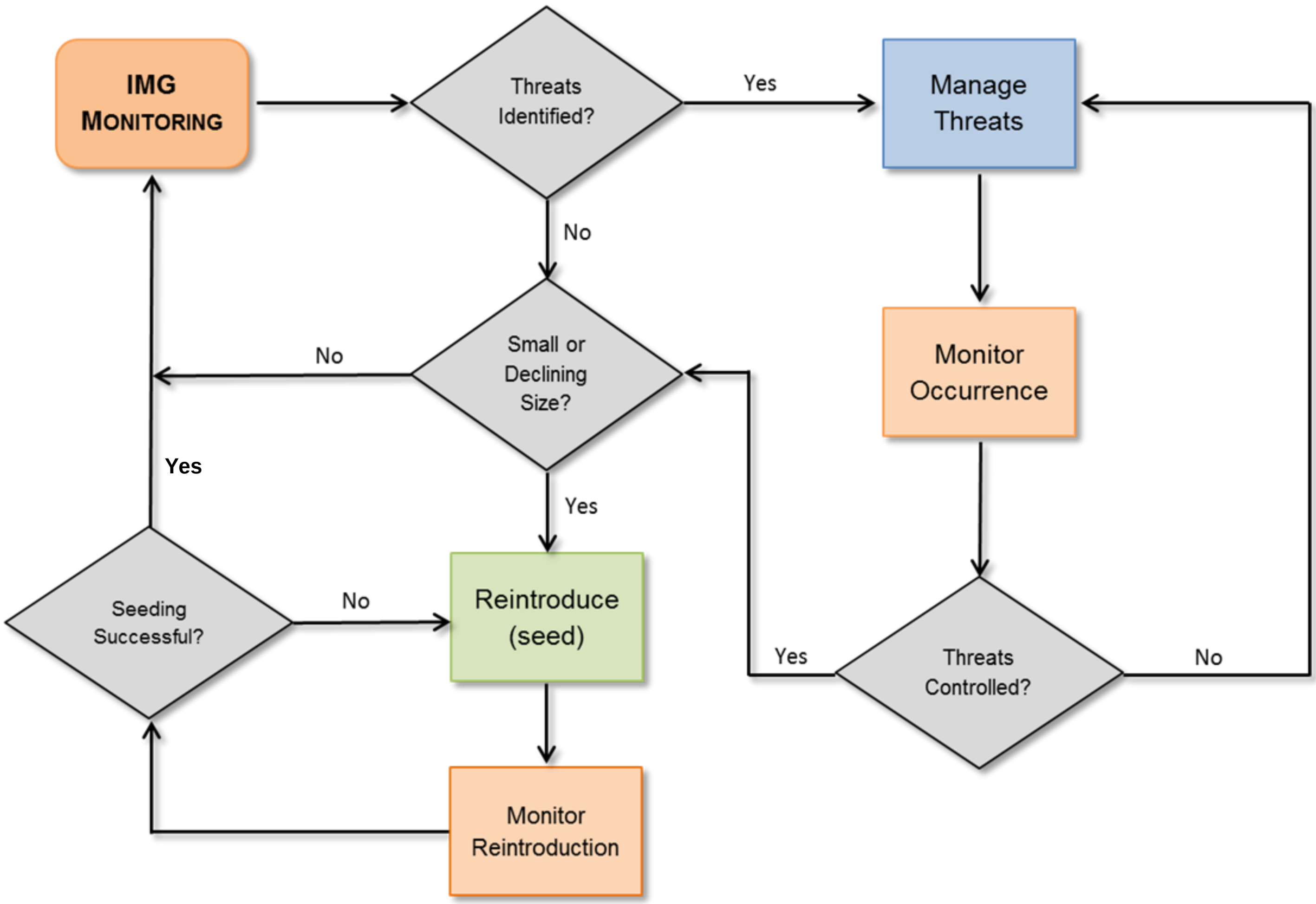

Figure 46. Salt Marsh Bird's-beak: Adaptive Management Flow Chart.

- Continue monitoring all salt marsh bird's-beak occurrences on conserved lands in the MSPA.
- Monitor newly conserved occurrences or occurrences that are conserved but have not yet been monitored per the IMG monitoring protocol.
- Prioritize large occurrences with high or moderate threats for management over small occurrences with high threats. This will ensure that large populations remain large and genetically diverse to help rescue smaller populations.
- Survey suitable habitat near extant occurrences or occurrences where the species has not been detected recently. Conduct surveys in years of favorable climatic conditions, as evidenced by 'boom' populations at known occurrences. Recommended survey locations include Border Field State Park, Tijuana Slough, San Diego Bay, Sweetwater Marsh, and Paradise Marsh.
- Improve habitat connectivity among and within population subgroups by managing or restoring habitat for salt marsh bird's beak or pollinators. If suitable habitat is available, reintroduce or introduce salt marsh bird's beak into opportunity areas (e.g., higher elevation saltmarsh habitat) at Famosa Slough, Kendall-Frost Reserve, San Dieguito Lagoon, San Elijo Lagoon, and Batiquitos Ecological Reserve (Zahn 2019).
- Conduct habitat suitability modeling under future climatic conditions to identify climate-resilient sites within the MSPA, and introduce the species experimentally. Potential locations for introductions may occur near existing occurrences (i.e., higher elevations within salt marsh) or possibly, to the north (e.g., north end of Mission Bay, Los Peñasquitos Lagoon, and Batiquitos Lagoon).

Preserve-level Priorities and Recommendations

Preserve-level priorities and recommendations are informed primarily by IMG monitoring, although they also address aspects of genetic structure or regional population structure that are specific to an occurrence. We do not provide recommendations for occurrences with no monitoring data.

For most occurrences on conserved lands, surveys have already been conducted. For occurrences where locational information appears to be incorrect or incomplete, the first step will be to either conduct baseline surveys or decide not to include the occurrence in IMG monitoring. For occurrences with accurate locational information but no monitoring data, the first step will be IMG monitoring to determine status and threats. For all occurrences, *manage threats prior to reintroducing seed*. Managing threats may be sufficient to restore habitat from the soil seed bank.

We use a variation of our earlier color-coded threats scheme to allow land managers to quickly identify priority levels for management (Figure 47). We assigned priority levels for threats at each occurrence using the highest threat level recorded for any sample during the monitoring period. In some cases, land managers may have already controlled threats effectively (e.g., trash removal). In other cases, threat levels may fluctuate between years (e.g., invasive plants).

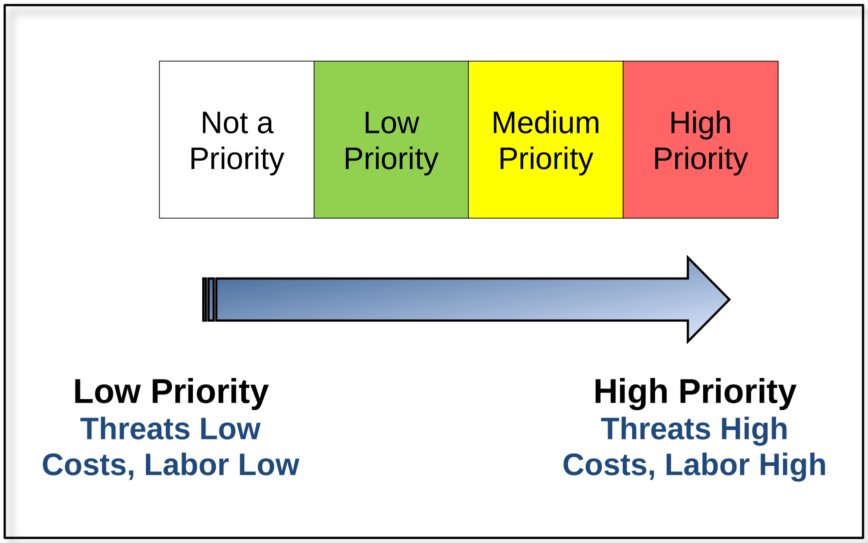

Figure 47. Salt Marsh Bird's-beak: Color-coded Management Priority Levels.

Table 48 presents management priorities for salt marsh bird's-beak occurrences. The steps below outline how to use Table 48 and other information in this document to identify and implement management priorities. Refer to Appendix B for general BMPs; species-specific BMPs are included in this chapter.

Steps to Identifying and Implementing Management Priorities

Salt Marsh Bird's-beak:

1. Locate the occurrence in **Table 48**.
2. Determine which threats occur at the target occurrence.
3. Determine which threats are most important to manage. In general, manage higher priority threats first and then move on to lower priority threats. If budgets are limited, manage smaller portions of the high priority threat(s) each year. Increase management efforts once budgets improve or if endowment or grant funding becomes available. Refer to **Table 42** for detailed threat levels.
4. Refer to general and species-specific BMPs to manage the identified threat(s). For example, if erosion and altered hydrology are high priority threats, refer to **general BMPs (Appendix B)** for control methods or other recommendations. If nonnative grasses and forbs are high priority threats, refer to **species-specific BMPs** in this chapter for control methods.
5. Once threats are controlled, refer to the genetics and regional population structure columns in **Table 48** to determine if the occurrence would benefit from reintroducing seed or restoring habitat.

   To reintroduce seed, identify appropriate seed source (**Figure 45, Tables 44, 46)**, collect seed per the **SCBBP**, and outplant seed per **species-specific BMPs** in this chapter.

   To restore habitat, determine extent and location of restoration effort after threats are controlled, and restore following **species-specific BMPs** in this chapter.
6. After implementing the appropriate management action(s), monitor the occurrence using the IMG monitoring protocol to determine if actions are successful and manage adaptively per the Adaptive Management flow chart (**Figure 46**).

Table 48. Salt Marsh Bird's-beak: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]														GN[5]	RP[6]
		AH	BR	D/T	EN	ER	HE	NNF	NNG	SC	TR	TP	UR	VA	OT	RE	RS
COMAM3_1DOBE007	Large	H	L	L	L			H	L		M	L	L	L			
COMAM3_1IMBE008	Medium	L		L			L	L	H		L		L		H		L
COMAM3_1SDBA004	Small			M				L								H	L
COMAM3_1SWMA005	Large	H	M	H	H	L		M	M	H	L	H			H		
COMAM3_1TIES001	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
COMAM3_1TIES002	Large	H		H				M	M	L	L	M			H		
COMAM3_1TIES003	Small			L				H								H	L
COMAM3_1TIES009	Small	H		L				L							H	H	L
COMAM3_1TISO010	Medium	H		L		L		L	L				L		H		L
COMAM3_1TISO011	Large	L		L				L	L				M		H		

[1] Management Priorities: L = Low Priority, M = Medium Priority, H = High Priority. If no priority level is indicated, then no management action is recommended at this time. Occurrences with no data (---) should be monitored per the IMG protocol to assess status and threats prior to identifying and recommending appropriate management actions.

[2] Size = population size category: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants; --- = no population size data available.

[3] Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **D/T** = Dumping/Trash, **EN** = Encampments, **He** = Herbivory, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **UR** = Urban Runoff, **VA** = Vandalism, **OT** = Other (see detailed IMG data for description of other threats).

[4] Threats per IMG monitoring protocol. --- = no data (occurrence not monitored per IMG monitoring protocol).

[5] **GN** = Genetics; **RE** = Reintroduce seed using seed from the target occurrence (if an adequate amount of seed is available) or from a genetically compatible seed source within the same population group (genetic cluster). We do not include recommendations for occurrences with no monitoring data.

[6] **RP** = Regional Population Structure; **RS** = restore habitat (enhance, expand habitat). We do not include recommendations for occurrences with no monitoring data.

Best Management Practices (BMPs)

We define a BMP as a tested, effective practice used to accomplish management goals or objectives. Land managers, biologists, restoration contractors, or ecologists (*practitioners*) typically implement BMPs. In this section, we outline BMPs to restore salt marsh bird's-beak habitat (*habitat restoration*) and occurrences (*species restoration*). These BMPs have been implemented successfully in San Diego, Santa Barbara, and Orange counties and represent the current state of management knowledge for this species (Noe et al. 2019, Tidal Influence 2017, Zedler 2001, 1996 *in* Tidal Influence 2017, Gevirtz pers. comm., Zahn pers. comm.).

The BMPs for habitat restoration address invasive plant control. The BMPs for species restoration address reintroducing, introducing, or translocating seed, and outplanting (sowing) seed. Although we identify seed collecting and bulking, we refer the reader to specific guidelines and BMPs in the SCBBP that address these practices. Finally, we provide a flow chart to assist with implementing BMPs (Figure 48). All BMPs may be refined in the future based on adaptive management or experimental studies.

As outlined in earlier sections of this chapter, occurrences of different sizes or threats will require different types and/or levels of management. For example, the primary management action for large occurrences will be managing threats to ensure that salt marsh bird's-beak continues to germinate, reproduce, and replenish the soil seed bank during favorable years. Managing threats is also critical for small and medium occurrences. However, these occurrences may require the addition of seed to increase size and potential for long-term persistence. In these cases, we recommend controlling threats before adding seed.

Based on input from experts, we recommend the following steps to restore salt marsh bird's-beak occurrences and habitat:

Step 1: Control nonnative grasses and forbs

Step 2: Reintroduce salt marsh bird's-beak seed (if warranted)

Step 3: Continue weed control

We discuss each of these steps below. It is important to stress that to successfully restore an occurrence, land managers must complete *each* step in the order indicated, unless one of the threats addressed in the steps is not present at the occurrence.

Habitat Restoration

Monitoring data show that invasive plants[9] are one of the primary threats to salt marsh bird's-beak in San Diego County. Therefore, controlling invasive plants is a key factor to ensuring

[9] For the purpose of this discussion, invasive plants are primarily nonnative species, but may include a few native species that out-compete salt marsh bird's-beak for resources.

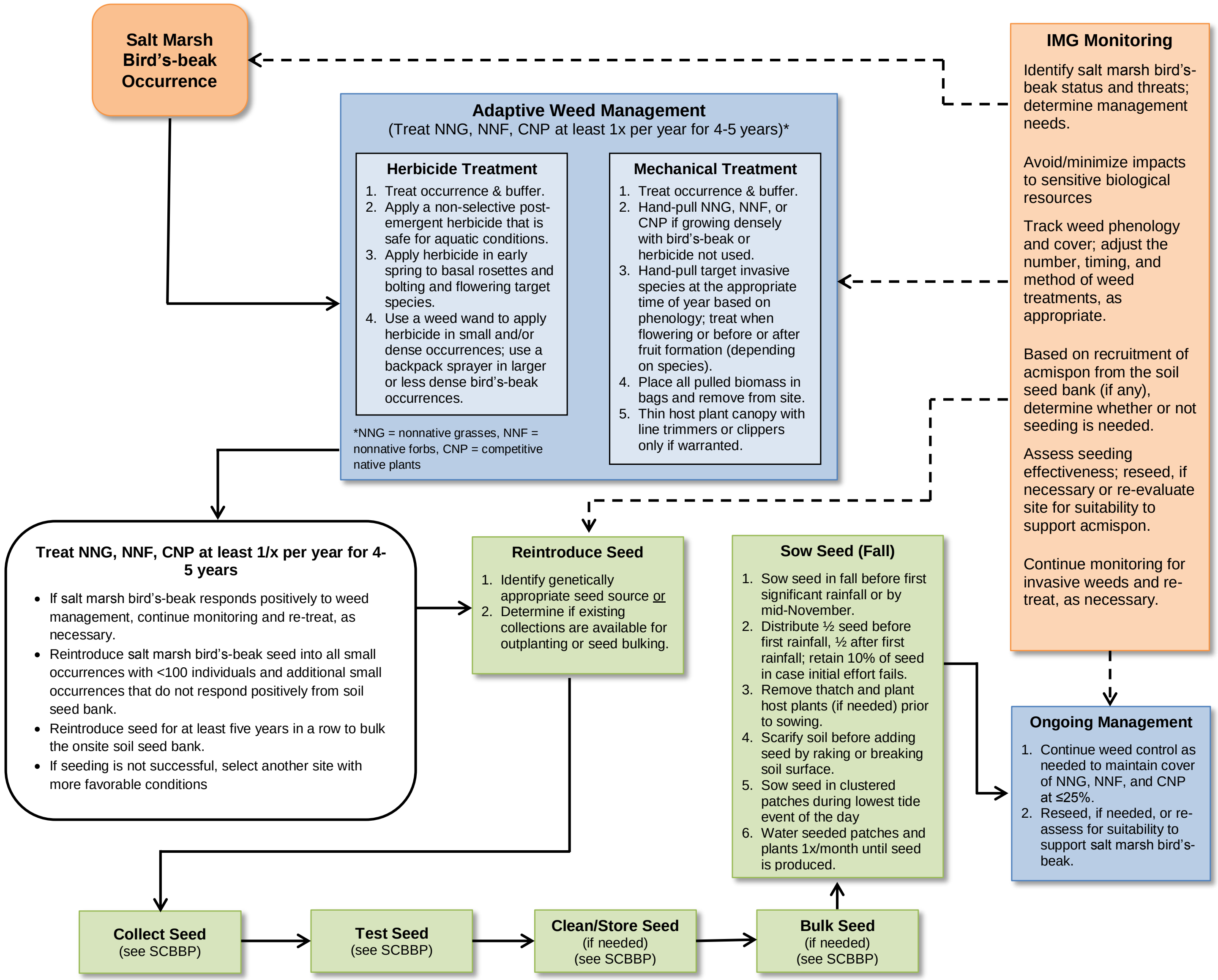

Figure 48. Salt Marsh Bird's-beak: Best Management Practices (BMP) Flow Chart.

persistence of large and many medium occurrences, and a necessary first step for small and medium occurrences where reintroducing seed is appropriate.

Practitioners should tailor invasive plant control actions to the specific salt marsh bird's-beak occurrence and its unique complement of invasive plants and habitat conditions. In addition, not all invasive plants will necessarily require management. Practitioners should prioritize management of invasive species known or strongly suspected to result in salt marsh bird's-beak population declines and habitat degradation.

For example, two invasive plants of particular concern to salt marsh bird's-beak are Algerian (*Limonium ramosissimum*) and European sea lavender (*L. duriusculum*). Both species are nonnative forbs that are invading coastal salt marsh habitat from southern to northern California. Land managers, consultants, and the public are reporting more incidences of these species each year. Both species are capable of producing many individuals that form dense mats and displace native vegetation, including salt marsh bird's-beak. European sea lavender is currently more common in San Diego County than Algerian sea lavender, and has been found growing in salt marsh bird's-beak habitat at Sweetwater Marsh and Dog Beach. A possible new species of *Limonium* may also occur at Dog Beach (Langsford pers. comm.). Both species are difficult to eradicate, especially when growing densely with salt marsh bird's-beak. Land managers and consultants have spent considerable time and effort to remove or test removal methods for both species (Gevirtz pers. comm., Manzanillo 2018, Lieberman et al. 2018). Eradicating these species is a high priority action because of their adverse effect on salt marsh bird's-beak. Likewise, early detection (through monitoring) and subsequent action is necessary to prevent these species from establishing in salt marsh habitat where they do not yet occur.

Invasive plant control methods described below have the potential to cause soil disturbance and, in some cases, bird's-beak mortality, particularly in large, dense occurrences. However, the net benefit to the occurrence is expected to outweigh any adverse consequences, and potential impacts can be avoided or minimized with care and experience.

Practitioners have found that reintroducing seed can restore occurrences successfully. Thus, seed reintroduction should be considered if salt marsh bird's-beak does not respond positively to at least three years of invasive plant control (including at least one year with favorable climatic conditions for salt marsh bird's-beak germination and growth).

Once the restoration process begins, practitioners should expect some level of perpetual management to maintain habitat conditions because of the weed seed bank, and continual input of weed seeds from surrounding, untreated areas via tide, wind, animal, or human dispersal. However, regular management should decrease management frequency, intensity, and cost over time. Conversely, if management is discontinued, even for a few years, some sites may revert quickly to pre-treatment conditions.

Timing is critical for treating invasive plants in salt marsh bird's-beak habitat. For example, if herbicide is applied too early in the season for annual species, then additional treatments may be required to treat late-germinating plants. Conversely, applying herbicide too late in the season will be ineffective if fruit has already hardened into viable seed. Finally, the phenology of both salt marsh bird's-beak and the target invasive plants differ by site based on geographic location, microclimate weather patterns, and vegetation association. For these reasons, experienced practitioners should visit an occurrence several times per season to ensure correct timing to apply herbicide(s). Note that practitioners have developed other methods (e.g., tarping, scraping) to treat invasive plants in salt marsh habitat. These methods are applicable to potential restoration areas that currently lack salt marsh bird's-beak, but should not be used once this species is established.

In any given year, the extent of invasive plant control will depend on weather conditions. Practitioners can expect treatments to be more intensive during years of average- and above-average rainfall because of increased germination of invasive plants and possibly, the need for multiple treatments. Treatments will be less expensive during drought years. To accommodate variations in treatment level, practitioners should include contingency funds in annual budgets and/or allow these funds to carry over to years where they are most needed.

<u>Step 1: Control Nonnative Forbs and Grasses</u>

Control nonnative forbs and grasses if IMG monitoring data indicate that cover of either group is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative forbs and grasses in the occurrence(s) and in the buffer using herbicides or hand-pulling, as appropriate.

Herbicide. Treat target species in early spring. Treat each species with an appropriate non-selective post-emergent, herbicide that is safe for aquatic habitats (if using in or near aquatic habitats), and ensure that the applicator(s) is experienced and possesses a QAL.

Apply herbicide to basal rosettes and bolting and flowering target invasive species using a backpack sprayer or weed wand. Use a backpack sprayer if salt marsh bird's-beak does not grow densely with nonnative forbs and grasses (i.e., greater than several inches of distance between bird's-beak and the target species). Expect some collateral damage to bird's-beak where it co-occurs densely with the target species. Use a weed wand for small populations and where bird's-beak grows densely with nonnative forbs and grasses. Manage target plants at least one time a year for 4-5 years.

Hand-pull. Use hand-pulling when salt marsh bird's-beak and the target species grow densely together and/or if not using herbicides. Hand-pull the target species based on phenology. Practitioners can hand-pull some species, such as sea lavender (*Limonium duriusculum*, *L. ramosissimum*) throughout the year, but hand-pull others, such as sea rocket

(*Cakile maritima*) and nonnative grasses (e.g., *Parapholis incurva*) in the spring. Hand-pull all target species when flowering or just after producing fruit; however, in the case of *Limonium*, hand-pull it after salt marsh bird's-beak has completed its life cycle because it is a suspected salt marsh bird's-beak host plant (Gevirtz pers. comm.). The *Limonium* species are easiest to locate when in flower. Place all hand-pulled biomass in bags placed nearby (to prevent dropping weed seeds into uninfested areas) and remove them from the site (Gevirtz pers. comm.).

Mechanical. Competitive native plants were not identified as a threat to salt marsh bird's-beak. However, one study showed that thinning of native host plant canopies increased salt marsh bird's-beak density and flower production (Fellows 1999 *in* Noe et al. 2019). For this reason, we discuss mechanical thinning of the host plant canopy to benefit bird's beak (Noe et al. 2019) if competitive native plants are identified as a threat in the future. Where thinning is warranted, use line trimmers or clippers to remove the canopy of competitive native plants. Coordinate these actions with the regulatory agencies to avoid impacts to other listed species (i.e., Belding's savannah sparrow [*Passerculus sandwichensis beldingi*]). Mow or clip the canopies of native plants when salt marsh bird's-beak has just germinated and is smaller than the target host plant.

Other Methods. Researchers have tested other methods for controlling *Limonium*, including steaming, scorching, tarping, and scraping. While all of these methods control *Limonium* effectively, none have been tested in co-occurring stands of salt marsh bird's-beak and *Limonium* species (Manzanillo 2018, Lieberman et al. 2018).

Species Restoration

In this section, we discuss seeding to restore occurrences. The BMPs in this section and the BMP flowchart (Figure 48) refer primarily to small and medium occurrences. Since large occurrences presumably support a stable soil seed bank, we do not recommend adding seed unless (1) there is a decline in occurrence size category when monitored over at least five years (including one or more years with favorable tidal and climatic conditions) or (2) there is evidence of low genetic diversity within the occurrence. In the latter case, use seed from the higher diversity occurrences within the Tijuana Estuary (if available).

We recommend *reintroducing* seed into small, declining occurrences if threats are controlled, habitat is likely to support this species in the future, and funding is available for short- and long-term management. Potential seed sources for reintroduction include (1) seed collection and *ex situ* bulking in a nursery setting (as needed) or (2) *in situ* management of existing plants (e.g., watering) to maximize seed production ('bulking onsite') and increase the soil seed bank. Practitioners may choose to reintroduce seed into medium occurrences to increase size and/or genetic diversity. Refer to Step 2 for guidelines on reintroducing seed.

We recommend *introducing* seed into suitable habitat within Opportunity Areas (e.g., gaps) to create steppingstone occurrences to maintain gene flow or improve species resilience by creating additional occurrences, following BMPs in Step 2 (below) for reintroducing seed into extirpated occurrences.

We recommend *translocating* seed only in the event of climatic changes that render existing occurrences unsuitable to support salt marsh bird's beak, unless conducted for experimental purposes. Where translocations are warranted, move seed into suitable habitat following BMPs in Step 2 (below) for reintroducing seed into extirpated occurrences. Because of the high genetic differentiation across the species' range, we recommend that translocations within San Diego County use seed only from the genetic cluster/population group within the county, rather than from occurrences to the north.

Refer to appropriate management strategies to improve genetic structure (Table 43), the genetic structure of the target occurrence (Table 44), and genetic cluster (Figure 43) and regional population subgroups (Figure 45) to identify genetically appropriate seed source(s). The SCBBP also designates seed zones to identify appropriate seed sources. In general, we recommend sourcing seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a genetically compatible occurrence (as addressed in this document and the SCBBP).

Refer to the SCBBP for BMPs for collecting salt marsh bird's-beak seed for restoration. The BMPs address timing of collections, amount of seed to collect, maximizing diversity in a collection, and transporting, storing, and processing seeds. Collect seed in the summer or fall, outside of the nesting season for Belding's savannah sparrow, and avoid any other existing conflicts with sensitive resources. We recommend that only experienced seed collectors collect bird's-beak seed per the SCBBP.

At this time, we do not recommend bulking seed for restoration purposes because practitioners have been able to collect sufficient amounts of seed from naturally-occurring populations. However, salt marsh bird's-beak can be grown in a nursery setting with and without a host plant, and we provide BMPs in the SCBBP in case bulking seed for restoration is necessary in the future. The BMPs include information on potential nurseries, and guidelines on bulking methods and maximizing genetic diversity in bulked samples.

At this time, species experts do not recommend growing salt marsh bird's-beak in a nursery and outplanting individual plants.

Finally, consider tidal and climatic conditions when assessing the success of any seeding effort. For example, changing tidal conditions or prolonged drought may prevent germination. Consider selecting another reintroduction site if these changes appear to be long-lasting (i.e., due to changing climate).

Step 2: Reintroduce Seed

Small, Extant Occurrences. We recommend the following guidelines to reintroduce seed into small, extant occurrences of salt marsh bird's-beak:

- Reintroduce salt marsh bird's-beak seed into all extant occurrences that support fewer than 100 plants *and* meet the reintroduction criteria outlined in the previous section. In these cases, seed reintroduction is critical to the long-term persistence of the occurrence.
- Reintroduce salt marsh bird's-beak seed into small occurrences that support more than 100 plants if these occurrences do not respond positively to control of nonnative or competitive native plants.
- For all seed reintroductions into small occurrences, refer to the genetics section of this chapter and seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive or competitive native plants after reintroducing seed, as necessary.
- For all seed reintroductions into small occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
    - Where small occurrences have increased in size, continue weed control at a frequency sufficient to maintain cover of target invasive or competitive native plants at ≤25% cover within the maximum extent area.
    - Where small occurrences have not increased in size or have decreased, even under favorable climatic conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

The objective of reintroducing seed in an extant occurrence is to increase population size to a level that reduces the potential for extirpation or adverse effects from inbreeding. For very small occurrences (<100 individuals), it may take time, multiple reintroductions, and intensive management to achieve this objective. In these cases, success of a single reintroduction may be measured by a two- or three-fold increase in occurrence size.

Medium, Extant Occurrences. We recommend the following guidelines to reintroduce seed into medium occurrences of salt marsh bird's-beak:[10]

- Reintroduce seed of salt marsh bird's-beak into medium occurrences that appear to be declining and that do not respond positively to control of nonnative or competitive native plants.

[10] Currently, there are no occurrences that fall into the medium size class. However, we include this information in case it is applicable in the future.

- For all seed reintroductions into medium occurrences, refer to the genetics section of this chapter and seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collection, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive or competitive native plants after reintroducing seed, as necessary.
- For all seed reintroductions into medium occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
  - Where medium occurrences appear stable under favorable conditions, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
  - Where medium occurrences are declining even under favorable conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

Extirpated Occurrences. We recommend the following guidelines to reintroduce seed into confirmed historic but extirpated occurrences, but caution that these reintroductions should proceed only if habitat supports the correct tidal influences, freshwater input, or conditions needed to support the host plants:

- Prior to reintroducing seed, restore habitat by controlling invasive or competitive native plants for three years (see Steps 1-3, above). Note that methods such as tarping and scraping may be more effective than herbicide or hand-pulling invasives in these areas.
- Identify an appropriate seed source, preferably from higher diversity occurrences within the Tijuana Estuary or consider composite provenancing from multiple occurrences to develop an appropriate seed source. Follow guidelines in the SCBBP to collect and bulk seed (if necessary). Refer to guidelines on outplanting (sowing) seeds in this section.
- Proceed with seed reintroduction steps outlined above for small, extant occurrences.

Outplanting (Sowing) Seed. In this section, we summarize recommendations from practitioners and researchers for sowing seed into receptor sites (e.g., Zahn pers. comm., Noe et al. 2019, Tidal Influence 2017, Zedler 2001 in Tidal Influence 2017). Refer to source documents for additional details. Note that land managers are currently restoring and creating salt marsh habitat at the Tijuana Estuary, San Elijo Lagoon, and Batiquitos Lagoon, which could provide opportunities to expand existing occurrences or introduce new occurrences of salt marsh bird's-beak in response to climate change.

- Suitable reintroduction/introduction sites must be adjacent or near to native upland habitat, because salt marsh bird's-beak requires pollinators (e.g., ground nesting bees) that are found in these upland areas (Lincoln 1985, Zahn pers. comm.). Suitable sites are further characterized as broad, flat to gently sloping areas in the upper marsh and upland transition zone located at or slightly above the median high tide line where native species are diverse, small in stature, and patchy in cover (Tidal Influence 2017, Zedler 2001 *in* Tidal Influence 2017, Zahn pers. comm.). Seeds will likely wash away if added to areas below the median high tide line, but will likely remain in place and germinate if added to areas at or 2 feet above the median high tide line (Tidal Influence 2017).

- Prepare the site prior to seeding, if needed. If thatch is present (i.e., *Distichlis* thatch), remove it prior to sowing seed to promote germination through increased seed-to-soil contact. Salt grass species (*Distichlis littoralis*, *D. spicata*) must also be present in the sowing area. If salt grass species are absent, procure container plants or plugs and plant them before adding seed of salt marsh bird's-beak (Zedler 2001 *in* Tidal Influence 2017 Zahn pers. comm.).
- Scarify the soil before adding seed by raking or breaking the soil surface, while minimizing impacts to host plants. Sow seed in the fall before the first significant rainfall event; however, if it has not rained by mid-November, sow seed anyway.
- Sow salt marsh bird's-beak seed in clusters of patches targeting 30-50 seedlings per dm^2. Sowing should occur during the lowest tide event and before the highest tide event of the day (Tidal Influence 2017, Zedler 1996 *in* Tidal Influence 2017).
- Distribute some of the collected seed before the first rainfall event and the rest later in the year, preferable in January (Zahn pers. comm., Zedler 1984). Retain approximately 10% of the seed to use in subsequent seeding efforts if the first effort fails. Hand-broadcast approximately 200 seeds at a time into clustered patches where nonnative or competitive native plants have been controlled, thatch removed, and soils scarified (Zahn pers. comm.).
- Water the seeded patches and resulting plants once a month, beginning when seed is sown and continuing until seed is produced.
- For sites that respond favorably to seeding, continue sowing seed into the site for at least five years in a row to bulk the onsite soil seed bank (Zahn pers. comm.).
- For sites that do not respond favorably to the first few seeding events, or where plants germinate but do not produce seed, select another site with more suitable conditions (Zahn pers. comm.).

<u>Step 3: Continue Weed Control</u>

After reintroducing seed, continue to manage nonnative grasses and forbs and competitive native plants as outlined in Step 1, at a frequency to maintain cover of these species at ≤25% cover in the maximum extent at an occurrence.

Additional Research Needs

The list of additional research needs is derived from a number of sources, including planning documents, research studies, and identified gaps in relevant information about salt marsh bird's-beak.

Genetics

- Conduct common garden experiments to examine differences range-wide before moving seed among genetic clusters throughout California (Milano and Vandergast (2018).

Herbivory

- Study the effects of herbivory by insects (i.e., moth species) on the formation of flowers and seed.

Hydrology

- Refine knowledge of hydrological conditions at high suitability sites to improve success of reintroductions and introductions.
- Develop habitat suitability models under future climatic scenarios to assist in managing occurrences threatened by rising sea levels. Combine the habitat models with projected increases in sea level, wetland accretion, and urban development to evaluate and prioritize sites for introducing new occurrences of salt marsh bird's-beak (SDMMP and TNC 2017). Milano and Vandergast (2018) suggested that potential climate refugia sites in San Diego may include Los Peñasquitos Lagoon, Mission Bay (north end, near Kendall Frost-Mission Bay Marsh Reserve), Batiquitos Lagoon, and Tijuana Estuary (east/upland of current sites). In San Elijo Lagoon, potential restoration sites may occur within restored or created salt marsh habitat.

Management

- Study the effects of tarping, which is used to control invasive plants, on salt marsh bird's-beak seed, including the soil seed bank.

Pollinators

- Determine *effective* pollinators of salt marsh bird's-beak in San Diego marshes (if pollinator species appear to be different than recorded in marshes further north in California).
- Determine habitat requirements for pollinators and possible threats to their survival.

Seed Biology

- Determine seed dormancy factors, germination cues (e.g., salinity levels that trigger germination), and viability rates.
- Determine dispersal agents and dispersal capabilities of salt marsh bird's-beak seed.

Taxonomy

- Study morphological variation between *Chloropyron maritimum* ssp. *maritimum*, *C. maritimum* ssp. *palustre*, and *C. maritimum* ssp. *canescens* to determine if taxonomic revisions are warranted.

4.4 OTAY TARPLANT (*DEINANDRA CONJUGENS*)

MSP Goals and Objectives

The MSP Roadmap identifies the following goal for Otay tarplant:

> *Maintain or enhance existing Otay tarplant occurrences to ensure multiple conserved occurrences with self-sustaining populations to increase resilience to environmental and demographic stochasticity, maintain genetic diversity, and ensure persistence over the long-term (>100 years) in native and nonnative grassland vegetation communities.*

Refer to Table 49 for objectives and actions for this species, per the MSP Roadmap (SDMMP and TNC 2017). In this chapter, we present species life history and ecological requirements, status and trends on conserved lands in the MSPA, genetics, and regional population structure, and recommend management priorities and actions to achieve goals and objectives.

Life History and Ecological Information

Species Description

Otay tarplant is an annual herb in the Sunflower (Asteraceae) family. This species is typically 1-5 dm (4-20 in) high with yellow ray and disk flowers; anthers on the staminate disk flowers are red to dark purple. Otay tarplant is distinguished from other closely-related tarplants in San Diego County by the presence of eight ray flowers (petals) and stalked or unstalked (sessile) glands of variable sizes on the phyllaries (Baldwin et al. 2012). Flowers produce a one-seeded, dry fruit (achene).

Distribution and Status

Otay tarplant is restricted to southern San Diego County and northern Baja California, Mexico (SDNHM 2018, CNDDB 2019d). Within San Diego County, the species is known only from MUs 2 and 3. Although a number of locations have been lost to development, the species persists at numerous locations in the MSPA, and is found from Otay Mesa in the south and Jamul in the east to Bay Terraces in the north and Paradise Valley in the west (Figure 49). Otay tarplant is listed as federally threatened and state endangered.

Table 49. Otay Tarplant: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
Monitoring				
MON-IMP-IMG: DEICON-1	Conduct IMG monitoring annually	IMP-1	Determine management needs (routine versus intensive).	IP
		IMP-2	Submit monitoring data to MSP Web Portal.	IP
MON-RES-GEN: DEICON-4	Conduct genetic studies	RES-1	Collect plant material for genetic samples.	C
		RES-2	Evaluate the long-term genetic trajectory of Otay tarplant in the MSPA.	C
		RES-3	Hold a workshop to develop management recommendations based on genetic analyses.	C
		RES-4	Submit project data, report to MSP Web Portal.	C
MON-IMP-MGTPL: DEICON-8	Monitor management effectiveness	IMP-1	Submit data, report to MSP Web Portal.	NS
MON-RES-SPEC: DEICON-11	Conduct soils study; develop habitat suitability and climate change models	RES-1	Test soils to determine key edaphic parameters for thornmint occupation.	C
		RES-2	Prepare habitat suitability models.	C
		RES-3	Collect covariate data for selected occurrences.	C
		RES-4	Prioritize locations for conservation, management, surveys.	C
		RES-5	Submit project data, report to MSP Web Portal.	C
Management				
MGT-IMP-IMG: DEICON-2	Conduct routine management identified through IMG monitoring	IMP-1	Perform routine management as needed (e.g., access control, weed control).	IP
		IMP-2	Submit project data to MSP Web Portal.	IP
MGT-DEV-BMP: DEICON-3	Develop BMPs for landscape-scale restoration	DEV-1	Conduct experiments to control nonnative grasses and forbs and compare seeding methods.	C
		DEV-2	Based on experiments, develop BMPs to restore Otay tarplant. Submit project data and BMP report to MSP web portal.	C

Table 49. Otay Tarplant: Objectives and Actions per the MSP Roadmap.

Objective Code[1]	Objective Description[2]	Action Code[3]	Action Description[2]	Status[4]
MGT-IMP-IEX: DEICON-5	Use BMPs (DEICON-3) to maintain experimental restoration sites	IMP-1	Control invasive plants at experimental restoration sites annually using BMPs until success criteria are met and then as needed thereafter.	IP
		IMP-2	Submit project data to the MSP Web Portal.	IP
MGT-PRP-MGTPL: DEICON-6	Prepare a section for Otay tarplant in the F-RPMP	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Develop a conceptual model for management.	C
		PRP-3	Prioritize occurrences for management.	C
		PRP-4	Develop an implementation plan that prioritizes management actions for the next 5 years.	C
		PRP-5	Submit data and plan to the MSP Web Portal.	C
MGT-IMP-MGTPL: DEICON-7	Implement highest priority management actions in the F-RPMP	IMP-1	Submit project data and report to MSP Web Portal.	NS
MGT-PRP-SBPL: DEICON-9	Prepare a section for Otay tarplant in the SCBBP	PRP-1	Consult the Rare Plant Working Group.	C
		PRP-2	Prepare a seed collection plan for occurrences on conserved lands in the MSPA.	C
		PRP-3	Include guidelines for collecting seeds on conserved lands based on genetic studies. Include provisions for collecting seed from unconserved occurrences that may be lost to development.	C
		PRP-4	Include protocols and guidelines for collecting and submitting voucher specimens.	C
		PRP-5	Include guidelines for seed testing.	C
		PRP-6	Submit data and plan to MSP Web Portal.	C
MGT-IMP-SBPL: DEICON-10	Collect and store seeds at a permanent seed bank; provide propagules for research and management actions	IMP-1	Bulk seed at a qualified facility using seed from genetically appropriate donor accessions in the propagation seed bank collection.	NS
		IMP-2	Maintain records for collected seed to document donor and receptor sites, collection dates, and amounts. Submit data to MSP Web Portal.	NS

[1] Objective Codes: **MGT** = Management, **MON** = Monitoring; **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare; **RES** = Research; **BMP** = Best Management Practices, **FMGT** = Fire Management, **GEN** = Genetics, **IMG** = Inspect and Manage, **MGTPL** = Management Plan, **SPEC** = Species, **SBPL** = Seed Banking Plan.
[2] Descriptions: Refer to MSP Roadmap for complete descriptions (SDMMP and TNC 2017).
[3] Action Codes: **DEV** = Develop, **IMP** = Implement, **PRP** = Prepare, **RES** = Research.
[4] Status: **C** = Completed, **IP** = In-progress (refers to some or all occurrences), **NS** = Not started.

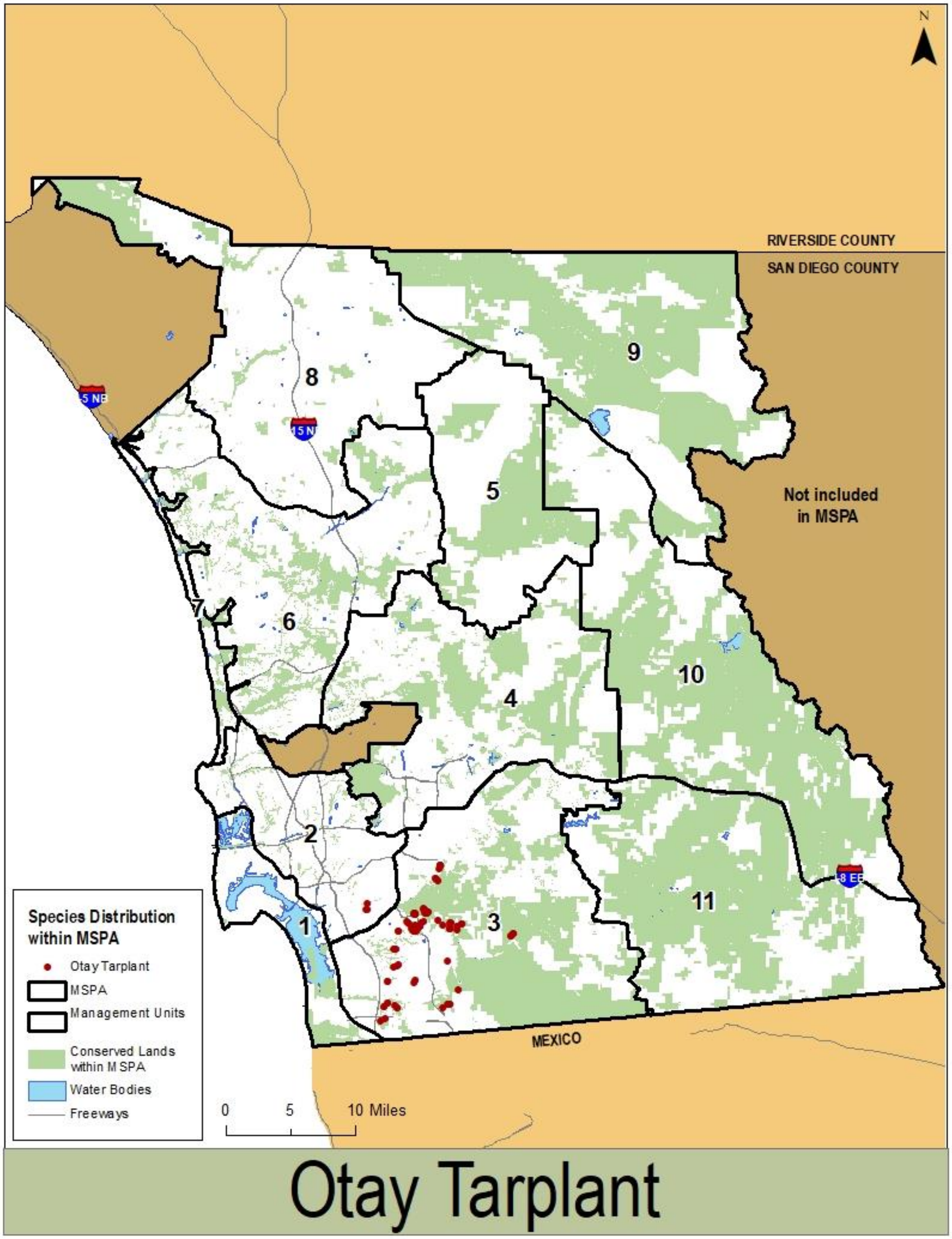

Figure 49. Otay Tarplant: Distribution within the MSPA.

Table 50 lists 27 occurrences of Otay tarplant on conserved lands in the MSPA, including population size(s) recorded during the 5-year monitoring period (2014-2018). Table 51 presents recent and historic maximum population sizes for each of these occurrences, and categorizes these occurrences into size classes (per Table 12) based on recent population size.

Ecological Requirements

Otay tarplant germinates in spring and flowers from April through July. It experiences wide fluctuations in annual population size (i.e., 'boom or bust' populations) that are driven primarily by annual climatic conditions (SDMMP 2010, USFWS 2004). The USFWS (2004) suggested that population size fluctuations are driven by the interaction between environmental and demographic stochasticity.

The SDMMP developed habitat suitability models for Otay tarplant under current and future climate scenarios in southern California (SDMMP *in* CBI 2018). Future conditions models predict no suitable habitat for this species in the region under the any of the global climate models, emission periods, or time periods used in the assessment, which underscores the need to build resilience for this species within its current range.

Within San Diego County, Otay tarplant occurs in native and nonnative grasslands, coastal sage scrub, and maritime succulent scrub, where it occurs on clay soils, subsoils, or lenses. CBI (2018) found that this edaphic endemic species correlates positively to clay, and occurs primarily on fine sandy clay. It also has a positive relationship with sodium and magnesium. Soils that support Otay tarplant have relatively low fertility compared to soils in the surrounding landscape (CBI 2018). Significant soil variables for this species include clay content (31-41%), sodium (84-173 ppm), zinc (0.06-2.5 ppm), and phosphorus (0.06 ppm and 4-6.6 ppm as assayed by Weak Bray method).

CBI (2018) also found that soil color at sites occupied by Otay tarplant was variable, but the species has a strong tendency to occur on "brown" soils. Otay tarplant was always associated with soil cracks, although cracks often occurred in adjacent habitat, as well. Within appropriate soils, tarplant occurred most frequently on undulating terrain versus flat or concave terrain.

Pollinators

Marschalek and Deutschman (2016) investigated potential pollinators of Otay tarplant and assessed visitation rates of insect species. They found that beetles (Coleoptera) were the most common visitor, with soft-winged flower beetles (Melyridae) accounting for most visits. Bees (Hymenoptera) and flies (Diptera) also visited flowers. Visits by beetles were about five times more common than bees and flies, and bees were more common than flies at most sites. The exception was Rice Canyon, where there were many long-horned flies (*Exiliscelis californiensis*). Butterflies (Lepidoptera) were uncommon, except at Rancho Jamul Ecological Reserve (Marschalek and Deutschman 2016).

Table 50. Otay Tarplant: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
Management Unit 2									
DECO13_2PAVA001	Paradise Valley	Paradise Hills Community Park	San Diego	San Diego PRD	---	---	---	---	24
DECO13_2PAVA030	Paradise Gardens	Paradise Valley	San Diego	San Diego PRD	---	---	---	---	76
Management Unit 3									
DECO13_3BOME009	Bonita Meadows	Bonita Meadows	Caltrans	Caltrans	---	---	200	18	0
DECO13_3DENC022	Dennery Canyon South	Hidden Trails	San Diego	San Diego PRD	---	---	0	---	---
DECO13_3DERA020	Dennery Ranch	Cal Terraces HOA	Cal Terraces HOA	San Diego PRD	0	5	2	4	4
DECO13_3DREA021	Dennery Ranch East	Dennery Ranch	San Diego	San Diego PRD	2	35,000	116,000	36,206	388
DECO13_3JABO028	Jamacha Boulevard	San Diego NWR	USFWS	USFWS	---	---	---	297,700	864
DECO13_3JAHI006	Jamacha Hills	San Diego NWR	USFWS	USFWS	---	---	86	1,500	148
DECO13_3JOCA019	Johnson Canyon	OVRP	County, Caltrans	OVRP JEPA, Caltrans	---	---	---	2,000	778
DECO13_3LOST027	Lonestar	Lonestar Preserve	Caltrans	Caltrans	---	---	1,130	45	
DECO13_3MMGR010	Mother Miguel Grassland	San Diego NWR	USFWS	USFWS	---	---	---	12,500	1,883
DECO13_3OMEA026	Furby North	Otay Mesa West (Furby North)	County DPR	County DPR	---	---	64	700	5
DECO13_3ORVA017	Otay Valley (east end)	Otay Ranch Preserve	Otay Ranch POM	POM (County, Chula Vista)	---	---	---	---	---
DECO13_3ORVA018	North side of Otay River Valley near Wolf Canyon	Future Central City Preserve	Chula Vista	Chula Vista	---	---	---	---	---
DECO13_3PMA1002	PMA1 (Rice Canyon & Other Canyons)	Central City Preserve	Chula Vista	Chula Vista	766	---	69,100	157,000	795
DECO13_3PMA2003	PMA2	Central City Preserve	Chula Vista	Chula Vista	---	---	685	4,070	0
DECO13_3PMA4005	PMA4	Central City Preserve	Chula Vista	Chula Vista	---	---	35,000	60,750	0

Table 50. Otay Tarplant: Population Size for Occurrences by MU on Conserved Lands in the MSPA, 2014-2018.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Population Size[5]				
					2014	2015	2016	2017	2018
DECO13_3PRVA013	Proctor Valley	Otay Lakes Cornerstone Lands	San Diego PUD	San Diego PUD	0	380	858	128	0
DECO13_3PRVA014	Proctor Valley (Bella Lago)	San Diego NWR	USFWS	USFWS	---	---	0	0	0
DECO13_3RHRA012	Rolling Hills Ranch	Rolling Hills Ranch	Private	Chula Vista	---	3,639	104	---	0
DECO13_3RJER015	Rancho Jamul ER Subpopulation #1	Rancho Jamul ER	CDFW	CDFW	---	---	94,377	286,615	10,498
DECO13_3SCPA016	Salt Creek Parcel	Future Central City Preserve	Chula Vista	Chula Vista	---	---	---	---	---
DECO13_3SMHA024	San Miguel HMA West - DECO13	OMWD	OWD	OWD	---	330	598	148	---
DECO13_3SMHA025	San Miguel HMA West - DECO13	OMWD	OWD	OWD	---	280	28	186	---
DECO13_3SVPC007	Shinohara Vernal Pool Complex (southeast Sweetwater Reservoir)	San Diego NWR	USFWS	USFWS	---	---	---	100,000	17
DECO13_3TRIM008	Trimark/Gobbler's Knob/Horseshoe Bend	San Diego NWR	USFWS	USFWS	---	---	33,000	126,030	0
DECO13_3WMCA023	West of Moody Canyon	Cal Terraces	San Diego	None	---	200	---	---	---

[1] Table lists only occurrences in the SDMMP's MOM database on conserved lands.
[2] Occurrence Identification (ID) per the SDMMP's MOM database.
[3] Occurrence name/preserve abbreviations: **ER** = Ecological Reserve, **HMA** = Habitat Management Area, **HOA** = Homeowner's Association, **NWR** = National Wildlife Refuge, **OWD** = Otay Water District, **OVRP** = Otay Valley Regional Park, **PMA** = Preserve Management Area, **POM** = Preserve Owner/Manager.
[4] Land owner/land manager: **Caltrans** = California Department of Transportation, **CDFW** = California Department of Fish and Wildlife, **Chula Vista** = City of Chula Vista, **County** = County of San Diego, **County DPR** = County of San Diego Department of Parks and Recreation, **HOA** = Homeowner's Association, **OMWD** = Otay Water District, **OVRP JEPA** = Otay Valley Regional Park Joint Exercise of Powers Agreement, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **San Diego PUD** = City of San Diego Public Utilities Department, **USFWS** = U.S. Fish and Wildlife Service.
[5] Population size information from IMG monitoring data, land manager data, and report and research data (CNDDB 2019d); (---) = not surveyed or data not available or not provided, 0 = surveyed, no plants detected.

Table 51. Otay Tarplant: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
Management Unit 2						
Small Populations						
DECO13_2PAVA001	Paradise Valley	Paradise Hills Community Park	San Diego	San Diego PRD	1,000 (2003)	200 (2016)
DECO13_2PAVA030	Paradise Gardens	Paradise Valley	San Diego	San Diego PRD	76 (2018)	76 (2018)
Management Unit 3						
Large Populations						
DECO13_3DREA021	Dennery Ranch East	Dennery Ranch	San Diego	San Diego PRD	116,000 (2016)	116,000 (2016)
DECO13_3JABO028	Jamacha Boulevard	San Diego NWR	USFWS	USFWS	297,700 (2017)	297,700 (2017)
DECO13_3MMGR010	Mother Miguel Grassland	San Diego NWR	USFWS	USFWS	1,900,000[7] (1998)	12,500 (2017)
DECO13_3ORVA018	North side of Otay River Valley near Wolf Canyon	Future Central City Preserve	Chula Vista	Chula Vista	50,000 (2003)	50,000 (2003)
DECO13_3PMA1002	PMA1 (Rice Canyon & Other Canyons)	Central City Preserve	Chula Vista	Chula Vista	157,000 (2017)	157,000 (2017)
DECO13_3PMA4005	PMA4	Central City Preserve	Chula Vista	Chula Vista	60,750 (2017)	60,750 (2017)
DECO13_3RJER015	Rancho Jamul ER Subpopulation #1	Rancho Jamul ER	CDFW	CDFW	286,615 (2017)	286,615 (2017)
DECO13_3SVPC007	Shinohara Vernal Pool Complex (southeast Sweetwater Reservoir)	San Diego NWR	USFWS	USFWS	1,900,000[7] (1998)	10,0000 (2017)
DECO13_3TRIM008	Trimark/Gobbler's Knob/Horseshoe Bend	San Diego NWR	USFWS	USFWS	1,900,000[7] (1998)	126,030 (2017)
Medium Populations						
DECO13_3JAHI006	Otay Valley (east end)	Otay Ranch Preserve	Otay Ranch POM	POM (County, Chula Vista)	2,000 (1993)	1,500 (2017)
DECO13_3JOCA019	North side of Otay River Valley near Wolf Canyon	Future Central City Preserve	Chula Vista	Chula Vista	580,000[8] (2001)	2,000 (2017)

Table 51. Otay Tarplant: Maximum Population Sizes for Occurrences by MU on Conserved Lands in the MSPA.[1]

Occurrence ID[2]	Occurrence Name[3]	Preserve[3]	Land Owner[4]	Land Manager[4]	Max Pop Size[5] (year)	Recent Max Pop Size[6] (year)
DECO13_3LOST027	PMA1 (Rice Canyon & Other Canyons)	Central City Preserve	Chula Vista	Chula Vista	330,000[9] (2002-2007)	1,130 (2016)
DECO13_3PMA2003	PMA2	Central City Preserve	Chula Vista	Chula Vista	4,070 (2017)	4,070 (2017)
DECO13_3RHRA012	San Miguel HMA West - DECO13	OMWD	OWD	OWD	3,639 (2015)	3,639 (2015)
Small Populations						
DECO13_3BOME009	Bonita Meadows	Bonita Meadows	Caltrans	Caltrans	1,900,000[7] (1998)	200 (2016)
DECO13_3PRVA013	PMA4	Central City Preserve	Chula Vista	Chula Vista	45,737[10] (2003)	858 (2016)
DECO13_3DENC022	Furby North	Otay Mesa West (Furby North)	County DPR	County DPR	---	---
DECO13_3DERA020	Proctor Valley (Bella Lago)	San Diego NWR	USFWS	USFWS	5 (2015)	5 (2015)
DECO13_3OMEA026	Rolling Hills Ranch	Rolling Hills Ranch	Private	Chula Vista	700 (2017)	700 (2017)
DECO13_3ORVA017	Rancho Jamul ER Subpopulation #1	Rancho Jamul ER	CDFW	CDFW	1 (2010)	1 (2010)
DECO13_3PRVA014	Salt Creek Parcel	Future Central City Preserve	Chula Vista	Chula Vista	28,864 (2000)	0 (2018)
DECO13_3SCPA016	San Miguel HMA West - DECO13	OMWD	OWD	OWD	Several individuals (2012)	---
DECO13_3SMHA024	Shinohara Vernal Pool Complex (southeast Sweetwater Reservoir)	San Diego NWR	USFWS	USFWS	598 (2016)	598 (2016)
DECO13_3SMHA025	Trimark/Gobbler's Knob/Horseshoe Bend	San Diego NWR	USFWS	USFWS	280 (2015)	280 (2015)
DECO13_3WMCA023	West of Moody Canyon	Cal Terraces	San Diego	None	1,300,000 (2003)	200 (2015)

1 Table lists only occurrences in the SDMMP's MOM database on conserved lands.
2 Occurrence Identification (ID) per the SDMMP's MOM database.

[3] Occurrence name/preserve abbreviations: **ER** = Ecological Reserve, **HMA** = Habitat Management Area, **HOA** = Homeowner's Association, **NWR** = National Wildlife Refuge, **OMWD** = Otay Municipal Water District, **OVRP** = Otay Valley Regional Park, **PMA** = Preserve Management Area, **POM** = Preserve Owner/Manager.

[4] Land owner/land manager: **Caltrans** = California Department of Transportation, **CDFW** = California Department of Fish and Wildlife, **Chula Vista** = City of Chula Vista, **County** = County of San Diego, **County DPR** = County of San Diego Department of Parks and Recreation, **HOA** = Homeowner's Association, **OMWD** = Otay Municipal Water District, **OVRP JEPA** = Otay Valley Regional Park Joint Exercise of Powers Agreement, **San Diego** = City of San Diego, **San Diego PRD** = City of San Diego Parks and Recreation Department, **San Diego PUD** = City of San Diego Public Utilities Department, **USFWS** = U.S. Fish and Wildlife Service.

[5] Population size information from IMG monitoring data, land manager data, and report and research data (CNDDB 2019d); (---) = not surveyed or data not available or not provided, 0 = surveyed, no plants detected.

[6] Indicates maximum recorded population size in the last 5 years (2012-2017) if data are available, or most recent year overall if data are not available.

[7] CNDDB combines these four occurrences (CNDDB 2019d).

[8] Population size recorded in 2001 applied to a larger area than recorded in 2017.

[9] The 2002-2007 maximum population size includes CNDDB data from adjacent properties, while the 2016 maximum population size is only from the portion of the preserve managed by SDHC.

[10] The 2003 maximum population size includes CNDDB data from USFWS, City of San Diego, and private property, while the 2016 maximum population size is only from the City of San Diego portion of the occurrence.

Marschalek and Deutschman (2016) also found that some insect visitors (e.g., bees: mason bee, European honey bee) tended to move between flowers more quickly than other species present in very large numbers (e.g., soft-winged flower beetle, long-horned fly), and hypothesized that both groups could be important pollinators of Otay tarplant.

Bauder et al. (2002) also investigated pollination in Otay tarplant and found that visitation rates were higher in occurrences near coastal sage scrub habitat compared to an occurrence in grassland habitat dominated by nonnative grasses and forbs.

Floral display is important in attracting insects to tarplant patches. A buildup of thatch that inhibits germination or plant size may reduce pollinator visits and reduce or eliminate bare ground for ground-nesting bees (CBI 2018, Dodero pers. comm.).

Reproductive Biology

Otay tarplant reproduces sexually from seed. The species is self-incompatible, and cannot cross with itself or another genetically similar individual (USFWS 2004). Bauder and Truesdale (2000) found no evidence of hybridization with co-occurring and closely-related *Deinandra* species in San Diego County, and earlier studies (Clausen 1951 and Clausen et al. 1945 *in* Bauder and Truesdale 2000) suggested strong reproductive barriers between most tarplant species.

Seed Biology

Otay tarplant seed forms in late spring and matures through summer. Each tarplant inflorescence (flower head) possesses 7-10 ray flowers, so may produce up to 10 seeds. Although each inflorescence contains 13-21 disk flowers, Baldwin et al. (2012) indicate that most of these are staminate (male), so would not produce seed. Where disk achenes are formed, they germinate more readily than ray achenes, possibly due to differences in the thickness of the seed coat (USFWS 2009, Bauder et al. 2002).

Deinandra species, in general, possess a hard seed coat that infers physical dormancy, which can be partially relieved by pre-treating the seed to soften the seed coat. Even with pre-treatment, maximum germination rates appear to be about 60-70%, and often lower (RSA 2018, RECON Native Plant Nursery 2014). In studies on a related species, Ogden Environmental (1999) found similar levels of germination for pre-treated seed, and tested ungerminated seed for viability. In most cases, total viability rates (germinated seed + ungerminated but viable seed) were nearly double the germination rate alone, suggesting that either pre-treatments were not fully relieving dormancy and/or there may be more than one type of dormancy present. Baldwin (pers. comm.) confirmed that excising the seed coat of tarplant species is the most effective way to promote germination, although this is not practical for bulking seed.

Otay tarplant seed disperses from the plant with the pappus (modified calyx) attached. The pappus, which is composed of 6-9 scales, may assist in animal- or possibly, wind-dispersal.

Otay tarplant forms a persistent soil seed bank, as demonstrated in an experimental study where the species germinated from the soil seed bank after approximately ten years of absence when thatch and nonnative grasses were removed (Land IQ and CBI 2017). Seed longevity is unknown; however, RSA will test long-term seed collections in the future, which may shed light on seed longevity, at least in controlled settings.

Status and Trends

We can compare population size and extent over time to determine trends. In Table 51, we presented maximum recent and historic population sizes for 25 of the 27 occurrences on conserved lands. Although these data are incomplete, they provide a preliminary indication of status and trends. Recent monitoring data (2014-2018) indicate the following:

- Over 50% of occurrences on conserved lands in the MSPA (14 of 25 occurrences; 56%) support >1,000 plants, including 9 occurrences (36%) that support >10,000 plants (Figure 50).

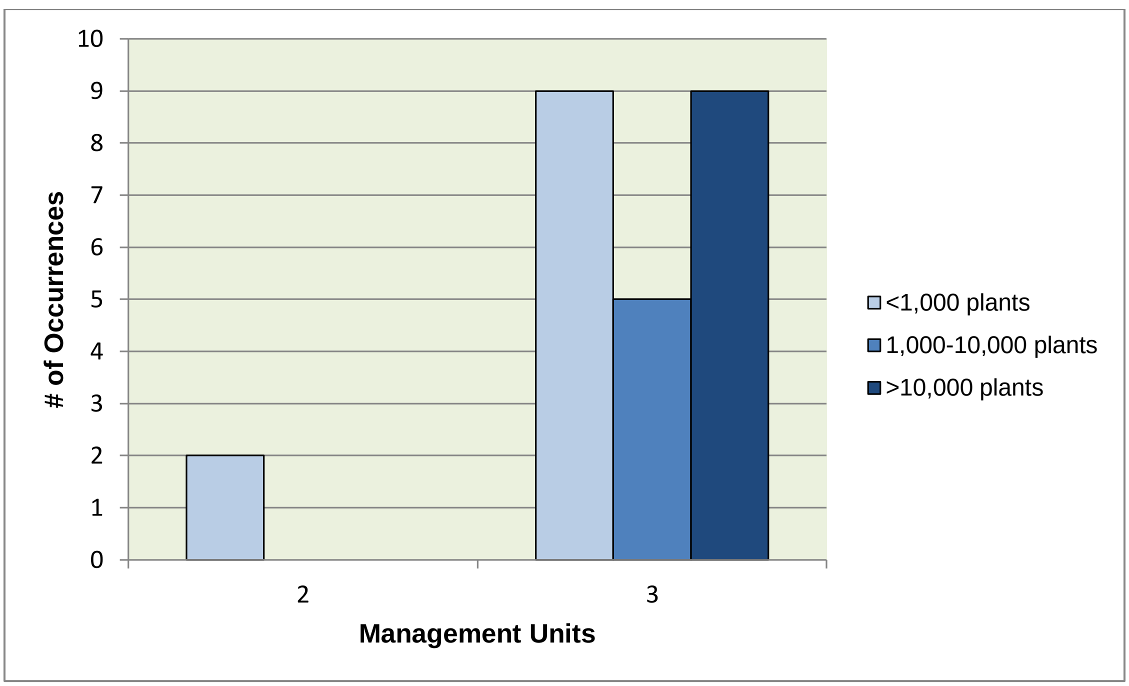

Figure 50. Otay Tarplant: Distribution by Population Size and MU (2014-2018).

- For the 11 occurrences that support <1,000 plants, 6 had >100 plants recorded in any year from 2014-2018 (55% of all occurrences in this size category), and 5 had ≤100 plants during this time period (45%). We recorded only one occurrence with no plants during this time period (Figure 51).

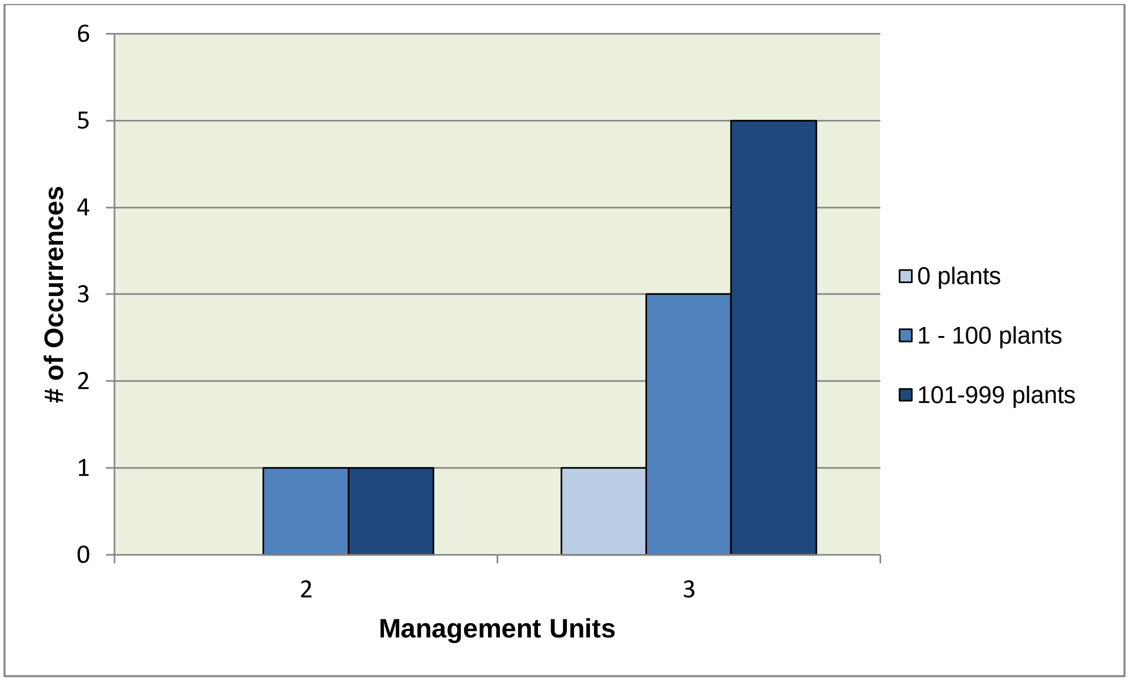

Figure 51. Otay Tarplant: Distribution by Population Size and MU for Occurrences with <1,000 plants (2014-2018).

Comparing recent (2014-2018) and historic population size data suggest the following:

- Of the 25 occurrences on conserved lands for which we have population size data, 18 occurrences (72%) appear relatively stable with respect to size based on available data, while 7 (28%) have declined over time and are now categorized into a smaller size category (Table 52). It should be noted that (1) the monitoring record is incomplete for many occurrences (and some occur partially on private land) and (2) the time scale is insufficient to detect some trends, such as those related to genetic factors that may affect long-term persistence (e.g., isolation, inbreeding depression).

Threats and Stressors

At a regional scale, Otay tarplant may be affected directly or indirectly by altered fire regimes, climate change, and possibly, nitrogen deposition (CBI 2018, Tonnesen et al. 2007). At a preserve-level, 21 categories of threats have been recorded at tarplant occurrences through the IMG monitoring process (Figure 52). The most common threats are invasive plants.

Threats at each occurrence are recorded as a continuum from no threat (threat level 1) to a threat that affects ≥75% of the maximum area occupied by tarplant (threat level 7). When reporting threats, we use a color-coded system to allow land managers to easily identify threat levels that are low versus high. In most cases, management costs and labor will increase with increasing threat level. Thus, addressing threats before they become a problem is a cost-effective strategy for managing occurrences.

Table 52. Otay Tarplant: Occurrences by Recent and Historic Population Size Category.

Occurrence ID[1]	MU[2]	Recent Population Size Category [3,4]	Historic Population Size Category[3,5,6]
DECO13_2PAVA001	2	Small	Medium
DECO13_2PAVA030	2	Small	Small
DECO13_3DREA021	3	Large	Large
DECO13_3JABO028	3	Large	Large
DECO13_3MMGR010	3	Large	Large
DECO13_3ORVA018	3	Large[7]	Large
DECO13_3PMA1002	3	Large	Large
DECO13_3PMA4005	3	Large	Large
DECO13_3RJER015	3	Large	Large
DECO13_3SVPC007	3	Large	Large
DECO13_3TRIM008	3	Large	Large
DECO13_3JAHI006	3	Medium	Medium
DECO13_3JOCA019	3	Medium	Large
DECO13_3LOST027	3	Medium	Large
DECO13_3PMA2003	3	Medium	Medium
DECO13_3RHRA012	3	Medium	Medium
DECO13_3BOME009	3	Small	Large
DECO13_3PRVA013	3	Small	Large
DECO13_3DENC022	3	No data	No data
DECO13_3DERA020	3	Small	Small
DECO13_3OMEA026	3	Small	Small
DECO13_3ORVA017	3	Small[7]	Small
DECO13_3PRVA014	3	Small[8]	Large
DECO13_3SCPA016	3	No data	No data
DECO13_3SMHA024	3	Small	Small
DECO13_3SMHA025	3	Small	Small
DECO13_3WMCA023	3	Small	Large

1 Occurrence ID = Occurrence identification code per the SDMMP's MOM database.
2 MU = Management Unit.
3 Population size categories: **Small** = <1,000 plants**, Medium** = 1,000-10,000 plants**, Large** = >10,000 plants.
4 Recent population size category is based on maximum size recorded at occurrence from 2014-2018.
5 Historic population size category is based on maximum size recorded at occurrence; may include data from 2014-2018 or earlier.
6 Cells highlighted with green shading indicate a change between historic and recent size categories.
7 Indicates occurrences with no IMG monitoring events during the 5-year period from 2014-2018. For the purpose of analysis, we have retained these occurrences their original population size category where suitable habitat still exists.
8 Indicates occurrences with at least one IMG monitoring event during the 5-year period from 2014-2018, but 0 plants detected.

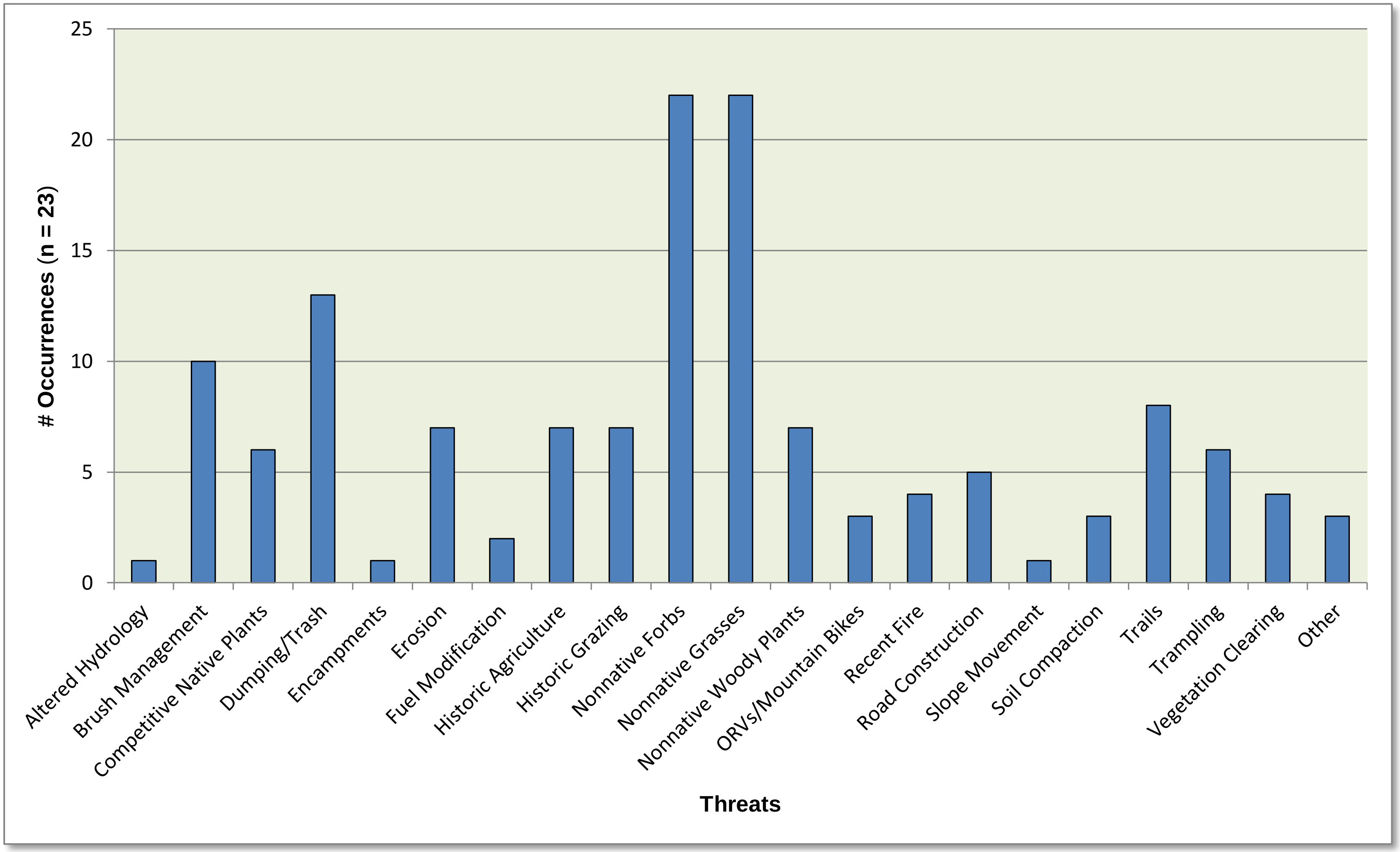

Figure 52. Otay Tarplant: Threats Recorded during IMG Monitoring (2014-2018) (note: data indicate the number of occurrences at which a threat was recorded).

We further stratify the color-coded system by different shades of the same color to (1) indicate magnitude of threat and (2) allow land managers to track whether threats are increasing or decreasing over time (taking into account annual variability due to climate). Table 53 defines threat levels per the IMG monitoring protocol (SDMMP 2019), while Figure 53 depicts the color-coded system used to display threats.

Table 53. Descriptions of Threat Levels.[1]

Threat Level	Description	Priority for Management
1	Threat not recorded at occurrence or in 10-m buffer	None
2	Threat not recorded at occurrence, but recorded in adjacent buffer	Low
3	Threat occurs over 0-10% of area within maximum extent	Low
4	Threat occurs in 10% to <25% of area within maximum extent	Medium
5	Threat occurs in 25% to <50% of area within maximum extent	Medium
6	Threat occurs in 50% to <75% of area within maximum extent	High
7	Threat occurs in ≥75% of area within maximum extent	High

[1] Threat level definitions per IMG monitoring protocol (SDMMP 2019).

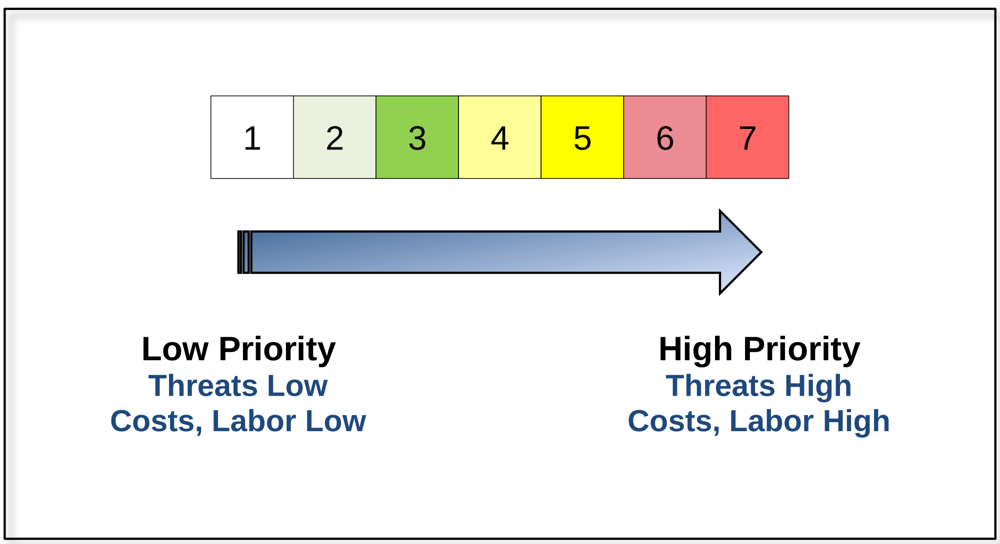

Figure 53. Otay Tarplant: Color-coded Threat Levels.

Table 54 summarizes threats and threat levels by year for those occurrences where IMG data were collected. In this table, we also include occurrences that were not monitored as a placeholder for future data, and to indicate where occurrences were visited but not monitored due to an absence of plants, or not visited at all. All IMG data are available on the SDMMP website:

https://sdmmp.com/view_project.php?sdid=SDID_sarah.mccutcheon%40aecom.com_57cf0196dff76.

Table 54. Otay Tarplant: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]																				
		AH	BR	CNP	D/T	EN	ER	FM	HG	HA	NNF	NNG	NWP	O/M	RF	RC	SM	SC	TR	TP	VC	OT
DECO13_2PAVA001	2018	1	1	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	1	1	1	1
DECO13_2PAVA030	2018	1	1	1	1	1	1	1	1	1	3	7	1	1	1	1	1	1	1	1	1	1
DECO13_3BOME009	2016	1	1	6	1	1	1	1	1	7	7	7	7	1	1	1	1	1	---	1	1	1
DECO13_3BOME009	2017	1	1	3	3	1	1	2	1	1	5	6	3	1	1	1	1	1	3	3	1	1
DECO13_3BOME009	2018	1	1	1	1	1	1	1	1	1	5	4	3	1	1	1	1	1	3	3	1	1
DECO13_DENC022	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3DERA020	2014	1	---	1	1	1	1	6	---	1	3	3	1	1	1	1	1	1	1	1	6	---
DECO13_3DERA020	2015	1	6	1	3	1	1	1	1	1	3	5	1	1	1	1	1	1	1	1	1	1
DECO13_3DERA020	2016	2	1	1	3	1	1	6	1	1	4	4	1	1	1	1	1	1	1	1	1	1
DECO13_3DERA020	2017	1	1	1	1	1	1	1	1	1	3	4	1	1	1	1	1	1	1	1	1	1
DECO13_3DERA020	2018	1	5	1	1	1	1	1	1	1	3	4	1	1	1	1	1	1	1	1	1	1
DECO13_3DREA021	2014	1	---	1	1	1	1	1	---	1	5	5	1	1	1	1	1	1	2	1	1	---
DECO13_3DREA021	2015	1	1	1	1	1	1	1	7	1	4	5	1	1	1	1	1	1	3	1	1	1
DECO13_3DREA021	2016	1	1	1	3	3	1	2	7	1	5	5	1	1	1	1	1	1	3	1	1	1
DECO13_3DREA021	2017	1	1	1	3	3	3	1	1	1	6	5	1	3	1	1	1	1	2	1	1	1
DECO13_3DREA021	2018	1	1	1	4	4	1	1	1	1	2	4	1	1	1	1	1	1	3	1	1	1
DECO13_3JABO028	2017	1	1	1	1	1	1	1	1	1	7	6	1	1	1	3	1	1	1	1	1	1
DECO13_3JABO028	2018	1	1	1	3	1	3	2	1	1	7	7	1	1	1	3	1	1	3	1	1	1
DECO13_3JAHI006	2016	7	7	3	3	1	6	7	1	1	7	5	1	1	---	1	1	7	---	3	1	---
DECO13_3JAHI006	2017	1	1	1	3	1	1	3	1	1	7	6	1	1	---	1	1	1	3	1	3	1
DECO13_3JAHI006	2018	1	1	1	1	1	1	7	1	1	4	7	1	---	1	1	1	4	5	1	2	1
DECO13_3JOCA019	2017	1	7	1	1	1	1	1	1	3	5	7	1	2	1	3	1	1	1	2	1	1
DECO13_3JOCA019	2018	1	3	1	3	1	1	1	1	1	5	3	1	2	1	3	1	1	1	1	1	1

Table 54. Otay Tarplant: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]																				
		AH	BR	CNP	D/T	EN	ER	FM	HG	HA	NNF	NNG	NWP	O/M	RF	RC	SM	SC	TR	TP	VC	OT
DECO13_3LOST027	2016	1	1	1	2	1	1	1	1	7	7	7	1	1	1	1	1	1	---	3	1	---
DECO13_3LOST027	2017	1	1	1	2	1	1	1	1	1	4	7	4	1	1	1	1	1	2	1	1	1
DECO13_3MMGR010	2017	1	3	1	3	1	1	1	1	1	5	7	1	1	7	1	1	1	1	1	1	1
DECO13_3MMGR010	2018	1	2	1	1	1	1	1	1	1	5	6	1	1	1	1	1	1	1	1	1	1
DECO13_3OMEA026	2016	1	1	1	4	1	3	1	1	1	5	7	1	1	7	1	1	1	---	1	1	---
DECO13_3OMEA026	2017	1	1	1	3	1	7	1	1	1	3	7	4	1	1	1	1	1	1	1	1	4
DECO13_3OMEA026	2018	1	1	1	1	1	1	1	1	1	7	7	1	1	1	1	1	1	1	1	1	1
DECO13_3ORVA017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3ORVA018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3PMA1002	2016	1	1	3	3	1	3	1	3	1	3	4	1	3	1	1	3	3	---	3	1	---
DECO13_3PMA1002	2017	1	1	1	1	1	1	1	1	1	7	7	1	1	1	1	1	1	2	1	2	1
DECO13_3PMA1002	2018	1	3	1	1	1	1	1	1	1	7	7	1	1	1	3	1	1	1	1	1	1
DECO13_3PMA2003	2016	1	1	1	1	1	3	1	7	1	7	5	3	1	1	4	1	1	---	1	1	---
DECO13_3PMA2003	2017	2	1	1	3	1	1	1	1	3	7	5	3	1	1	3	1	1	3	1	1	1
DECO13_3PMA2003	2018	2	1	1	3	1	1	1	1	1	5	4	3	1	1	1	1	1	3	1	1	1
DECO13_3PMA4005	2016	1	1	1	3	1	3	1	7	1	7	4	1	1	---	1	1	1	---	1	1	4
DECO13_3PMA4005	2017	1	1	1	1	1	3	1	7	1	7	4	1	1	1	1	1	1	---	1	3	4
DECO13_3PRVA013	2014	1	---	1	1	1	1	1	6	1	3	5	2	1	6	2	1	1	1	1	1	---
DECO13_3PRVA013	2015	1	1	1	1	1	1	1	7	1	3	5	1	3	7	1	1	1	1	1	1	1
DECO13_3PRVA013	2016	1	1	1	1	1	1	1	7	1	4	6	1	1	7	1	1	1	3	1	1	1
DECO13_3PRVA013	2017	1	1	1	1	1	1	1	1	1	3	7	1	1	1	1	1	1	1	1	1	1
DECO13_3PRVA013	2018	1	1	1	1	1	1	1	1	1	4	7	1	1	1	1	1	1	3	1	1	1

Table 54. Otay Tarplant: Summary of IMG Threats Data, 2014-2018.[1]

MSP Occurrence	Year	Threats[2,3]																				
		AH	BR	CNP	D/T	EN	ER	FM	HG	HA	NNF	NNG	NWP	O/M	RF	RC	SM	SC	TR	TP	VC	OT
DECO13_3PRVA014	2016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3PRVA014	2017	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3PRVA014	2018	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3RHRA012	2016	1	1	1	1	1	1	1	1	1	4	4	1	1	1	1	1	1	---	1	1	1
DECO13_3RHRA012	2018	1	4	1	3	1	1	2	1	1	4	3	1	1	1	2	1	1	1	1	2	1
DECO13_3RJER015	2016	1	7	3	1	1	1	1	7	1	7	7	1	1	1	2	1	2	---	4	1	---
DECO13_3RJER015	2017	1	7	5	1	1	1	1	3	3	7	7	1	2	1	2	1	1	1	1	1	1
DECO13_3RJER015	2018	1	2	4	1	1	1	1	1	1	4	6	2	1	1	1	1	1	1	1	1	---
DECO13_3SCPA016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
DECO13_3SMHA024	2015	1	7	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	---	1	1	---
DECO13_3SMHA024	2016	1	7	1	1	1	1	1	1	1	3	6	1	1	1	1	1	1	---	1	1	---
DECO13_3SMHA024	2017	1	4	1	1	1	1	1	1	1	3	6	1	---	1	---	1	1	---	1	---	---
DECO13_3SMHA025	2015	1	7	2	1	1	1	1	1	1	2	2	1	1	1	1	1	1	---	2	1	---
DECO13_3SMHA025	2016	1	7	1	1	1	1	1	1	1	3	3	1	1	1	1	1	1	---	1	1	---
DECO13_3SMHA025	2017	1	7	5	1	1	1	1	1	1	4	6	1	1	1	1	1	1	2	1	1	1
DECO13_3SVPC007	2017	1	7	1	1	1	1	1	1	1	7	7	1	1	1	1	1	1	1	1	1	1
DECO13_3SVPC007	2018	2	7	1	2	1	1	1	1	1	7	5	3	1	1	1	1	2	1	1	1	7
DECO13_3TRIM008	2016	1	1	3	1	1	1	1	1	1	7	7	1	1	3	1	1	1	---	1	1	1
DECO13_3TRIM008	2017	1	1	3	3	1	1	1	1	3	7	7	2	1	3	3	1	1	2	2	3	1
DECO13_3TRIM008	2018	1	1	1	2	1	1	1	1	1	4	7	3	1	1	5	1	3	5	5	1	1
DECO13_3WMCA023	2015	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

1 Table includes only occurrences on conserved lands within the MSPA.

2 Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **EN** = Encampments, **ER** = Erosion, **FM** = Fuel Management, **HG** = Historic Grazing, **HA** = Historic Agriculture, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **NWP** =

Nonnative Woody Plants, **O/M** = Off-road Vehicles, Mountain Bikes, **RF** = Recent Fire, **RC** = Road Construction, **SM** = Slope Movement, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **VC** = Vegetation Clearing, **OT** = Other (see detailed IMG data for description of other threats).

[3] Threats Ranking: numbers represent percent (%) of maximum extent disturbed by threat:

1 = 0% in maximum extent or adjacent 10 m buffer; **2** = 0% in maximum extent but threat detected in surrounding 10 m buffer; **3** = >0-<10% of maximum extent; **4** = 10-<25% of maximum extent; **5** = 25-<50% of maximum extent; **6** = 50-<75% of maximum extent; **7** = ≥75% of maximum extent; --- = data not collected or not available.

Genetic Considerations

Genetic studies of Otay tarplant in San Diego County indicate that this species has low genetic differentiation (divergence), high genetic diversity within occurrences, and low levels of inbreeding (Milano and Vandergast 2018; Table 55). The USGS study did not find distinct genetic clusters or evidence of isolation by distance, and concluded that the species has a high rate of gene flow and low risk of outbreeding depression (Milano and Vandergast 2018).

Table 55. Otay Tarplant: Genetic Structure within the MSPA.[1]

Genetic Parameter	Status[2]	Management Trigger[3]	Management Strategy[4]
Genetic Differentiation	Low (1 genetic cluster)	**No**	(1) Restore species or habitat for pollinators or seed dispersers in opportunity areas to ensure connectivity and gene flow among occurrences.
Genetic Diversity	High	**No**	(1) Manage threats to maintain or increase occurrence size; (2) reintroduce seed into small occurrences to increase size; (3) source seed from any larger occurrence within genetic cluster.
Inbreeding & Relatedness	Inbreeding: Low Relatedness: Mostly Low	**No**	(1) Manage threats to maintain or increase size and retain gene flow within occurrences; (2) reintroduce seed into small occurrences to increase size; (3) source seed from any larger occurrence within genetic cluster.
Ploidy level	No differences	**No**	None

1 Results and recommendations from Milano and Vandergast 2018.
2 Status: results of genetic testing per Milano and Vandergast 2018.
3 Management Trigger: **No** = genetic testing indicates that no specific actions are required to manage genetic parameter for this species.
4 Management Strategy: refers only to strategy to manage genetic parameter. Additional strategies may be needed to manage other threats; management of multiple threats should be coordinated. Where management trigger is **No**, strategies are presented to ensure no decline of genetic structure.

Figure 54 depicts the single genetic cluster identified for this species in San Diego County (South); refer to Table 56 for the actual or presumed genetic structure of Otay tarplant occurrences within this cluster. We use the term 'actual' structure for occurrences tested genetically, and 'presumed' structure for occurrences not yet tested. The latter may be refined in the future.

The primary strategies to manage genetic resources within this species include:

- Manage threats (e.g., invasive plants, thatch) at all occurrences to increase population size, maintain or increase genetic diversity, replenish the soil seed bank, and encourage pollinator activity.

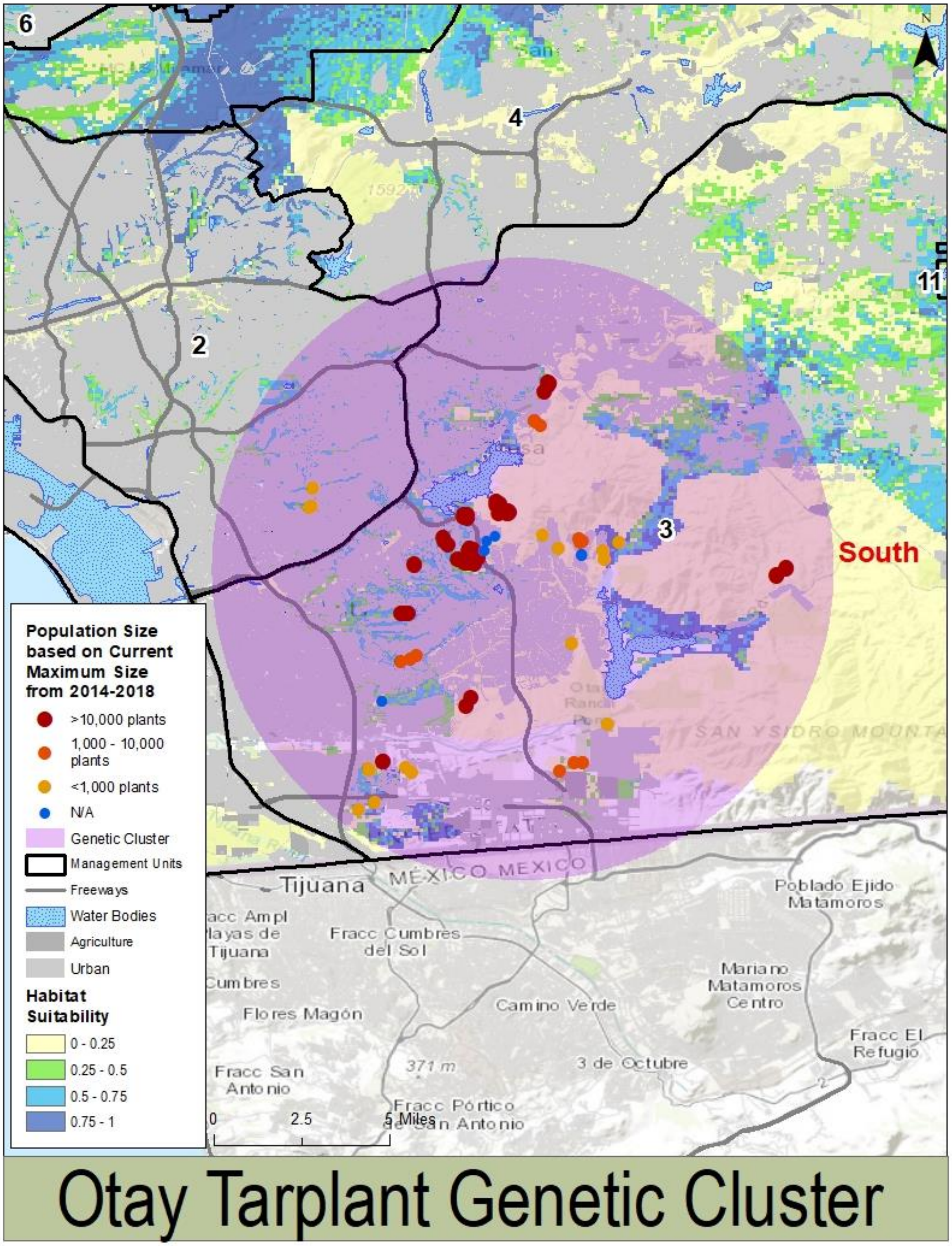

Figure 54. Otay Tarplant: Genetic Cluster.

Table 56. Otay Tarplant: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster	Genetic Structure	Potential Management Actions[1]
Management Unit 2			
DECO13_2PAVA001	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_2PAVA030	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
Management Unit 3			
DECO13_3BOME009	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3DENC022	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_3DERA020	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_3DREA021	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3JABO028	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats •
DECO13_3JAHI006	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
DECO13_3JOCA019	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
DECO13_3LOST027	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
DECO13_3MMGR010	South	Low Differentiation + High Diversity + Low Inbreeding, Some Relatedness	• Manage threats
DECO13_3OMEA026	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size if occurrence does not respond positively to management
DECO13_3ORVA017	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_3ORVA018	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats

Table 56. Otay Tarplant: Actual or Presumed Genetic Structure of Occurrences by MU.

Occurrence ID	Genetic Cluster	Genetic Structure	Potential Management Actions[1]
DECO13_3PMA1002	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3PMA2003	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
DECO13_3PMA4005	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3PRVA013	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size if occurrence does not respond positively to management
DECO13_3PRVA014	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_3RHRA012	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed if occurrence declines in size
DECO13_3RJER015	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3SCPA016	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size
DECO13_3SMHA024	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size if occurrence does not respond positively to management
DECO13_3SMHA025	(South)	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size if occurrence does not respond positively to management
DECO13_3SVPC007	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3TRIM008	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats
DECO13_3WMCA023	South	Low Differentiation + High Diversity + Low Inbreeding and Relatedness	• Manage threats • Reintroduce seed to increase occurrence size

[1] Reintroduce/introduce seed from larger occurrence(s) within genetic cluster to increase size.

- Reintroduce seed into consistently small (<1,000 individuals) occurrences to increase population size *if determined necessary after managing threats*. Follow guidelines in the SCBBP on seed collecting and bulking. Collect seed from the target occurrence or larger occurrences *within the single genetic cluster* identified for tarplant in San Diego County.

  Not all small occurrences will require seed reintroduction. This strategy is most appropriate under the following conditions: (1) occurrence is small *and* declining, even with management, (2) suitable habitat persists, and (3) adequate funding is available for both the reintroduction effort and long-term management. Occurrences with fewer than 100 plants are the highest priority for reintroduction (if the conditions above are met), because they are particularly susceptible to extirpation. We recognize that some small occurrences are stable and will not require additional seed.

- Improve connectivity among larger occurrences by managing or restoring steppingstone sites (e.g., reintroducing/introducing the species into suitable, unoccupied habitat or enhancing/creating habitat for pollinators).

  Note that enhancing or creating habitat for pollinators to improve connectivity should occur only between occurrences within the dispersal capability of a pollinator. This will allow the pollinator to transfer pollen from one occurrence to another, thereby promoting gene flow. These actions will not be effective if the distance between occurrences exceeds the distance that a pollinator can travel.

Regional Population Structure

Size Class Distribution

For Otay tarplant, we used the population size classes for annual plant species from Table 12. Table 57 presents the distribution of size classes for tarplant across MUs. Where recent monitoring data were not available or plants were not detected at an occurrence during IMG monitoring (2014-2018), we used historic data (pre-2014) to assign size class. Although this method is imprecise, it highlights the need for comprehensive monitoring data.

Table 57. Otay Tarplant: Size Class Distribution by MU.

Management Unit	Occurrence Size Class[1]			Total
	Large	Medium	Small	
2	---	---	2 (100%)	2
3	10 (40%)	5 (20%)	10 (40%)	25
Total	10 (37%)	5 (19%)	12 (44%)	27

[1] Refer to text and Table 12 for description of size classes. Number = number of occurrences in size class; percent (%) = percent of occurrences in size class for management unit.

We identified one population group for tarplant across the MSPA, based on population size, geographic location, and actual or presumed levels of genetic differentiation (Figure 55). This group corresponds to the genetic cluster identified by Milano and Vandergast (2018). All occurrences within this group are currently genetically compatible. However, fragmentation and subsequent isolation are relatively recent events that could increase genetic differentiation and/or decrease genetic diversity within the group over time. Therefore, we identified seven subgroups based on proximity and/or the presence of suitable habitat to potentially allow for gene flow, population expansion, or movement of pollinators between occurrences (Table 58, Figure 56).

Group and subgroup designations refine earlier regional population structures developed for this species in the absence of genetic data (CBI 2018). We assigned occurrences not included in genetic studies to the nearest subgroup. We refer to the group and subgroups by their population codes (Table 58), with the group abbreviation (South = S) followed by the subgroup number. For example, subgroup 3 in the South population group is S-3.

Habitat Connectivity

Habitat fragmentation and loss of connectivity among subgroups are a concern for Otay tarplant (Figure 56). This species likely occurred as a single, nearly continuous population prior to urban development. Although genetic studies indicate no genetic differentiation and high genetic diversity for this species in San Diego County (Milano and Vandergast 2018), we do not know if this scenario will persist if gene flow between occurrences is impeded. By designating subgroups, we can identify areas to maintain or improve connectivity by managing or restoring steppingstone occurrences or habitat to maintain gene flow or habitat for pollinators or seed dispersers, per recommendations in Milano and Vandergast (2018). Improving connectivity between selected subgroups would maintain or strengthen the regional population structure for this species.

Regional Management Strategies for Opportunity Areas

Management actions will occur within *Opportunity Areas* identified through the regional population structure process. Opportunity Areas are conserved lands within the MSPA that have the potential to enhance regional population structure and long-term resilience of the target species through various conservation and management actions. Opportunity Areas occur within the population subgroups or in gap areas between subgroups (SDMMP in CBI 2018).

We recommend the following strategies to maintain or improve regional population structure and long-term resilience of Otay tarplant within opportunity areas across the MSPA:

- **Survey** high suitability habitat within or among population subgroups to determine whether additional occurrences exist.

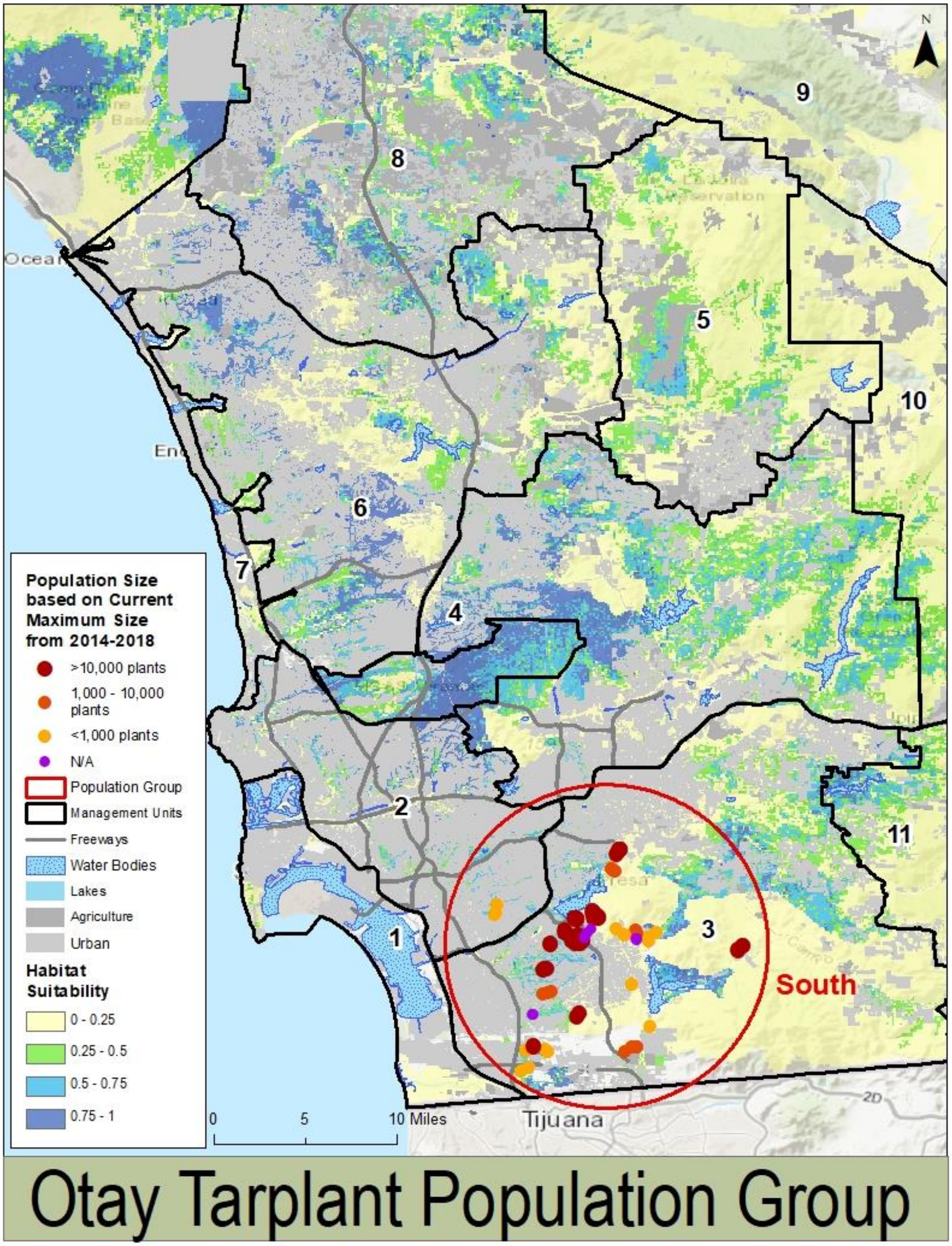

Figure 55. Otay Tarplant: Population Group within the MSPA.

Table 58. Otay Tarplant: Population Group and Subgroups.

Population Group[1]	Population Subgroup	Population Code	Occurrence ID	Population Size[2]	Group Characterization[3]
(South)	1	S-1	DECO13_3JABO028	Large	Large
South	1	S-1	DECO13_3JAHI006	Medium	
South	2	S-2	DECO13_3PAVA001	Small	Small
(South)	2	S-2	DECO13_3PAVA030	Small	
South	3	S-3	DECO13_3MMGR010	Large	Large
South	3	S-3	DECO13_3SVPC007	Large	
(South)	3	S-3	DECO13_3RHRA012	Medium	
South	3	S-3	DECO13_3PRVA013	Small	
(South)	3	S-3	DECO13_3PRVA014	Small	
South	3	S-3	DECO13_3SMHA024	Small	
(South)	3	S-3	DECO13_3SMHA025	Small	
South	4	S-4	DECO13_3BOME009	Large	Large
South	4	S-4	DECO13_3PMA1002	Large	
South	4	S-4	DECO13_3PMA4005	Large	
South	4	S-4	DECO13_3TRIM008	Large	
South	4	S-4	DECO13_3PMA2003	Medium	
South	5	S-5	DECO13_3DREA021	Large	Large
(South)	5	S-5	DECO13_3DENC022	Small	
(South)	5	S-5	DECO13_3DERA020	Small	
(South)	5	S-5	DECO13_3OMEA026	Small	
South	5	S-5	DECO13_3WMCA023	Small	
(South)	6	S-6	DECO13_3ORVA018	Large	Large
(South)	6	S-6	DECO13_3JOCA019	Medium	
South	6	S-6	DECO13_3LOST027	Medium	
(South)	6	S-6	DECO13_3ORVA017	Small	
(South)	6	S-6	DECO13_3SCPA016	Small	
South	7	S-7	DECO13_3RJER015	Large	Large

[1] The population group corresponds to the genetic cluster (see Table 56; Milano and Vandergast 2018). Where the group is in parentheses, the occurrence was not tested and is placed in the subgroup based on proximity to tested occurrences.
[2] Population size categories: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants.
[3] Group characterization: **large** = group has at least one large occurrence; **small** = group has small occurrences only.

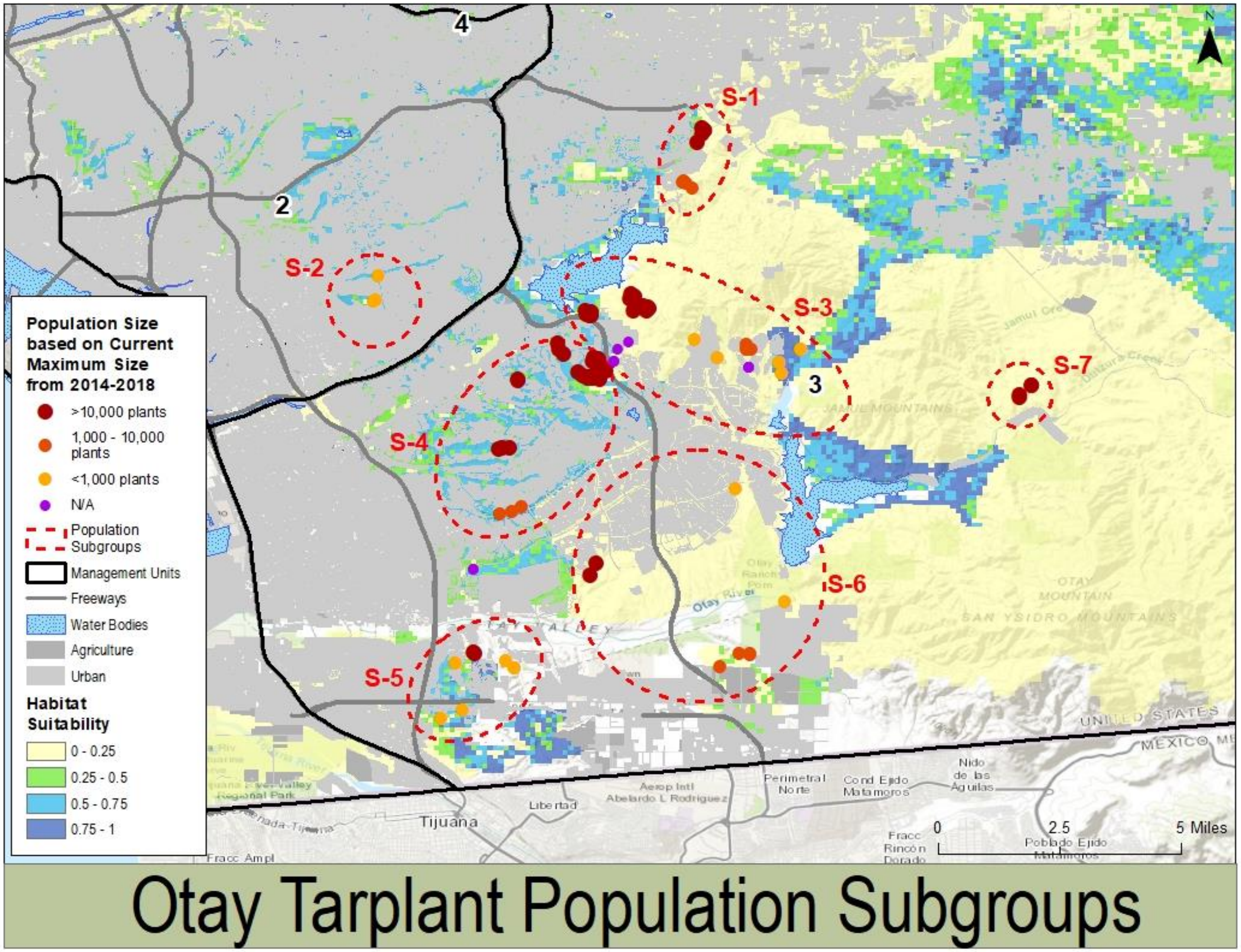

Figure 56. Otay Tarplant: Population Subgroups within the MSPA.

- **Manage** all occurrences through site-specific actions (e.g., invasive plant control), as determined necessary through monitoring.
- **Reintroduce** the species into small occurrences that do not respond positively to management by adding seed from the target occurrence or larger occurrence(s) within the subgroup or nearby subgroups. A positive response to management is an increase in occurrence size under favorable climatic conditions.

  For small occurrences that supported no plants in recent monitoring periods, test soil first to ensure it is still suitable to support Otay tarplant.
- **Expand** habitat at selected small occurrences by enhancing adjacent habitat and/or introducing or reintroducing seed. Test soil first to ensure it is suitable to support Otay tarplant.
- **Introduce** new occurrences into high suitability habitat within or among the subgroups above *if* surveys fail to locate new occurrences in these gap areas.
- **Maintain or restore** habitat for pollinators and/or seed dispersers among all subgroups, where feasible.

Management Priorities and Recommendations

Management priorities and recommendations are based on IMG monitoring data, and genetic and regional population structures, and informed by management strategies outlined in previous sections. The current focus is managing Otay tarplant under existing (versus future) conditions.

Table 59 presents criteria for prioritizing management actions; priorities are assigned for each management category. For example, an occurrence may be a high priority for all categories, or a high priority in one category and a lower priority in other categories. For threats, prioritize large occurrences with high or moderate threats over small occurrences with high threats.

Table 59. Otay Tarplant: Criteria for Prioritizing Management Actions.

Management Category	Priority Level[1,2]			
	Not A Priority	Low Priority	Medium Priority	High Priority
Threats	Threat level 1	Threat levels 2-3	Threat levels 4-5	Threat levels 6-7
Genetic Structure	Large occurrence	Medium occurrence	Small occurrence (>100 plants)	Small occurrence (<100 plants)
Regional Population Structure	Large population group, intact habitat within group	Large population group, fragmented habitat within group	Mixed or medium population group	Small population group

[1] Priority levels may differ for each management category within an occurrence.
[2] For threats, prioritize large occurrences with high or medium threats over small occurrences with high threats.

Although the focus is on managing high priority levels within a management category, land managers may address lower priority levels, as well. For each priority level, refer to companion tables in this document for relevant information needed to manage the occurrence, including appropriate management strategies:

- Threats (Table 54)
- Genetic Structure (Tables 55, 56)
- Regional Population Structure (Table 58)

For some proposed actions, management may be a one-time event (e.g., removing trash). For others, management may be a long-term effort that requires multiple years and considerable expense (e.g., controlling invasive plants). In many cases, land managers can reduce management costs by addressing threats at an early stage (e.g., threat levels of 3, 4, 5). This is particularly important for large occurrences to maintain their status and prevent decline. Where early intervention is not possible, land managers should have adequate funding or other resources available before starting a large-scale or expensive management program, unless these actions can be phased. As an example, invasive plant control may require an initial and intensive 3-5 year treatment program, but if this is not followed by long-term maintenance, then the site may revert quickly to its pre-treatment condition. In all cases, continue IMG monitoring to assess status and threats, as well as effectiveness of management actions.

We recommend an adaptive approach to managing tarplant occurrences, as outlined in the steps below and presented in Figure 57:

1. Monitor occurrence using IMG rare plant monitoring protocol.
2. If threats are identified, manage to reduce impacts to rare plant occurrence.
3. Continue monitoring to assess management effectiveness.
4. If threats are not controlled, continue management actions or manage adaptively.
5. If there are no threats or if threats are controlled through management actions, and occurrence is small or declining, reintroduce seed per species-specific BMPs in this document and in the SCBBP.
6. Continue monitoring to assess success of seeding effort.
7. If seeding is unsuccessful, reintroduce additional seed (per flow chart) or reassess seeding effort and site conditions to determine if continued seeding is worthwhile.
8. If seeding is successful, continue monitoring per IMG rare plant monitoring protocol to assess occurrence status and threats.

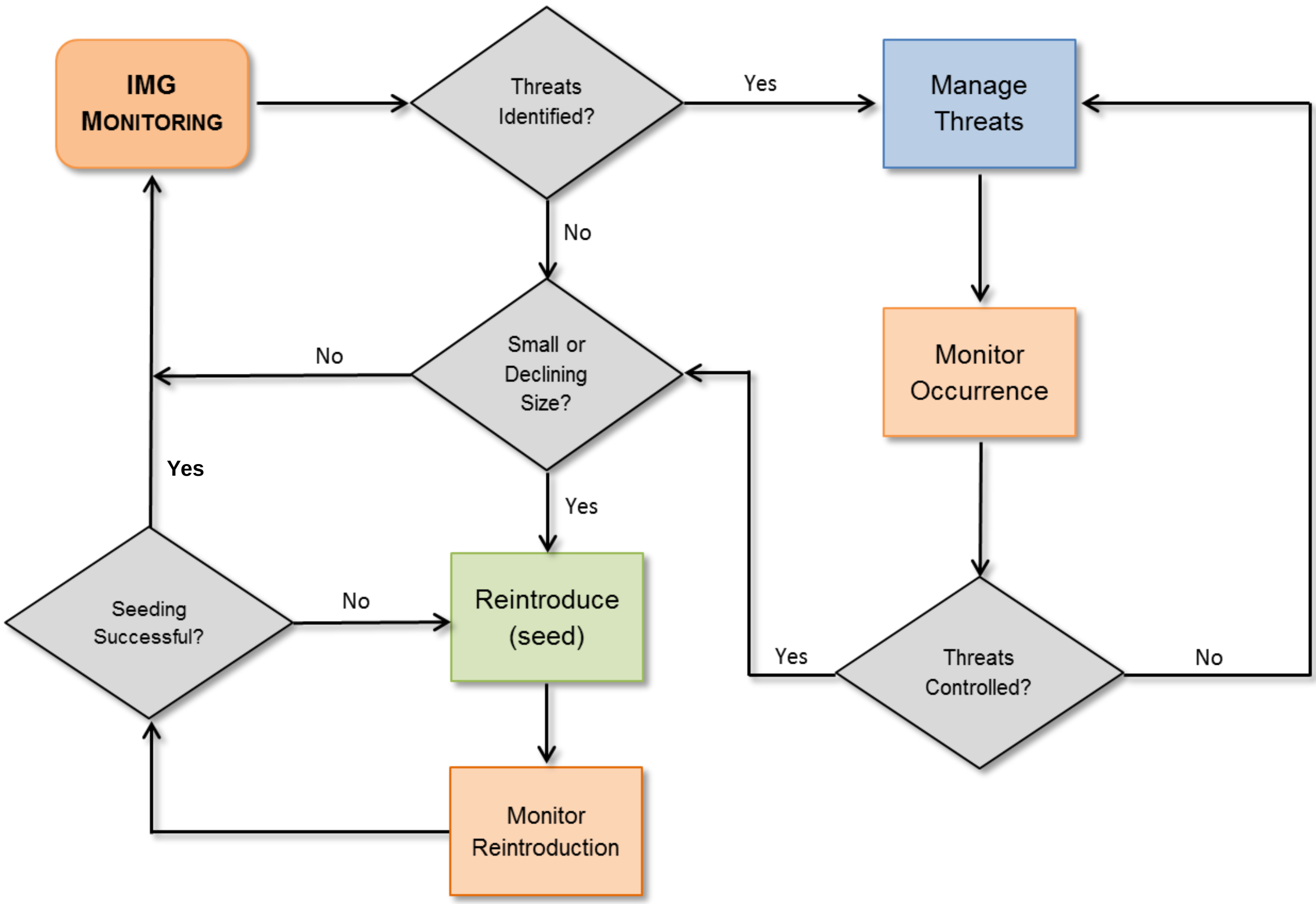

Figure 57. Otay Tarplant: Adaptive Management Flow Chart.

Regional Priorities and Recommendations

Regional priorities focus first on actions that would benefit the species within its current range (e.g., regional monitoring, baseline surveys, possibly species introductions). At this time, actions that would occur outside the current range of the species (e.g., species translocations) are not recommended based on results of habitat suitability modeling under future climate scenarios. Regional management actions identified to date for Otay tarplant include the following:

- Continue monitoring all Otay tarplant occurrences on conserved lands in the MSPA.
- Monitor newly conserved occurrences or occurrences that are conserved but have not yet been monitored per the IMG monitoring protocol.
- Prioritize large occurrences with high or moderate threats for management over small occurrences with high threats. This will ensure that large populations remain large and genetically diverse to help rescue smaller populations.
- Conduct baseline surveys in suitable habitat near extant occurrences or occurrences where the species has not been detected recently to determine population presence and extent. Conduct surveys in years of favorable climatic conditions, as evidenced by 'boom' populations at known occurrences.
- Survey additional, high suitability habitat within population subgroups S-6 and S-7 and among subgroups S-1 and S-3 and S-3 and S-7, respectively. Where new occurrences are detected, monitor annually per the IMG monitoring protocol.
- Improve habitat connectivity between population subgroups by managing or restoring habitat for Otay tarplant and/or pollinators. If suitable habitat is available, reintroduce or introduce Otay tarplant into opportunity areas. Potential opportunity areas occur between the following subgroups: S-1 and S-3; S-2 and S-3; S-3 and S-7; S-4 and S-5, S-5 and S-6; S-6 and S-7; S-3 and S-7

Preserve-level Priorities and Recommendations

Preserve-level priorities and recommendations are informed primarily by IMG monitoring, although they also address those aspects of genetic structure or regional population structure that are specific to an occurrence. For some occurrences, recommendations are incomplete or not provided at all due to a lack of monitoring data.

For most occurrences on conserved lands, surveys have already been conducted. For occurrences where locational information appears to be incorrect or incomplete, the first step will be to conduct baseline surveys. For occurrences with accurate locational information but no monitoring data, the first step will be IMG monitoring to determine status and threats. For all occurrences, *control threats prior to reintroducing seed*. Managing threats may be sufficient to restore habitat from the soil seed bank.

We use a variation of our earlier color-coded threats scheme to allow land managers to quickly identify priority levels for management in the context of this plan (Figure 58). We assigned priority levels for threats at each occurrence using the highest threat level recorded for any sample during the monitoring period to accommodate differences due to annual climatic variation or surveyor variability. In some cases, land managers may have controlled threats effectively. In other cases, threat levels may fluctuate between years (e.g., invasive plants).

Table 60 presents management priorities for Otay tarplant occurrences. The steps to identifying and implementing management priorities (next page) outline how to use Table 60 and other information in this document to identify and implement management priorities. Refer to Appendix B for general BMPs; species-specific BMPs are included in this chapter.

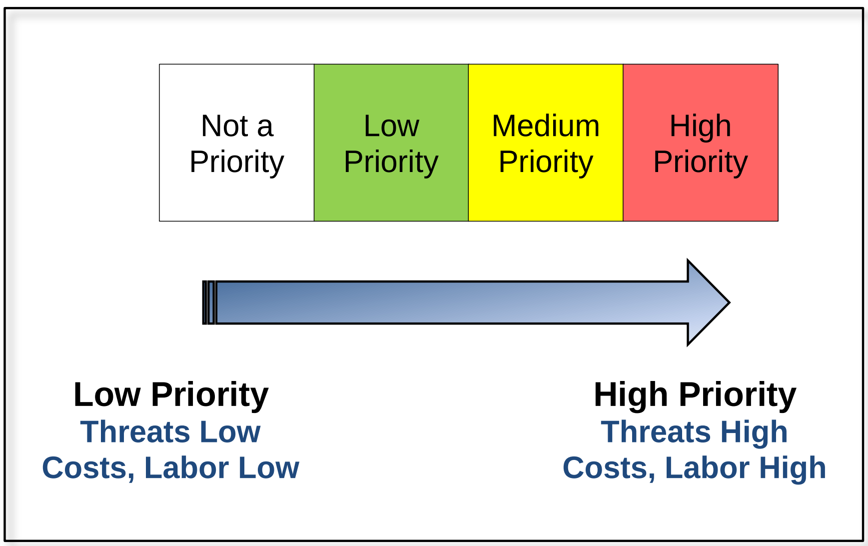

Figure 58. Otay Tarplant: Color-coded Management Priority Levels.

Steps to Identifying and Implementing Management Priorities

Otay tarplant:
1. Locate the occurrence in **Table 60**.
2. Determine which threats occur at the target occurrence.
3. Determine which threats are most important to manage. In general, manage higher priority threats first and then move on to lower priority threats. If budgets are limited, manage smaller portions of the high priority threat(s) each year. Increase management efforts once budgets improve or if endowment or grant funding becomes available. Refer to **Table 54** for detailed threat levels.
4. Refer to general and species-specific BMPs to manage the identified threat(s). For example, if erosion and altered hydrology are high priority threats, refer to **general BMPs (Appendix B)** for control methods or other recommendations. If nonnative grasses and forbs are high priority threats, refer to **species-specific BMPs** in this chapter for control methods.
5. Once threats are controlled, refer to the genetics and regional population structure columns in **Table 60** to determine if the occurrence would benefit from reintroducing seed or restoring habitat. To reintroduce seed, identify appropriate seed source (**Figure 56, Table 58**), collect seed per the **SCBBP**, and outplant seed per **species-specific BMPs** in this chapter. To restore habitat, determine extent and location of restoration effort after threats are controlled, and restore following **species-specific BMPs** in this chapter.
6. After each management action (control threats, reintroduce seed, restore habitat), monitor the occurrence using the IMG monitoring protocol to determine if actions are successful and manage adaptively per the Adaptive Management flow chart (**Figure 57**).

Table 60. Otay Tarplant: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																					GN[5]	RP[6]
		AH	BR	CNP	D/T	EN	ER	FM	HG	HA	NNF	NNG	NWP	O/M	RF	RC	SM	SC	TR	TP	VC	OT	RE	RS
DECO13_2PAVA001	Small										L	L											H	H
DECO13_2PAVA030	Small										L	H											H	H
DECO13_3BOME009	Small			H	L			L		H	H	H	H						L	L				L
DECO13_3DENC022	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
DECO13_3DERA020	Small	L	H		L			H			M	M									H		H	L
DECO13_3DREA021	Large				M	M	L	L	H		H	M		L					L					
DECO13_3JABO028	Large				L		L	L			H	H				L			L					
DECO13_3JAHI006	Medium	H	H	L	L		H	H			H	H						H	M	L	L		L	
DECO13_3JOCA019	Medium		H		H					L	M	H		L		L				L			L	
DECO13_3LOST027	Medium				L					H	H	H	M						L	L			L	
DECO13_3MMGR010	Large		L		L						M	H			H								L	
DECO13_3OMEA026	Small				M		H				H	H	M		H							M	M	L
DECO13_3ORVA017	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
DECO13_3ORVA018	Large	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
DECO13_3PMA1002	Large		L	L	L		L		L		H	H		L			L	L	L	L	L			L
DECO13_3PMA2003	Medium	L			L		L		H	L	H	M	L			M			L				M	L
DECO13_3PMA4005	Large				L		L		H		H	M									L	M	M	L
DECO13_3PRVA013	Small								H		M	H	L	L	H	L			L				M	
DECO13_3PRVA014	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
DECO13_3RHRA012	Medium		M		L			L			M	M				L					L		L	L
DECO13_3RJER015	Large		H	M					H	L	H	H	L	L		L		L		M				

Table 60. Otay Tarplant: Management Priorities.[1]

MSP Occurrence	Size[2]	Threats[3,4]																					GN[5]	RP[6]
		AH	BR	CNP	D/T	EN	ER	FM	HG	HA	NNF	NNG	NWP	O/M	RF	RC	SM	SC	TR	TP	VC	OT	RE	RS
DECO13_3SCPA016	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		
DECO13_3SMHA024	Small		H								L	H			L								M	L
DECO13_3SMHA025	Small		7	M							M	H							L	L			M	L
DECO13_3SVPC007	Large	L	H		L						H	H	L					L				H		
DECO13_3TRIM008	Large			L	L				L	L	H	H	M		L	M		L	M	M	L			L
DECO13_3WMCA023	Small	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---		

1 Management Priorities: **L** = Low Priority, **M** = Medium Priority, **H** = High Priority. If no priority level is indicated, then no management action is recommended at this time. **---** indicates no data collected or available.

2 Size = population size category: **large** = >10,000 plants, **medium** = 1,000-10,000 plants; **small** = <1,000 plants; **---** = no population size data available.

3 Threat Categories: **AH** = Altered Hydrology, **BR** = Brush Management, **CNP** = Competitive Native Plants, **D/T** = Dumping/Trash, **EN** = Encampments, **ER** = Erosion, **FM** = Fuel Management, **HG** = Historic Grazing, **HA** = Historic Agriculture, **NNF** = Nonnative Forbs, **NNG** = Nonnative Grasses, **NWP** = Nonnative Woody Plants, **O/M** = Off-road Vehicles, Mountain Bikes, **RF** = Recent Fire, **RC** = Road Construction, **SM** = Slope Movement, **SC** = Soil Compaction, **TR** = Trails, **TP** = Trampling, **VC** = Vegetation Clearing, **OT** = Other (see detailed IMG data for description of other threats).

4 Threats per IMG monitoring protocol. **---** = no data (occurrence not monitored per IMG monitoring protocol).

5 **GN** = Genetics; **RE** = Reintroduce seed using seed from the target occurrence (if an adequate amount of seed is available) or from a genetically compatible seed source within the same population group (genetic cluster). For occurrences with no data, assess status and threats to add or refine recommendation.

6 **RP** = Regional Population Structure; **RS** = restore habitat (enhance, expand habitat). For occurrences with no data, assess status and threats to add or refine recommendation.

Best Management Practices (BMPs)

We define a BMP as a tested, effective practice used to accomplish management goals or objectives. Land managers, biologists, restoration contractors, or ecologists (*practitioners*) typically implement BMPs. In this section, we outline BMPs to restore Otay tarplant habitat (*habitat restoration*) and occurrences (*species restoration*). These BMPs have been implemented successfully in San Diego County and represent the current state of management knowledge for this species (Land IQ and CBI 2017, Dodero pers. comm., Ekhoff pers. comm.).

The BMPs for restoring Otay tarplant habitat include dethatching and invasive plant control. The use of herbicides to control invasive plants in tarplant habitat is based on many factors, including (but not limited to) goals and objectives, management approach, occurrence history, proximity of target invasive species to tarplant, practitioner experience, restoration timeline, budget, and herbicide restrictions. Currently, herbicide is the preferred method to control invasive plants in tarplant habitat, especially for larger occurrences, and has been tested by multiple land managers in San Diego County. Nonetheless, we also provide mechanical methods in case herbicide is unnecessary, inadvisable, or restricted.

The BMPs for herbicide use in this section focus only on synthetic herbicides. We do not provide BMPs for non-synthetic herbicide use at this time due to (1) a lack of research regarding their effectiveness in tarplant habitat or (2) existing research that indicates variable and/or marginally effective results (i.e., Suppress®) in controlling primary invaders in tarplant habitat (i.e., *Brachypodium distachyon*, *Centaurea melitensis*) (Natural Communities Coalition 2018). We acknowledge that using non-synthetic herbicides alone or in combination with mechanical methods may be appropriate to control specific invasive species in some situations.

Refer to Natural Communities Coalition (NCC 2018) for additional information and guidelines on the selection and use of manual and chemical control methods on conserved lands. The NCC document is specific to Orange County; however, the *general* recommendations on invasive plant control methods apply broadly to San Diego County and have the support of both the USFWS and CDFW. Refer to BMPs in this section for invasive plant control methods developed and tested specifically for Otay tarplant.

The BMPs for restoring tarplant occurrences include reintroducing, introducing, or translocating seed, and are used primarily to increase small and medium occurrences. Although we identify seed collecting and bulking needs in this document, we refer the reader to the SCBBP for specific guidelines and BMPs that address these practices. Finally, we provide a flow chart to assist practitioners with implementing BMPs (Figure 59). All BMPs may be refined in the future based on adaptive management or experimental studies.

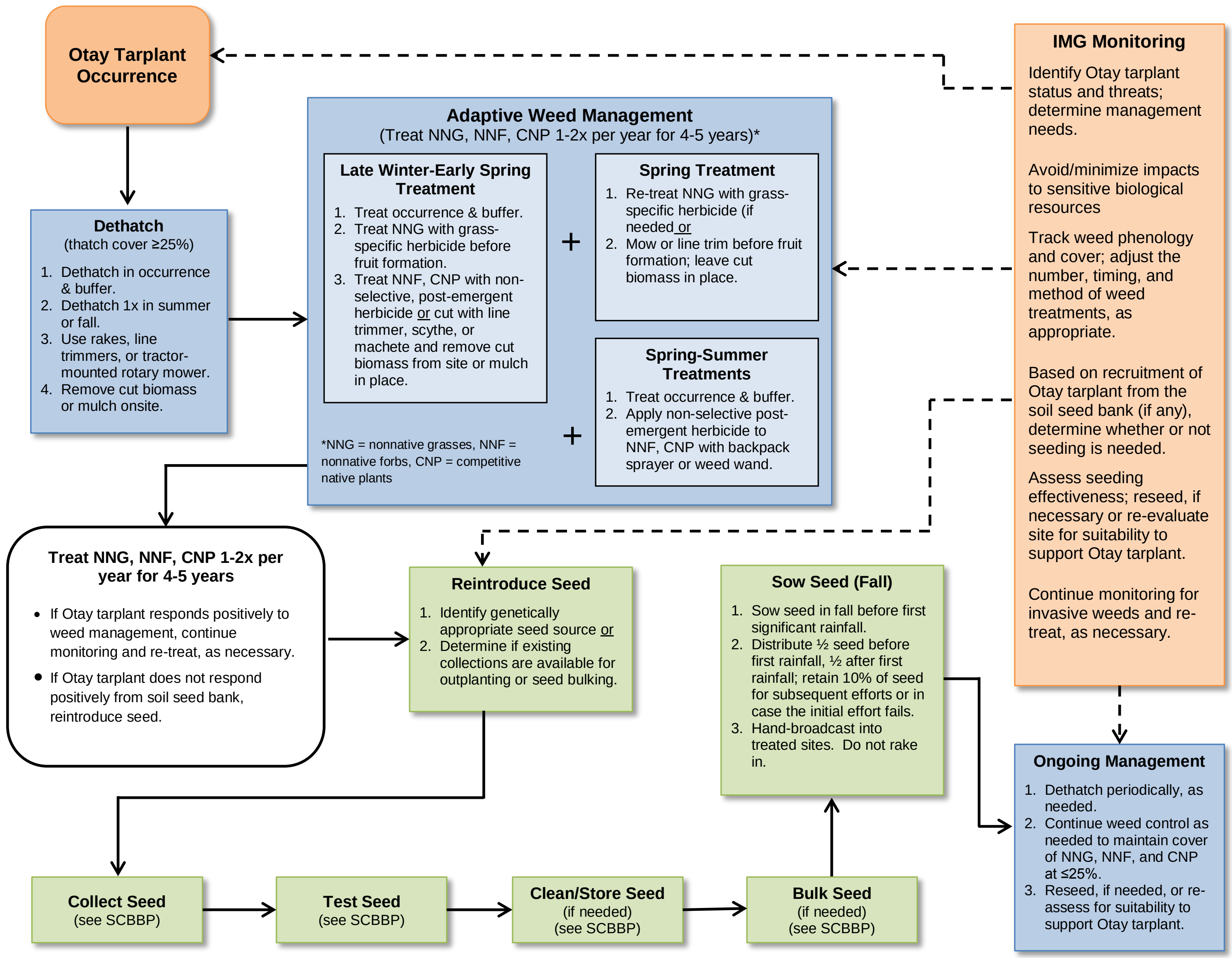

Figure 59. Otay Tarplant: Best Management Practices (BMP) Flow Chart.

As outlined in earlier sections of this chapter, occurrences of different sizes or threats will require different types and/or levels of management. For example, the primary management action for large occurrences will be managing threats to ensure that tarplant continues to germinate, reproduce, and replenish the soil seed bank during favorable years. Managing threats is also critical for small and medium occurrences. However, these occurrences may require the addition of seed to increase size and potential for long-term persistence. In these cases, we recommend controlling threats before adding seed.

Practitioners have found they can successfully restore populations of Otay tarplant and native forblands using a process that includes all of the following steps implemented in the order shown (Land IQ and CBI 2017, Dodero pers. comm., Ekhoff pers. comm.):

Step 1: Dethatch (prepare) the site

Step 2: Control nonnative grasses

Step 3: Control nonnative forbs and competitive native plants

Step 4: Reintroduce tarplant seed (if warranted)

Step 5: Continue weed control

We discuss each of these steps below. It is important to stress that to successfully restore an occurrence, land managers must complete *each* step in the order indicated.

Habitat Restoration

Monitoring data show that invasive plants[11] are the primary threat to Otay tarplant. Therefore, controlling invasive plants and thatch buildup from nonnative grasses are key factors to ensuring persistence of large and many medium occurrences, and a necessary first step for small and medium occurrences where reintroducing seed is appropriate.

Practitioners should tailor invasive plant control actions to the specific tarplant occurrence and its unique complement of invasive plants and habitat conditions. In addition, not all invasive plants will necessarily require management. Practitioners should prioritize management of invasive species known or strongly suspected to result in tarplant population declines and habitat degradation.

Invasive plant control methods described below have the potential to cause soil disturbance and in some cases, tarplant mortality, particularly in large, dense occurrences. However, the net benefit to the occurrence is expected to outweigh any adverse consequences, and potential impacts can be avoided or minimized with care and experience.

[11] For the purpose of this discussion, invasive plants are primarily nonnative species, but may include a few native species that out-compete Otay tarplant for resources.

Practitioners have found that by preparing the site (dethatching) and controlling weeds (nonnative grasses, forbs, and competitive native plants) with herbicide or mechanical methods, they can successfully restore Otay tarplant occurrences and native forb habitats (Land IQ and CBI 2017, Dodero pers. comm., Ekhoff, pers. comm.). Reintroducing seed can also restore occurrences successfully, but may not be necessary if there is an extant soil seed bank (Land IQ and CBI 2017). Practitioners should consider reintroducing seed if the species does not respond positively to at least three years of invasive plant control (including at least one year with favorable climatic conditions for tarplant germination and growth).

Once the restoration process begins, practitioners should expect some level of perpetual management to maintain habitat conditions because of the extensive weed seed bank at many sites, and continual input of weed seeds from surrounding, untreated areas via wind, animal, or human dispersal. However, regular management should decrease management frequency, intensity, and cost over time. Conversely, if management is discontinued, even for a few years, some sites may revert quickly to pre-treatment conditions.

Timing is critical for treating nonnative grasses and forbs in Otay tarplant habitat. For example, if herbicide is applied too early in the season, then additional treatments may be required to treat late-germinating plants. Conversely, applying herbicide too late in the season will be ineffective if fruit has already hardened into viable seed. Finally, the phenology of both Otay tarplant and the target invasive plants differs by site based on geographic location, site topography, slope aspect, microclimate weather patterns, vegetation association, and cover and depth of thatch. For these reasons, experienced practitioners should visit an occurrence several times per season to ensure correct timing to apply herbicide(s).

In any given year, the extent of invasive plant control will depend on weather conditions. Practitioners can expect treatments to be more intensive during years of average- and above-average rainfall because of increased germination of invasive plants and possibly, the need for multiple treatments. Treatments will be less expensive during drought years. To accommodate variations in treatment level, practitioners should include contingency funds in annual budgets and/or allow these funds to carry over to years where they are most needed.

Step 1: Dethatch

For unburned sites, determine if dethatching is necessary by either reviewing IMG monitoring data or estimating the cover of nonnative grass thatch. Dethatch if thatch cover is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Dethatch in the occurrence(s) and in the buffer.

Dethatch only once in the summer or fall using dethatch rakes (small occurrences), line trimmers, or a tractor-mounted rotary mower (large occurrences). Remove all cut biomass from the site or pile it onsite if removing it is not possible for logistical or budgetary reasons. For biomass left onsite, place it in mulch piles and/or in temporary fenced enclosures, or cover with black plastic or tarp to prevent seed from germinating (Ekhoff pers. comm.). Monitor and treat any invasive plants that germinate from uncovered mulch piles.

For sites that have burned naturally (wildfire) or where fire has been prescribed to remove thatch (prescribed burn), dethatching may not be necessary if invasive plants are controlled with herbicide or mechanical methods within one year of the fire. If dethatching is necessary in recently burned areas, follow the methods above for unburned sites.

<u>Step 2: Control Nonnative Grasses</u>

Control nonnative grass if IMG monitoring data indicate that cover of nonnative grass is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative grass in the occurrence(s) and in the buffer.

Herbicide. Follow herbicide label directions to determine application rates, timing, and limitations/restrictions, and proper personal protection equipment Apply a grass-specific herbicide (i.e., Fusilade® DX) over the top of nonnative grasses in the winter (January-early March), when most grasses are between 4-6 inches tall and before grasses produce fruit. Some grasses (*Avena* spp.) may be taller than 4-6 inches. Spray before the target invasive species bolts and flowers. If fruit has hardened and seed is beginning to form, do not apply herbicide since seed will continue to mature and the treatment will be ineffective. Post-emergent, grass specific herbicide (i.e., Fusilade® DX) is the preferred method for controlling purple false brome versus mowing or line trimming because it is relatively small in stature compared to other nonnative annual grasses (Land IQ and CBI 2017).

Mature bunchgrasses will not die from Fusilade® DX application. Nonnative, annual grasses will die from Fusilade® DX application with the exception rat-tail fescue (*Festuca myuros*), which is unaffected by this herbicide. Fusilade® DX kills native, annual grasses and native, perennial grass seedlings.

Apply herbicide using a back-pack sprayer in small to medium occurrences or truck-mounted or all-terrain vehicle (ATV)-mounted spray systems in large occurrences. It is less expensive to treat grass in large occurrences using truck and ATV-mounted systems compared to back-pack sprayers.

Apply herbicide at least once, and possibly a second time if grasses germinate again after a late winter or early spring rain. Apply herbicide for 4-5 years and ensure that the applicator(s) is experienced and possesses a Qualified Applicator License (QAL).

Mowing and Line Trimming. Mow or line trim nonnative, annual grasses (if not using herbicides) in February-March, prior to fruit formation (when species is flowering or just as fruit is forming); however, as with herbicide treatments, timing is critical and target species phenology is known to differ each year and by site; thus, experienced restoration ecologists/biologists should check a site several times to ensure correct timing for mowing and line trimming. If fruit has matured and seed is setting, then it is too late to mow or line trim nonnative grasses.

Establish a management buffer around the target population(s) of at least 3 feet. Mow nonnative grasses in the population and buffer using a tractor-mounted rotary or flail mower and line trim using a line (string) trimmer. Line trimmers are effective for small and inaccessible populations or where native shrubs grow with Otay tarplant. Use tractor-mounted rotary mowing when grasses are initially dense and switch to a flail mower when grasses are less dense, i.e., several years after rotary mowing (Land IQ and CBI 2017).

Leave all cut biomass in place since it precludes germination of nonnative forbs, unlike the combination of dethatching followed by applying herbicide, which increases cover of bare ground and germination of nonnative forbs. Leaving cut biomass onsite also decreases native species germination in the short-term. However, this material breaks down over time. In addition, the cover of nonnative species decreases with each mowing or trimming event. Eventually, site conditions will allow for increased germination of native (and nonnative) species (CBI 2014b).

<u>Step 3: Control Nonnative Forbs and Competitive Native Plants</u>

Control nonnative forbs and competitive native plants if IMG monitoring data indicate that cover of either group is ≥25% within the maximum extent. Establish a management buffer around the target occurrence(s) of at least 3 feet. Control nonnative forbs and competitive native plants in the occurrence(s) and in the buffer.

Herbicide. Follow herbicide label directions to determine application rates, timing, and limitations/restrictions, and proper personal protection equipment. Treat nonnative forbs and target species unaffected by Fusilade® DX® (i.e., rat-tail fescue) in late winter and early spring (March-April) based on target species phenology with a non-selective post-emergent herbicide. Choose the appropriate herbicide based on the target nonnative or competitive native plant(s) and ensure that the applicator(s) is experienced and possesses a QAL.

Apply herbicide to basal rosettes and bolting and flowering target species using a backpack sprayer (e.g., battery-operated Birchmeier) or weed wand. Use a backpack sprayer if Otay tarplant does not grow densely with nonnative forbs and competitive native plants (i.e., greater than several inches of distance between Otay tarplant and the target species). Expect some native species collateral damage where native and nonnative species co-occur densely. Use a weed wand or hand clip target plants for small populations and where Otay tarplant grows densely with nonnative forbs and competitive native plants.

Manage nonnative forbs and competitive native plants at least one time a year for 4-5 years.

Mowing and Line Trimming. Do not use a tractor-mounted mower to cut nonnative forbs or competitive native forbs since it will impact Otay tarplant and other desirable native species. Use a line trimmer, scythe, or machete to cut nonnative forbs and competitive native species in late winter and early spring (March-April, depending on target species phenology) if not using herbicide.

Remove all cut biomass from the site or pile it onsite if removing the biomass is not possible for logistical or budgetary reasons. For biomass left onsite, place it in mulch piles and/or in temporary fenced enclosures, or cover with black plastic or tarp to prevent seed from germinating (Ekhoff pers. comm.). Monitor and treat any invasive plants that germinate from uncovered mulch piles.

Manage nonnative forbs and competitive native plants at least two times a year for 4-5 years.

Species Restoration

In this section, we discuss seeding to restore occurrences and increase population size. The BMPs in this section and BMP flowchart (Figure 59) refer primarily to small and possibly, medium occurrences. Since large occurrences presumably support a stable soil seed bank, we do not recommend adding Otay tarplant seed unless there is a decline in population size category when monitored over at least five years (including one or more years with favorable climatic conditions).

We recommend *reintroducing* seed into small, declining occurrences if threats are controlled, habitat is likely to support this species in the future, and funding is available for short- and long-term management. Potential seed sources for reintroduction include (1) seed collection and *ex situ* bulking in a nursery setting (as needed) or (2) *in situ* management of existing plants (e.g., watering) to maximize seed production (‘bulking onsite’) and increase the soil seed bank. Practitioners may choose to reintroduce seed into medium occurrences to increase size. Refer to Step 4 for guidelines on reintroducing seed.

We recommend *introducing* seed into suitable habitat within Opportunity Areas (e.g., gaps) to create steppingstone occurrences that improve gene flow, if warranted by genetic or regional population structure, and following BMPs in Step 4 (below) for reintroducing seed into extirpated occurrences.

At this time, we do not recommend *translocating* seed outside of the species’ current range, based on habitat suitability models under future climate scenarios (SDMMP in CBI 2018).

Refer to appropriate management strategies to improve genetic structure (Table 55), the genetic structure of the target occurrence (Table 56), and the genetic cluster (Figure 54) to identify genetically appropriate seed source(s) for reintroduction. The SCBBP also designates seed zones to identify appropriate seed sources. In general, we recommend sourcing seed from the target occurrence (if adequate seed is available to bulk or sow directly) or from a genetically compatible occurrence (as addressed in this document and the SCBBP).

Refer to the SCBBP for BMPs for collecting, banking, and bulking tarplant seed for restoration. The BMPs address timing of collections, amount of seed to collect, maximizing diversity in a collection, and transporting, storing, and processing seeds. We recommend that only experienced seed collectors collect tarplant seed per the SCBBP. The BMPs for bulking seed address potential nurseries, bulking methods, and maximizing genetic diversity in bulked samples.

At this time, species experts do not recommend growing Otay tarplant in a nursery and outplanting individual plants.

Finally, consider climatic conditions when assessing the success of any seeding effort. For example, drought may prevent sufficient germination, but seed may persist in the soil seed bank.

Step 4: Reintroduce Seed

Small, Extant Occurrences. We recommend the following guidelines to reintroduce seed into small, extant occurrences of Otay tarplant:

- Reintroduce tarplant seed into all extant occurrences that support fewer than 100 plants *and* meet the reintroduction criteria outlined in the previous section. In these cases, seed reintroduction is critical to the long-term persistence of the species.
- Reintroduce tarplant seed into small, declining occurrences that support more than 100 plants if these occurrences do not respond positively to dethatching and control of nonnative or competitive native plants.
- For all seed reintroductions into small occurrences, refer to the genetics section of this chapter and seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive plants after reintroducing seed, as necessary.
- For all seed reintroductions into small occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
- Where small occurrences have increased in size, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
- Where small occurrences have not increased in size or have decreased, even under favorable conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

The objective of reintroducing seed in an existing occurrence is to increase population size to a level that reduces the potential for extirpation or adverse effects from inbreeding. For very small occurrences (<100 individuals), it may take time, multiple reintroductions, and intensive management to achieve this objective. In these cases, success of a single reintroduction may be measured by a two- or three-fold increase in occurrence size.

Medium, Extant Occurrences. We recommend the following guidelines to reintroduce seed into medium occurrences of Otay tarplant:

- Reintroduce seed of Otay tarplant into medium occurrences that appear to be declining and that do not respond positively to dethatching and control of nonnative or competitive native plants.
- For all seed reintroductions into medium occurrences, refer to the genetics section of this chapter and seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collection, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section. Continue managing invasive plants after reintroducing seed, as necessary.
- For all seed reintroductions into medium occurrences, assess the success of the reintroduction effort annually for 4-5 years after seeding:
    - Where medium occurrences appear stable under favorable conditions, continue weed control at a frequency sufficient to maintain cover of target invasive plants at ≤25% cover within the maximum extent area.
    - Where medium occurrences are declining even under favorable conditions, consider reintroducing additional seed or assess the site to determine whether it can reasonably support this species in the future.

Extirpated Occurrences. We recommend the following guidelines to reintroduce seed into confirmed historic but extirpated occurrences:

- Prior to reintroducing seed, restore habitat by dethatching (if necessary) and controlling invasive or competitive native plants for three years (see Steps 1-3, above).
- Prior to reintroducing seed, test the soil to ensure that it falls within identified soil parameters known to support this species (e.g., texture, chemical composition, cracks).
- Refer to the genetics section of this chapter and seed zones in the SCBBP for genetically appropriate seed sources. Refer to the SCBBP for guidelines on seed collecting, banking, and bulking for this species. Refer to guidelines on outplanting (sowing) seeds in this section.
- Proceed with seed reintroduction steps outlined above for small, extant occurrences.

Outplanting (Sowing) Seed. Based on input from species experts, we provide the following guidelines for outplanting (sowing) tarplant seed into prepared sites:

- Sow seed in the fall before the first significant rainfall event. Consider (1) distributing one half of the bulked or collected seed before the first rainfall event and the second half after the second rainfall event and (2) retaining a portion of the seed (e.g., 10%) to use in subsequent seeding efforts if the first effort fails or if rainfall is not sufficient for tarplant germination, flowering and seed set.
- Hand-broadcast seed only into sites where thatch has been removed and/or invasive plants controlled. Removing cover prior to sowing will promote germination through increased seed-to-soil contact and reduce competition for tarplant seedlings. After hand-broadcasting, do not rake seed into the soil as Otay tarplant soils support microtopography sufficient for protecting seed and stimulating germination (Dodero pers. comm.).

Step 5: Continue Weed Control

- After reintroducing seed, continue to manage nonnative grasses and forbs and competitive native plants as outlined in Steps 2 and 3, at a frequency to maintain cover of these species at ≤25% cover in the maximum extent at an occurrence.

Additional Research Needs

The list of additional research needs is derived from a number of sources, including planning documents, research studies, and identified gaps in relevant information about Otay tarplant.

Genetics

- Collect genetic samples throughout the range of this species in Baja California to compare with San Diego occurrences in terms of genetic diversity.

Pollinators

- Determine *effective* pollinators and their host plants, maximum pollinator migration/travel distance, and potential effects of climate change on pollinator communities in relation to Otay tarplant phenology.

Seed Biology

- Refine our understanding of seed dormancy factors, germination cues, and viability rates.
- Determine dispersal agents and dispersal capabilities of Otay tarplant seed.

Soils

To isolate the potential effects of sodium on habitat preferences of Otay tarplant, we recommend experiments to differentiate between salinity and clay mineralogy effects. Potential experiments include:

- Test the effect of sodium on competitive success by comparing establishment and growth of Otay tarplant at a range of sodium concentrations in monoculture or in competition with exotic annuals
- Test the role of clay mineralogy experimentally by comparing establishment of seedlings in soils that have identical clay content but vary in mineralogy.
- Test direct and indirect effects of pH with a factorial experiment varying pH and micronutrients, and adding nitrogen in two forms (nitrate vs. ammonium).

Additional soil experiments include:

- Explore the importance of sand, silt, and clay fractions, as well as porosity and bulk density for this species. Examining the vertical soil structure in a careful, fine scale fashion could also be helpful.
- Test the hypothesis that Otay tarplant exhibits a low fertility strategy by comparing competitive performance along a fertility gradient where phosphorus and possibly micronutrients such as zinc are increased.
- Test Otay tarplant tolerance to deviations from the reported soil chemistry and texture. Otay tarplant appears to exist in a broader envelope of soil properties (in terms of chemistry and texture) than other clay endemics in San Diego County (CBI 2018). There might be habitat outside of the historic range of this species (its realized niche) that is suitable for establishing or translocating new populations.

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Appendix A

Meeting Participants

Rare Plant Management Group Steering Committee

Rare Plant Working Groups

Appendix A

Participants in Rare Plant Management Group, Steering Committee Meeting and Working Group Meetings

Rare Plant Management Group Steering Committee Meeting: June 12, 2019.

Steering Committee Participant	Organization
Sara Allen	City of San Diego
Mark Berninger	City of San Diego
Mary Crawford	U.S. Fish and Wildlife Service
Mark Dodero	RECON Environmental
Patricia Gordon-Reedy	Conservation Biology Institute
Jenna Hartsook	AECOM
Christa Horn	San Diego Zoo Global
Joyce Maschinski	San Diego Zoo Global
Sarah McCutcheon	San Diego Management and Monitoring Program
Scott McMillan	Dudek
Thomas Oberbauer	AECOM
Chelsea Ohanesian	AECOM
Kris Preston	San Diego Management and Monitoring Program
Kyle Rice	California Department of Fish and Wildlife
Fred M. Roberts	Botanist
Kim Smith	San Diego Association of Governments
Amy Vandergast	U.S. Geological Survey
Susan Wynn	U.S. Fish and Wildlife Service

San Diego Thornmint Working Group Meeting: June 25, 2019.

Working Group Participant	Organization
Sara Allen	City of San Diego
Stacy Anderson	San Diego Zoo Global
Mark Berninger	City of San Diego
Cindy Burrascano	California Native Plant Society-San Diego
Carol Crafts	Friends of Goodan Ranch & Sycamore Canyon
Mark Dodero	RECON Environmental
Justin Daniel	California Native Plant Society-San Diego
John Ekhoff	California Department of Fish and Wildlife
Sarah Godfrey	Center for Natural Lands Management
Patricia Gordon-Reedy	Conservation Biology Institute
Christa Horn	San Diego Zoo Global
Mike Kelly	Friends of Los Peñasquitos Canyon Preserve
Anna Leavitt	RECON Environmental
Chris Manzuk	Endangered Habitats Conservancy
John Martin	San Diego National Wildlife Refuge
Joyce Maschinski	San Diego Zoo Global
Sarah McCutcheon	San Diego Management and Monitoring Program
Scott McMillan	Dudek
Margie Mulligan	Mulligan Biological Consulting
Tracie Nelson	California Department of Fish and Wildlife
Thomas Oberbauer	AECOM
Chelsea Ohanesian	AECOM
Meredith Osborne	California Department of Fish and Wildlife
Eric Piehel	AECOM
Kathleen Pollett	San Diego Habitat Conservancy
Kristine Preston	San Diego Management and Monitoring Program
Kyle Rice	California Department of Fish and Wildlife
Jonathan Snapp-Cook	U.S. Fish and Wildlife Service
Markus Spiegelberg	Center for Natural Lands Management
Fred Sproul	AECOM
Amy Vandergast	U.S. Geological Survey
Jessie Vinje	Conservation Biology Institute
Phoenix Von Hendy	Friends of Goodan Ranch & Sycamore Canyon
Gina Washington	City of San Diego

Otay Tarplant Working Group Meeting: June 25, 2019.

Working Group Participant	Organization
Sara Allen	City of San Diego
Mark Berninger	City of San Diego
Mark Dodero	RECON Environmental
John Ekhoff	California Department of Fish and Wildlife
Patricia Gordon-Reedy	Conservation Biology Institute
Christa Horn	San Diego Zoo Global
Anna Leavitt	RECON Environmental
John Martin	San Diego National Wildlife Refuge
Sarah McCutcheon	San Diego Management and Monitoring Program
Margie Mulligan	Mulligan Biological Consulting
Tracie Nelson	California Department of Fish and Wildlife
Chelsea Ohanesian	AECOM
Meredith Osborne	California Department of Fish and Wildlife
Kristine Preston	San Diego Management and Monitoring Program
Trish Smith	The Nature Conservancy
Linnea Spears-Lebrun	ICF
Jessie Vinje	Conservation Biology Institute

Nuttall's Acmispon Working Group Meeting: June 27, 2019.

Working Group Participant	Organization
Sara Allen	City of San Diego
Stacy Anderson	San Diego Zoo Global
Alys Arenas	Nature Collective
Christine Beck	California Department of Fish and Wildlife
Mark Berninger	City of San Diego
Cindy Burrascano	California Native Plant Society-San Diego
Megan Flaherty	San Diego Audubon
Patricia Gordon-Reedy	Conservation Biology Institute
Christa Horn	San Diego Zoo Global
Frank Landis	California Native Plant Society-San Diego
Carolyn Lieberman	U.S. Fish and Wildlife Service
Joyce Maschinski	San Diego Zoo Global
Sarah McCutcheon	San Diego Management and Monitoring Program
Andrew Meyer	Audubon
Margie Mulligan	Mulligan Biological Consulting
Tracie Nelson	California Department of Fish and Wildlife
Thomas Oberbauer	AECOM
Kris Preston	San Diego Management and Monitoring Program
Debbie Schafer	San Diego Gas & Electric
Julie Simonsen	Nature Collective
Darren Smith	California State Parks
Jessie Vinje	Conservation Biology Institute

Salt Marsh Bird's-beak Working Group Meeting: June 27, 2019.

Working Group Participant	Organization
Sara Allen	City of San Diego
Stacy Anderson	San Diego Zoo Global
Alys	Nature Collective
Mark Berninger	City of San Diego
Patricia Gordon-Reedy	Conservation Biology Institute
Christa Horn	San Diego Zoo Global
Carolyn Lieberman	U.S. Fish and Wildlife Service
Sarah McCutcheon	San Diego Management and Monitoring Program
Margie Mulligan	Mulligan Biological Consulting
Thomas Oberbauer	AECOM
Julie Simonsen	Nature Collective
Jessie Vinje	Conservation Biology Institute
Daniel North	Tidal Influence
Mark Hannaford	Tidal Influence
Kris	San Diego Management and Monitoring Program
Bronti Patterson	California State Parks
Sarah Hutmacher	San Diego River Park Foundation
Carol Williams	California Department of Fish and Wildlife
Heather Schneider	Santa Barbara Botanic Garden
Amy Vandergast	U.S. Geological Survey (U.S. Geological Survey)
Cindy	California Native Plant Society-San Diego
Araceli Dominguez	City of San Diego
Chelsea Ohanesian	AECOM

Appendix B

General Framework

Best Management Practices

Appendix B
General Best Management Practices

Standard or routine land management/stewardship practices will be sufficient to control many threats, and are often straightforward, included in preserve management plans, and accommodated within annual preserve budgets. For other threats, particularly those related to habitat or species management, species-specific actions may be required.

This appendix briefly describes standard or routine BMPs or indicates where more specific BMPs are provided in this document. These BMPs are appropriate for any MSP rare plant species.

<u>Altered Hydrology</u>

Depending on type and extent of altered hydrology, control water source (e.g., increased runoff from surrounding area) by diverting water away from or increasing flow toward MSP rare plant occurrence(s). Where source of altered hydrology occurs on adjacent land, work with surrounding land owners/managers or regional entities to develop a long-term solution to hydrology. Where altered hydrology is due to changing climatic conditions or permanent disturbance (e.g., a road bisecting or influencing the hydrology of an occurrence), prepare a long-term hydrological management plan that may include moving MSP rare plants or modifying habitat. If altered hydrology is due to historic disturbances (i.e., altering of rivers, creeks, estuaries; installing dams) that cannot be managed, continue to monitor the occurrence to determine if altered hydrology is an ongoing threat or if the occurrence has stabilized in spite of the historic disturbance. If altered hydrology is an ongoing threat, refer to species-specific BMPs for introducing or translocating populations outside of affected areas.

<u>Brush Management</u>

Prior to brush management, flag maximum extent of occurrence (or portions of occurrence adjacent to proposed brush management area) to ensure there is no damage to MSP plants or habitat; consider monitoring the activity to ensure boundaries are respected and cut material is not left within occurrences.

<u>Competitive Native Plants</u>

Refer to species-specific chapters for BMPs to control competitive native plants.

<u>Dumping/Trash</u>

In general, land managers should remove trash during routine or stewardship visits.

Where the dumping is ongoing or recent, identify how trash is arriving onto the site and prevent further incidents by installing or reinforcing gates, fences, and/or signage. Remove trash using the annual preserve budget. If the annual budget is insufficient, phase removal over several years or apply for grant funding. Hire a contractor to assist with removal if the trash presents unsanitary or unsafe conditions or is too large to remove using available equipment.

Where dumping appears to be old or historic, remove using the annual preserve budget. If the annual budget is insufficient, phase removal over several years or apply for grant funding. Hire a contractor to assist with removal if the trash presents unsanitary or unsafe conditions or is too large to remove using available equipment.

Encampments

Determine whether the encampment is currently occupied or abandoned. For occupied encampments, contact local law enforcement to assist with the proper removal process. For abandoned encampments, remove debris using the annual preserve budget or phase removal over several years if the annual budget is insufficient. Hire a contractor to assist with removal if the trash presents unsanitary or unsafe conditions or is too large to remove using available equipment.

Erosion

Install erosion control devices (e.g., gravel or gravel bags, straw wattles, water bars) as needed to reduce or eliminate adverse effects to MSP rare plants or habitat from erosion. Inspect erosion control measures annually (prior to winter rains) and repair or replace, as needed.

Where gullies threaten MSP rare plants, smooth and contour gully slopes as needed where soil is falling away. To stabilize the smoothed slope and prevent further erosion, install erosion control blankets (e.g., jute mesh, Coir mat).

Where erosion occurs due to natural processes (i.e., erosion along edges of estuary banks) and cannot be managed, continue to monitor to determine the effects of erosion on the occurrence. If erosion is an ongoing threat, refer to species-specific BMPs for introducing or translocating populations outside of areas prone to ongoing erosion.

Fuel Modification

For MSP rare plants that are most at-risk from fire, manage thatch and invasive annuals every 3-5 years at large occurrences to reduce fire threat, particularly if either the ignition probability or fire frequency is greater than 3, per fire maps in the MSP Roadmap, or the occurrence has burned since 2003 (SDMMP and TNC 2017). Maps of fire ignition probabilities and fire frequency can be found at:

https://sdmmp.com/upload/threats/threats_background/MSP%20Vol2B%20Fire%202017%20ReducedSize_1494454260.pdf

MSP target plants with occurrences at-risk from fire include:

- San Diego thornmint

Historic Grazing

Nonnative grasslands and other disturbed habitats are often a legacy of historic grazing. Where MSP rare plants occur on formerly grazed sites with a high cover of nonnative species and/or associated thatch, refer to species-specific chapters for BMPs to restore habitat or the rare plant species.

Historic Agriculture

Nonnative grasslands and other disturbed habitats are often a legacy of historic agriculture. Where MSP target plants occur on former agricultural sites with a high cover of nonnative species and associated thatch, refer to species-specific chapters for BMPs to restore habitat or the rare plant species.

Nonnative Forbs

Where nonnative forbs are identified as a threat to MSP rare plant species, refer to species-specific chapters for BMPs to control these invasive plants.

Nonnative Grasses

Where nonnative grasses are identified as a threat to MSP rare plant species, refer to species-specific chapters for BMPs to control these invasive plants.

Nonnative Woody Plants

Cut nonnative woody plants that occur within an MSP rare plant occurrence and remove debris. In some cases, it may be necessary to remove woody plants from buffer areas where they are shading habitat for the MSP rare plant. Use herbicides to control nonnative woody plants that resprout after cutting.

ORVs, Mountain Bikes

Where ORV or mountain bike activity is identified as a threat to an occurrence, consider (1) informing users of the threat and discussing alternative routes through an organized outreach event, (2) fencing the occurrence or preserve, (3) removing or rerouting trails, or (4) installing barriers or signage to prevent damage to the MSP rare plant and habitat. Refer to species-specific BMPs to restore habitat or species, if necessary. Maintain regular contact with adjacent homeowners and regular preserve users to ensure that illegal ORV or mountain bike activity ceases.

Use annual preserve budgets to conduct outreach events and to monitor, maintain and repair damaged fencing, barriers, and signage.

Where mountain bike activity is an ongoing threat, consider contacting the San Diego Mountain Bike Association for assistance in designing/rerouting trails.

<u>Recent Fire</u>

Where fire impacts MSP rare plant occurrences, implement the following actions post-burn:

- Conduct post-fire surveys for 2-3 years after the fire to map the extent of the occurrence burned and monitor recovery of the MSP rare plant.
- Conduct invasive plant surveys for 2-3 years after the fire to identify invasive plants that emerge in the burned portion of the occurrence; treat invasive plants per species-specific BMPs.
- Continue monitoring the occurrence to track post-fire response. If the MSP rare plant does not respond positively within 5 years (i.e., stable or increased population size), consider reintroducing seed when threats are controlled per species-specific BMPs.

<u>Road Construction</u>

Prior to road construction (or maintenance), flag maximum extent of occurrence (or portions of occurrence) adjacent to proposed road construction or maintenance area to prevent damage to MSP rare plants or habitat; consider monitoring the activity to ensure boundaries are respected and brush or soil is not left within occurrences.

If roads are maintained by utility companies, prepare and distribute maps to utility maintenance personnel that show the locations of MSP rare plants to avoid.

<u>Slope Movement</u>

Slope movement can be very slow and barely noticeable (i.e., soil creep) or so rapid that it results in massive amounts of soil loss (i.e., rock fall, debris flow, earth slump). Where soil creep is affecting an MSP rare plant occurrence, determine the cause of slope movement and install BMPs to prevent or reduce soil loss or erosion. Annual preserve budgets should be sufficient to cover the costs of addressing minor slope movement and installing erosion control devices.

For massive slope movement events that affect MSP rare plants or habitat significantly, the land manager may need to develop a restoration plan that addresses the underlying issue and repairs the damage. In this case, regional and/or grant funding may be needed to fund the restoration effort.

Soil Compaction

Where soil compaction is negatively affecting a MSP rare plant, consider collecting seed, ripping the soil, and reintroducing seed. If the soil is too compact or ripping is not possible due to onsite or preserve restrictions, consider bringing soil from nearby areas or other suitable habitat locations before reintroducing seed. Importing soil should be used only for species with fairly broad soil requirements and as a last resort. We do not recommend importing soil for MSP rare plants that are edaphic endemics with specific soil requirements (e.g., San Diego thornmint, Otay tarplant).

Trails

Where trails are identified as a threat to an occurrence, consider holding outreach events to inform the public of the threat to MSP rare plants and reroute the trail, and/or install fencing, barriers or signage to prevent damage to the MSP rare plant and habitat. Refer to species-specific BMPs to restore habitat or species, if necessary.

Use annual preserve budgets to conduct outreach events and to monitor, maintain and repair damaged fencing, barriers, and signage. Signs featuring children's artwork appear to be effective in promoting compliance with trail regulations.

Trampling

Where trampling has been identified as a threat to an occurrence, install fencing, barriers, and/or signage to prevent further damage to the MSP rare plant and habitat. If the trampling is associated with trail use, refer to the trails BMP. Refer to species-specific BMPs to restore habitat or species, if necessary.

Vandalism

Vandalism is most often associated with large woody shrubs and trees and not expected to be a common threat to most MSP rare plants; however, if a land manager observes vandalism, install fencing around the occurrence or vandalized plants and install educational signage. Consider holding outreach events to inform users of the effects to the MSP rare plant from vandalism.

Vegetation Clearing

Prior to vegetation clearing, flag maximum extent of occurrence (or portions of occurrence adjacent to proposed vegetation clearing) to ensure there is no damage to MSP plants or habitat; consider monitoring the activity to ensure boundaries are respected and cut material is not left within occurrences.

Other Threats

During IMG monitoring, there were a number of threats recorded that did not fit into the established threat categories. Examples include climate change and associated effects (i.e., sea level rise, king tides, prolonged drought), equipment storage (e.g., storage containers, portable dumpsters), historic grading, and BMX bike tracks and jumps.

Mitigating the effects of climate change should be addressed at the regional level using regional and/or grant funding. In some cases, land managers may need to participate in and assist with preparing and implementing a long-term climate adaptation strategy for the MSP rare plant or habitat.

Remove all large equipment, portable dumpsters and storage containers from MSP rare plant occurrences. Monitor the area and identify any associated threats, such as nonnative invasive forbs and grasses, erosion, or soil compaction. Restore damaged occurrences (if needed) following the BMPs specific to each identified threat. Educate land managers, rangers, and other agency staff to prevent the storage of land management equipment on rare plant occurrences in the future.

For historic grading or soil disturbance associated with BMX bike tracks and jumps, restore the graded or damaged habitat and follow the BMPs outlined above for ORVs and mountain bikes, trails, and soil compaction. Fence restored occurrences and install signage. Consider holding outreach events to inform users of the effects to MSP rare plants from the identified threat.