South San Diego County

Coastal Cactus Wren *(Campylorhynchus brunneicapillus)*

Habitat Conservation and Management Plan

Prepared for:

San Diego Association of Governments

Prepared by:

The Nature Conservancy

In collaboration with

San Diego Management and Monitoring Program

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Table of Contents

Appendices

List of Tables

Page

List of Figures

Page

SOUTH SAN DIEGO COUNTY

COASTAL CACTUS WREN
CONSERVATION AND MANAGEMENT PLAN

1 INTRODUCTION

Cactus wrens (*Campylorhynchus brunneicapillus*) are distributed across the arid regions of southwestern United States and northern and central Mexico (Hamilton et al. 2011). While the desert populations are fairly abundant, populations of coastal cactus wrens have declined dramatically over the past 20 years, with extirpation from many locations as a result of habitat loss, habitat fragmentation, edge effects of development, and catastrophic fires (Solek and Szijj 2004). The coastal population is unique in that it occurs exclusively within the coastal sage scrub plant community, ranging from Ventura County south into San Diego County, U.S.A. and northwestern Baja California, Mexico.

Within San Diego County, the coastal cactus wren is found almost entirely within the Management Strategic Plan (MSP) Area. The MSP provides a biologically-based foundation to support decision making and funding priorities for managing species and vegetation communities across western San Diego County. As such, the coastal cactus wren has been designated a "Category SO" species within the MSP - a species whose persistence at one or more significant occurrences in the planning area is at high risk of loss without immediate management action above and beyond that of daily maintenance activities. The MSP has been divided into 8 management units (MUs) for planning purposes, and the cactus wren is found in MUs 1, 2, 3, 4, 5 and 6. The largest concentrations of cactus wrens are found in MU's 3 (Janal MU) and MUs 5 and 6 (Lake Hodges/San Pasqual Valley). The south San Diego County study area is shown in Figure 1.

The MSP's Janal MU3, which extends southward from Interstate 8 to the Mexican border and eastward from Interstate 5 to the San Diego Multiple Species Conservation Plan (MSCP) boundary, represents the largest assemblage of Conserved Lands in the MSCP and also the most biodiverse landscapes in all of San Diego County, supporting more than 75 species considered rare or listed as threatened or endangered.

Conserved Lands in MU3 have long been recognized as a stronghold for the coastal cactus wren with estimates in the 1990s of over 100 occurrences distributed from the Sweetwater River southward to the Otay River Valley (CNDDB 2013). Since the 1990's, the coastal cactus wren population in this area has declined significantly. Several factors may have contributed to this decline, including habitat loss/fragmentation from agriculture and urban development, wildfire, habitat degradation, predation and intensive drought with low productivity. As identified herein, since 1992, cactus wrens have been extirpated from several areas within MU3, with some small populations possibly disappearing in just the last few years. Moreover, recent regional coastal cactus wren genetics studies by US Geological Survey (Barr et al. 2012, 2013, 2015) have revealed that cactus wrens in the Otay River Valley area are genetically isolated from populations to the north, and that this population is experiencing a genetic

South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 1: Study Area Location

Management Unit

Conservation / Public Land*

*Conservation / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations.
Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

bottleneck. Although physical distance is close (~10 km), there is no habitat connectivity to the El Cajon/San Diego genetic cluster to the north.

Recognizing the significance of these populations and the implications for additional loss, this 5-year action plan proposes specific management actions to be implemented to ensure the persistence of the coastal cactus wren in MU3 over the next 100 years.

1.1 Purpose

This document has been prepared to help fulfill MSP Goals and Objectives established for management of the Coastal Cactus Wren in MU3 (Appendix A).

Specifically, the Goal for MU3 established in the MSP is as follows:

"*Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the Otay River and San Diego/El Cajon genetic clusters to expand the occurrences to a sustainable effective size to avoid inbreeding, enhance habitat connectivity throughout the Otay River Valley, and potentially connect this occurrence to the San Diego/El Cajon genetic cluster (depending on results of the in-progress study on historic genetic structure) to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years)*."

The Specific Management Objective relating to the purpose and need for this plan is outlined in the MSP Objectives:

"*In 2014, prepare an implementation plan for enhancing and restoring cactus scrub habitats on Conserved Lands in MUs 3 and 4 in order to expand the Otay and San Diego/El Cajon cactus wren genetic clusters and enhance connectivity*."

This plan identifies and prioritizes management and restoration needs for the cactus wren across the entire MU3, and also assesses connectivity to core habitat areas on Conserved Lands within the San Diego/El Cajon cactus wren genetic cluster in MUs 2 and 4 to further ensure persistence of the cactus wren in MU3 over the next 100 years.

1.2 Approach and Planning Area

The approach used to develop this plan is outlined below.

1. Review existing data, including US Fish and Wildlife Service (USFWS) 2009 and 2011 cactus scrub mapping and cactus wren survey data, historic cactus wren location data, property ownership to identify Conserved Lands available for survey and potential management, available cactus scrub restoration plans and status reports prepared by land managers, and USGS genetics study survey data (including negative data).
2. Identify potential environmental correlates based on regional cactus wren habitat data, and develop a cactus wren habitat suitability model for southern California to identify potential cactus scrub restoration sites in MUs 2, 3 and 4.
3. Conduct surveys on Conserved Lands in MUs 2, 3 and 4 to document current cactus wren occupancy, assess current cactus scrub habitat conditions, evaluate current restoration activities,

characterize potential threats, and determine management needs. Identify and prioritize suitable sites for potential cactus scrub enhancement/creation that will expand occurrences and increase connectivity *within* the genetic clusters, particularly in MU3.

4. Using the habitat suitability model developed in step 2, identify potential restoration scenarios to connect cactus scrub habitat *between* the San Diego/El Cajon and Otay River genetic clusters. Evaluate and prioritize suitable sites for restoring cactus scrub between the two genetic clusters.
5. Using habitat suitability modelling information gathered in step 2, conduct surveys to assess potential connectivity between MUs 2, 3 and 4.
6. Review existing restoration efforts across the MUs to evaluate methods/success and update established Best Management Practices for cactus scrub restoration, including cactus harvest and salvage, restoration site selection, restoration and maintenance.
7. During field surveys, identify cactus sources that can be salvaged for transplanting of pads and entire plants for restoration and enhancement. Identify sites for harvesting vegetative cuttings that can be grown at a locally established cactus nursery and later planted as entire plants or segments at the restoration and/or enhancement sites.

1.3 Methods

In spring 2014 USGS revisited cactus scrub within MU3 that was previously mapped by US Fish and Wildlife Service (USFWS) during 2009 and 2011 cactus wren habitat monitoring efforts. The objectives of the 2014 surveys were to:

1) Generally assess the current condition of cactus scrub on Conserved Lands, paying particular attention to threats and potential for management action. This information was used to identify and prioritize areas in need of restoration and enhancement.

2) Conduct presence/absence surveys for cactus wrens during the breeding season. Determine the number of cactus wren territories in each conserved area. This information helped us determine the loss of wrens relative to past monitoring efforts and prioritize areas for near-term cactus scrub habitat restoration and enhancement.

These surveys were conducted in the following locations/genetic clusters in MU3, (land ownership as indicated).

<u>Otay River Valley Genetic Cluster Sites (Land Owners)</u>

- Salt Creek (Otay Ranch Preserve Owner Manager (Otay Ranch POM))
- Johnson Canyon/Lonestar Ridge (USFWS Refuge/Caltrans)
- Otay River Valley Conserved Lands (Otay Ranch POM)
- Furby North Property (County of San Diego)
- Dennery Canyon/Cal Terraces (City of San Diego)
- Upper Wolf Canyon (Otay Ranch POM)

San Diego/El Cajon Genetic Cluster Sites

- Long Canyon/Corral Canyon (City of Chula Vista)
- Sweetwater Reservoir (USFWS Refuge)
- Sweetwater Reservoir Open Space (Sweetwater Authority)
- Summit Park (County of San Diego)
- Sweetwater Reservoir (County of San Diego)
- Bonita Meadows (Caltrans/USFWS Refuge)

Study sites are depicted in Figure 2.

Cactus Wren Survey Methods

In addition to habitat assessments, USGS conducted two to three surveys at each mapped cactus patch/polygon between the months of April and June to determine presence/occupancy of cactus wren within the habitat patch. All wrens detected during habitat assessments were mapped, with information on sex, age, and color band combinations noted as possible. Following the habitat assessment, all but the Sweetwater Authority site were visited one to two additional times to conduct focused searches for wrens that included tape playback to enhance detection. Nests were checked to determine reproductive status and brood nests were mapped.

Cactus Habitat Mapping Methods

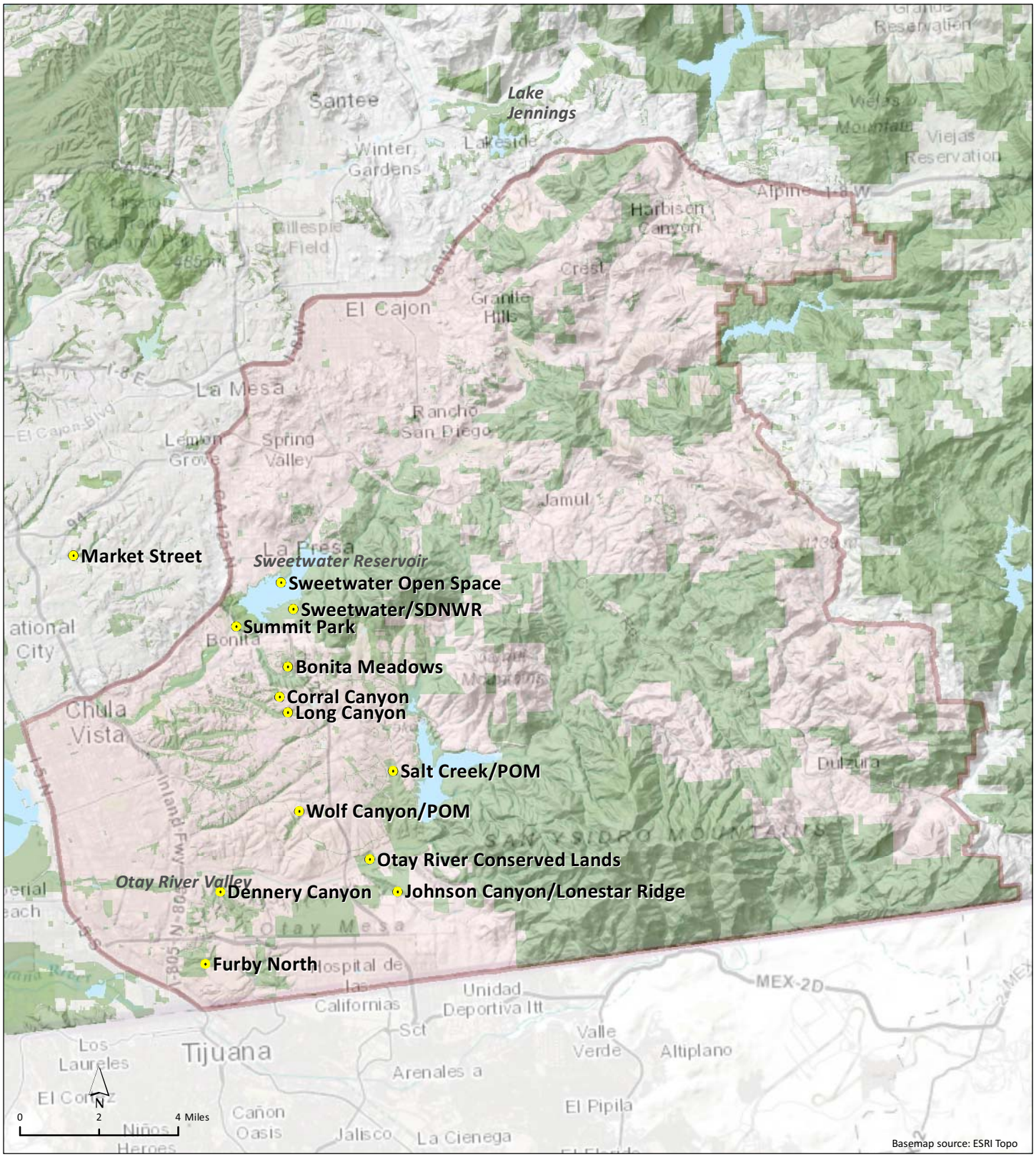
Habitat assessments consisted of first mapping the cactus patches. The mapping surveys did not overlap precisely onto previously identified USFWS polygons. Rather, cactus patches were generally mapped and assigned new polygon numbers. The habitat condition of each mapped patch was then evaluated as follows:

a. Presence (Y/N) of Mexican elderberry (*Sambucus nigra*);
b. Presence (Y/N) of lemonadeberry (*Rhus integrifolia*);
c. Identification of the top three dominant non-cactus native shrubs;
d. Identification (Y/N) of vine or shrub overtopping of cactus, to species and cover class (0-25 percent; 26-50 percent; >50 percent);
e. Identification (Y/N) of shrub crowding, to species and cover class (0-25 percent; 26-50 percent; >50 percent);
f. Identification to species and cover class of top three exotic forbs and grasses;
g. Identification of cover class of bare ground/rock (0-25 percent; 26-50 percent; >50 percent);
h. Presence and distance of tall trees (as measure of predation potential by corvids/ hawks);
i. Presence and cover class of desiccated/dead cactus (0-25 percent; 26-50 percent; >50 percent);
j. Identification (Y/N) of existing disturbances: corvids, hawks, fire, trails, encampments, urban runoff, erosion;
k. Overall habitat condition (Poor, Fair, Good, Very Good);
l. Potential for cactus scrub expansion (Y/N).

Data were recorded in the field into electronic data files on Geographic Positioning System (GPS) units.

South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 2: 2014 Cactus Wren Study Sites



Management Unit 3

Conservation / Public Land*

Study Site

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Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

2 Results and Analysis

2.1 Cactus Wren Survey Results and Analysis

A total of 155 cactus scrub polygons were mapped and surveyed on Conserved Lands in MU3 during this study. Not included in this assessment are privately owned habitat patches in the vicinity of Sweetwater Reservoir that support wrens and enhance connectivity, nor lands within the Otay River Valley that are yet to be conserved. Cactus wrens were detected at 23 (15%) of the 155 mapped polygons. Table 1 provides a summary of current habitat conditions and the number of cactus polygons where cactus wrens were detected at each conserved site surveyed by USFWS in 2009 and 2011, and by USGS in 2014. Note that, for 2014, overall cactus wren detection was likely low due to drought conditions. Cactus wren detections by USGS in 2014 surveyed polygons are depicted in Figure 3.

Overall, the number of cactus wrens detected in 2014 decreased since 2009 at all but one conserved site within the study area. One new cactus wren location was documented on San Diego National Wildlife Refuge (SDNWR) lands south of Sweetwater Reservoir, in an area that supported cactus wrens prior to the 2007 Harris fire and that has been undergoing cactus scrub enhancement since 2009.

Cactus wren detections over time within the study area are shown in Figure 4. During the 2014 surveys, cactus wrens were not detected at five locations where they were detected during 2009 and 2011 surveys. These five sites include Long Canyon and Corral Canyon in the San Diego genetic cluster, and Furby North, Otay River Conserved Lands, and Dennery Canyon in the Otay genetic cluster. All of these sites supported only one territory in 2009/2011.

Cactus wren declines were most severe at Salt Creek, where only seven cactus wren territories were detected in 2014, compared to 14 territories in 2009. Johnson Canyon cactus wren populations appear to be more stable.

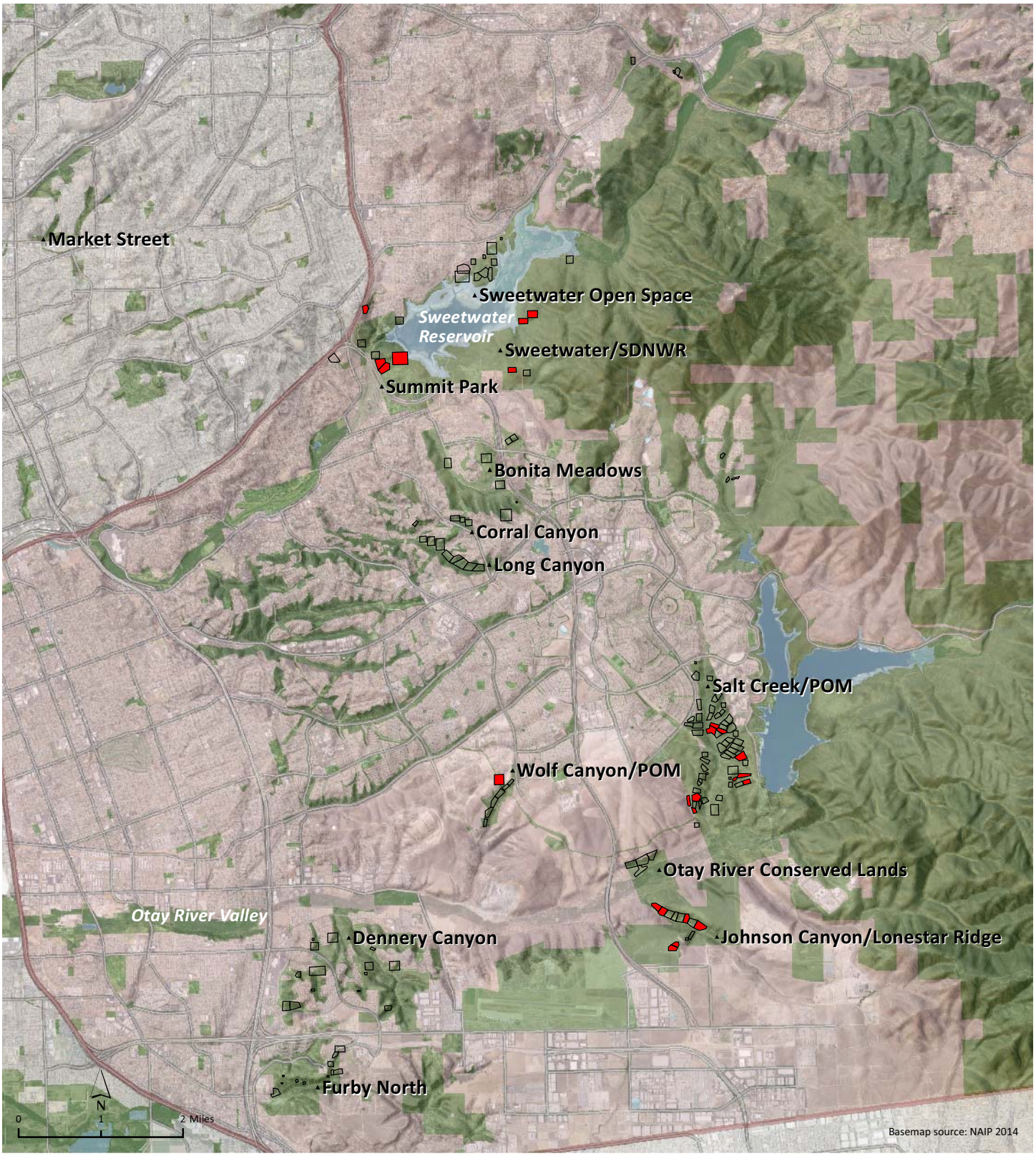
Cactus wren declines were also of concern on Sweetwater Authority lands north of the Sweetwater Reservoir, where four pairs were detected in 2009 and 2011 but none were detected in 2014. However, there was only a single survey of these Sweetwater Authority lands during the habitat assessment, which could partially explain the lack of wren detections. The single pair of cactus wrens detected in 2014 on Sweetwater Authority lands was found on the south side of the reservoir, which was also occupied in 2011.

TABLE 1: SUMMARY OF HABITAT CONDITIONS IN MU3 BY STUDY SITE

MU 3 Location	Manager	# Occupied Cactus Scrub Polygons			Summary of Habitat Conditions	Priority
		2009	2011	2014		
Otay Ranch Preserve/Salt Creek	Otay Ranch POM	23	16	6	Habitat condition variable, ranging from poor to very good. Cactus desiccation noted at most polygons. Shrub crowding and overtopping common. Ongoing habitat enhancement by Otay Ranch POM of unoccupied habitat has expanded CACW habitat and has additional benefit of reducing fuels in the event of wildfire. Several acres of additional restoration and enhancement of existing CACW habitat are possible, through weed control, shrub thinning, understory enhancement and cactus planting. Some issues with human disturbance (trails/encampments).	High
Johnson Canyon-Lonestar Ridge	Caltrans/ USFWS	8	9	6	Overall condition of cactus scrub is good to excellent as a result of ongoing enhancement efforts which were initiated in 2008. No reported cactus die off or shrub crowding. Site would benefit from addition of forbs/native grasses and expansion of cactus habitat, particularly on Lonestar portion of site.	High
Otay River Valley Conserved Lands	Otay Ranch POM	3	4	0	Habitat ranked poor to good. Some shrub crowding/overtopping and desiccation noted. ORV trespass a possible issue. Close to occupied habitat in Wolf Canyon, Salt Creek and Johnson Canyon.	High
Otay River East/Furby Ranch	County of SD	1	1	0	Overall habitat condition ranked fair-poor because of shrub overtopping, crowding and invasive plants. There remain large areas of well-developed stands of cholla. Threatened by ORV use and fragmentation. Isolated from sites known to be occupied by cactus wrens.	Low
Dennery Canyon/Cal Terraces	City of SD	1	1	0	Condition of cactus scrub ranges from poor to very good; some areas of healthy cactus scrub but also areas of cactus die-off, shrub crowding, invasive grasses, dumping and degradation from historic grazing and ORV use. Isolated from sites known to be occupied by cactus wrens.	Low
Otay POM/Upper Wolf Canyon	Otay Ranch POM	2	5	1	Site has been undergoing extensive cactus scrub restoration since 2007; habitat is developing very well and was ranked fair-good. Very little shrub crowding was noted and there were minimal signs of cactus desiccation. Some additional cactus scrub planting could be performed on east side of canyon. CACW surveys of lower Wolf Canyon are needed to assess overall status and need for management. Future development may alter hydrology and create edge effects/predator issues.	High
Long Canyon/Corral Canyon	City Chula Vista	2	0	0	Overall habitat quality ranked as poor due to shrub crowding, and overtopping, invasive plants (fennel), cactus desiccation, and habitat (perches) for potential predators. Isolated from sites known to be occupied by cactus wrens.	Low
Sweetwater/ SDNWR	USFWS	1	1	2	Site is undergoing active restoration following Harris Fire; Current habitat condition ranked as fair-good; weed cover is low with extensive areas of bare ground. One new pair of cactus wrens observed using restored/recovering habitat. Several acres of cactus scrub expansion available.	High
Sweetwater Reservoir OS	Sweetwater Authority	4	4	1	Cactus scrub ranked good to very good. Some overcrowding by sagebrush as well as CA pepper noted.	Moderate-High
Sweetwater Reservoir – Summit Park	County of SD	4	3	3	Habitat ranked as good-very good. Well-developed stands of mature cholla, open habitat with low cover of invasives and no observed shrub crowding; minimal cactus desiccation	High
Sweetwater Reservoir-County	County of SD	2	2	1	Habitat ranked as fair-good. Well-developed patches of cholla. Some human disturbance and shrub crowding noted.	High
Bonita Meadows	Caltrans/ USFWS		0	0	Overall habitat quality is fair to good. Cactus is experiencing shrub crowding, invasive plants, and die-back. Tall trees provide habitat for potential predators. Site could be potential refugia from wildfire.	Low

South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 3: 2014 Cactus Wren Detections



Survey Polygon

2014 Cactus Wren Detection

Study Site

Management Unit 3

Conservation / Public Land*

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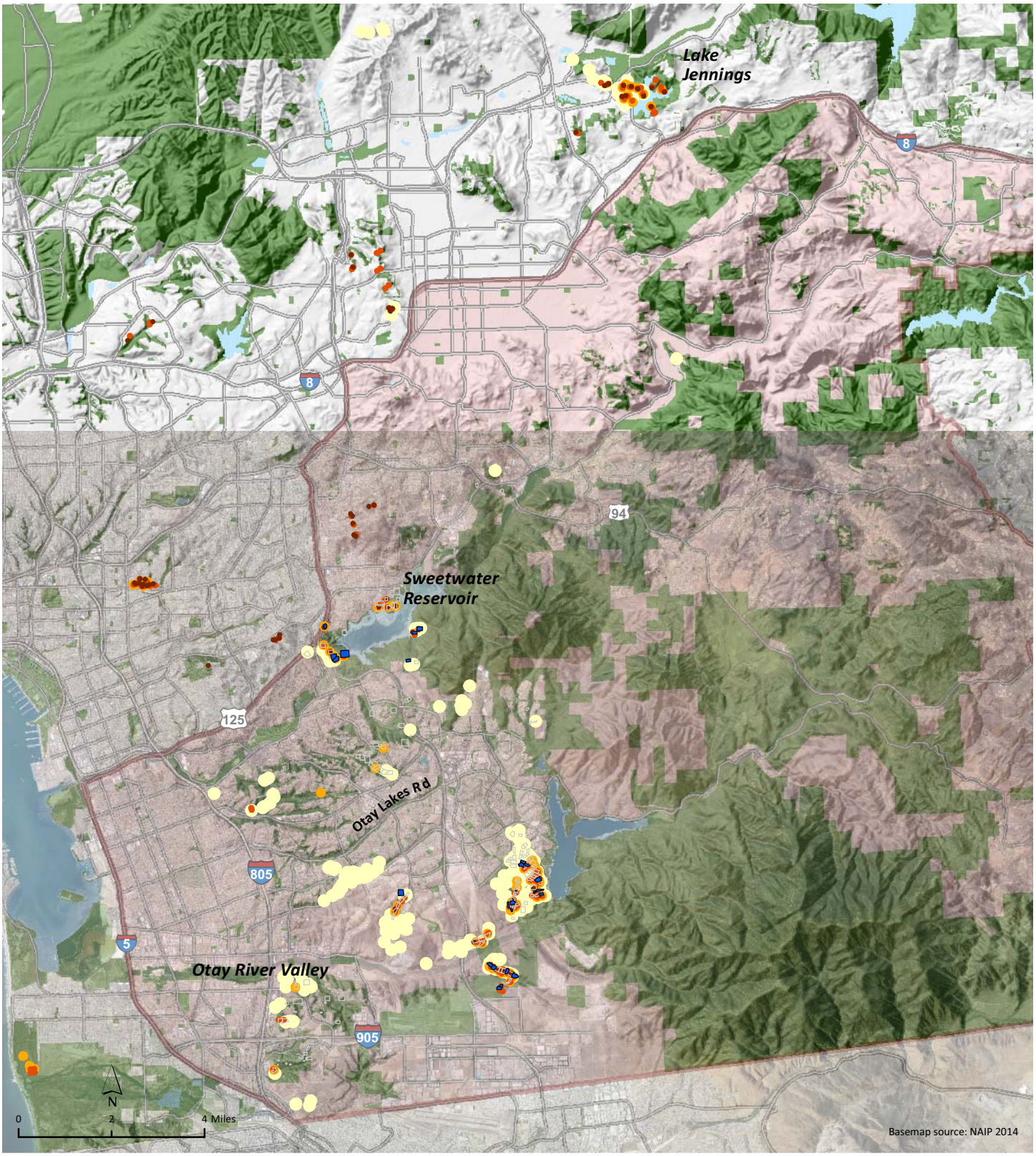
South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 4: Cactus Wrens in Management Unit 3



2014 Detection, USGS

- Detection
- No Detection

Occupied Territory, Survey Year

- 2012 USGS
- 2011 USGS
- 2009 USGS
- Historic (REGIS)

- Management Unit 3
- Conservation / Public Land*

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2.2 Otay River Valley Cactus Wren Population Status

Cactus wren declines over the last several years are of particular concern within the Otay River Valley. To better understand the possible drivers of this decline, the SDMMP analyzed three consistently surveyed conserved sites in the Otay River Valley since 1992 (Upper Wolf Canyon, Salt Creek and Johnson Canyon). This analysis is summarized below and is presented fully in Appendix B.

In the Otay River Valley, cactus wren surveys were conducted in 1988, 1989, 1992, 2009, 2011 and 2014 on Conserved Lands at Upper Wolf, Salt Creek and Johnson Canyons. Methods, survey effort and types of data collected differ among surveys, but surveyors typically provided an estimate of the number of territories (see Appendix B). We estimated the numbers of cactus wrens in cases where there were multiple entities surveying the same site in the same year or if the surveying entity did not provide an estimate. The number of territories each year represents an estimate based on available data that includes mapped wren locations over time, banding records and pairing /reproductive information.

This analysis shows that the total estimated number of territories on undeveloped lands at the three consistently surveyed sites shows a peak in 1992 with 53 territories (Figure 5). The next highest years were 1988 and 2009 with 25 territories and the low was in 2014 with 14 territories (12 pairs and 2 single males). Between 2009 and 2014 the estimated number of territories decreased overall by 40 percent.

Salt Creek declined from an estimated 41 cactus wren territories in 1992 to 15 territories in 2009 and to seven territories in 2014. Most of the decline was in the northern half of the site. Johnson Canyon was more stable over this same time period with six to nine territories, although in 2014 two of the six territories had single males rather than pairs. Upper Wolf Canyon typically supports one to two pairs, with one pair in 2014.

Based on two to three surveys per territory between April and June within the study area, productivity was unusually low in 2014. Across these three sites in the Otay River Valley, three territories (21%) produced single fledglings, eight exhibited no successful reproduction and three had unknown reproductive success.

2.3 Factors Associated with Coastal Cactus Wren Decline

Several factors may be at play in the decline of cactus wrens in the study area and in southern California, in general, including wildfire, prolonged and intensive drought with reduced productivity, predation, invasive species and habitat degradation, and population isolation (Solek and Szijj 2004, Hamilton et al. 2011, Mitrovich and Hamilton 2007, Preston and Kamada 2012, Barr et al. 2015).

Food availability and nest predation are two primary drivers of avian productivity and have been shown to be important in southern California shrub nesting songbirds (e.g., Morrison & Bolger 2002, Bolger et al. 2005, Preston & Rotenberry 2006 a, b). In arid ecosystems, the timing and amount of precipitation drives primary productivity, which affects plant and arthropod food sources available for breeding birds.

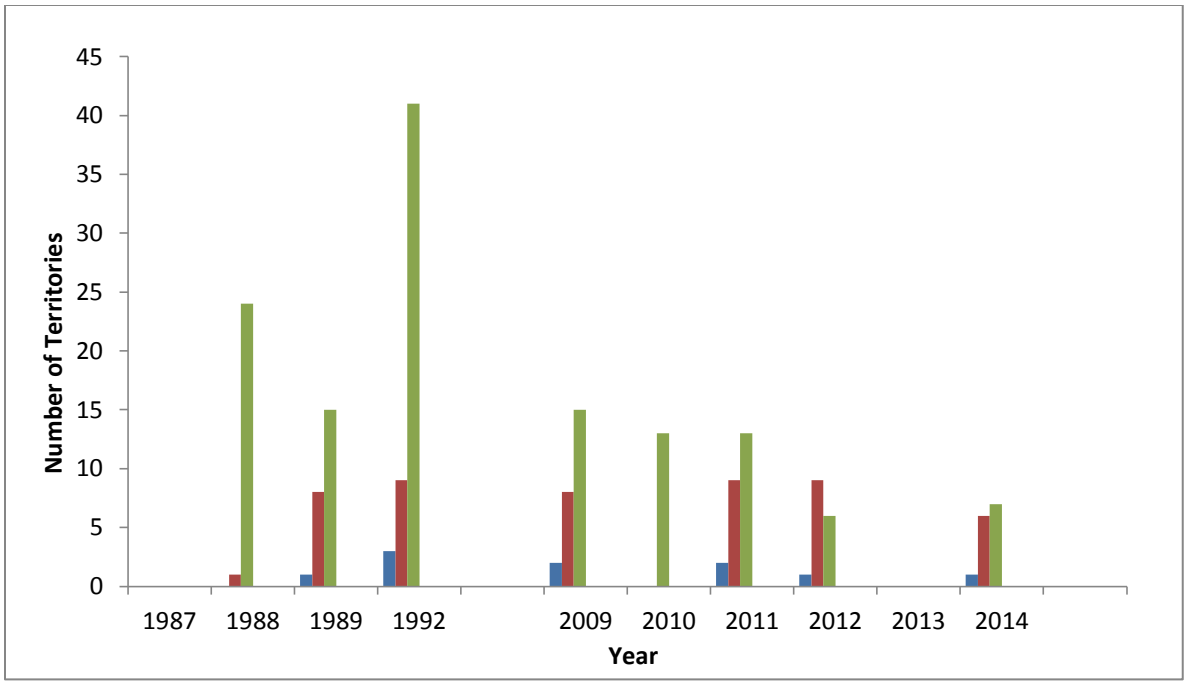

Figure 5: Estimated number of cactus wren territories between 1988 and 2014 at three conserved sites in the Otay River Valley.

In southern California arthropod abundance and biomass were significantly reduced during 2002, an extreme drought year in which there was total reproductive failure among several coastal sage scrub bird species (Bolger et al. 2005). Songbirds respond to reduced food availability by not breeding, delaying nesting, attempting fewer nests, having smaller clutches and fewer broods. Studies from the Nature Reserve of Orange County (NROC) found that cactus wren productivity was low from 2009 to 2013 and was associated with lower than average January to April precipitation (Preston and Kamada 2012, Kamada and Mitrovich 2013). There was also evidence at some territories of delayed nestling development, nestling starvation, and delayed nest initiation.

Drought is associated with substantial cactus wren population reductions following 2002 and 2007 extreme droughts and multiple years of below average rainfall between 1996 and 2014 at NROC's Coastal Reserve (Hamilton 2004, Mitrovich & Hamilton 2007, Preston & Kamada 2012). Multiple years of drought may be associated with smaller population sizes in the Otay Valley in the late 1980s (Dudek 1995) and in recent years, as southern California is in the midst of a prolonged and extreme drought, with only 4.6 inches of rain measured in Chula Vista during the 2013-14 bio year.

Habitat loss to development and catastrophic wildfire are also considered primary drivers of cactus wren population declines. Cactus wren populations declined by more than 80% in the NROC's Coastal and Central Reserves, as a result of catastrophic wildfires in 1993 and 2007 (Mitrovich & Hamilton 2007, Leatherman BioConsulting 2009). Wildfires have also affected wren populations in San Diego County over the last decade (e.g., Hamilton 2009), including the 2007 Harris Fire that burned cactus scrub habitat at the Sweetwater Reservoir, lower slopes of San Miguel Mountain, and in Proctor Valley.

A 5-year study monitoring cactus wren reproduction, dispersal and survival indicate that there are also other factors that influence wren population dynamics (Preston & Kamada 2012, Preston unpub. data). Small, isolated populations are vulnerable to local extinction with insufficient habitat and limited ability of wrens to disperse through habitat fragmented by urbanization (Barr et al. 2015). Small populations are often subject to low productivity (# fledglings/pair/year) related to rainfall and nest predation, high juvenile mortality with low levels of recruitment into the breeding population, habitat degradation from urban edge effects, and potentially high levels of predation by corvids and Cooper's hawks (Preston and Kamada 2012, Preston unpub. data). At the NROC, sites with fewer than four territories were highly variable in occupancy between 1999 and 2004 (Hamilton 2004), whereas sites with more birds tended to remain occupied over time. During the extreme 2007 drought, birds disappeared from sites with small numbers of pairs and most of these sites have not been re-colonized.

As noted above, cactus wrens have recently been extirpated or are declining in habitat fragments within the southern San Diego County study area. This decline is likely due to prolonged and intensive drought, habitat loss and fragmentation, and in some areas to large-scale wildfires.

2.4 Cactus Scrub Habitat Condition Summary and Analysis

Habitat Quality Assessments

During field surveys, information for each survey polygon was recorded for several habitat variables that are considered important to overall cactus wren habitat suitability. These included shrub crowding, shrub overtopping, cover by invasive plants, and cactus die-back/desiccation. Results are summarized below.

Shrub crowding and overtopping

In many locations throughout southern California, it has been observed that large shrubs within cactus scrub habitat, such as lemonadeberry (*Rhus integrifolia*) and laurel sumac (*Malosma laurina*), sometimes dominate and crowd out existing cactus. This crowding can cause competition for light and water resources, and can result in cactus die-back or desiccation. Moreover, if the shrubs become too large, they can over-top the cactus, creating conditions favorable to predators.

Shrub crowding was assessed at each cactus polygon by visually estimating, by species and cover class, the percentage by which existing cactus was being crowded by non-cactus plant species. If present, the amount of shrub crowding was assigned to one of three cover classes: 0-25 percent, 26-50 percent, and >50 percent. Shrub crowding was documented in 141 of 155 (91 percent) mapped cactus scrub polygons. Shrub crowding exceeding 25 percent cover was noted at 65 of the cactus scrub polygons (40 percent) that were assessed. Notably, cactus wrens were only detected in four polygons where shrub crowding exceeded 25 percent, with the remaining 19 cactus wrens detected in cactus scrub polygons that had no crowding or less than 25percent shrub crowding. Survey plots with greater than 25 percent shrub crowding are shown in Figures 6 and 7.

Shrub overtopping was assessed at each polygon by visually estimating, by species and cover class, the percentage by which existing cactus were being overtopped by surrounding non-cactus shrub or vine plant species. If documented, the amount of shrub over-topping was assigned to one of three cover classes:

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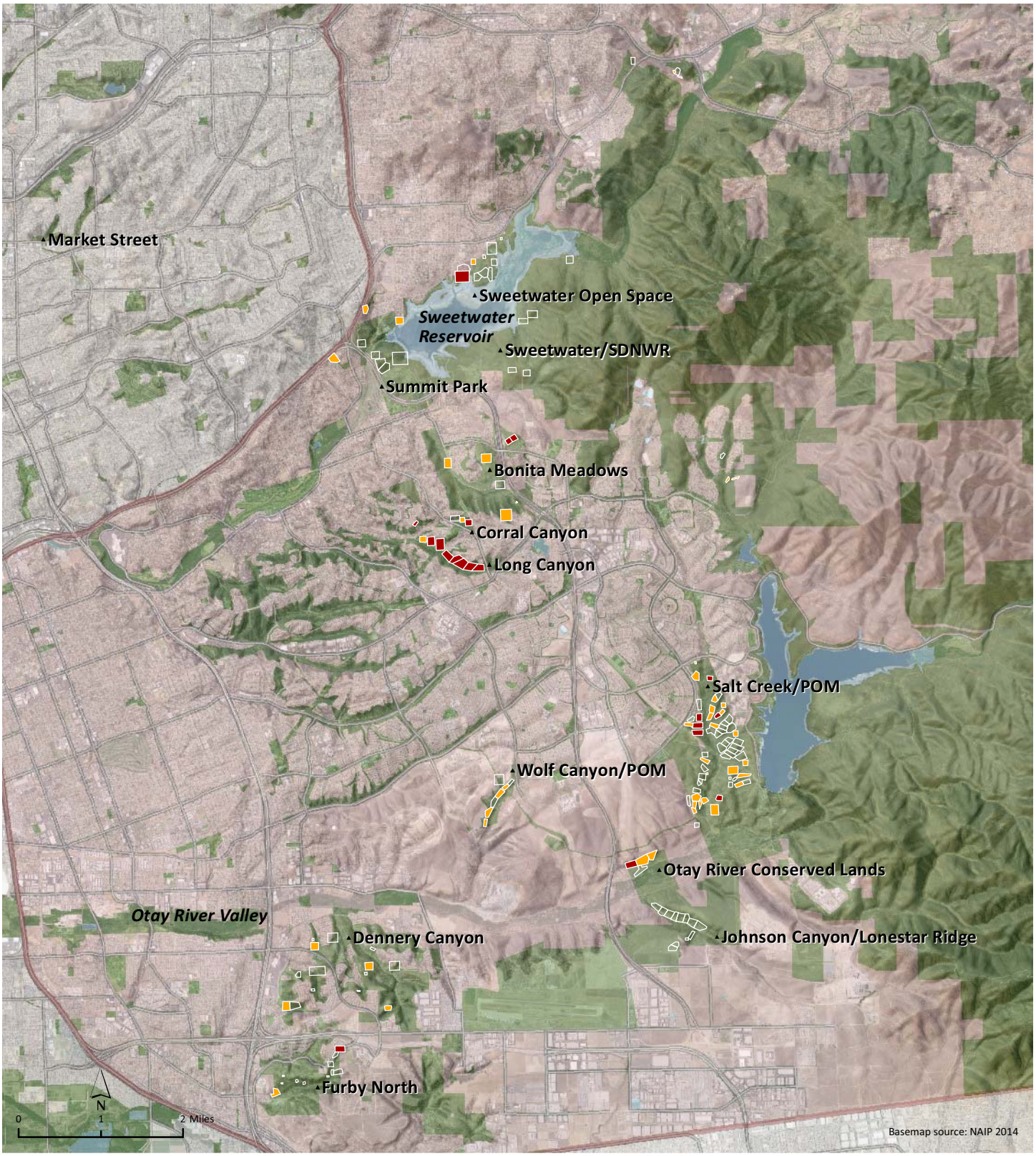
Figure 6: Cactus Wren Habitat Quality Shrub Crowding



Shrub Crowding

- < 25%
- 25% - 50%
- > 50%

- Management Unit 3
- Conservation / Public Land*

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0-25 percent, 26-50 percent, or >50 percent. Shrub overtopping was noted at 130 of 155 (84 percent) of cactus scrub polygons (Figure 7). Of these, shrub overtopping greater than 25 percent was documented at 57 (37 percent) of the cactus scrub polygons. Cactus wren territories were documented in cactus scrub polygons only where shrub overtopping was less than 25 percent.

Shrub crowding and overtopping were noted at all but the Johnson Canyon site, with the highest level of crowding and overtopping noted at Long Canyon, followed by Salt Creek, Wolf Canyon, and a few cactus scrub polygons on the SDNWR.

The dominant plant species crowding or overtopping cactus scrub within the study area is California sagebrush (*Artemisia californica*), followed a distant second by lemonadeberry and California buckwheat (*Eriogonum fasciculatum*). Other shrubs crowding and overtopping cactus include Ceanothus sp., laurel sumac, and California sunflower (*Encelia californica*). Because California sagebrush and California buckwheat are often the preferred nesting substrate for the California gnatcatcher, careful consideration should be given as to whether management of these two shrubs is warranted.

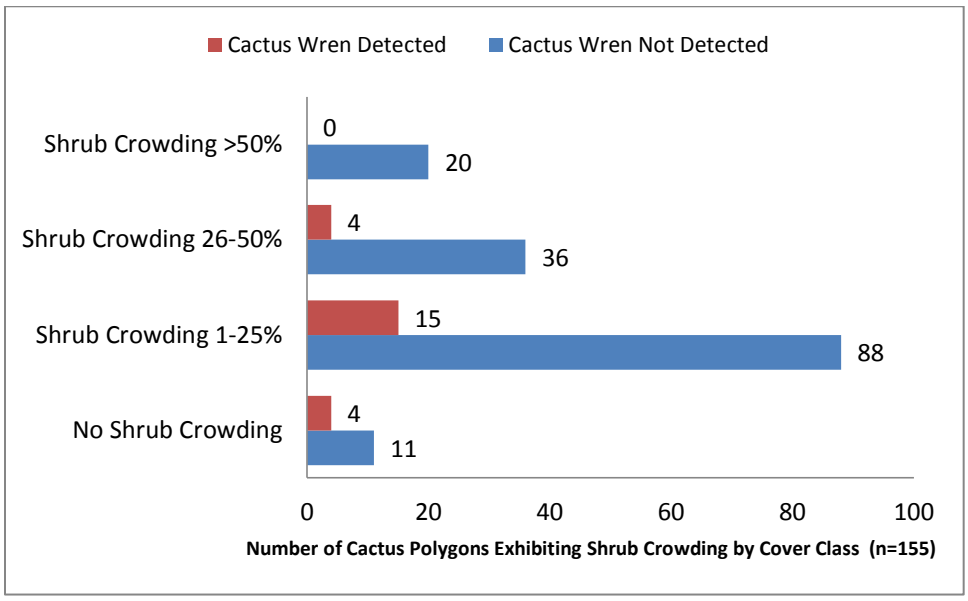

Figure 7: Cactus Scrub Polygons Exhibiting Shrub Crowding by Cover Class and Occupancy

Invasive Plants

In areas where the cactus is sparser and there is more open ground, invasive grasses and forbs can become established. Invasive forbs and grasses can compete for water and nutrients, affecting cactus health, and also can create flashy fuels that can carry a wildfire. Preston and Kamada (2012) hypothesized that a dense cover of invasive grasses and forbs creates unsuitable ground foraging conditions for the cactus wren. Because of current drought conditions, the cover of invasive grasses and forbs was generally lower than expected across all sites (average cover less than 25 percent). The most dominant invasive plants noted were annual grasses, followed by black mustard (*Brassica nigra*), and fennel (*Foeniculum vulgare*). Fennel is of particular concern because of its presence at nearly every site, its potential to spread quickly,

and because of its potential to alter habitat structure. Long Canyon had the highest average cover of exotic plants and also the lowest average cover of bare ground. In contrast, Johnson Canyon had the lowest average cover of exotic plants (averaging 0-25 percent cover) and the highest average cover of bare ground, followed by Salt Creek and Dennery Canyon.

Cactus Desiccation/Die-back

Cactus die-back and desiccation has been noted in the past several years throughout southern California.. Since the early 2000s, there has been extensive cholla mortality in the Sonoran, Mohave, and Colorado Deserts associated with prolonged multi-year and intensive drought (Miriti et al. 2007, McAuliffe and Hamerlynck 2010, Bobich et al. 2014). There have also been reports of cholla desiccation and mortality in coastal areas, including southern San Diego County. This drought stress is brought on by low rainfall and elevated temperatures, and may be worsened through resource competition caused by shrub crowding and invasive plants. Cactus die-off could also be related to disease exacerbated by drought. Within MU3, cactus desiccation was observed at all sites but Johnson Canyon. Additionally, cactus wrens were only detected at one site where cactus desiccation exceeded 25 percent (Figure 8), and that was at a polygon at SDNWR which burned in 2007 and was undergoing active restoration. Cactus desiccation was noted in 86 of 155 polygons surveyed (55.4 percent), with the highest number of polygons exhibiting cactus desiccation documented at Salt Creek. Here, 48 of 57 cactus scrub polygons (84 percent) exhibited desiccation. Notably, Salt Creek was one of the sites with the highest cover of bare ground (averaging greater than 26 percent bare ground) and lowest level of exotic plant cover. Low invasive plant cover and high percent bare ground would seem to indicate that competition for water and nutrients is low, which does not explain the high rate of cactus desiccation at this site. Three years of extended drought and/or shrub crowding may be the factor driving high rates of cactus desiccation, but further studies are warranted to identify if there are other causal factors, including possible disease. Cactus patches exhibiting greater than 25 percent dieback and cactus wren 2014 occupancy are shown in Figure 8 and 9.

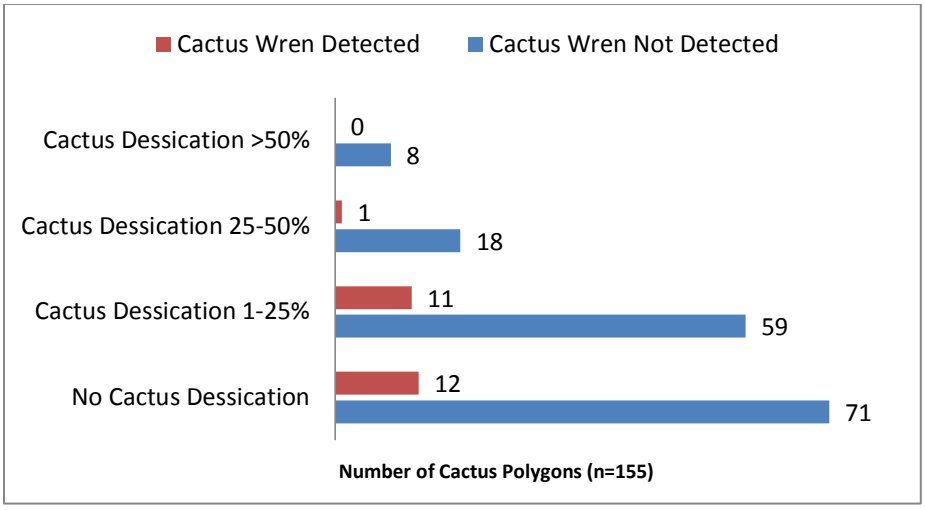

Figure 8: Cactus Scrub Polygons Exhibiting Die-Back by Cover Class and Occupancy

South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 9: Cactus Wren Habitat Quality Cactus Die-back

Cactus Die-back

- < 25%
- 25% - 50%
- > 50%

- Management Unit 3
- Conservation / Public Land*

*Conservation / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations.
Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

2.5 Habitat Connectivity Assessment

Connectivity refers to the linkage of habitat, species, natural communities, and ecological processes across multiple spatial and temporal scales (Noss 1992). Maintaining connectivity within reserve networks is widely regarded as essential to maintaining functional landscapes and evolutionary processes (Taylor et al 2006, Noss 1991, Beier and Noss 1998).

For non-migratory birds such as the cactus wren, maintaining habitat connectivity is essential for allowing dispersal and recolonization in response to disturbances such as fire, and maintaining gene flow. Although cactus scrub is naturally patchy, cactus wrens will disperse through non-cactus habitat, with dispersal distances of up to 5- 9 km but generally less than 2 km (Atwood 1993, Preston and Kamada 2012, Kamada and Preston 2012, Barr et al. 2012, 2013). Some short distance dispersal across man-made barriers has been documented (Preston, unpub. data) but these events are likely uncommon. The maximum dispersal distance is 10-11 km as documented by banding and genetic studies (Kamada and Preston 2013, Barr et al. 2015).

Using regional cactus wren genetics information from USGS and available habitat data from past cactus wren monitoring studies, including soils, aspect, and elevation, we developed a habitat suitability model to identify connectivity gaps and potential linkages within and between cactus wren populations in MUs 2, 3 and 4 (Figure 10). The methods for developing this suitability model and an evaluation of model performance are presented in Appendix C.

We reviewed these habitat suitability maps along with historic cactus wren population data to identify existing connectivity, possible connectivity gaps as well as opportunities to restore connectivity between populations on Conserved Lands. These data are shown in Figure 11.

Connectivity within MU3

Historically, cactus habitat patches within MU3 were likely connected, but natural and man-made disturbances of the last century, including agriculture, grazing, wildfire, invasive species, and more recently, roads and urban development, have altered connectivity for the cactus wren. This loss of connectivity is most apparent in the urbanized portions of MU3. While many small coastal sage scrub habitat patches supporting cactus wrens were conserved as a part of the reserve design, the intervening non-cactus habitat has been developed, creating small, linear islands of cactus wren habitat that are subject to urban edge effects and loss of connectivity between habitat patches. As referenced in Section 2.3, in Orange County it has been demonstrated that small, isolated populations can be extirpated when subject to exacerbating threats of predation and extended drought. This is possibly the case for the city canyons in Chula Vista and Otay Mesa, where cactus wrens were detected in many of the habitat fragments as recently as 2011, but were not detected during the 2014 surveys.

In contrast to these more recently (1990s) fragmented habitats where cactus wrens have been possibly extirpated, some cactus wrens remain in several older, isolated fragments that are outside of the reserve system but are in close proximity to Sweetwater Reservoir and west toward Intestate 805. It is uncertain why cactus wrens persist in these patches and not in the more recently fragmented urban canyons, but it is possible that their continued persistence may be related to habitat condition, urban edge conditions, or

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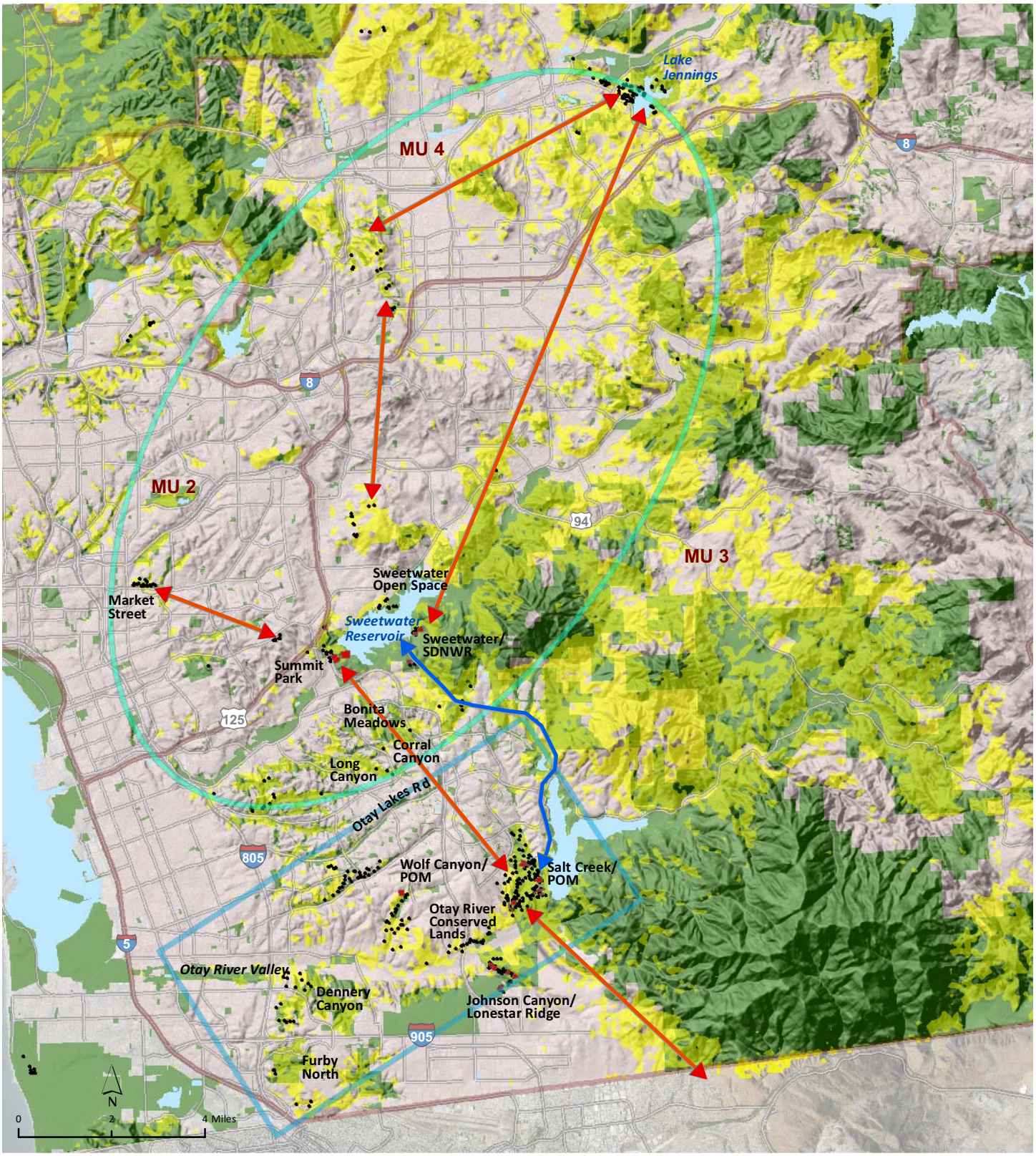
South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 11: Cactus Wren Connectivity in MU 3 and MU 4



Habitat Suitability Model R11P1

- Suitable Habitat, private land
- Suitable Habitat, Conservation / Public land*

Genetic Cluster

- Sweetwater
- Otay

- Potential Connectivity Creation / Restoration
- Potential Connectivity Gap
- Cactus Wren Detection ('09 - '12)
- Cactus Wren Detection ('14)

- Management Unit
- Conservation / Public Land*

*Conservation / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations.
Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

time/period of isolation. In general, the habitat in these small patches is more open with less crowding of other shrubs. Additionally, the mean distance between occupied patches is generally 1-2 km, with occasional patches of intervening unoccupied habitat in between, and it is possible that habitat between these patches may be helping to support a metapopulation for the greater Sweetwater Reservoir area. There are also small populations of cactus wrens persisting on fragmented Conserved Lands in canyons near the city of San Diego (e.g., Market Street) and north of I-8 in the Fletcher Hills and Lakeside area that may be helping to retain gene flow with birds in the Sweetwater Reservoir area (Barr et al. 2012, 2013, 2015).

In the Otay River Valley, connectivity likely remains intact from the Furby North site eastward to Salt Creek. Survey teams were unable to survey future preserve lands within the Otay River Valley, but it is assumed that connectivity along the river valley persists as the habitat appears to remain intact. Surveys of these future Conserved Lands in Otay River Valley are strongly recommended for 2015 to verify habitat connectivity, to assess the condition and extent of cactus scrub and to survey for the presence of cactus wrens. This will provide a greater sense of the overall health of the Otay cactus wren population as well as opportunities for habitat enhancement/creation.

Connectivity between the Otay (Salt Creek, Johnson Canyon, Wolf Canyon) and San Diego/El Cajon (Sweetwater) genetic clusters is a concern within MU3. Genetic studies of the cactus wren (Barr et al. 2012, 2013, 2015) identified two separate genetic clusters: the San Diego/El Cajon genetic cluster of which the Sweetwater population is a part, and the Otay genetic cluster, which includes the entire Otay River and Tijuana River watersheds. Of these two clusters, the Otay genetic cluster is of particular concern because of the decline in numbers and local population extinctions as well as evidence of a recent genetic bottleneck which threatens the persistence of this population. It is not known whether connectivity between these two populations existed within the last 50 years, and it is possible that the Otay genetic cluster was more closely associated with populations south of the border. However, the nearest potential habitat south of the border is at Jesus Maria Mesa, and may no longer support cactus wrens. Thus, creating or restoring connectivity between the Otay and Sweetwater cactus wren populations should be considered as a measure to ensure the long term persistence of the Otay River Valley population into the future.

Opportunities for enhancing connectivity between the Otay and San Diego/El Cajon genetics cluster are extremely limited, as most of the cactus scrub habitat between the populations has been developed and the distances between remaining habitat patches exceeds the average dispersal distance of the cactus wren. Additionally, Otay Lakes is a major barrier, and no existing occupied and little potentially suitable habitat exists to the east. Currently there is a 10 km distance between currently occupied habitat at Salt Creek and Sweetwater Reservoir, but almost the entire intervening habitat has been developed. What remains for establishing connectivity between these two populations is a narrow 10 km long and 1 km wide band of potentially suitable habitat that stretches between the two sites along the western edge of Otay Lake. Because little or no cactus scrub currently exists along this potential corridor, its current function as a linkage for cactus wrens is unlikely. Strategies for ultimately improving connectivity between the two populations are addressed in Section 3.3.

Connectivity between MUs 3 and 4

In addition to assessing connectivity within MU 3, we also reviewed possible connectivity between MU3 and MU4. The San Diego/El Cajon cactus wren genetic cluster spans MUs 2, 3 and 4, extending from south of Sweetwater Reservoir northwesterly to Market Street, and northeasterly to Lake Jennings and Fletcher Hills.

Connectivity between occupied cactus wren habitat at Sweetwater Reservoir and Market Street appears to be highly constrained by urban development. While remnant, degraded non cactus habitat occurs in patches ranging from 3 to 10 km apart, the density of urban development and quality of remnant habitat patches likely hinders cactus wren movement between Sweetwater and Market Street. Recognizing this, land managers at the Market Street population are expanding cactus wren habitat at that site, and investigating opportunities to expand/connect habitat northeasterly to intact but unoccupied habitat at Chollas Reservoir.

Connectivity between occupied habitat at Sweetwater Reservoir in MU3 and Lake Jennings in MU4 likely follows the Sweetwater River, but there is little if any cactus scrub that remains along this stretch; the habitat has been replaced by dense rural and urban development and/or is unsuitable in terms of elevation in the vicinity of Interstate 8.

3 MANAGEMENT STRATEGIES

An analysis of field data and habitat conditions across MU3 reveals the following:

- Within the last two to five years cactus wrens have disappeared from several conserved areas where they were previously documented in 2009 or 2011.
- Within the last six years, cactus wren populations have declined 40 percent in unburned core cactus wren habitat areas such as Johnson Canyon, Salt Creek, and Otay River Valley Conserved Lands.
- Extreme drought conditions of the last three years, resulting in limited food availability and degraded habitat conditions, are likely contributing to population declines.
- Shrub crowding, shrub over-topping, and cactus desiccation and mortality appear to be negatively correlated with cactus wren detections.
- Cactus wren population declines are of concern in Otay River Valley. If wrens are lost from Otay River Valley, it would be unlikely they could be re-established due to lack of source populations. The Otay population is isolated from other wren populations as indicated by the genetic study, so natural immigration from other populations is unlikely. Translocation would be difficult and expensive, as there are no extra birds at other sites that could be used for translocations.
- Opportunities for linking cactus wrens between the Otay and San Diego genetic cluster are limited.
- Habitat enhancement through cactus plantings and weed control have improved habitat conditions for cactus scrub and the cactus wren on SDNWR lands at Sweetwater Reservoir and Johnson Canyon.

Taken together these observations signify an urgent need for management intervention to ensure the persistence of the cactus wren in MU3. Lindermayer et al. (2013) equates a 20 percent decline over five generations as a catastrophic decline that triggers research into threats and increased surveillance. If threats are known then management actions to abate these threats should be implemented. Cactus scrub enhancement efforts at SDNWR and Johnson Canyon have improved conditions for the cactus wren; these efforts should be expanded for the Otay and Sweetwater genetic clusters to further stabilize and increase these populations. Although opportunities are limited, efforts to link the Sweetwater and Otay River Valley cactus wren populations should be pursued through additional study and planning efforts. Conlisk et al. (2014) recommends that given finite resources for management, investment in augmenting existing cactus wren habitat should receive initial priority for sustaining populations versus creating "stepping stones" of habitat to link populations.

3.1 Bolster Existing Populations through Habitat Enhancement and Restoration

The first priority is stabilizing and bolstering *existing* cactus wren populations at SDNWR, Johnson Canyon/Lonestar Ridge, and Salt Creek (Figure 12). Ongoing cactus scrub restoration efforts at these locations appear to be working as birds are using restored sites where the habitat appears of good quality. Efforts should be focused on expanding and enhancing habitat within or in close proximity (0.5-1 km) to currently occupied sites, to provide sufficient habitat to accommodate larger, more stable populations.

Habitat expansion and enhancement should focus on 1) planting of cholla (*Cylindropuntia prolifera*) and prickly pear cactus (*Opunita littoralis, O. oricola*), 2) shrub thinning and invasive plant control where needed, and 3) enhancement of the native grass and forb understory to improve cactus wren foraging conditions. During 2014-2018, USGS will conduct a study to investigate associations between habitat quality and food availability and their relationship to individual reproduction and survival in Otay River Valley, Sweetwater Reservoir, and Lake Jennings populations. The study will include measuring vegetation and environmental conditions (topography, soils, and climate) and relate these attributes to arthropod food resources. The results of this study will provide specific criteria for habitat enhancement and restoration to increase resilience, especially during drought periods.

Planting of cholla and, to a lesser degree, prickly pear should be performed at sufficient density and sized patches to ultimately support cactus wrens, following Cactus scrub Restoration Best Management Practices, outlined in Appendix D. Current cactus planting practices at all three sites are in accordance with these practices, and should be continued.

The current die-off of cholla at various locations in south San Diego County warrants more attention. The drought as well as shrub crowding and invasive plants are thought to be the major factors in the deterioration of cholla, but disease could also be involved and should be investigated, particularly at Salt Creek, where over 80 percent of the polygons had desiccated cactus. Management to reduce competition for water where shrubs or invasive plants are competing with cactus at Johnson Canyon and Salt Creek has improved the overall condition of cactus, and these efforts should be expanded. In future cholla plantings, consideration should be taken for planting in microsites that are likely to have greater soil moisture and more mesic conditions, such as in small draws or less exposed sites. It is possible that

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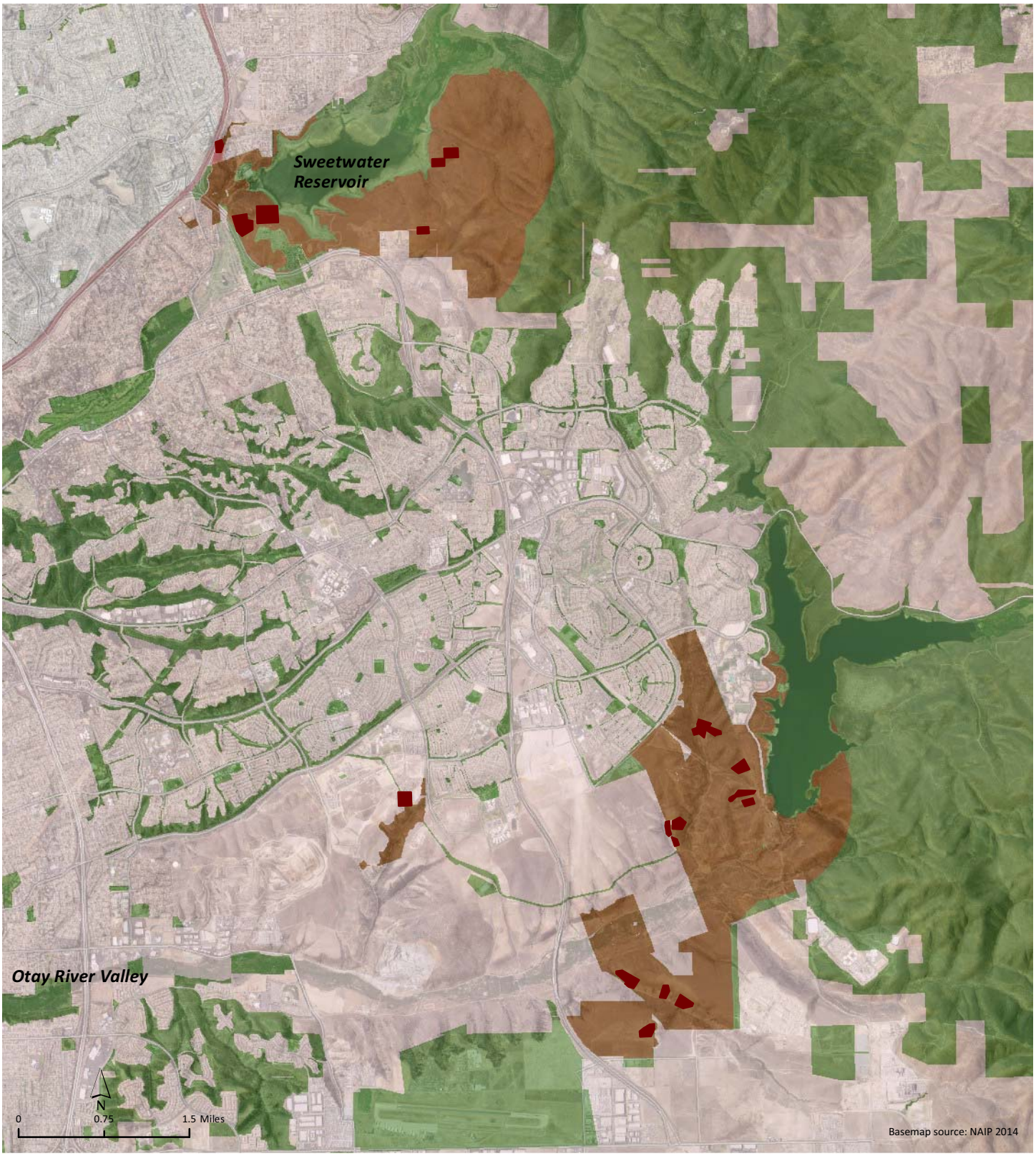
Figure 12: Priority Locations for Cactus Scrub Expansion and Enhancement



2014 Cactus Wren Detection

Priority Restoration Area

Management Unit 3

Conservation / Public Land*

*Conservation / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations.
Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

planting on more southeasterly facing slopes or at the bottom of the slope might enhance soil moisture to help mitigate the effects of drought on cholla mortality.

Another action that is strongly recommended is the enhancement of native forbs and grasses in the shrub understory to both replace invasive plants and improve foraging conditions for the cactus wren. Enhancement of the shrub understory in cactus scrub has not yet been specifically targeted by any known projects, but enhancement of the shrub understory has been identified as a measure to enhance foraging opportunities for the cactus wren. Forbs and grasses that may be considered include foothill needlegrass (*Nasella lepida*), purple needlegrass (*Nasella pulchra*), blue eyed grass (*Sisyrinchium bellum*), osmadenia (*Osmadenia* sp.), matchweed (*Guiterrizia* sp.), tarplant (*Deinandra* sp.) and other native forbs and subshrubs that are on or near each site.

The NROC is conducting a cactus wren foraging and arthropod study to inform these types of efforts. Preliminary results indicate that large arthropods (>3 mm) are abundant in the soil below Mexican elderberry, lemonadeberry, coastal prickly pear, California sagebrush, native grasses, and mustard. California buckwheat also supported high abundance of larger arthropods. An analysis of nestling food is ongoing to determine if there are particular arthropods important to nesting cactus wrens and the relationship of these arthropods to specific plant species. The results of this study, when available, should be integrated into the USGS study and the results of both studies incorporated into the design of cactus scrub enhancement and restoration projects to increase the availability of arthropod food resources.

3.2 Establish Cactus Nursery Stands in South San Diego County

The need for designated, permanent nursery sites to propagate and grow mature cactus specimens has been identified as a priority in the MSP and in the proceedings from the Fire Management Workshop held by USGS in 2013 (Rochester and Fisher 2014). These nursery sites would provide a source of mature cactus for use in restoration and in post-fire emergency habitat recovery efforts in North and South County. The City of San Diego has adopted an ordinance that requires succulents such as prickly pear and cholla to be salvaged from proposed development sites for use in restoration in the planning area. The Rancho Jamul Ecological Reserve has functioned as a nursery site for cactus salvaged from the Bayshore Bikeway Project, and may provide an excellent permanent site for cactus propagation in South County if funding for establishment and maintenance is secured.

The objective for the cactus nursery sites in South County is to establish two outdoor facilities for the propagation of small to large sized classes of cactus for ultimate relocation to priority cactus wren management areas within MUs 3 and 4.

Because of microclimatic and soils differences, two nursery stands, one in the Sweetwater River/Lake Jennings watershed, and one in the Otay River watershed, should be considered to support restoration in each watershed.

Below are listed several criteria for the establishment of a cactus nursery sites:

- Each of the two nursery sites must be of adequate size to produce 1) 7,000 rooted prickly pear/cholla segments for transplanting and 2) an additional 2,000 unrooted cholla/prickly pear segments annually for 5 years.
- If the proposed nursery site is on currently Conserved Lands, it should not be on lands that support significant native vegetation.
- All cacti grown for transplantation should be irrigated as necessary to ensure significant annual growth and adequate to achieve greater than 1 meter in height after five growing seasons.
- The species composition of the cactus production. including unrooted segments, should be approximately 70 percent *Cylindropuntia prolifera* and 30 percent *Opuntia littoralis* and *O. oricola* at the Otay site and in reverse proportions at the Lake Jennings site
- Cactus propagules can be planted either directly into the ground or in appropriately-sized containers and their provenance must be from the watershed of the nursery site or immediate adjacent areas.
- Propagules obtained from different sites should be grouped together and separated into discreet identifiable units within the nursery to protect genetic provenance.
- The nursery site and all cactus propagules will be kept weed and Argentine ant free as documented by regular inspection.
- If propagules are planted directly in the ground, the spacing shall be adequate to allow their removal without significant damage to adjacent plants.
- Those planted directly in the ground at the nursery site shall be made available for bareroot transplanting with a 2-week notice by the restoration project coordinator to allow for hardening of roots prior to transport.

Sources of Cactus

Ideally, cactus for use in restoration would be salvaged from sites identified for development that are within the MU but outside any pre-approved mitigation areas or preserve areas. During field surveys for this project, we identified two properties for sale in the Sweetwater and Otay watersheds that support large stands of unoccupied cholla. The condition of these properties should be monitored and opportunities pursued to salvage plant materials from these two sites.

In the absence of development, cactus propagules will need to be collected from existing conservation areas. As outlined in the Cactus Scrub Restoration Best Practices in Appendix D, cactus propagules should be collected only from the lower limbs of unoccupied cactus, and should not exceed 5 percent of the total individual cactus mass. Areas where cacti are threatened by development or unlikely to be used by cactus wren should be prioritized for harvesting (e.g., along roadsides or in isolated patches that are unoccupied by wrens).

3.3 Plan and Implement a Cactus Scrub Habitat Linkage between Sweetwater and Otay River Valley Conserved Lands

As indicated by genetic studies, the long term persistence of the Otay River Valley population is likely dependent upon establishing habitat connectivity northward to the Sweetwater populations. While first priority should focus on expanding existing occupied habitat within the Otay and Sweetwater areas, planning, design and funding sources should be pursued within the next 5 years to implement the Sweetwater-Otay cactus wren habitat linkage.

Opportunities for establishing connectivity are limited. The closest available "route" for establishing connectivity for the cactus wren between Sweetwater and Otay River Valley populations lies along the western edge of Otay Lakes between the Salt Creek and SDNWR/Sweetwater Reservoir lands. The distance between these two populations is roughly 10 km or 6.2 miles. Creation of the habitat linkage would involve expanding existing cactus scrub along the linkage path where it already occurs as well as creating new patches of cactus scrub.

Similar cactus scrub habitat linkage projects have been implemented on NROC lands in coastal Orange County, California (Preston et al. 2011, NROC et al. 2012). In one case, reserve managers are attempting to link two cactus wren populations that are roughly 3 km apart. The effort has focused on expanding existing cactus stands along the linkage corridor, as well as creating islands of "live in" habitat in areas with appropriate soils and aspect between remnant patches. In the other case, the project consists of augmenting live-in habitat and creating stepping stone patches between Upper Newport Bay and conserved lands to the east in the San Joaquin Hills. Considerations for creating a cactus scrub habitat linkage include:

Cactus Wren Dispersal Distance: The distance between created cactus patches should generally be less than 3-4 km. the NROC reproductive, survival and dispersal study and the southern California genetic study produced similar results for cactus wrens in Orange County, with most dispersing cactus wrens moving less than 1 km, with some individuals moving up to 10-11 km (Barr et al. 2012, Preston and Kamada, 2012, Kamada and Preston 2013). Genetic analysis shows that individuals in the Otay wren population tend to move less than 5 km (Barr et al. 2012).

Line of Sight: Created cactus patches should be within line of site of each other in order to optimize cactus wren movement. This may necessitate patches being closer than 3 km.

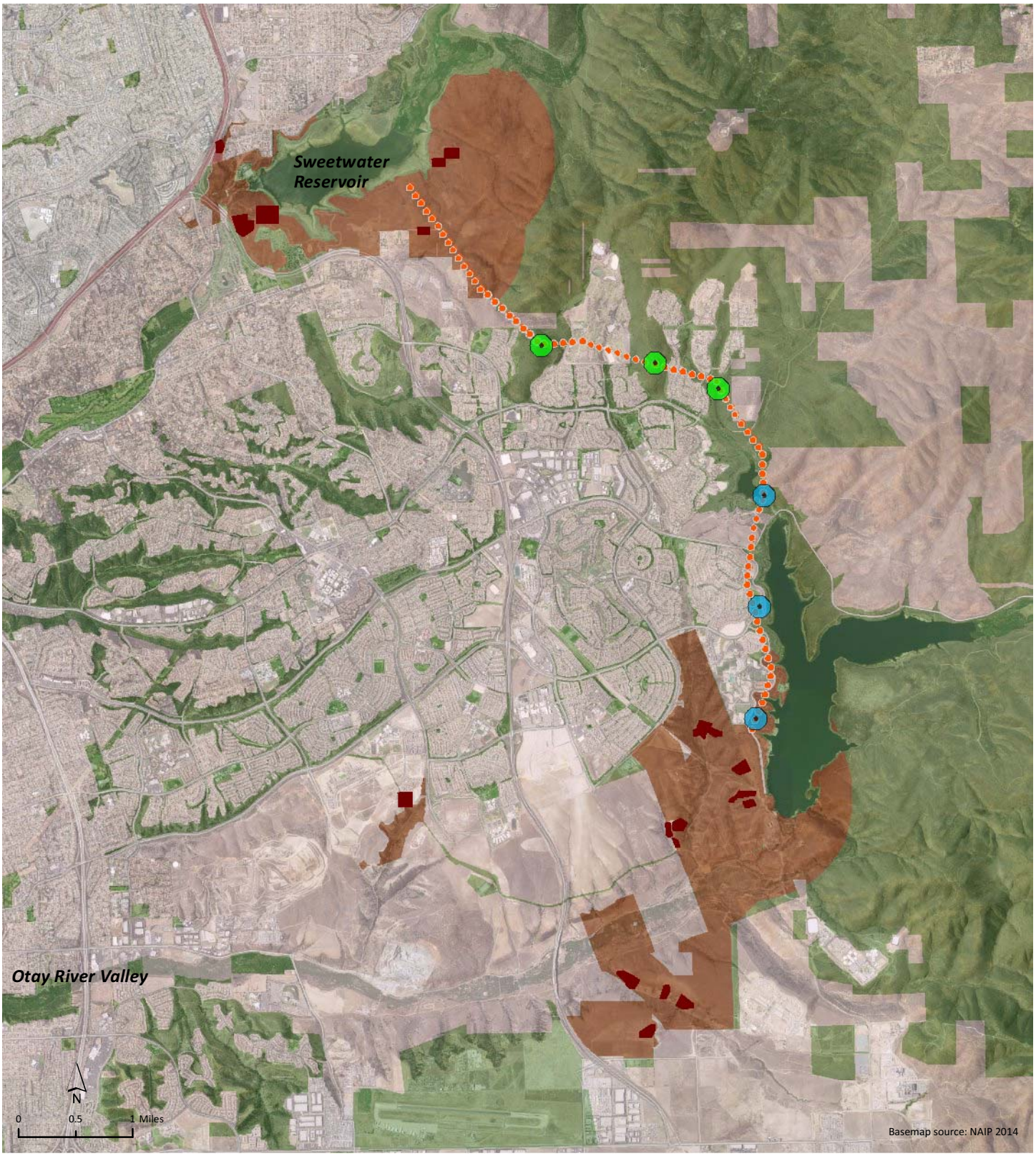
Creation of "Live In" Habitat: Patches of created habitat should be of sufficient size (2-3 ha) to support nesting cactus wrens. For those sites along the corridor that historically supported cactus wrens, habitat should be expanded to several hectares.

Given these considerations, we used the cactus wren habitat suitability model to identify a potential pathway for creating suitable habitat along the Sweetwater-Otay cactus wren linkage. The model identifies that, in order to create a viable linkage where each created habitat patch is within line of site of the coastal sage scrub, there may be a need to create habitat patches in areas that are not highly suited to cactus scrub along the edge of Otay Lake. A conceptual spacing of potential cactus habitat patches to

create this linkage is depicted in Figure 13. Prior to selecting sites, a detailed field assessment will be necessary to evaluate accessibility, the presence of sensitive species, line of site, soils, aspect and landscape position.

South San Diego County Coastal Cactus Wren Conservation and Management Plan

Figure 13: Conceptual Connectivity Design for Sweetwater - Otay Cactus Wren Linkage



2014 Cactus Wren Detection

Priority Restoration Area

Linkage Path

Cactus Scrub

Creation

Expansion

Management Unit 3

Conservation / Public Land*

*Conservation / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations.
Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy; CPAD

4 CACTUS SCRUB RESTORATION IMPLEMENTATION PLAN

4.1 Salt Creek

Existing Habitat Conditions

The Salt Creek Management area, part of the Otay Ranch POM, is managed jointly by the County of San Diego and the City of Chula Vista. RECON Environmental, Inc., under contract with the POM as the Preserve Biologist/Steward, performs several monitoring and management activities. Cactus wren habitat enhancement and restoration has been a focus of management efforts in the Salt Creek area. Since 2010, the POM has received two San Diego Association of Government's Environmental Mitigation Program Working Group (EMPWG) TransNet Grants to restore cactus scrub habitat in Salt Creek. Additionally, the POM has spent available POM funding to augment cactus wren habitat enhancement in several areas. The POM was recently awarded two additional TransNet Grants to fund additional cactus scrub restoration beginning in 2016.

The status of existing cactus scrub enhancement efforts in Salt Creek POM are summarized below.

The County of San Diego received a Transnet Grant in 2010 to implement 0.6 hectare of cactus scrub restoration in the upper Salt Creek open space area. This project was implemented by Merkel and Associates. Work entailed removal of exotic grasses and forbs, followed by the planting of patches of prickly pear and cholla cuttings which were harvested from unoccupied cactus patches onsite. Shrubs such as *Bahiopsis lacianata*, *Artemisa californica* and *Eriogonum fasciculatum* were also planted by seed. Maintenance included 1 year of supplemental irrigation and a 5 year (2009-2014) weed control program. USGS detected one cactus wren pair using this restoration project in 2014.

In 2012, the POM received another TransNet Grant to create an additional 7 hectares of cactus scrub within Salt Creek (Recon 2013, 2014). The work entails 3 years of invasive grass/forb control and supplemental cactus plantings on 7 hectares of unoccupied cactus scrub habitat. This work included initial clearing of exotic grasses in year 2012, followed with annual early season herbicide treatment of exotic grasses and forbs (*Hirschfeldia incana*, *Erodium* spp., *Centaurea melitensis* and *Bromus* spp).

Opportunities for Enhancement and Restoration

Enhancement/Restoration

In addition to the 7 hectares currently being restored by the POM, there is at least another 16 hectares of degraded current or formerly occupied cactus scrub habitat that could be enhanced or expanded within Salt Creek. Priority will be given to restoring habitat that is within 0.5-1 kilometer of existing occupied cactus scrub, as delineated in Figure 12. Restoration activities will be consistent with that performed previously by the POM, including exotic forb/grass control, eradication of fennel, thinning of large shrubs, and planting of cholla and prickly pear cactus. In addition, we recommend establishing native forbs, grasses and subshrubs in areas where exotic plants have been removed. When the results become available from the NROC and USGS studies of cactus wren habitat quality and arthropod community abundance should be used to inform plant palettes in order to enhance wren food availability. All

activities should also be consistent with current practices and with Best Management Practices outlined in Appendix D.

In addition, the 7 hectares that are currently undergoing restoration by the POM would benefit from the planting of native forbs and grasses, particularly since extensive invasive plant control has already been completed. These understory species would replace the invasive grasses and forbs, and would reduce the need for long term weed control once established. Moreover, native grasses and forbs will provide a source of insects that would benefit foraging cactus wrens. Native grass and forb enhancement should avoid areas of cryptobiotic soils and other rare species that have been documented, such as variegated dudleya (*Dudleya variegata*). Plant species to be considered for introduction include purple needlegrass, foothill needlegrass, blue-eyed grass, osmadenia, *Deinandra* sp. and other species deemed appropriate by the Preserve Steward/Biologist.

Fire Management and Protection

Wildfire is a major threat for remaining cactus wren populations in MU3. Existing cactus scrub restoration and enhancement efforts performed by the POM on the 7 hectares has included thinning of large shrubs and the reduction of invasive grasses. While the primary purpose of these efforts has been to reduce shrub crowding and lessen drought stress to adjacent cactus, these efforts have the added benefit of reducing large as well as flashy fuels which could carry a fire.

The incorporation of these practices into the management of occupied habitat and in any future cactus scrub restoration/enhancement are recommended, and the condition of large shrubs should continue to be monitored over the long term, and shrub thinning should be performed when they become a problem.

4.2 Johnson Canyon/Lonestar Ridge

Existing Habitat Conditions

These two adjacent sites are currently owned by Caltrans and the USFWS and have been undergoing habitat enhancement for the cactus wren and other species since 2005. Habitat enhancement includes ongoing (in perpetuity) invasive grass/forb control as well as planting of cholla and prickly pear salvaged from road construction associated with SR 905 and SR 125.

The SR 125 mitigation site, known as Lonestar Ridge, was established primarily as mitigation for vernal pools and burrowing owl, but cactus wren habitat has also been successfully established (for non-mitigation purposes) at this site through planting of cactus transplants and cuttings. There were no cacti or cactus wrens at this site originally, but through restoration, mature cactus stands have been established over the six years of enhancement and currently support at least one pair of cactus wrens.

The Johnson Canyon site has long supported a fairly stable population of cactus wrens over the last 20 years, although a decline was noted this year, likely due to drought conditions. Caltrans has been conducting weed control treatments around existing stands of cactus, with some plantings of prickly pear and cholla, since 2008. The overall condition of this habitat was identified to be very good, with little or no shrub crowding, overtopping or desiccation noted, likely a result of ongoing successful management efforts.

Opportunities for Enhancement and Restoration

The existing restoration efforts on the Lonestar site have been very successful, and to build upon this success, it is recommended that existing patches of restored cactus scrub on the Lonestar Ridge site be expanded to $10m^2$ or greater, where feasible, and where plantings would not interfere with other mitigation efforts. Possible thinning or removal of shrubs such as lemonadeberry should be considered where crowding of cactus could be an issue.

For both the Johnson Canyon and Lonestar sites, we recommend the establishment of native forbs, grasses, and subshrubs where invasive plant control has been performed. Fennel, although currently in low numbers, should be controlled to prevent further expansion.

Lastly, we recommend continued expansion of existing cactus stands at the Johnson Canyon site through the planting of cuttings of cholla and prickly pear. The cactus wren habitat suitability model indicates that there are approximately 20 hectares available for habitat enhancement/expansion at Johnson Canyon.

4.3 San Diego NWR - Sweetwater Reservoir

Existing Habitat Conditions

The SDNWR lands south of the Sweetwater Reservoir burned in the Harris Fire of 2007. Prior to the fire these lands supported large healthy stands of cholla and several pairs of cactus wrens. The 2007 Harris Fire burned much of the available cactus wren habitat and cactus wrens were lost from the burn area but remained on adjacent unburned NWR and Sweetwater Authority lands to the north. In response to the loss of habitat and cactus wrens following the Harris fire, the USFWS applied for and received an EMPWG TransNet Grant to enhance 60 hectares of cactus wren habitat. Restoration efforts included 3 years of invasive plant control within recovering coastal sage scrub on south and southwest facing slopes and planting of cholla and prickly pear cactus. Cactus cuttings used in this restoration effort were salvaged from the Bayshore Bikeway Project in 2008, and temporarily planted at a cactus nursery established at Rancho Jamul Ecological Reserve while the planting area at Sweetwater Reservoir was being prepared.

Over 50 $10m^2$ patches of rooted and unrooted cholla and prickly pear segments were planted in the spring of 2009 on south and southwest facing slopes within the 60 hectare weed treatment area. Weed control efforts, which continued from 2009 through 2012, focused on the early season herbicide treatment of exotic grasses as well as exotic forbs such as *Erodium* spp. Some native herbs such as fascicled tarweed (*Hemizonia fasciculata*) were also controlled, as they were observed to be limiting other native plant species recovery.

During the 2014 USGS cactus wren survey, an un-banded pair of cactus wrens was detected in a portion of the restored area that last supported cactus wrens in 2007, prior to the Harris Fire. This indicates the success of the recovery and restoration efforts and supports the need for additional cactus scrub restoration at this site.

Opportunities for Enhancement and Restoration

Restoration efforts should focus on the expansion of existing cactus stands and establishment of additional large cactus stands to create cactus patches that exceed 2 hectares in size within the 60 hectare weed treatment areas.

During the spring of 2015, following sufficient rain, an evaluation of native forb and grass cover conditions should be performed within the 60 hectare weed treatment area to determine the need for additional weed control and to identify if there is a need for planting native forbs and grasses in addition to the planting of additional cholla and prickly pear cactus.

Because this site burned in 2007, there is currently no need for shrub thinning or fuels management; however, the condition and extent of competing shrubs should be monitored over time.

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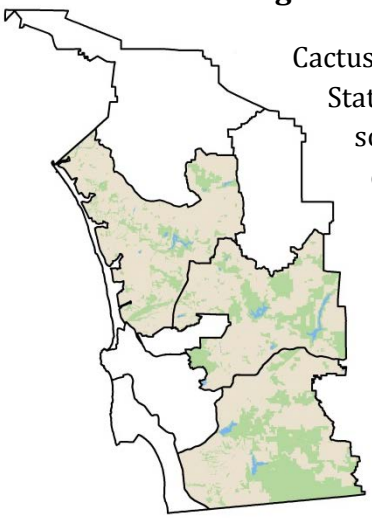
Appendix A.
Management Strategic
Plan Goals and Objectives for Coastal Cactus Wren

Available for downloading at
http://www.sdmmp.com/reports_and_products/Management_Strategic_Plan.aspx

2.2.11 Coastal Cactus Wren *(Campylorhynchus brunneicapillus sandiegensis)* - CSC

Management Units with Known Occurrences



Cactus wrens are distributed across the arid regions of southwestern United States and northern and central Mexico (Hamilton et al. 2011). In southern California, the coastal cactus wren subspecies is restricted to cactus dominated coastal sage scrub habitats from Ventura south to San Diego and inland to San Bernardino and Riverside Counties.

The USGS recently conducted a study on the genetic connectivity between occurrences of coastal cactus wren in southern California (Barr et al. 2012, 2013). Overall, cactus wrens appear to be poor dispersers (Kamada and Preston 2013), particularly in fragmented landscapes, which has led to genetic differentiation between clusters of wrens (Barr et al. 2013). In Orange and San Diego Counties four distinct genetic clusters were detected with calculated effective occurrence sizes [harmonic mean N_e], in the following areas: Orange County and MCB Camp Pendleton/Fallbrook NWS [152]; San Pasqual Valley and Lake Hodges [86]; San Diego and El Cajon [36]; and Otay River [45] (Table 2-2.8 and Figure 2-2.13). The goals and objectives for coastal cactus wren are informed by the results of this study.

The USFWS also conducted an occupancy study of coastal cactus wren in San Diego County between 2009 and 2011 (Winchell 2011). Coastal cactus wrens were detected at sampling sites in MUs 1, 2, 3, 4, 5 and 6. In MU1, a few wrens occur in the Tijuana Slough NWR and occur in low numbers in the urban canyon areas of MU2. Larger occurrences in MU3 (Figure 2-2.14) fall into two genetic clusters. The occurrences that occur in the Sweetwater River watershed are within the San Diego/El Cajon genetic cluster and are genetically connected to the occurrences at Lake Jennings to the north in MU4. The occurrences in the Otay River and Tijuana River watersheds are within the Otay River Genetic Cluster and are considered isolated from the San Diego/El Cajon Genetic Cluster (and potentially to occurrences in Mexico) even though the physical distance is close. Coastal cactus wrens in MU4 (Figure 2-2.15) occur within the San Diego/El Cajon Genetic Cluster and are genetically connected to the coastal cactus wrens in the Sweetwater area in MU3, although the physical habitat connection is somewhat tenuous due to development. Coastal cactus wrens in MUs 5 and 6 (Figure 2-2.16) are within the San Pasqual and Lake Hodges genetic cluster and represent the largest concentration of coastal cactus wrens in San Diego County outside of Camp Pendleton. Coastal cactus wren was not detected on conserved lands in MUs 7 or 8 during the 2009-2011 USFWS

Category SO
Significant occurrence(s) determined to be at risk of loss from MSPA

surveys. However, during the genetic studies a few pairs were found in the Pauma Valley area of MU8 on private lands. See SC_MTX for a complete listing of all locations where coastal cactus wren has been detected.

Management Categorization Rationale

Coastal cactus wrens should be managed as a Species Management Focus Category SO Species due to a high risk of loss genetic clusters, particularly the Otay Valley and Sweetwater clusters, from Conserved Lands in the MSPA and because managing vegetation alone will not ensure persistence of the species (Categorization Table, Vol. 1, App. 1C). Coastal cactus wren should be managed at a species-specific level due to the isolation of occurrences, low dispersal ability of individuals, and specific habitat requirements (i.e. large cacti).

Cactus wren occurrences face many threats in southern California (see Vol. 3 Sec. 2.0, Species Profiles). A primary threat is altered fire regime that causes direct mortality of birds and destroys cactus scrub, which can take many years to recover (Bontrager et al. 1995, Mitrovich and Hamilton 2007, Hamilton 2008, Leatherman BioConsulting 2009). Other threats include invasive Plant species reducing open habitat for foraging (Preston and Kamada 2012, Kamada and Preston 2013), declines in productivity during drought, and predation by domestic cats, roadrunners, snakes, loggerhead shrikes, and especially Cooper's hawks.

Management Approach

The pair of cactus wrens at Tijuana Slough NWR fall into the Otay genetic cluster but is separated from the occurrences in the Otay River Valley by development; therefore management has not been prioritized in this area over the next 5 years. Note that this occurrence may serve as refugia for coastal cactus wren in the event of a major wildfire in the remainder of the Otay genetic cluster. Management actions in MU3 will reduce the distance between the MU1 occurrence and the MU3 occurrence. The small numbers of coastal cactus wren in urban canyons in MU2 are surrounded by development and potentially high predation pressure and management has not been prioritized over the next 5 years. Note that these areas may serve as refugia for coastal cactus wren in the event of a major wildfire in the Otay and Sweetwater areas.

The occurrences that occur in the Sweetwater River watershed (MU3) are within the San Diego/El Cajon genetic cluster and are genetically connected to the occurrences at Lake Jennings (MU4) to the north, although the physical habitat connection is restricted as a result of development. The occurrences in the Otay

River and Tijuana River watersheds (MU3) are within the Otay River Genetic Cluster and are considered isolated from the San Diego/El Cajon Genetic Cluster even though the physical distance is close. Restoration and enhancement of cactus wren habitat within these genetic clusters have been prioritized over the next 5 years due to the high risk of extirpation of these occurrences (i.e. effective occurrence size is less than 50; see Vol. 3, Section 5).

Coastal cactus wrens in MUs 5 and 6 are within the San Pasqual and Lake Hodges genetic cluster and represent the largest concentration of coastal cactus wrens in San Diego County outside of Camp Pendleton. A significant portion of this area burned during the 2007 Witch Fire, fragmenting the cactus and coastal sage scrub habitat used by cactus wrens and reducing the wren occurrence (Hamilton 2008). Management actions are already under way to improve the connectivity and expand at San Diego Zoo Safari Park and Lake Hodges and to protect the occurrence from major wildfire (Zoological Society of San Diego and City of San Diego Water Department 2009).

The lack of coastal cactus wren on Conserved Lands in MUs 7 and 8 means that management of wren in these units has not been prioritized over the next 5 years.

See Table 2-2.9 for coastal cactus wren management goals and objectives.

Table 2-2.8. Conserved Lands identified for potential restoration of cactus scrub to expand occurrences and maintain connectivity within Coastal cactus wren genetic clusters in MUs 3, 4, 5, and 6. N_e is the effective occurrence size as determined by genetic analysis and is associated with the number of successful breeding individuals in a occurrence (Barr et al. 2013). An N_e of less than 50 individuals is considered at immediate risk of extinction because inbreeding depression and demographic stochasticity can result in an extinction vortex (Franklin 1980).

Genetic Cluster	MUs	Preserves	Land Ownrs.	Land Mgrs.	N_e	Threats	Source
Otay River	3	• Otay Lakes Cornerstone Lands • Johnson Canyon, Lonestar Ridge • Furby North Property • Otay Ranch Preserve • O'Neal Canyon Preserve • Dennery Canyon • Dennery Ranch/Otay Mesa North • Cal Terraces • Otay Valley Regional Park	• City San Diego PUD • CALTRANS • County San Diego • Otay POM, • City San Diego • CALTRANS • City San Diego • City San Diego • City San Diego/County San Diego/City Chula Vista	• City San Diego PUD • CALTRANS • County San Diego DPR • Otay POM • City San Diego PRD • CALTRANS • City San Diego PRD • Private • City San Diego PRD/County San Diego DPR/City Chula Vista	45	Loss of connectivity, small isolated occurrences.	Winchell 2011, Barr et al. 2013
San Diego/ El Cajon	3,4	• San Diego National Wildlife Refuge • Sweetwater Reservoir Open Space • Mount Miguel Open Space • Otay Lakes Cornerstone Lands • Rolling Hills Ranch • Otay Ranch Preserve • Lake Jennings Watershed • Lakeside Linkage Open Space • Hansons Aggregates	• USFWS • Sweetwater Authority • Otay MWD • City San Diego PUD • City Chula Vista • Otay POM • Helix Water District • County San Diego • EHC	• USFWS • Sweetwater Authority • Otay MWD • City San Diego PUD • City Chula Vista • Otay POM • Helix Water District • County San Diego DPR • County San Diego DPR	36	Portions of cluster burned in 2007 with loss of wrens and cactus scrub.	Winchell 2011, Barr et al. 2013
San Pasqual Valley/ Lake Hodges	5,6	• San Pasqual Valley • San Diego Zoo Safari Park • Battlefield Park • San Dieguito River Park • Lake Hodges	• City San Diego PUD • City San Diego PUD • City San Diego PUD • San Dieguito River Park JPA • City San Diego PUD	• City San Diego PUD • San Diego Zoological Society • City San Diego PUD • San Dieguito River Park JPA • City San Diego PUD	86	Most of the cluster burned in 2007 with loss of, especially at Lake Hodges.	Winchell 2011, Barr et al. 2013

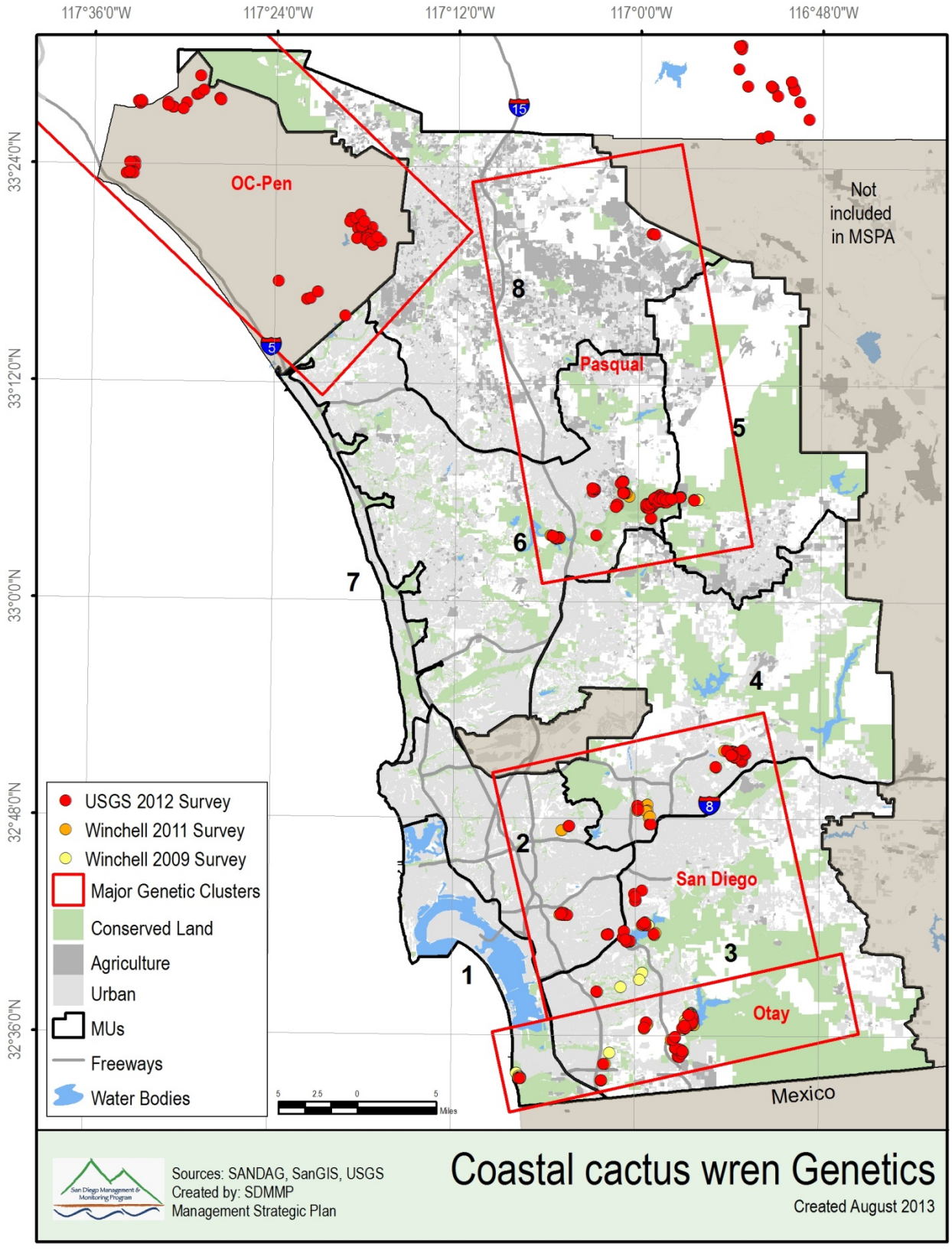


Figure 2-2.13. Major genetic clusters for coastal cactus wren in the MSPA.

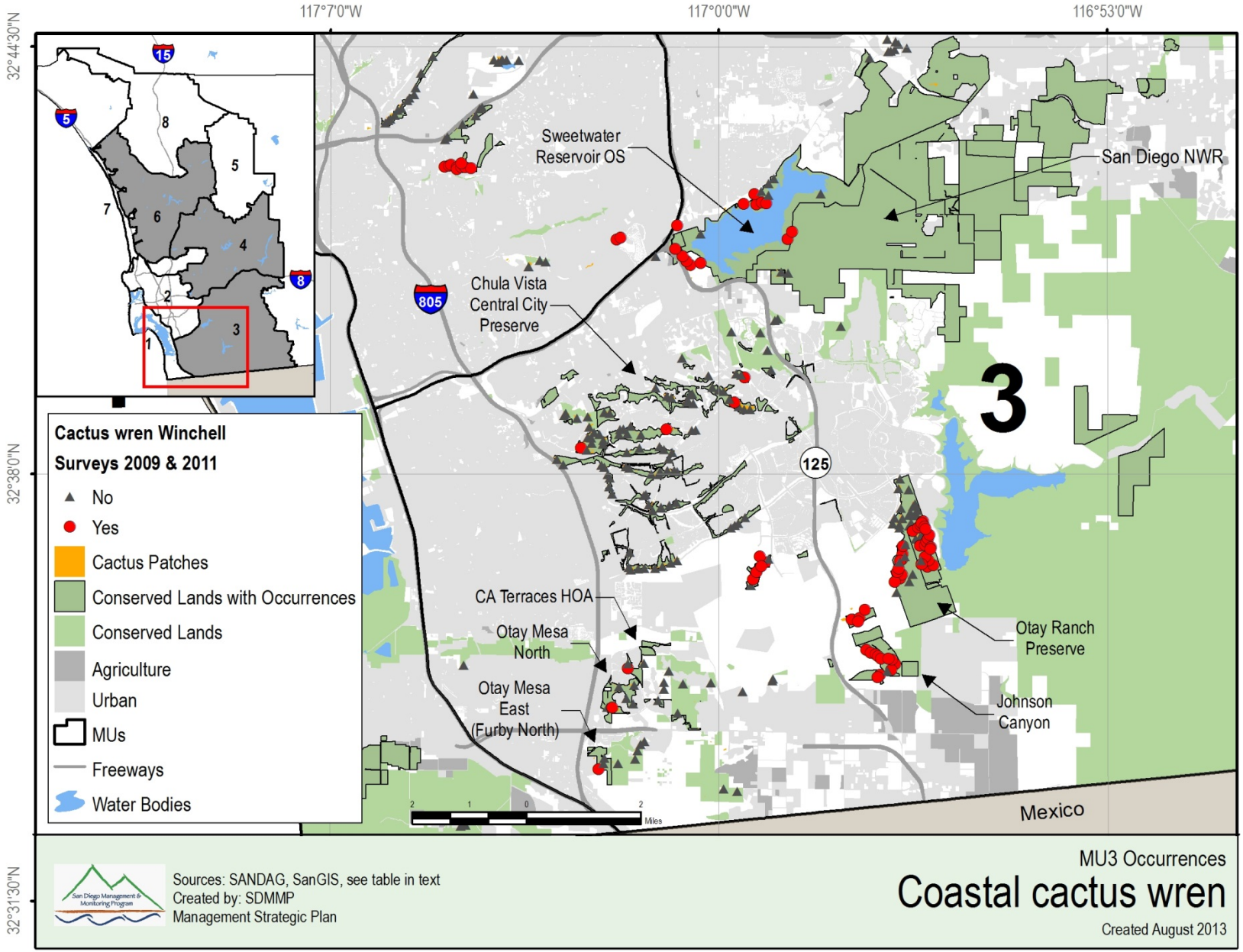


Figure 2-2.14. Distribution of coastal cactus wren on Conserved Lands in MU3.

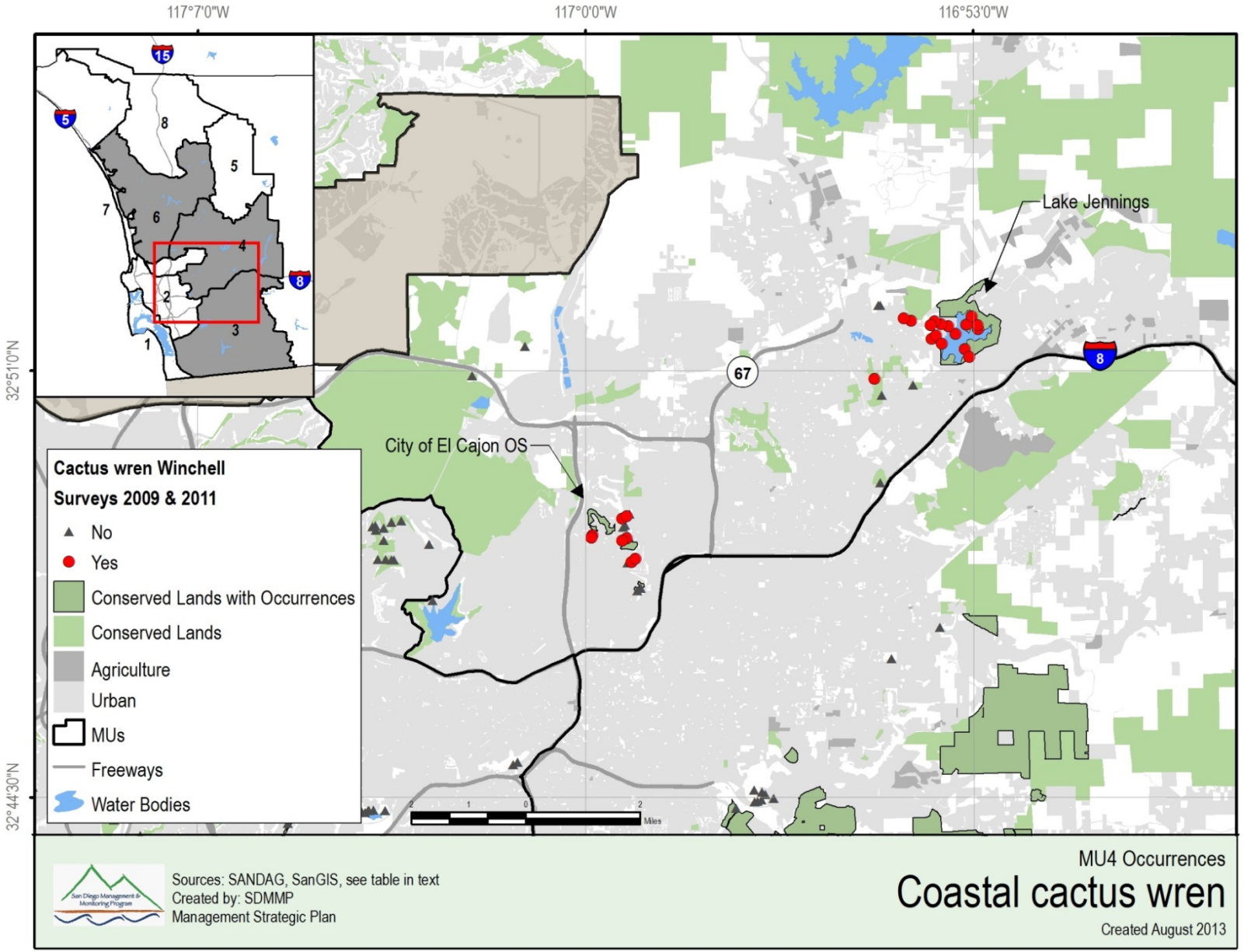


Figure 2-2.15. Distribution of coastal cactus wren on Conserved Lands in MU4.

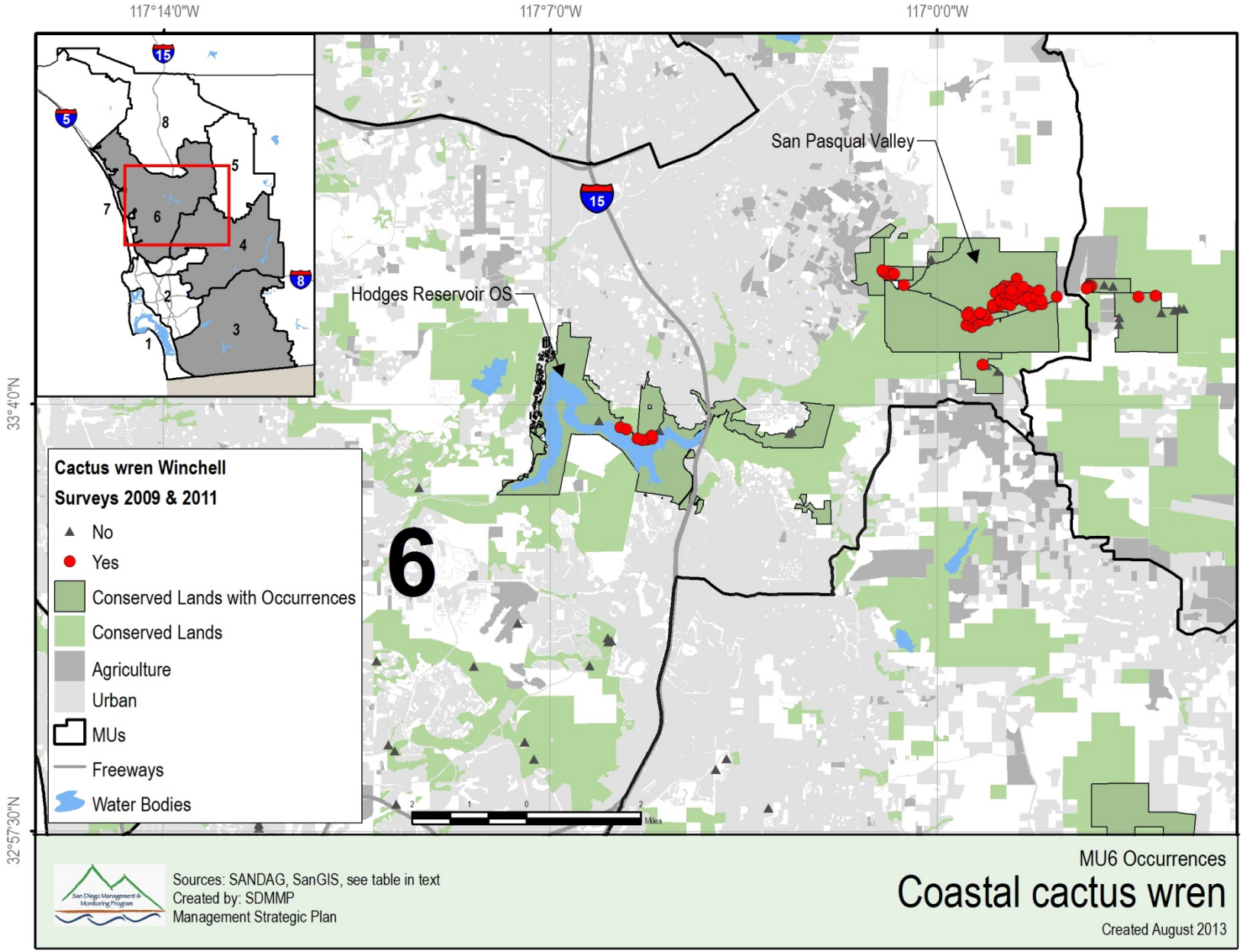


Figure 2-2.16. Distribution of coastal cactus wren on Conserved Lands in MU6.

Table 2-2.9. Management goals and objectives for coastal cactus wren.

Regional Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within and between the recently identified coastal cactus wren genetic clusters to increase the effective occurrence size to a sustainable level (e.g. 50/500; see Vol. 3, Section 5), provide habitat connections to allow for movement within genetic clusters and potentially between the San Diego/El Cajon and Otay genetic clusters, and prioritize management in areas with low predation pressures to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MU3 Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the Otay River and San Diego/El Cajon genetic clusters to expand the occurrences to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5), enhance habitat connectivity throughout the Otay River Valley, and potentially connect this occurrence to the San Diego/El Cajon genetic cluster (depending on results of the in-progress study on historic genetic structure) to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MU4 Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the San Diego/El Cajon genetic cluster to expand the occurrence to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5) and enhance habitat connectivity within the genetic cluster to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MUs 5 and 6 Management Goals: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the San Pasqual genetic cluster to expand the occurrence to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5) and enhance habitat connectivity within the genetic cluster to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

Type	Objectives	MUs	Actions
PIP; Regional	In 2014, prepare an implementation plan for enhancing and restoring cactus scrub habitats on Conserved Lands in MUs 3 and 4 in order to expand the Otay and San Diego/El Cajon cactus wren genetic clusters and enhance connectivity.	3,4	• Use the historic genetic analysis to determine if connectivity should be restored between the San Diego/El Cajon and Otay genetic clusters to enhance genetic diversity and reduce the potential for inbreeding, and to increase resilience to demographic stochasticity. • Construct dynamic occurrence viability models incorporating the landscape matrix of urban development and natural lands, habitat suitability and existing cactus scrub, fire risk, and wren occurrences, demography and dispersal capabilities. Use this model to compare alternative restoration scenarios connecting and enhancing cactus scrub habitat for the San Diego/El Cajon and Otay River genetic clusters in MUs 3 and 4. • Conduct site visits to potential cactus scrub enhancement and restoration sites and collect information on current wren occupancy, condition of cactus scrub, cover of invasive plant species, potential threats, and identify management needs. Map suitable areas for cactus scrub enhancement and restoration that avoid impacting sensitive plant and animal species. • Prioritize suitable habitat for enhancing and restoring cactus scrub to expand the occurrence and to increase connectivity within genetic clusters. • If it is determined by the historic genetics study that connectivity should be improved between the San Diego/El Cajon clusters, evaluate and prioritize sites for restoration between these genetic clusters that would enhance connectivity.

Type	Objectives	MUs	Actions

	(continued from previous page)		• Identify cactus sources that can be salvaged for transplanting of pads and entire plants into restoration and enhancement. Identify sites for harvesting vegetative cuttings that can be grown at the cactus nursery and later planted as entire plants or segments at the restoration and/or enhancement sites. • Specify BMPs for cactus harvest and salvage, cactus scrub restoration, restoration site selection, restoration and maintenance. • Develop ASMDs to reduce the exotic/invasive plant cover and to provide bare ground for foraging cactus wrens. • Develop ASMDs to reduce predation pressure and other threats to cactus wrens. • Prepare an implementation plan that takes into account the above factors and specifies total acreage and prioritized locations for restoration and enhancement of cactus, source material including availability of large cactuses, reduction of predation pressures, elimination of riparian and urban runoff from habitat historically xeric areas to reduce predation pressures and argentine ant occupation of cactus wren habitat, protection from wildfire, and decrease in invasive/exotic plant cover and creation open areas/bare ground.
NU; Regional	Starting in 2014, develop and maintain two cactus nurseries at approved facilities in MU3/4 and in MU6 and grow cactus pads, segments, and entire plants sufficient for restoration projects in the South County and the San Pasqual Valley as identified in cactus restoration implementation plans.	3,4,6	• Prepare a plan with specifications of BMPs for harvesting and growing cactus at a nursery in preparation for transplant into natural lands. • Develop and maintain a nursery for growing cactus harvested/salvaged from the MUs 2, 3, and 4 for use in restoration projects in the South County. The nursery should be set up to grow and supply cactus pads, segments and entire plants from locally harvested native cactus and the composition of species should reflect those found in that geographic area. • Develop and maintain a nursery for growing cactus harvested/salvaged from MUs 5, 6, and 8 for use in restoration projects in the North County. The nursery should be set up to grow and supply cactus pads, segments and entire plants from locally harvested native cactus and the composition of species should reflect those found in that geographic area. The amount and type of cactus will be determined by the South County implementation plan and by the ongoing restoration projects in the San Pasqual Valley. • Submit to the SC-MTX website portal the cactus nursery plans and annual reports documenting number, size class (pad, segment, entire plant), and type of cactus that were harvested by source site, planted at restoration sites, and that are at the nursery and available for planting.

Type	Objectives	MUs	Actions
FWP; Regional and/or Local	In 2014 and 2015, implement pre-fire management actions identified in the Strategic Fire Plan in order to reduce the effects of an altered fire regime on coastal cactus wrens and cactus scrub habitats on Conserved Lands in MUs 3, 4, 5, and 6.	3,4,5,6	• Perform pre-fire actions applicable to coastal cactus wrens and cactus scrub in the Strategic Fire Plan, including specific actions to protect cactus scrub from high intensity fires and recurrent fires. • Submit management data to the SC-MTX website portal.
IEX, RS; Local	In 2014 continue the ongoing cactus scrub restoration projects for the San Pasqual/Lake Hodges genetic cluster in MU6.	5,6	• Support cactus scrub restoration in the San Pasqual/Lake Hodges genetic cluster. • Support ongoing research into cactus wren abundance, habitat relationships, demographics, and response to restoration.
IIP, IEX; Regional and/or Local	In 2015, begin implementing high priority management actions identified in the implementation plan for the Otay and San Diego/El Cajon genetic clusters in MUs3/4 and continue to manage existing and restored cactus scrub habitat occupied by cactus wrens to allow for the continued growth and expansion of cactus by reducing invasive plant cover to ≤25% absolute cover, increasing the amount of bare ground to 50% cover, and removing predator opportunities and/or prioritizing management in areas with reduced predation pressure.	3,4,5,6	• Implement high priority management actions, including enhancing and restoring cactus scrub habitats as detailed in the implementation plan. • Implement ASMDs at existing occurrences to reduce the exotic/invasive plant cover and to provide bare ground for foraging cactus wrens. • Implement ASMDs at existing occurrences with high risk of predation to reduce predation pressure on cactus wrens.

Appendix B.

Status of Otay River Valley Cactus Wrens – Monitoring and Management Options

Appendix B. Status of Otay River Valley Cactus Wrens –
Monitoring & Management Options

Prepared by K Preston, San Diego Management & Monitoring Program, 7/9/14

Historic Cactus Wren Surveys Conducted at Otay Ranch from 1988 to1992

- Comprehensive cactus wren surveys were conducted in 1988, 1989 & 1992 throughout Otay Valley (Fig. 1; Dudek & Associates 1995). 1988 & 1989 survey methods unknown except that they were different from 1992 (Table 1).

- 1988 & 1989 surveys compiled to reduce "double-counting". Three survey years considered "baseline" to compare with future monitoring data.

- > 2.5- fold increase in cactus wrens in 1992 compared with 1988 & 1989 (Fig. 1; Dudek & Associates 1995). 1992 surveys documented 64 pairs & 16 single individuals, whereas 1988 & 1989 birds were all considered paired.

- Population increase attributed to end of prolonged drought occurring during 1980s (Fig. 2). It is unknown how differences in survey methods/effort between years affect territory estimates.

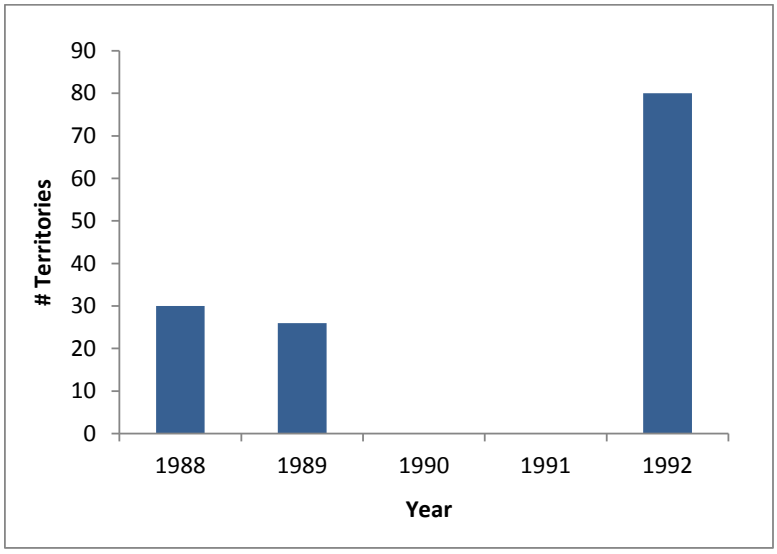


Fig. 1. Number of cactus wren territories estimated in the Otay Valley in 1988, 1989 and 1992.

Impacts to Cactus Wren Habitat

- Compiled all available survey data & overlaid it with GIS layers for conserved lands, urban development, agriculture & parcel boundaries. Cactus wren locations appear directly impacted by agriculture, highway construction & urban development since 1992. A total of 68 cactus wren locations recorded in 1992 are on conserved or future conserved lands.

- In 1994 a fire burned through south end of Salt Creek & northeast edge of Otay Valley impacting two 1992 wren locations. These locations were occupied during 2009 & 2011 surveys.

Table 1. Survey entity, survey effort, method & type of population estimate for different sites surveyed for cactus wren in the Otay Valley between 1988 & 2014.

Year	Poggi Canyon (Entity/Method/Est)	Upper Wolf Cyn (Entity/Method/Est)	Lower Wolf Cyn (Entity/Method/Est)	Otay River Valley (Entity/Method/Est)	Johnson Cyn (Entity/Method/Est)	Salt Creek (Entity/Method/Est)
1988	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs
1989	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs
1992	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males
1994				? for SR-125 / unknown method & effort/# prs		
2000	? in CNDDB database/ unknown method & effort/# territories				SDNHM in SanBios/unknown method & effort/# territories	
2009	USFWS/2 surveys at established pts/ occupancy	USFWS/2 surveys at established pts/ occupancy		USFWS/2 surveys at established pts/ occupancy		USFWS/2 surveys at established pts/ occupancy Dudek/3 surveys/# territories
2010						RECON/1 survey & photomonitoring pts/ # pairs & single indivs
2011	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs			USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs
2012		USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs.			USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs	USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs
2013		USGS/1 check of 2012 occupied locations/partial est # territories			USGS/1 check of 2012 occupied locations/partial est # territories	USGS/1 check of 2012 occupied locations/partial est # territories
2014	SDMMP/1 habitat assessment visit/presence	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs	USGS surveys pending	USGS surveys pending	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs

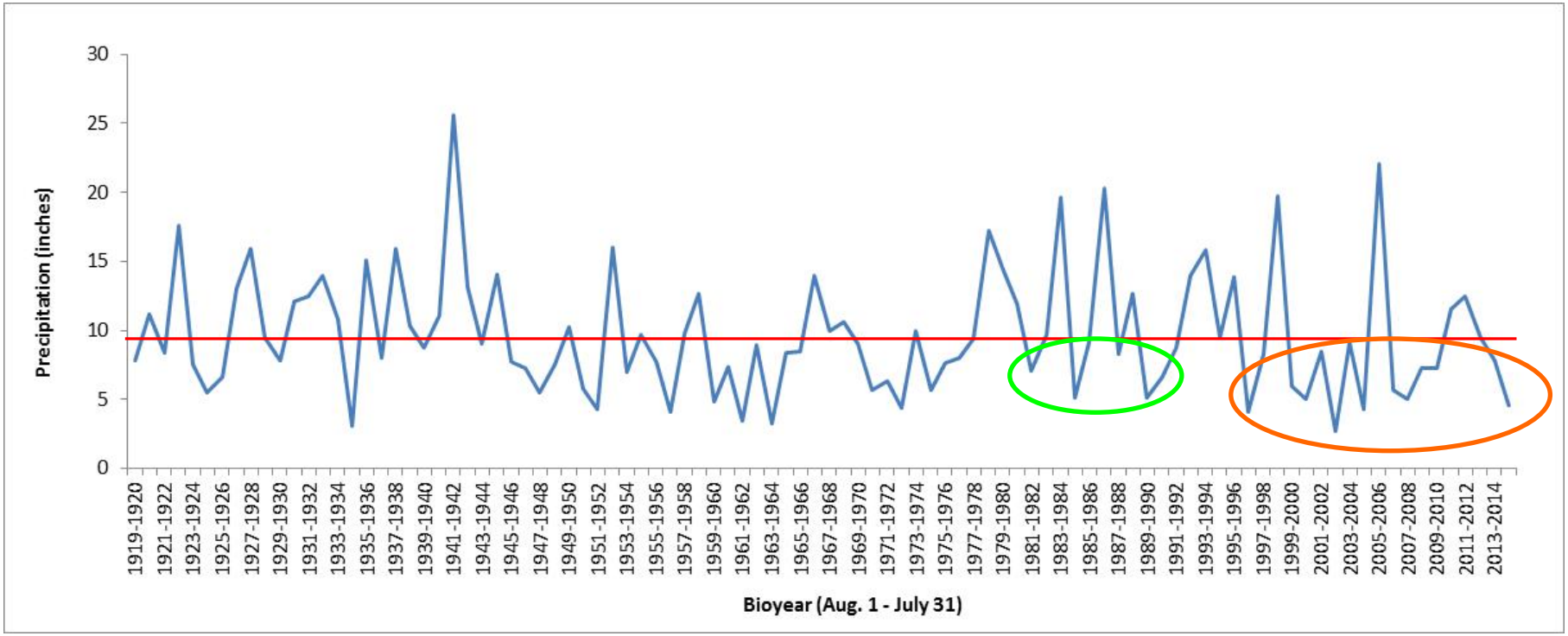


Fig 2. Bioyear precipitation in Chula Vista from 1921-2013. The red line represents average bioyear rainfall, the green circle shows drought years in the 1980s, and the orange circle highlights drought years from the mid-1990s to 2014.

Current Otay Cactus Wren Population Status

- Surveys were conducted from 2009 to 2014 on conserved lands at different sites in the Otay Valley. Methods, survey effort & types of data collected differ among surveys (Table 1). Surveyers typicallly provided an estimate of the number of territories. I developed an estimate in cases when there were multiple entities surveying the same site in the same year or an estimate was not provided by the surveying entity. The number of territories each year represents an estimate based on available data that includes mapped wren locations over time, banding records & pairing /reproductive information.

- The total estimated number of territories on undeveloped lands at 3 consistently surveyed sites (Wolf Canyon, Salt Creek, Johnson Canyon) shows a peak in 1992 with 53 territories (Fig. 3). The next highest years were 1988 & 2009 with 25 territories and the low was in 2014 with 14 territories (12 pairs & 2 single males). Between 2009 & 2014 the estimated number of territories decreased by 40%.

- Salt Creek declined from an estimated 41 territories in 1992 to 15 in 2009 & to 7 in 2014 (Fig. 4). Most of the decline was in the northern half of the canyon (Fig. 5 & 6). Johnson Canyon was more stable with 6-9 territories, although in 2014 two of the 6 territories had single males rather than pairs (Fig. 4 & 7). Upper Wolf Canyon typically supports 1-2 pairs, with 1 pair in 2014 (Fig. 4 & 8). No GIS survey data were available after 1992 for the privately owned, future conserved lands in lower Wolf Canyon and along the Otay River Valley (Fig. 4, 8 & 9).

- Based on 2-3 surveys/territory between April and June, productivity was unusually low in 2014. Three territories (21%) produced single fledglings, 8 exhibited no successful reproduction and 3 had unknown reproductive success.

Factors Associated with Population Dynamics of Songbirds in Southern California Shrublands

- In arid ecosystems, the timing and amount of precipitation drives primary productivity which affects plant and arthropod food source available for birds and small mammal populations. In southern California arthropod abundance and biomass were significantly reduced during an extreme drought year (Bolger et al. 2005).

- Food availability and nest predation are two primary drivers of avian productivity and have been shown to be important in southern California shrubland nesting songbirds (e.g., Morrisonand Bolger 2002, Bolger et al. 2005, Preston and Rotenberry 2006 a,b).

- In southern CA drought induced food limitation has resulted in low productivity and even total reproductive failure among shrubland birds (Bolger et al. 2005, Preston and Rotenberry 2006 a,b). However, nest predation may still play a role as food limitation and nest predation were shown to have equal and independent effects on productivity in an extreme drought. Songbirds respond to reduced food availability by not breeding, delaying nesting, attempting fewer nests, having smaller clutches and fewer broods.

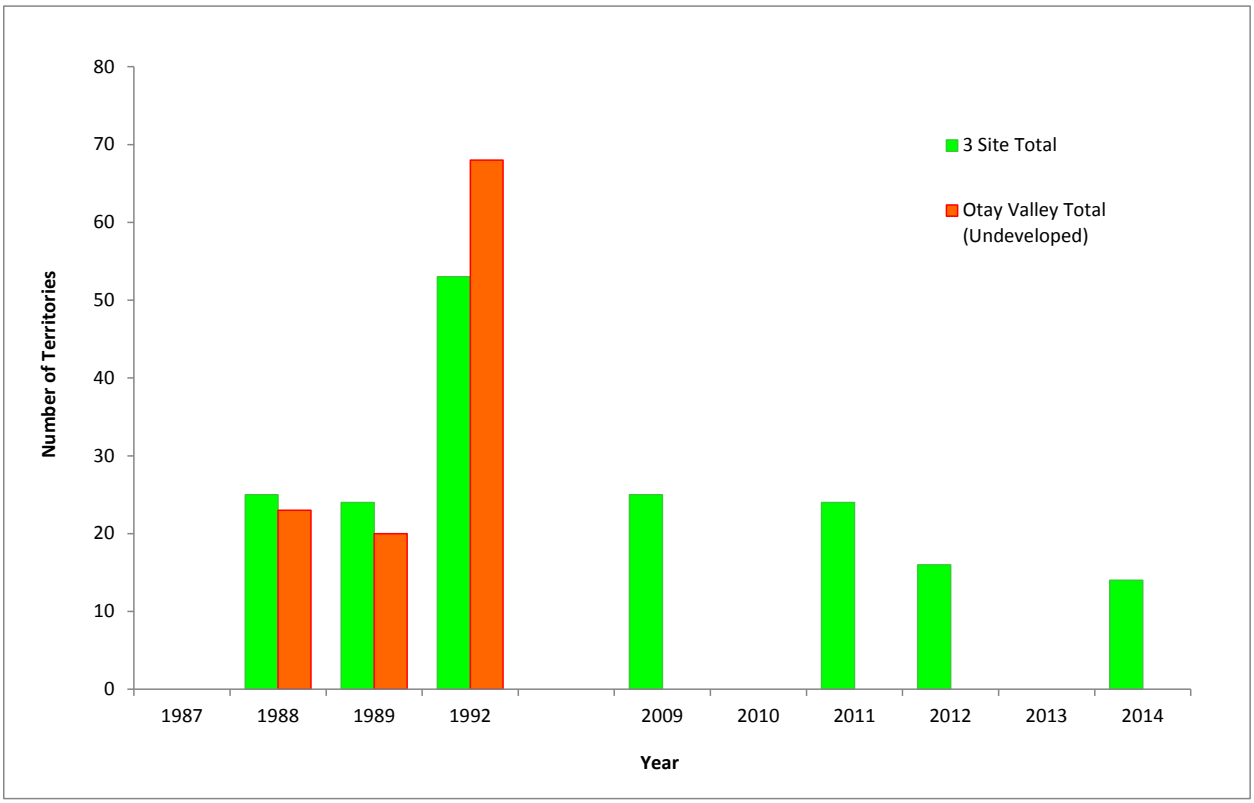


Fig. 3. Estimated total number of undeveloped cactus wren territories and combined total number of territories at three sites (upper Wolf Canyon, Johnson Canyon and Salt Creek) consistently surveyed in the Otay Valley between 1988 and 2014.

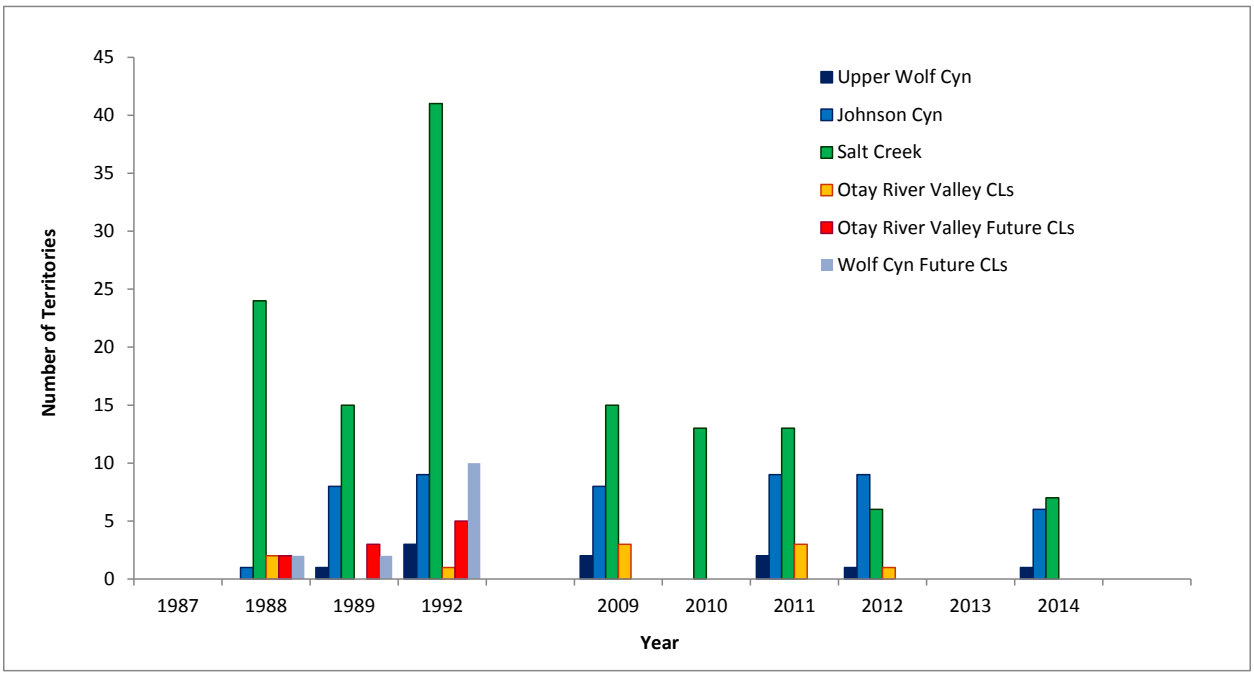


Fig. 4. Estimated number of cactus wren territories between 1988 and 2014 at various sites within the Otay Valley.

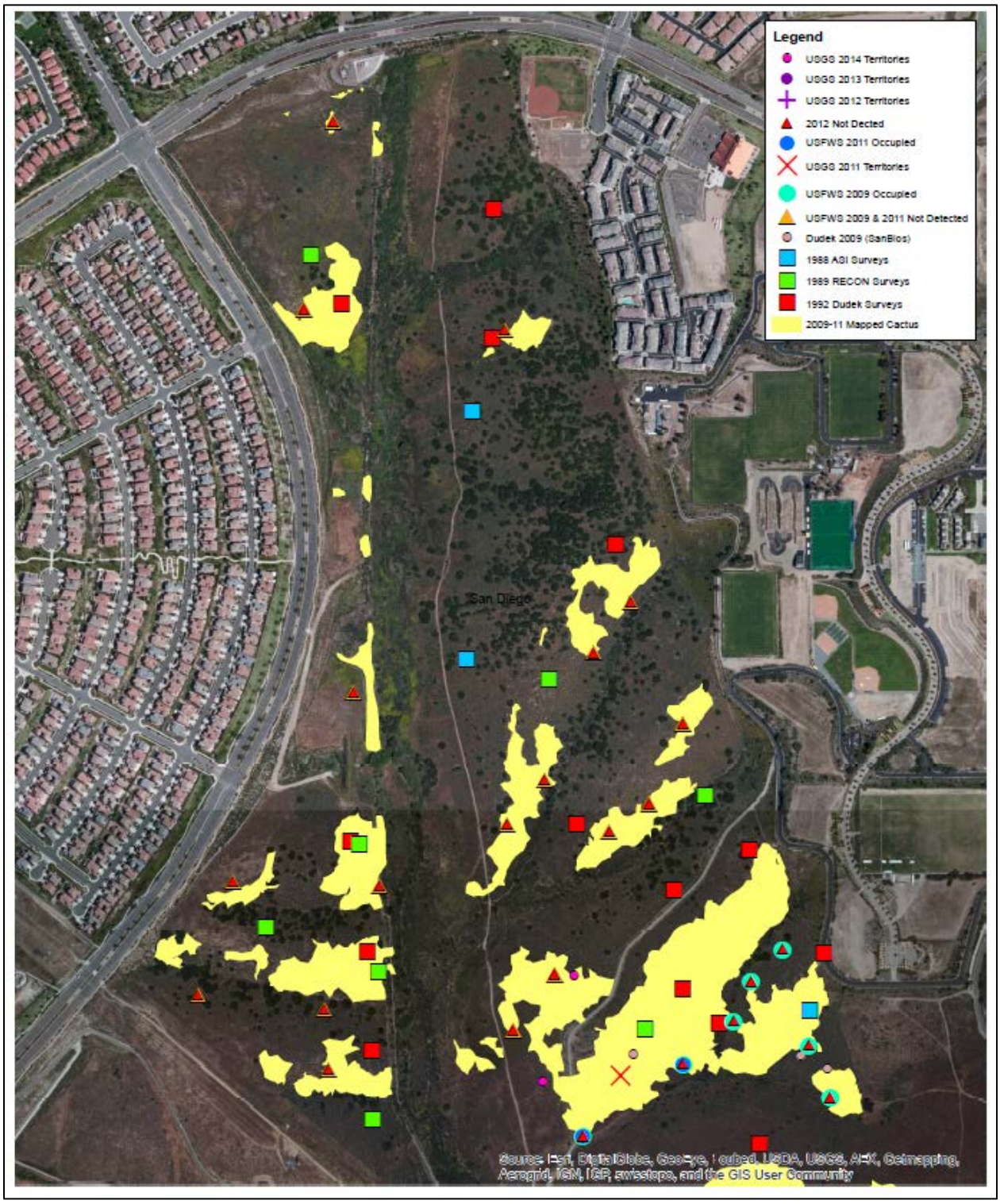


Fig. 5. Distribution of cactus wren territories from 1988 to 2014 in northern Salt Creek.

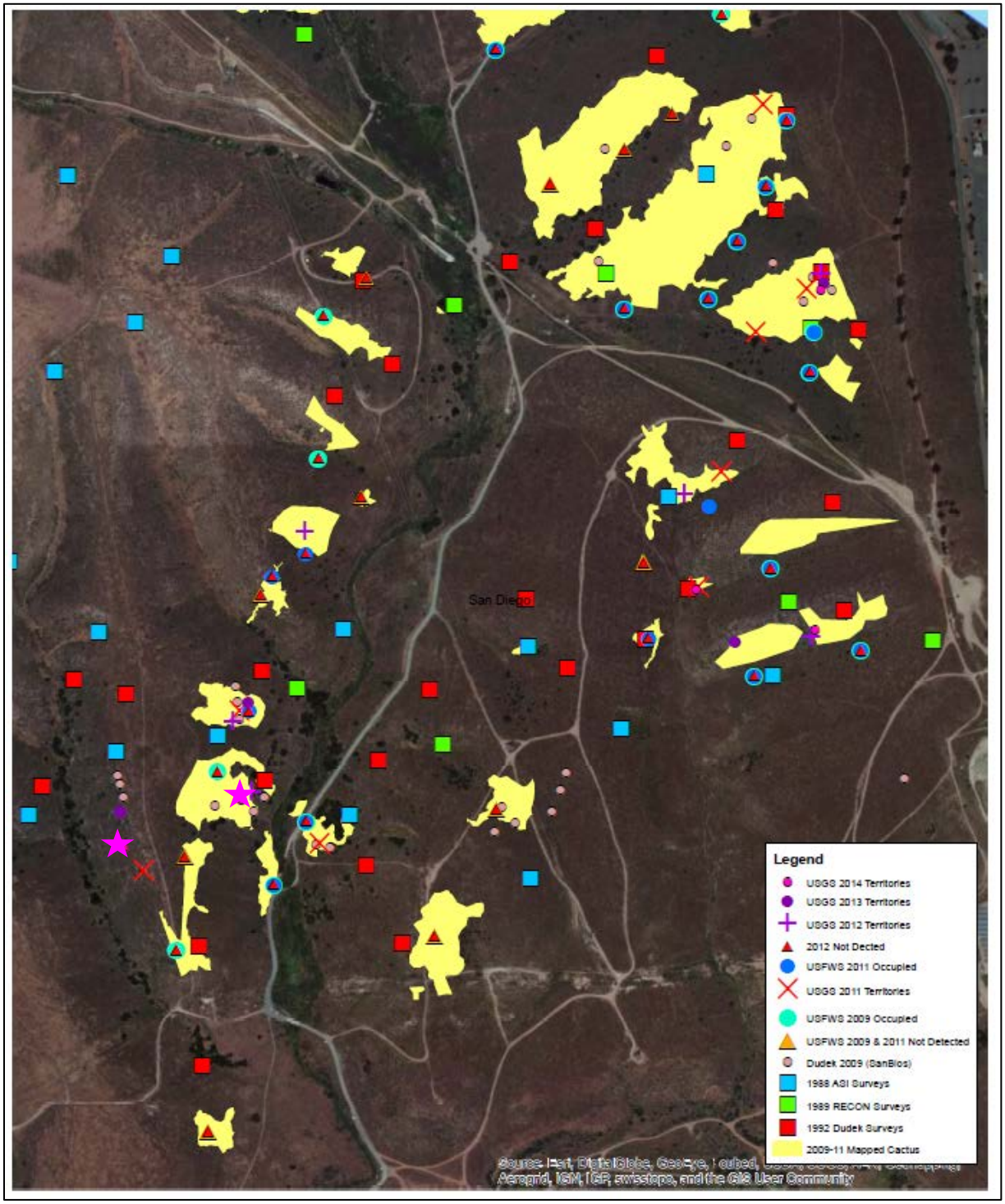


Fig. 6. Distribution of cactus wren territories from 1988 to 2014 in southern Salt Creek. Pink stars represent two pairs producing single fledglings in 2014.

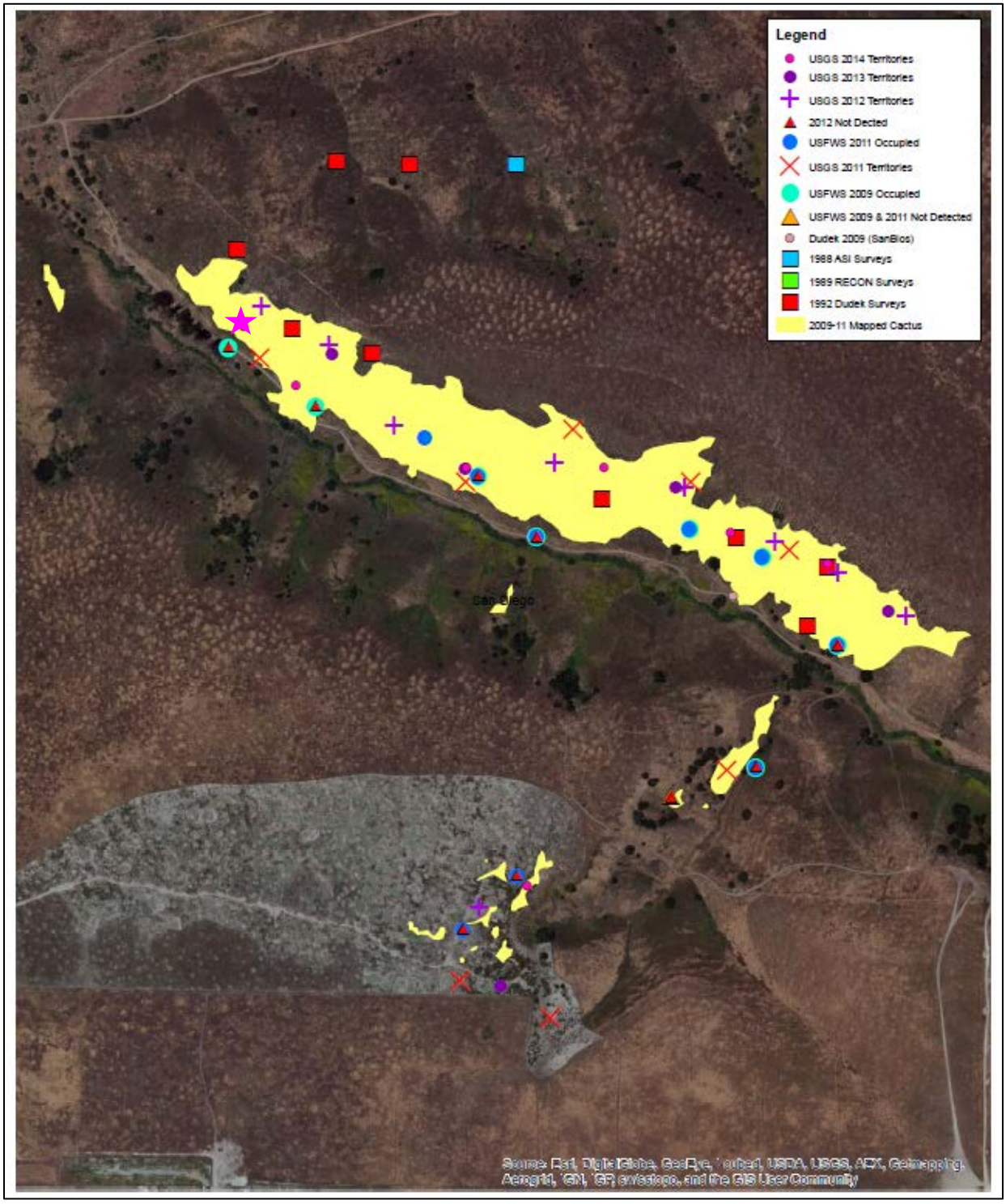


Fig. 7. Distribution of cactus wren territories from 1988 to 2014 in Johnson Canyon. The pink star represents a pair that produced a single fledgling in 2014.

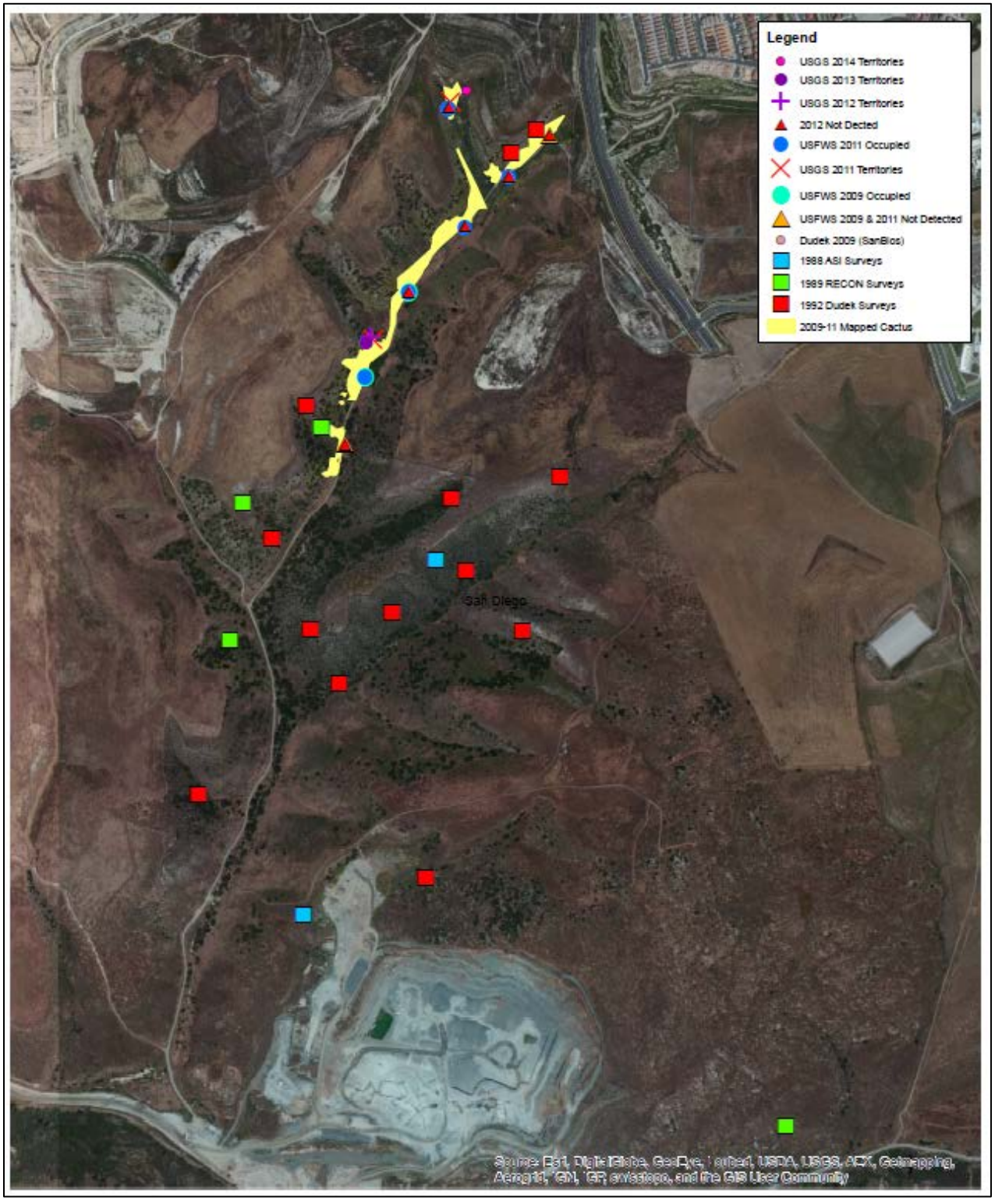


Fig. 8. Distribution of cactus wren territories from 1988 to 2014 in Wolf Canyon.

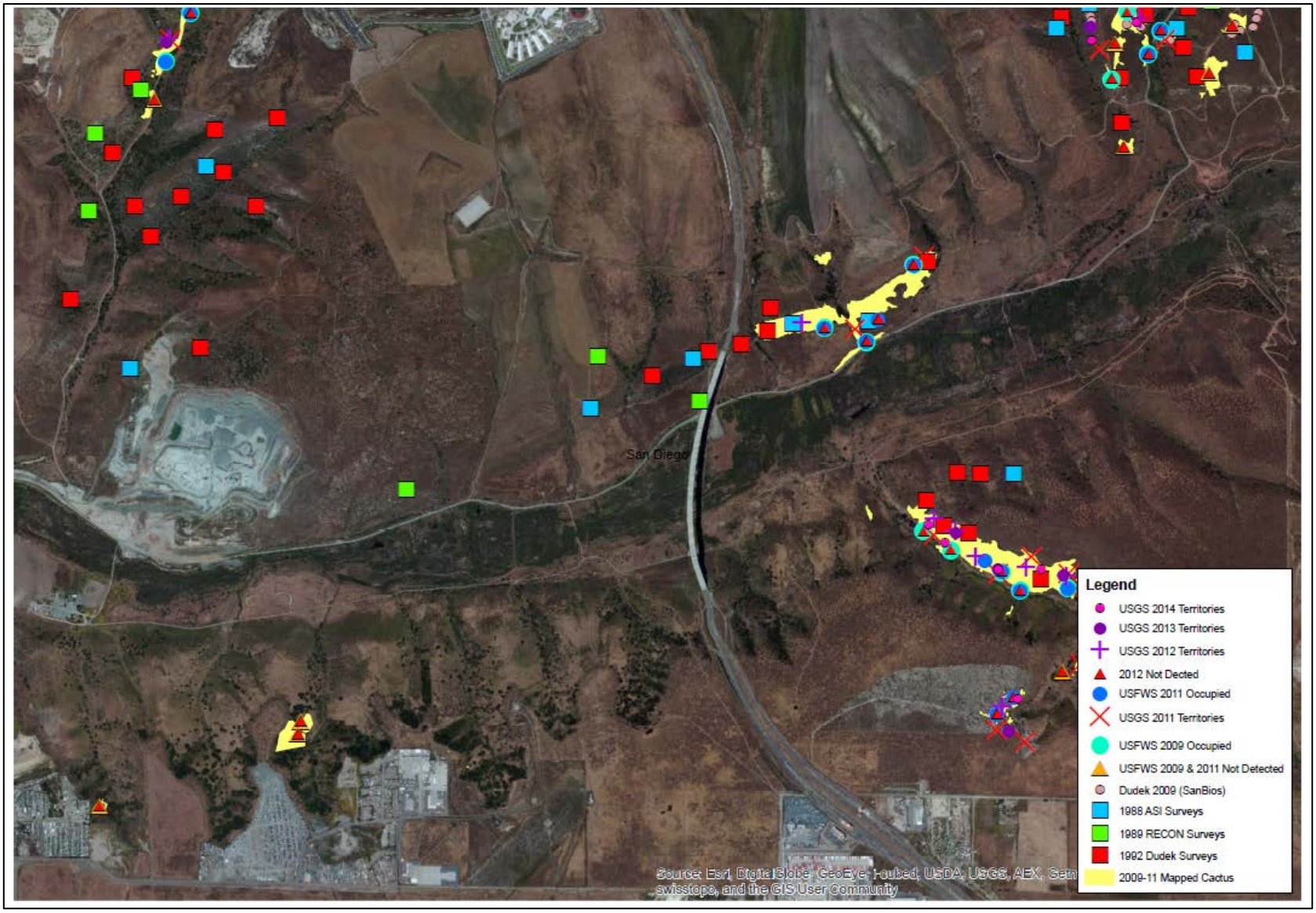


Fig. 9. Distribution of cactus wren territories from 1988 to 1992 along the Otay River Valley.

Factors Associated with Cactus Wren Population Declines

- Habitat loss to development and catastrophic wildfire are considered primary drivers of cactus wren population declines. However, a 5-year study monitoring cactus wren reproduction, dispersal and survival indicate that there are also other factors that influence wren population dynamics (Preston and Kamada 2012, Preston unpub. data). These include small isolated populations with insufficient habitat, limited ability to disperse through fragmented habitat, low productivity (# fledglings/pr/yr) related to rainfall and nest predation, high juvenile mortality with low levels of recruitment into the breeding population, high levels of predation in some habitat fragments and habitat degradation.

- Cactus wren populations declined by more than 80% in the Nature Reserve of Orange County's (NROC) Coastal and Central Reserves, as a result of catastrophic wildfires in 1993 and 2007 (Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009). Wildfires have also affected wren populations in San Diego County over the last decade (e.g., Hamilton 2009).

- Cactus wren productivity at NROC was low from 2009-2013 and was positively associated with January to April precipitation indicating the importance of food availability (Table 4 and Fig. 10 a-d; Preston unpub. data). Productivity is also positively related to elevation (most productive site was at highest elevation) and negatively associated with first egg lay date (earlier nesters can produce more broods) and presence of corvids (nest predators).

- Drought is associated with cactus wren population declines. Substantial population reductions following 2002 and 2007 droughts at NROC's Coastal Reserve indicate decreased productivity and/or survival during droughts (Hamilton 2004, Mitrovich and Hamilton 2007, Preston and Kamada 2012). Multiple years of drought may be associated with smaller population size in the Otay Valley in the late 1980s (Dudek 1995) and more recently (Fig. 2).

- The current drought is affecting cactus and there is dead or dying cholla at some sites in south San Diego County (Fig. 11). There are indications cacti were dying in 2009 in parts of Salt Creek (Preston unpub. data), which could be a factor in the loss of wrens from this area.

- Small populations are vulnerable to local extinction. At NROC, sites with <4 territories were highly variable in occupancy between 1999-2004 (Hamilton 2004), whereas sites with more birds tended to remain occupied over time. During the extreme 2007 drought birds disappeared from sites with small numbers of pairs and most sites were not re-colonized (Table 3).

- Cooper's hawk predation is likely associated with increased mortality and rapid decline in small populations, especially in urban fragments (Preston and Kamada 2012, Preston unpub. data).

Table 3. Disappearance of cactus wrens from sites with small numbers of birds at the Coastal Reserve of Orange County during the 2007 drought.

Site	Original # Territories	Year	Year Disappeared	Association with drought	Connected to Other Sites?	Recolonized?
Boat Canyon	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	Yes (2011)
Bonita Reservoir	2	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
El Moro Ridge	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
Emerald Ridge	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
James Dilley	8	2002	2008	4 of 6 years <average rainfall (2 extreme years @ 32% and 40% of average)	Yes	No (Translocated 9 birds but all left/died after 2 years)

- Habitat quality may influence food availability, with high thatch cover of invasive non-native grasses altering cactus wren foraging ability and potentially arthropod composition and abundance. A study is underway by the University of California at Irvine, NROC and the Irvine Ranch Conservancy to relate cactus wren productivity to arthropod community composition and abundance in different species of shrubs, cactus, forbs, native and non-native grasses and bare ground. Fecal samples from nestlings wrens were collected to determine what arthropods they were fed. The results of this study will be useful in developing habitat management criteria to improve productivity by enhancing habitat quality and food availability.

- In southern California there is little connectivity among cactus wren populations that are isolated by urbanization and habitat fragmentation (Barr et al. 2012, 2013). Cactus wren are poor dispersers and isolated populations are becoming less genetically diverse. Genetic analyses show the Otay population has little recent connectivity with wrens to the north, even though they are only several km apart.

Table 4 General least squares models predicting minimum number of cactus wren fledglings/pair/ year. Models include exponential spatial-temporal correlation structure to account for spatial and temporal autocorrelation.

Model Parameters	K	Δ_i	ω_i	Evidence Ratio ω_i/ω_1
Year, Pair Density Occupied Cactus, PCorvids, Julian 1st Egg, Jan to Apr Precip, Min Jan & Feb Temp, Elevation, Topographical Heterogeneity, % Cactus 200m	**11**	**0.0000**	**0.9980**	
Year, Pair Density Occupied Cactus, Pcorvids, Julian 1st Egg, Jan to Apr Precip, Min Feb Temp, Max Mar & Apr Temp, Topographical Heterogeneity, Northness, % Urban 1km, % Cactus 200m	13	8.9990	0.0020	499.00
Year, # Territories, PCOHA, Julian 1st Egg, Jan to Apr Precip, Min Jan & Feb Temp, Max Mar & Apr Temp, Topographical Heterogeneity, Northness, % Slope, % Cactus 200m	13	13.1796	0.0004	2,495.25
Year, Pair Density Occupied Cactus, PCorvids, Julian 1st Egg, Jan to Apr Precip, Min Apr Temp, Max Apr Temp, Elevation, Topographic Heterogeneity, Northness, % CSS 1km, % Urban 1km, % Cactus 200m	15	21.4090	0.0000	24,952.50
Year, Pair Density All Cactus, PAll Predators, Julian 1st Egg, Biological Rainfall Yr, Min Jan & Feb Temp, Max Mar & Apr Temp, Elevation, Topographic Heterogeneity, Northness, % Slope, NDVI, % Cactus 25m	15	26.0594	0.0000	332,700.00

Rationale for Potentially Triggering Management Actions to Maintain Population of Otay Cactus Wrens

- Lindermayer et al. (2013) equates a 20% decline over 5 generations as a catastrophic decline that triggers research into threats and increased surveillance (Fig. 11). If threats are known then management of threats should be implemented.

- Southern California is in the midst of a prolonged and extreme drought, with only 4.6" of rain measured in Chula Vista during the 2013-14 bioyear. The Otay cactus wren population at 3 surveyed sites has declined 40% over 6 years. We have reached a trigger point where we need to decide if we are sufficiently comfortable with our knowledge of threats that we can undertake management actions. We have enough t knowledge to understand that drought is a factor in the decline of cactus wren populations. We know that cactus wren productivity is related to rainfall and this relationship was further confirmed by the very low productivity of the Otay population in 2014. What is currently unknown is the degree to which drought affects survival. Low rainfall is associated with reduced arthropod abundance and biomass, which means that food is limited (as is supported by the lack of productivity). There is concern that some cactus wrens may lack

sufficient arthropod and plant food resources to survive as the drought progresses through the summer into the fall. Unfortunately, populations are becoming small enough that there is insufficient time or number of birds to study if drought is affecting survival. Survival data from NROC will be analyzed to see if there is a link between rainfall and survivorship. However, at this point any individual mortality makes the population more vulnerable to loss. Concerns are that without management to enhance survival, the population is on a downward trajectory that could eventually result in the loss of cactus wrens in the Otay Valley.

- If wrens are lost from Otay Valley, it would be unlikely they could be re-established. The Otay population is isolated from other wren populations as indicated by the genetic study. So natural immigration from other populations is unlikely. There are currently no wren populations in the region with sufficient populations to serve as a source of wrens to be re-established through translocation. Translocation would also be very expensive.

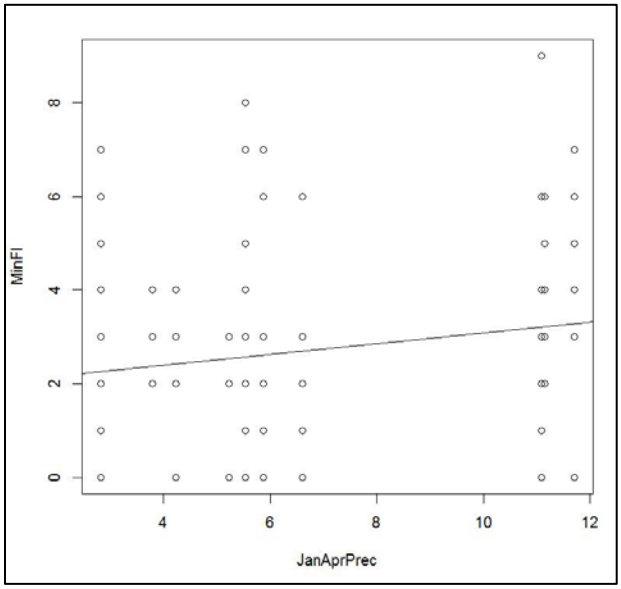
- The importance of food availability in cactus wren reproductive success has been documented in two studies. A study of cactus wrens breeding in the desert found significant differences in reproductive success and nesting phenology between years that was related to the availability of grasshoppers, the primary food source for nestlings (Marr and Raitt 1983). In a second study of desert cactus wrens, food supplemented nestlings and fledglings survived at a higher rate in one of two years and productivity was increased (Simons and Martin 1990).

- The effect of food limitation on survival is unknown in cactus wrens, although loss of wrens during drought periods indicate a reduction in survivorship is occurring (Table 2). Potential management actions to enhance survival in times of limited food availability is to provide supplemental food. This has been done for endangered populations of translocated and naturally occurring songbirds on islands. Food supplementation was shown to enhance survival of 2 of 3 species of translocated songbirds in New Zealand(Armstrong et al. 2002, Chauvenet et al. 2012). One species declined despite the supplemental food because of a fungus prevalent in the habitat. The populations for the two other species increased and after several years led to density dependent reductions in juvenile survivorship in one case and decreased recruitment into the breeding population in the other. A fourth study found that food supplementing an endangered robin during the breeding season resulted in significantly more offspring surviving to 1 year of age (Komdeur 1996).

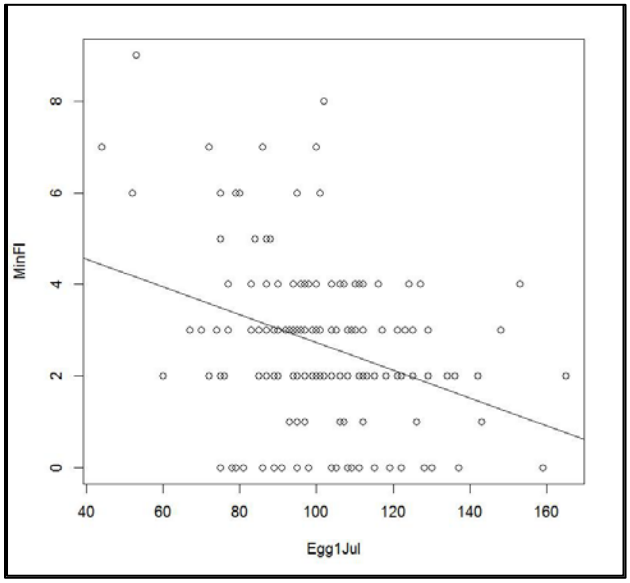
- One course of actions is to survey the Otay River Valley and lower Wolf Canyon sites to document the number of birds in the entire Otay population. We are attempting to obtain access to do this and there is currently sufficient funding to cover this. If there are at least 10 pairs of wrens in the Otay River Valley/lower Wolf Canyon, this would equal a population of 24 and be comparable to the 1989 population level of 26 pairs. A survey should be conducted later this summer to determine if the wren population is stable. If there are fewer individuals, then food supplementation would be an option to try and reduce further loss during the remainder of the drought. Food supplementation has been successfully implemented with cactus wrens in NROC's Coastal Reserve (Kamada and Mitrovich 2013).

- It is important to monitor productivity and survival of Otay cactus wrens over the next few years to better understand the mechanisms underlying the decline and to identify threats to persistence. This will require banding birds and conducting periodic surveys to document survival and production of fledglings.

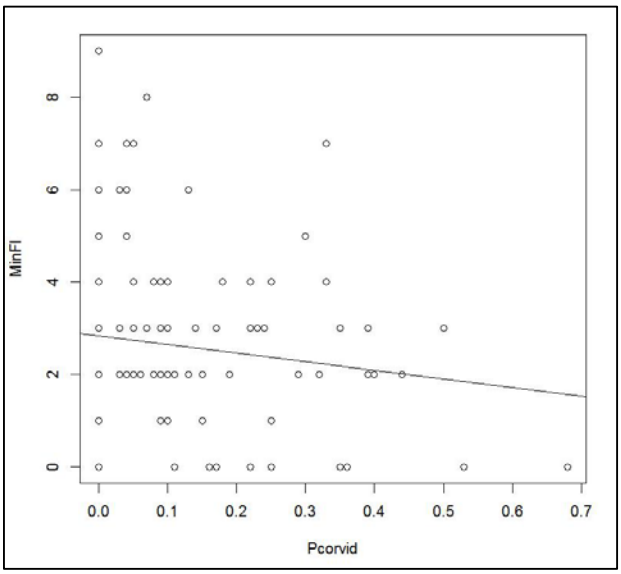
- The Otay population is small and should be managed for increased abundance. Habitat restoration appears to be working at all three sites as birds are using restored sites and the habitat appears of good quality. Continued habitat enhancement and restoration is needed to provide sufficient habitat to accommodate larer more stable population. The current die-off of cholla at various locations in southern San Diego County warrants more attention. The drought is thought to be the major factor in the deteriorating condition of cholla, but disease could also be involved. Management to reduce competition for water where shrubs are overgrowing the cactus has been shown to improve the overall condition of cholla (M. Dodero, pers. comm.). The results of the cactus wren foraging and arthropod study, when available, should be incorporated into the design of cactus scrub enhancement and restoration projects to increase the availability of arthropod food resources.



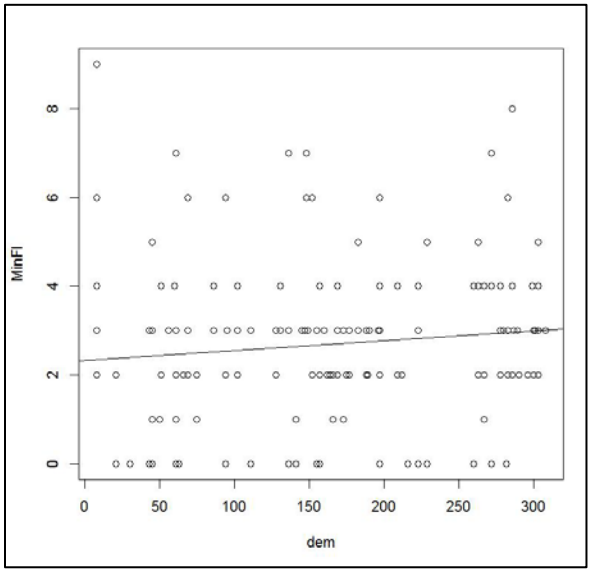
a. January to April precipitation



b. Egg lay date



c. Proportion of corvids detected



d. Elevation

Fig. 10. Factors showing significant positive and negative associations with cactus wren productivity (#fls/pr/yr) at the Nature Reserve of Orange County from 2009 to 2013.

Fig. 11. Drought stressed cactus in southern San Diego County in 2014.

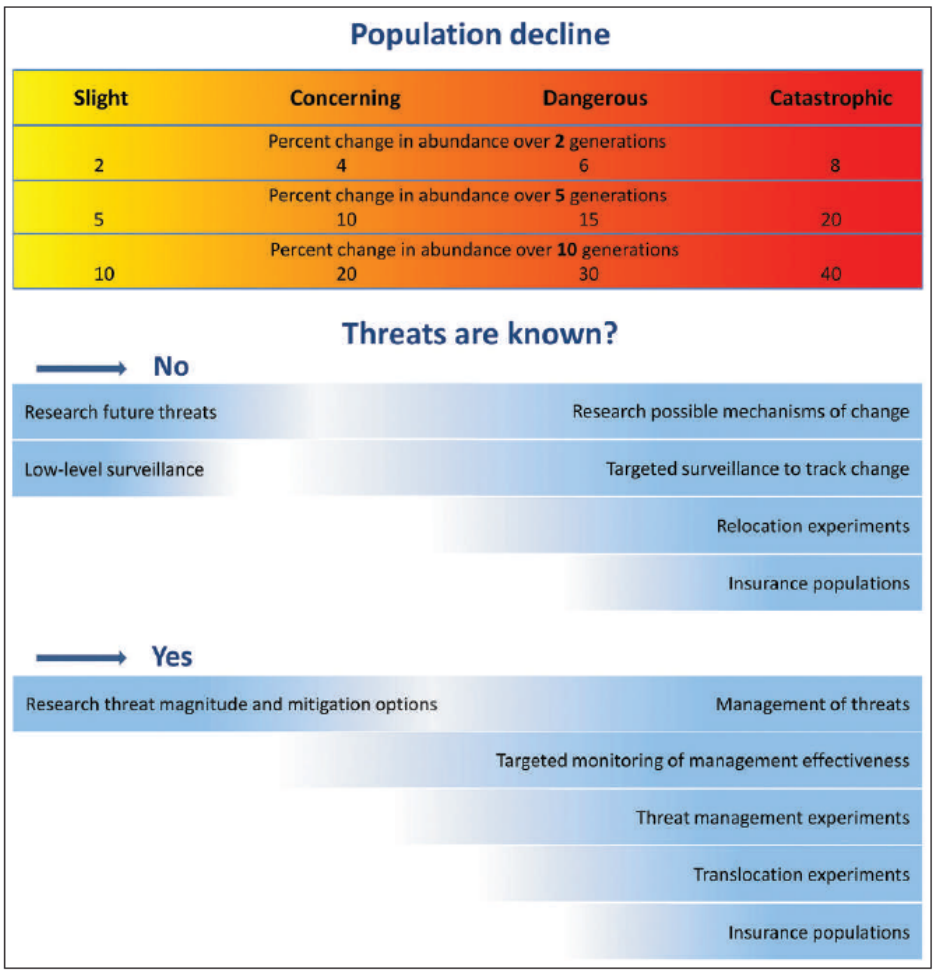


Figure 4. *Planning a response to monitoring. The length of the blue bars indicates the range of declines over which a particular management response might be appropriate, including seeking more information through research, targeted monitoring, or surveillance monitoring. The percent population declines (red panels) provide an indication of the levels of decline that would trigger particular actions (blue panels).*

From Lindenmayer et al. 2013

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Appendix C.

Coastal Cactus Wren Habitat Suitability Model

Appendix C. Coastal Cactus Wren Habitat Suitability Model

Spatially explicit habitat suitability models can be important tools for conserving, monitoring, and managing rare species (Maes et al. 2005, Guisan et al. 2006, 2013, Marcer et al. 2013). These models can be used to increase our understanding of a species' habitat requirements, prioritize areas to survey for new populations, delineate areas important for conservation, and identify potential sites for population translocation. More recently, habitat suitability models have also been used to identify restoration opportunities to enhance habitat for species of conservation interest (Bartel and Sexton 2009, Funk et al. 2013). Habitat suitability or niche models calculate environmental variables with Geographic Information Systems (GIS) and use associations between species locations and environmental variables to identify potentially suitable habitat.

The San Diego Management and Monitoring Program (SDMMP) developed a coastal cactus wren habitat suitability model for southern California. This model is used to assess potential sites for cactus restoration in order to meet an important management objective of the Management Strategic Plan for Conserved Lands in Western San Diego County (SDMMP 2013). The objective is:

"*Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the Otay River and San Diego/El Cajon genetic clusters to expand the occurrences to a sustainable effective size to avoid inbreeding, enhance habitat connectivity throughout the Otay River Valley, and potentially connect this occurrence to the San Diego/El Cajon genetic cluster (depending on results of the in-progress study on historic genetic structure) to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years)*."

Methods

Study Area and Coastal Cactus Wren Datasets

The southern California study area includes San Diego, Riverside, San Bernardino, Orange, Los Angeles and Ventura Counties and encompasses more than 8,148,121 hectares (>20 million acres). We compiled cactus wren location data from throughout coastal southern California. We removed spatially redundant records so that all wren locations used in constructing and evaluating models were at least 150 m apart. Sources of cactus wren location records included:

- US Geological Survey southern California cactus wren surveys and collection of genetic material from 2012 to 2013
- Nature Reserve of Orange County cactus wren surveys from 2006 to 2008
- Western Riverside County Multiple Species Habitat Conservation Plan cactus wren location records from 2006, 2007 and 2011
- U.S. Fish and Wildlife Service cactus wren surveys in San Diego County in 2009 and 2011
- The Nature Conservancy, Sea and Sage Audubon, and California Department of Fish and Wildlife volunteer surveys for cactus wrens in Orange, LA and Ventura Counties from 2009 to 2012
- California Natural Diversity Database cactus wren locations from 2000 to 2012
- SANBIOS cactus wren locations for San Diego County from 2000 to 2009

We also used 1981-1999 CNDDB records available for Orange and San Diego Counties to identify historically occupied suitable habitat where there are no current wren observations. For Los Angeles, Ventura, Riverside, and San Bernardino Counties, we relied on Solek and Szijj (2004) for historically occupied sites where wrens were reported in the late 1980s and early 1990s. Desert populations of cactus wren were not included in the habitat modeling, as the focus was on characterizing suitable habitat for populations on the west side of the Peninsular Mountain ranges.

GIS-based Habitat Variables

Using GIS and digital spatial layers, we calculated topographic, climatic, vegetation, and land use variables to represent environmental conditions across southern California. We created a grid of points that encompassed the study area, with each point falling within the center of a 150 m x 150 m grid cell. We calculated values for various environmental variables at each point in the grid (Table C-1). To characterize the environment used by wrens, we used ArcGIS to spatially join every wren location to the closest grid point with calculated environmental attributes. If two cactus wren records fell within 150 m of each other, then one was removed from the modeling datasets.

Cactus wrens are obligates of cactus scrub habitat in southern California. However, we lack comprehensive mapping of the coastal cactus scrub vegetation community for much of the study area. Cacti have a patchy distribution within the larger and more widespread coastal sage scrub plant community. To characterize suitable conditions for cacti, we developed a habitat model for the widespread and abundant coastal prickly pear cactus (*Opuntia littoralis*). We developed and compared alternative models following methods detailed in Preston et al. (2008). We selected the best performing model and included habitat suitability predictions for prickly pear in selected cactus wren habitat models. Similarly, we modeled an important coastal cactus scrub shrub, California sagebrush (*Artemisia californica*), and included it as a predictive variable in one of our candidate models.

Partitioned Mahalanobis D^2 Modeling Approach

We constructed partitioned Mahalanobis D^2 models for cactus wrens in southern California (Dunn and Duncan 2000, Rotenberry et al. 2002, 2006). Mahalanobis D^2 is the standardized distance between the multivariate mean for environmental variables calculated at locations where a species occurs and values calculated for the same set of environmental variables at a point in the landscape. The more similar environmental characteristics are at a point in the landscape to the species' multivariate mean, the more suitable the habitat is for the species. The D^2 distance is scaled following a chi-squared distribution and ranges from 0 to 1.0. These rescaled values form a Habitat Similarity Index (HSI), with 1.0 indicating environmental conditions identical to the species' multivariate mean (i.e., most suitable) and 0 indicating conditions that are highly dissimilar (i.e., unsuitable).

Mahalanobis D^2 can be divided into independent components or partitions using principal components analysis (PCA; Rotenberry et al. 2002, 2006). Each partition represents an independent environmental relationship. The last partition with the smallest eigenvalue (measure of variance) represents the linear combination of environmental variables that vary the least.

Table C-1

Environmental Variables Used in Coastal Cactus Wren Habitat Suitability Modeling

Variable(s)	Scale(s)	Description
Elevation	At point	Computed elevation (m) using ArcGIS to extract values from a 10m USGS digital elevation model raster at each point.
Topographical Heterogeneity	30m x 30m area	Computed topographic heterogeneity, a measure of topographic ruggedness (Sappington et al. 2007), using ArcGIS and the elevation raster to calculate a median value for a 30m neighborhood centered on each point.
Slope in Degrees	At point	Computed slope (º) using ArcGIS to extract values from the elevation raster at each point.
Northness	At point	Northness is a measure of northerly aspect. Used the "Aspect" tool in ArcGIS to calculate the cosine of aspect from the elevation raster using the "Raster Calculator" at each point.
Eastness	At point	Eastness is a measure of easterly aspect. Used the "Aspect" tool in ArcGIS to calculate the sine of aspect from the elevation raster using the "Raster Calculator" at each point.
Precipitation: Annual (rainfall year: August 2 to July 31); October to January; February to May	At point	Computed precipitation variables (mm) for monthly, seasonal and annual time periods at each point using ArcGIS and a raster with 1981-2010 precipitation averages downloaded from the PRISM Climate Group (http://www.prism.oregonstate.edu)
Temperature: January Minimum; July Maximum	At point	Computed monthly minimum and maximum temperature (°C) for each point using ArcGIS and rasters with 1981-2010 minimum and maximum monthly temperature averages downloaded from the PRISM Climate Group.
Vegetation/Land Use: % Coastal Sage Scrub % Chaparral % Urban	150m x 150m, 1 km x 1 km	Subregional vegetation maps were merged together from western Riverside County (2005), western San Diego County (2014), southern (2013) and central/coastal (2013) Orange County, NAS Miramar (2012-14), MCB Camp Pendleton (2003) and NWS Fallbrook (2010). The 2010 Fire Resource Assessment Program Vegetation Map for California was used for areas in southern California without subregional mapping. Calculated % of vegetation or land use type within 150m grid cells and 1 km neighborhoods.
Normalized Difference Vegetation Index (NDVI)	At point	Extracted NDVI values from MODIS satellite imagery at each grid point for images taken 5/28 to 6/2/2012. Imagery resolution is 1 pixel = 250 m.
Habitat Suitability Coastal Prickly Pear HSI California Sagebrush HSI	At point	1,741 calibration and 747 validation records used to develop prickly pear habitat model. Median validation HSI = 0.7. 196 calibration and 105 validation records to develop California sagebrush habitat model. Median validation HSI = 0.6.

A partition with a larger eigenvalue indicates an increase in the amount of variance in environmental relationships represented by that partition. The underlying idea is that those environmental relationships that vary the least are the most limiting and indicative of suitable habitat, whereas environmental relationships that are highly variable are less informative. Partitions are additive and together add up to the original D^2. Partitions are added by starting with the last partition with the smallest variance and adding that to the next higher partition with the next lowest variance and so on. The more partitions retained, the greater the variability in environmental conditions specified by the model. Combinations of partitions with low variance represent ecological minimums for a species, while combinations that retain more partitions and higher variability represent habitat relationships that are not as limiting for a species distribution.

Determining the number of partitions to retain in a model depends on the modeling objectives, an analysis of eigenvalues, and an evaluation of model performance using calibration and validation datasets. Median HSI values are calculated for calibration and validation datasets and used compare alternative models with different combinations of environmental variables and selected partitions. To further evaluate model performance, 1000 points were randomly selected from the southern California study area grid and classified as pseudo-absences. HSI values for these random absences were compared with values for occupied points by developing a Receiver Operating Curve (ROC) and determining the Area Under the Curve (AUC) value (Fielding and Bell 1997). AUC values range between 0 and 1.0 with no predictive power for models with an AUC of ≤ 0.5. An AUC value of ≥ 0.7 is considered acceptable in terms of model performance, with higher AUC values representing greater model performance. Once a model and partition were selected, an HSI value was calculated for every point in the grid across the study area, resulting in a habitat suitability map.

Cactus wrens are patchily distributed across southern California, with some areas supporting substantially more wrens than others. To avoid spatially biased sampling, we used a subsampling strategy to balance spatial representation of cactus wren locations used in model construction (Knick et al. 2013). We divided the study area into 8 geographic areas and randomly subsampled 20 cactus wren locations from each area (i.e., 160 total wren locations) and created a PCA to calibrate the model. We repeated this subsampling and construction of a PCA for 1,000 iterations and then averaged the PCA results to develop the model partitions.

Results

Cactus Wren Habitat Suitability Model

We randomly selected 60% (n = 507) of the 845 spatially distinct cactus wren records to calibrate alternative Mahalanobis D^2 models and used the remaining 40% (n = 338) as a validation dataset to compare among models and partitions. We constructed 11 different habitat models using different combinations of variables (Table C-2). The best performing model (R11, Partition 1) has excellent predictive capability with an AUC of 0.95. The median HSI for the validation dataset was 0.75, while the calibration dataset was slightly lower at 0.72, indicating model over-fitting is not a concern.

Table C-2. Comparison of alternative coastal cactus wren Mahalanobis D^2 habitat suitability models for southern California.

Environmental Variables	R11	R1	R2	R7	R9	R6	R3	R10	R4	R8	R5
Minimum January Temperature	X	X	X	X	X	X	X	X	X	X	X
Maximum July Temperature	X	X	X	X	X	X	X	X	X	X	X
Annual Precipitation (August 1 – July 31)	X	X		X	X	X			X	X	X
October to January Precipitation			X								
February to May Precipitation							X	X			
Elevation	X	X	X	X	X	X	X	X	X	X	X
Northness	X	X	X	X	X	X	X	X	X	X	X
Eastness	X	X	X	X	X	X	X	X	X	X	X
Slope in Degrees	X	X	X	X	X	X	X	X	X	X	X
Topographical Heterogeneity	X	X	X	X	X	X	X	X	X	X	X
% Coastal Sage Scrub –150m x 150m cell	X	X	X	X			X	X	X	X	X
% Chaparral –150m x 150m cell	X	X	X	X			X	X	X	X	
% Urban –150m x 150m cell	X	X	X	X	X		X	X	X		
% Coastal Sage Scrub –1km x 1km cell					X	X					
% Chaparral –1km x 1km cell					X	X					
% Urban –1km x 1km cell						X				X	
NDVI									X		X
Prickly Pear HSI	X			X	X			X		X	
California Sagebrush HSI	X										
Model Results											
Number of Partitions	13	11	11	12	12	10	11	12	12	12	10
Selected Partition	1	1	1	1	1	1	1	1	2	1	1
Eigenvalue of Selected Partition	2.988	2.480	2.467	2.717	2.879	2.781	2.456	2.677	1.824	2.781	2.766
Median - Calibration HSI	**0.719**	**0.728**	**0.704**	**0.734**	**0.679**	**0.714**	**0.745**	**0.725**	**0.704**	**0.698**	**0.640**
Mean - Calibration HSI	0.630	0.639	0.623	0.627	0.622	0.629	0.630	0.620	0.619	0.617	0.584
Standard Deviation - Calibration HSI	0.328	0.314	0.317	0.329	0.303	0.306	0.334	0.327	0.326	0.311	0.289
Median - Validation HSI	**0.752**	**0.740**	**0.726**	**0.724**	**0.728**	**0.705**	**0.734**	**0.685**	**0.712**	**0.674**	**0.610**
Mean - Validation HSI	0.653	0.647	0.643	0.640	0.635	0.631	0.631	0.623	0.618	0.614	0.574
Standard Deviation - Validation HSI	0.303	0.291	0.295	0.301	0.292	0.284	0.309	0.296	0.316	0.297	0.281

Variables in the selected model included minimum January and maximum January temperatures, annual precipitation, elevation, northness, eastness, topographic heterogeneity, percent of coastal sage scrub, chaparral and urban development within 150 m grid cell, and modeled habitat suitability for prickly pear and California sagebrush. Environmental variables that made the greatest contributions to the model included maximum July temperature, elevation, northness and eastness, % coastal sage scrub, and prickly pear and California sagebrush habitat suitability predictions.

Figure C-1 shows predicted habitat for coastal cactus wren in southern California and the distribution of wrens observed between 2000 and 2013. There are large areas of potentially suitable habitat with no recent wren records. The lack of wren observations in predicted habitat can be explained by several factors. One explanation is that some areas may not have been recently surveyed or have been surveyed but the specific location data are unavailable. Throughout the study area there were extensive focused surveys between 2006 and 2013, so considerable habitat has been assessed for wrens. However, in some areas there were no surveys often because access could not be obtained or because the areas were not identified as suitable for wrens. For those areas that have been surveyed, it is important to note that habitat models identify environmental conditions that are similar to occupied habitat. There may be areas of suitable habitat where the species has not yet dispersed to, areas where the species is excluded by competitors, or areas formerly occupied but where the species is now extirpated. Many wren populations are small and local extinction from a site can result from environmental and demographic stochasticity. Cactus wrens are also poor dispersers (Atwood et al. 1998, Preston and Kamada 2012, Kamada and Preston 2013, Barr et al. 2015) and natural habitats in parts of southern California are highly fragmented due to urban development. Thus, wrens may not occupy some areas with suitable habitat as they are unable to disperse to and recolonize isolated sites where local populations went extinct. In addition, the habitat may not be suitable as cacti may be absent or the habitat may be degraded due to land use practices or invasive plants. The model identifies conditions that are suitable for prickly pear cactus but it may not be present. For example, large catastrophic wildfires in the last two decades have destroyed cactus patches over thousands of acres and a significant amount of cactus has not recovered sufficiently to support nesting wrens (e.g., Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009).

Many of the areas in Orange and San Diego County predicted to be suitable were historically occupied between 1981 and 1999 (Figure C-2), but have no wrens or a significantly reduced number of wren observations since 2000. These areas include the Chino Hills, southern Marine Corps Base Camp Pendleton, Bonsall, San Luis Rey River Valley east of I-15, Rancho Santa Fe, coastal lagoons, parts of the San Dieguito River Valley and Lake Hodges, Lusardi Creek, north of Ramona Airport, Rose Canyon, west of Santee, the San Diego River Valley west of Lake Jennings, south of the Sweetwater Reservoir, north of Upper Otay Lake, City of Chula Vista Canyons, parts of the Otay River Valley and adjoining canyons, Dennery Canyon, and canyons south of Otay Mesa. Southern Orange County has large amounts of suitable habitat that is still occupied but for which we did not have specific location information. There are also reports of historic cactus wren populations from the late 1980s to early 1990s for Los Angeles, Ventura, Riverside and San Bernardino Counties in areas identified as suitable habitat but with no current observations (Solek

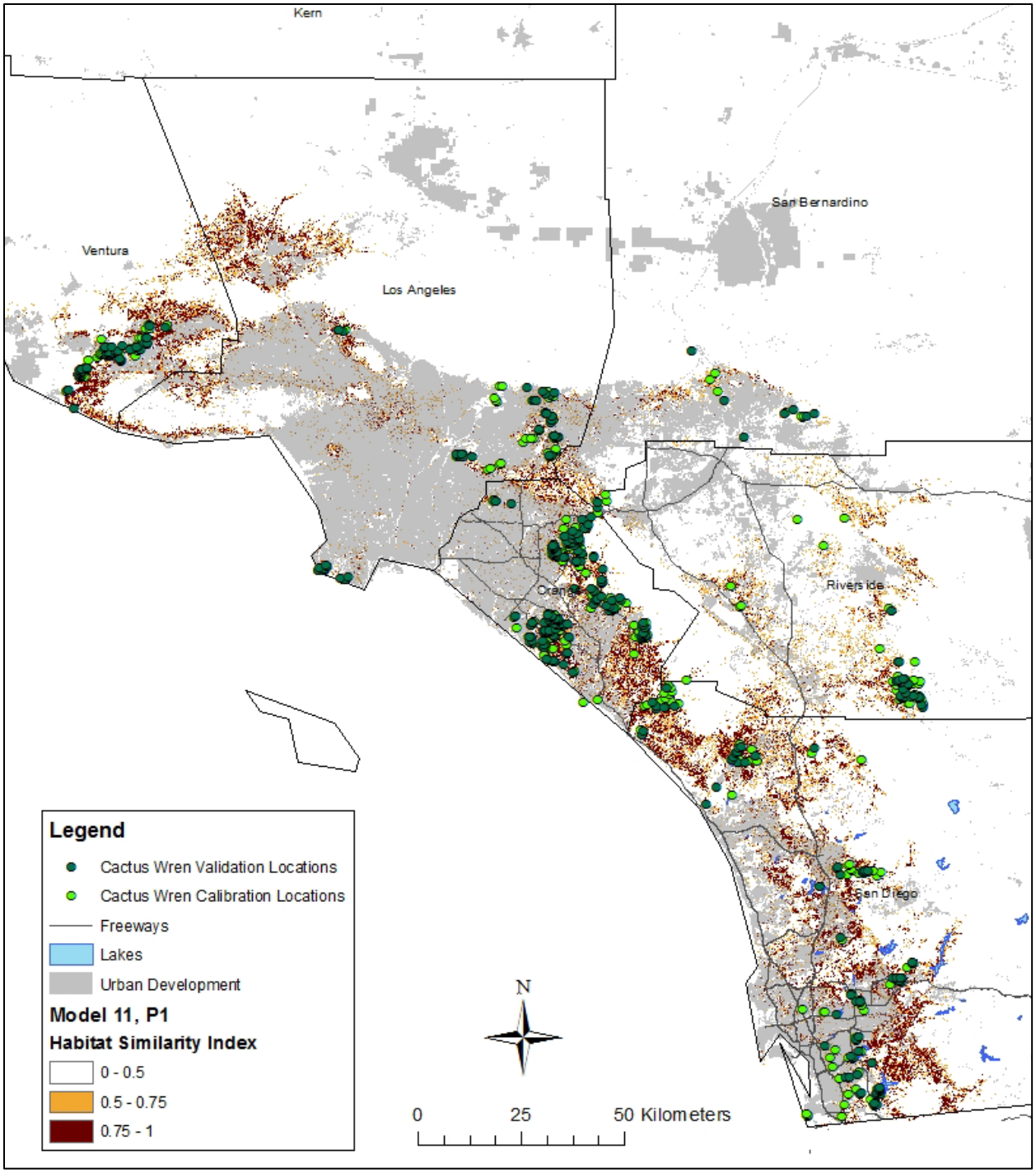

Figure C-1. The recent (2000-2013) distribution of coastal cactus wrens in southern California with potentially suitable habitat predicted by Model R11, partition 1. Highest habitat suitability is indicated by dark brown pixels, intermediate suitability by orange pixels, and low suitability by white pixels.

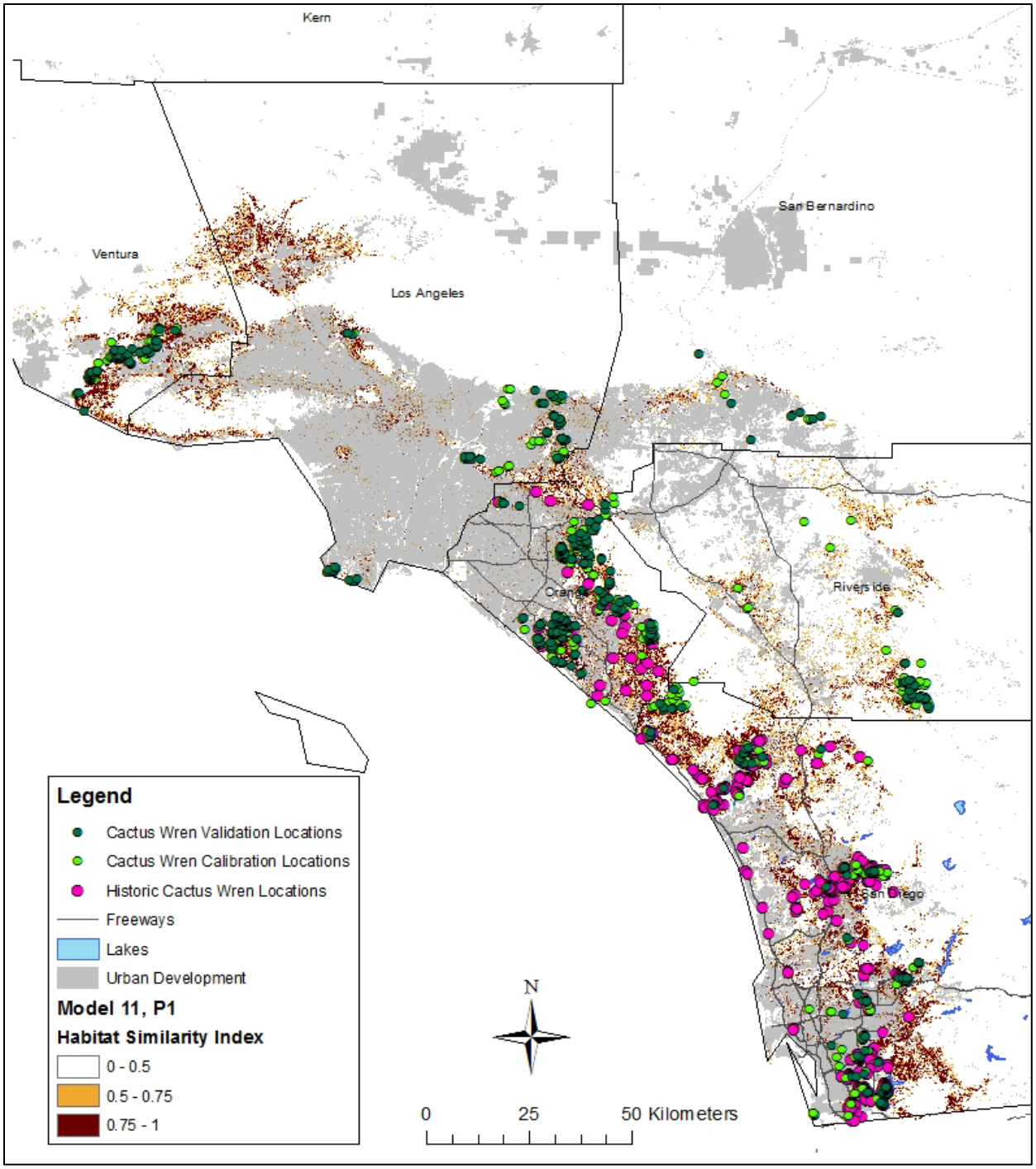

Figure C-2. The recent (2000-2013) distribution of coastal cactus wrens in southern California indicated by green circles and historic distribution (1981-1999) by pink circles with potentially suitable habitat predicted by Model R11, partition 1. Highest habitat suitability is indicated by dark brown pixels, intermediate suitability by orange pixels, and low suitability by white pixels.

and Szijj 2004). Some of these areas include the Santa Clara River east of Santa Clarita, Alamos Canyon north of Simi Valley, Baldwin Hills, Chino Hills, Fontana, Rancho Cucamonga, southwest Beaumont, the Badlands, Temescal Wash, and Santa Rosa Plateau.

Overall, the large amount of suitable habitat predicted by the model for which there are historic records but no recent occurrences is consistent with the significant decline and extinction of coastal cactus wren populations since the 1990s. This decline is attributed to a number of processes, including habitat loss and fragmentation, mega wildfires, extended and severe drought, habitat degradation, and predation (Bontrager et al. 1995, Hamilton 2004, 2009, Solek and Szijj 2004, Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009, Preston and Kamada 2013, Barr et al. 2015).

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Appendix D.

Best Practices for Cactus Scrub Restoration for the Coastal Cactus Wren

Appendix D

Best Practices for Cactus Scrub Restoration for the Coastal Cactus Wren

A Best Practice is the belief that there is a technique, method, process, activity or reward that is more effective at delivering a particular outcome than any other technique, method, or process. The idea is that with proper processes, checks, and testing, a desired outcome can be delivered with fewer problems and unforeseen complications (Global Restoration Network).

The following Best Practices for Cactus Scrub Restoration are based upon the experience of many land managers and restoration practitioners in southern California who have worked to restore habitat for the coastal cactus wren (*Campylorhynchus brunneicapillus*). These practices represent the current state of knowledge on the topic, and are not meant as a mandate or "one size fits all" type of guidance, but rather suggestions for those who are seeking input on their own restoration project.

Indeed, every site and restoration objective is different, and all cactus scrub restoration actions should be tailored to the specific site, management goals, and unique habitat conditions. Over time, these methods may be refined or replaced with alternative methods based on results of adaptive management or experimental programs.

1 Site Selection

Optimally, if the goal is to create new stands of cactus scrub for near-term occupation by cactus wren, the restoration site should be established <1 km from occupied habitat but not more than 4 km. This is based on the average dispersal distance of juvenile cactus wrens (Atwood 1993, Preston and Kamada 2012, Kamada and Preston 2013, Barr et al. 2012, 2013, 2015, Kamada 2014).

Typically, occupied cactus wren habitat is found on south, southwest or west-facing slopes; however, planting on south-east facing slopes with coastal sage scrub or maritime chaparral present (which indicates appropriate soils) may be appropriate and could lessen drought stress, particularly as the climate changes.

Occupied cactus scrub is generally found on slopes <1500 feet in elevation and on flat or slightly sloping hillsides with less than 2:1 slope. However, if there is occupied habitat nearby on steeper slopes, then these criteria may not be as important.

Cactus scrub is often planted within openings in coastal sage scrub or maritime chaparral. The following should be considered when planting within scrub communities:

- Select planting sites with a matrix of bare ground, scrub, grassland and crytpotbiotic soil crust to provide optimal foraging and habitat conditions for the cactus wren;
- Select sites with a diversity of micro-topography – areas with drainages and draws as well as flat areas – to provide a diversity of microclimates and soil moisture conditions;
- Avoid disturbing or planting directly in areas with cryptobiotic soil crusts; these are unique communities that naturally exclude weeds and take many years to recover from disturbance;

- Avoid areas with dense/tall shrubs to minimize shrub crowding and the need for shrub thinning;
- Avoid weedy areas unless you are willing to commit to several years of weed maintenance;
- If you have the time to plan out your restoration, implement a year or two of pre-planting weed control. Weed control may also have the added benefit of promoting other native species (e.g., *Dudleya variegata*).

Check the California Natural Diversity Database and MSP-MOM and conduct spring botanical surveys in advance of site preparation or active planting to ensure that the restoration site does not support rare or other sensitive species that may be impacted by planned enhancement activities.

Ensure that you select cactus planting sites that accessible for maintenance with sufficient buffering from trails to minimize human disturbance.

2 Patch Size

Guidance on how large a restored cactus patch should be to support cactus wrens is evolving. Generally, restoration practitioners have targeted creating cactus scrub patches of at least 1 acre where there is occupied habitat nearby.

Data from cactus wren monitoring efforts in Orange and San Diego counties indicate that a functional patch size ranges from 2-3 acres, although more study is needed. However, when creating stepping stones of habitat between populations, larger habitat patches of 5 acres or greater may be necessary to support more than one pair of cactus wrens. Since small populations are more vulnerable to extinction, a larger stepping stone patch (e.g., several acres) is more likely to support multiple wren territories and persist over time.

In terms of how much cactus is needed in a created patch of cactus scrub, it is generally recommended that cactus cover 40-50 percent of the habitat at maturity. Expanses of cactus scrub dominated by cactus often are packed with cactus wrens, indicating that restored cactus scrub should contain as much cactus as practically feasible.

3 Cactus Salvage

Optimally, cactus propagules should be salvaged from cactus that is planned to be removed by development. The type (*Opuntia* vs *Cylindropuntia*) and proportion of cactus collected and planted should be based upon detailed studies of nearby occupied cactus scrub reference habitat.

If timing allows, cactus propagules should be collected when they are least drought stressed, e.g. not during late fall. However, if the project is urgent, cactus propagules can be collected at any time of year.

When collecting prickly pear cactus, ensure that you are not collecting specimens that have hybridized with the non-native Mission fig (*Opuntia ficus-indica*). Mission fig generally has few or no spines and grows much larger, and is not known to be used for nesting by the cactus wren.

If no source of cactus is readily available from a proposed development site, it is recommended that cactus salvage be performed from unoccupied cactus near the restoration site, with no more than 5 percent of cactus pads/segments removed from any one cactus or patch.

When salvaging from conserved cactus, mature pads/segments should be salvaged from the lower 1/3 of cactus and not from the top of cactus. Cactus collection can be tricky because of the spines, and many practitioners use machetes, pitch forks and tongs to aid in cactus collection.

Cactus should be broken off at joints with a minimum two pads/segments per cutting; larger cuttings with multiple pads/segments are more desirable to promote faster habitat establishment

It is common to end up with many individual pads/segments that have fallen away during salvage/collection. These can be scattered on the ground, either around the outer planting area or below the cactus from where they were salvaged, as they will easily take root.

4 Large Specimen Collection

For more immediate habitat, salvage of large cactus specimens >1 meter in height is desirable. Larger specimens are best taken from areas to be lost to development.

Large cactus salvage is most easily accommodated with large equipment – back hoe, small front end loader, and a flat-bed truck for transport. Ropes, straps, pitch forks and shovels may also be necessary to guide the salvage effort.

Large specimens can be transported “bare root” but you may want to consider boxing large specimens if they are going to sit at the acceptor site for more than a few days. Alternatively, the exposed root ball can be covered with shade cloth or burlap (or soil) at the acceptor site until transplanting.

When salvaging large specimens, it is best performed during the early summer or early winter, when there is some soil moisture in the ground, to facilitate salvage. However, it is recognized that salvage may have to be done during the driest time of the year. When salvaging large specimens, excavate as much of the rootball as you can (2-plus feet) recognizing you will likely only get a portion of the above ground growth, so root pruning will be offset by loss of above ground growth. Large specimens should be irrigated following transplanting. Some temporary staking may also be required after transplanting to keep cactus growing upright.

5 Propagule Selection

Cactus can be established from transplants (discussed above), unrooted cuttings, dry-rooted cuttings or from container/propagated stock. The type of propagule selected depends on funding, lag time between propagule collection and planting date, and urgency to create occupied habitat, among other factors.

Un-rooted cuttings (pads or segments) are the most efficient and cost effective method for establishing cactus scrub. Pads or segments are usually allowed to harden/callus prior to planting, which can take several days or weeks depending on the time of year. Optimally, cactus cuttings should be laid out and allowed to callus in indirect sun, if possible. Shade cloth or burlap can be placed over the cactus to avoid desiccation and sunburn during callusing if necessary. Cactus stems or pads can be placed in the soil or

laid directly on the soil surface to take root. Generally, better results are achieved from planting in the soil, but if there are many small segments left over after planting, simply laying those pads/segments on the ground should be sufficient. To prevent weeds, it is recommended that soil disturbance be minimized; using a hand pick to make a small hole for each cactus cutting is preferred to ripping large swaths of ground with large equipment.

Dry-rooted cuttings involves temporarily planting pads, segments or whole plants in the ground in a nursery type setting for later transplantation to the acceptor/restoration site. This method requires that cuttings be spaced far enough apart to allow for easier harvesting later. Some irrigation can encourage root development and growth prior to out-planting. Once per month irrigation should be sufficient but should only be done when the soil is completely dry. If the cuttings are irrigated, it is likely that weeds will grow as well, so be prepared to perform weed control around cuttings. When ready for out-planting, the rooted cactus should be carefully dug up and stored in indirect sun for a week or so to allow the roots to harden off prior to transplanting. Hardening of roots minimizes the potential for root rot following transplanting. The transplants can be transported bare root (in a flatbed truck or pickup truck) to the restoration site. For ease of planting (if time allows), the planting holes at the acceptor site could be prepared prior to delivery of rooted cuttings. This will minimize the amount of time that the roots are exposed to sun/air at the site.

Container stock (also referred to as "propagated") involves rooting pads or segments or larger cactus specimens in pots for later transplantation to the restoration site. This is often the preferred method for establishing larger, sturdier plants with established root systems that are less susceptible to herbivory. For one gallon sized pots, plant callused cuttings with one to three pads/segments. Place pad/segment at base of cutting at least halfway into soil to keep it upright. Larger cuttings/specimens will require larger pots to keep from falling over. Larger specimens may also require some staking to keep them growing upright. Use potting mix that is fast draining. Do not use topsoil. Propagated/potted cactus will require periodic irrigation. Some pads/segments may fall off during transport, but they can be placed on the ground at the restoration site and allowed to root. Alternatively, you can remove side branches prior to transport and use as additional propagation material.

6 Planting layout

Cactus spacing

Cuttings of cholla and prickly pear can be planted several per square meter, or 2-3 feet on center. This can result in very dense plantings if all the cuttings take root, and some thinning may be necessary later on. However, the "thinned" propagules can be used for additional onsite planting. Cactus planted from containers may be planted further apart. Because prickly pear branches more easily, it can be planted at lower densities, e.g., one per square meter.

Co-plantings

Evaluation of data taken from cactus wren monitoring studies in Orange and San Diego counties have suggested that cactus scrub restoration should avoid and/or minimize the planting of large shrubs such as lemonadeberry (*Rhus integrifolia*), laurel sumac (*Malosma laurina)* and Mexican elderberry (*Sambucus nigra).*

A few scattered Mexican elderberry and lemonadeberry for use as cover or perches are appropriate if they are found in the area. These should be planted sparingly and on the edges of cactus groupings (3-5 meters away).

It is also recommended to plant shrubs that are locally adapted and will not exceed the height of cactus plantings at maturity and may provide good foraging habitat, such as California buckwheat (*Eriogonum fasciculatum*) and California sagebrush (*Artemisia californica*). Shrub plantings should not crowd cactus plantings at maturity. Generally, black sage (*Salvia mellifera*) should be avoided.

Consider delaying seeding of shrubs and forbs until second or third year post cactus planting to allow easier weeding between the cacti during establishment. Delayed seeding may have the added benefit of promoting the germination of the native seed bank in the interim.

Other plantings that could be considered in low numbers and if native to the site include *Jojoba*, *Baccharis sarathroides*, *Brickelia* sp., *Bahiopsis lacianata*, *Acmispon glaber*, *Isacoma menziesii* and *Encelia californica*.

Native forbs and grasses in the cactus scrub understory or in openings between patches could help promote a healthy invertebrate community and could serve as placeholders to help keep weeds at bay. Plant locally adapted native forbs and grasses.

7 Plant protection

Protective above-ground wire mesh cages may be considered for individual or groupings of cactus in areas subject to herbivory. Protective cages can ensure better growth and development of cactus and can generally be removed a year or two after planting.

8 Weed Control

Control of invasive grasses and forbs prior to and following planting of cactus is critical to ensuring successful cactus establishment. Invasive grasses and forbs compete for water, light and nutrients, thereby impeding cactus growth. If invasive grasses and forbs are found on the restoration site, they should be removed prior to planting to ensure that there is good contact between the soil and cactus cuttings.

Once the cactus are planted, ongoing control of invasive plants will be required for several years, either with hand pulling or spot spraying with an herbicide such as glyphosate. Weed control efforts should carefully avoid any native plants that also may be emerging.

9 Supplemental Watering

Supplemental watering should be considered if rainfall is low. Supplemental watering can assist with growth and development of cactus, but should be used sparingly so as not to encourage weeds, rotting, shallow root development or Argentine ant invasion. Studies at the San Diego Zoo Safari Park have demonstrated that cactus watered every four to eight weeks during the first summer following planting experienced increased growth as compared to un-watered cactus. Supplemental watering beyond the first summer is generally not required.

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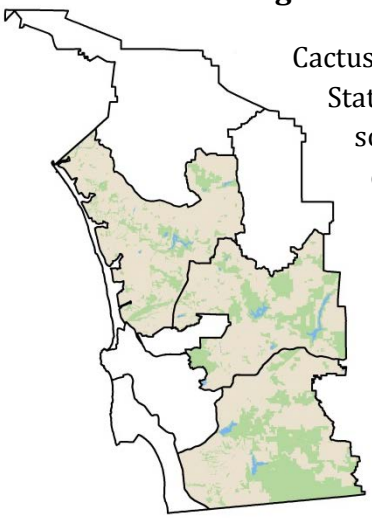
Appendix A.
Management Strategic
Plan Goals and Objectives for Coastal Cactus Wren

Available for downloading at
http://www.sdmmp.com/reports_and_products/Management_Strategic_Plan.aspx

2.2.11 Coastal Cactus Wren *(Campylorhynchus brunneicapillus sandiegensis)* - CSC

Management Units with Known Occurrences



Cactus wrens are distributed across the arid regions of southwestern United States and northern and central Mexico (Hamilton et al. 2011). In southern California, the coastal cactus wren subspecies is restricted to cactus dominated coastal sage scrub habitats from Ventura south to San Diego and inland to San Bernardino and Riverside Counties.

The USGS recently conducted a study on the genetic connectivity between occurrences of coastal cactus wren in southern California (Barr et al. 2012, 2013). Overall, cactus wrens appear to be poor dispersers (Kamada and Preston 2013), particularly in fragmented landscapes, which has led to genetic differentiation between clusters of wrens (Barr et al. 2013). In Orange and San Diego Counties four distinct genetic clusters were detected with calculated effective occurrence sizes [harmonic mean N_e], in the following areas: Orange County and MCB Camp Pendleton/Fallbrook NWS [152]; San Pasqual Valley and Lake Hodges [86]; San Diego and El Cajon [36]; and Otay River [45] (Table 2-2.8 and Figure 2-2.13). The goals and objectives for coastal cactus wren are informed by the results of this study.

The USFWS also conducted an occupancy study of coastal cactus wren in San Diego County between 2009 and 2011 (Winchell 2011). Coastal cactus wrens were detected at sampling sites in MUs 1, 2, 3, 4, 5 and 6. In MU1, a few wrens occur in the Tijuana Slough NWR and occur in low numbers in the urban canyon areas of MU2. Larger occurrences in MU3 (Figure 2-2.14) fall into two genetic clusters. The occurrences that occur in the Sweetwater River watershed are within the San Diego/El Cajon genetic cluster and are genetically connected to the occurrences at Lake Jennings to the north in MU4. The occurrences in the Otay River and Tijuana River watersheds are within the Otay River Genetic Cluster and are considered isolated from the San Diego/El Cajon Genetic Cluster (and potentially to occurrences in Mexico) even though the physical distance is close. Coastal cactus wrens in MU4 (Figure 2-2.15) occur within the San Diego/El Cajon Genetic Cluster and are genetically connected to the coastal cactus wrens in the Sweetwater area in MU3, although the physical habitat connection is somewhat tenuous due to development. Coastal cactus wrens in MUs 5 and 6 (Figure 2-2.16) are within the San Pasqual and Lake Hodges genetic cluster and represent the largest concentration of coastal cactus wrens in San Diego County outside of Camp Pendleton. Coastal cactus wren was not detected on conserved lands in MUs 7 or 8 during the 2009-2011 USFWS

Category SO
Significant occurrence(s) determined to be at risk of loss from MSPA

surveys. However, during the genetic studies a few pairs were found in the Pauma Valley area of MU8 on private lands. See SC_MTX for a complete listing of all locations where coastal cactus wren has been detected.

Management Categorization Rationale

Coastal cactus wrens should be managed as a Species Management Focus Category SO Species due to a high risk of loss genetic clusters, particularly the Otay Valley and Sweetwater clusters, from Conserved Lands in the MSPA and because managing vegetation alone will not ensure persistence of the species (Categorization Table, Vol. 1, App. 1C). Coastal cactus wren should be managed at a species-specific level due to the isolation of occurrences, low dispersal ability of individuals, and specific habitat requirements (i.e. large cacti).

Cactus wren occurrences face many threats in southern California (see Vol. 3 Sec. 2.0, Species Profiles). A primary threat is altered fire regime that causes direct mortality of birds and destroys cactus scrub, which can take many years to recover (Bontrager et al. 1995, Mitrovich and Hamilton 2007, Hamilton 2008, Leatherman BioConsulting 2009). Other threats include invasive Plant species reducing open habitat for foraging (Preston and Kamada 2012, Kamada and Preston 2013), declines in productivity during drought, and predation by domestic cats, roadrunners, snakes, loggerhead shrikes, and especially Cooper's hawks.

Management Approach

The pair of cactus wrens at Tijuana Slough NWR fall into the Otay genetic cluster but is separated from the occurrences in the Otay River Valley by development; therefore management has not been prioritized in this area over the next 5 years. Note that this occurrence may serve as refugia for coastal cactus wren in the event of a major wildfire in the remainder of the Otay genetic cluster. Management actions in MU3 will reduce the distance between the MU1 occurrence and the MU3 occurrence. The small numbers of coastal cactus wren in urban canyons in MU2 are surrounded by development and potentially high predation pressure and management has not been prioritized over the next 5 years. Note that these areas may serve as refugia for coastal cactus wren in the event of a major wildfire in the Otay and Sweetwater areas.

The occurrences that occur in the Sweetwater River watershed (MU3) are within the San Diego/El Cajon genetic cluster and are genetically connected to the occurrences at Lake Jennings (MU4) to the north, although the physical habitat connection is restricted as a result of development. The occurrences in the Otay

River and Tijuana River watersheds (MU3) are within the Otay River Genetic Cluster and are considered isolated from the San Diego/El Cajon Genetic Cluster even though the physical distance is close. Restoration and enhancement of cactus wren habitat within these genetic clusters have been prioritized over the next 5 years due to the high risk of extirpation of these occurrences (i.e. effective occurrence size is less than 50; see Vol. 3, Section 5).

Coastal cactus wrens in MUs 5 and 6 are within the San Pasqual and Lake Hodges genetic cluster and represent the largest concentration of coastal cactus wrens in San Diego County outside of Camp Pendleton. A significant portion of this area burned during the 2007 Witch Fire, fragmenting the cactus and coastal sage scrub habitat used by cactus wrens and reducing the wren occurrence (Hamilton 2008). Management actions are already under way to improve the connectivity and expand at San Diego Zoo Safari Park and Lake Hodges and to protect the occurrence from major wildfire (Zoological Society of San Diego and City of San Diego Water Department 2009).

The lack of coastal cactus wren on Conserved Lands in MUs 7 and 8 means that management of wren in these units has not been prioritized over the next 5 years.

See Table 2-2.9 for coastal cactus wren management goals and objectives.

Table 2-2.8. Conserved Lands identified for potential restoration of cactus scrub to expand occurrences and maintain connectivity within Coastal cactus wren genetic clusters in MUs 3, 4, 5, and 6. N_e is the effective occurrence size as determined by genetic analysis and is associated with the number of successful breeding individuals in a occurrence (Barr et al. 2013). An N_e of less than 50 individuals is considered at immediate risk of extinction because inbreeding depression and demographic stochasticity can result in an extinction vortex (Franklin 1980).

Genetic Cluster	MUs	Preserves	Land Ownrs.	Land Mgrs.	N_e	Threats	Source
Otay River	3	• Otay Lakes Cornerstone Lands • Johnson Canyon, Lonestar Ridge • Furby North Property • Otay Ranch Preserve • O'Neal Canyon Preserve • Dennery Canyon • Dennery Ranch/Otay Mesa North • Cal Terraces • Otay Valley Regional Park	• City San Diego PUD • CALTRANS • County San Diego • Otay POM, • City San Diego • CALTRANS • City San Diego • City San Diego • City San Diego/County San Diego/City Chula Vista	• City San Diego PUD • CALTRANS • County San Diego DPR • Otay POM • City San Diego PRD • CALTRANS • City San Diego PRD • Private • City San Diego PRD/County San Diego DPR/City Chula Vista	45	Loss of connectivity, small isolated occurrences.	Winchell 2011, Barr et al. 2013
San Diego/ El Cajon	3,4	• San Diego National Wildlife Refuge • Sweetwater Reservoir Open Space • Mount Miguel Open Space • Otay Lakes Cornerstone Lands • Rolling Hills Ranch • Otay Ranch Preserve • Lake Jennings Watershed • Lakeside Linkage Open Space • Hansons Aggregates	• USFWS • Sweetwater Authority • Otay MWD • City San Diego PUD • City Chula Vista • Otay POM • Helix Water District • County San Diego • EHC	• USFWS • Sweetwater Authority • Otay MWD • City San Diego PUD • City Chula Vista • Otay POM • Helix Water District • County San Diego DPR • County San Diego DPR	36	Portions of cluster burned in 2007 with loss of wrens and cactus scrub.	Winchell 2011, Barr et al. 2013
San Pasqual Valley/ Lake Hodges	5,6	• San Pasqual Valley • San Diego Zoo Safari Park • Battlefield Park • San Dieguito River Park • Lake Hodges	• City San Diego PUD • City San Diego PUD • City San Diego PUD • San Dieguito River Park JPA • City San Diego PUD	• City San Diego PUD • San Diego Zoological Society • City San Diego PUD • San Dieguito River Park JPA • City San Diego PUD	86	Most of the cluster burned in 2007 with loss of, especially at Lake Hodges.	Winchell 2011, Barr et al. 2013

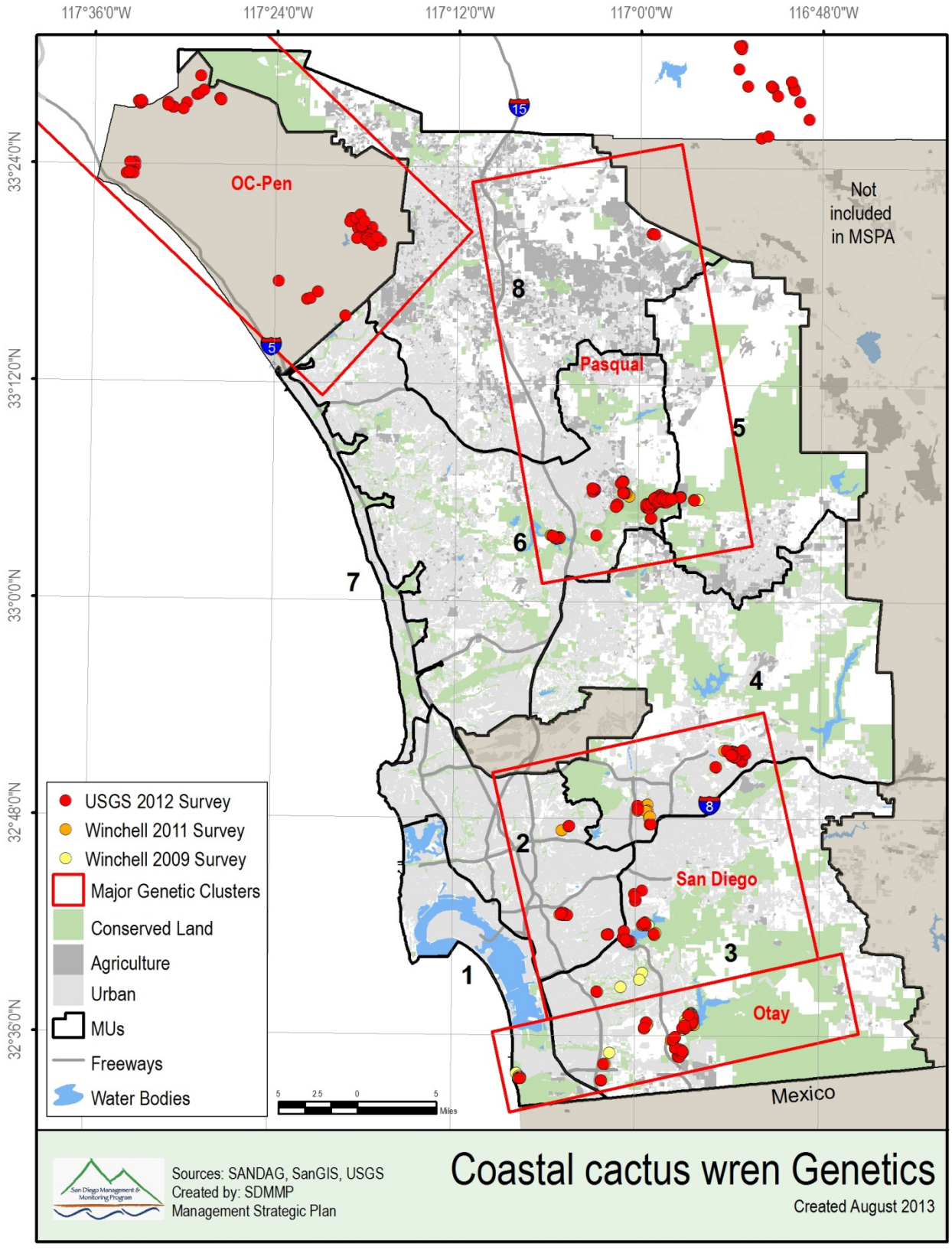


Figure 2-2.13. Major genetic clusters for coastal cactus wren in the MSPA.

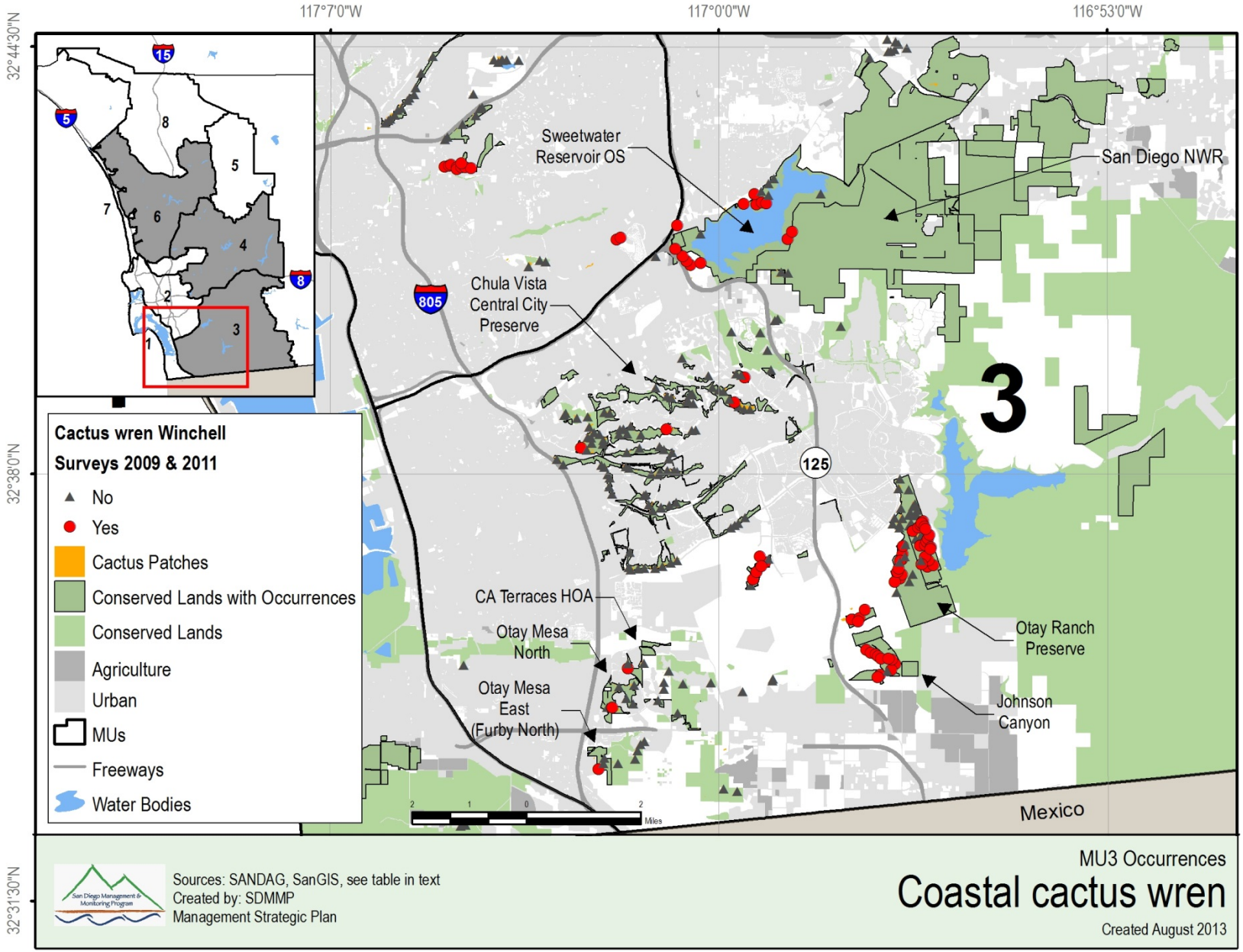


Figure 2-2.14. Distribution of coastal cactus wren on Conserved Lands in MU3.

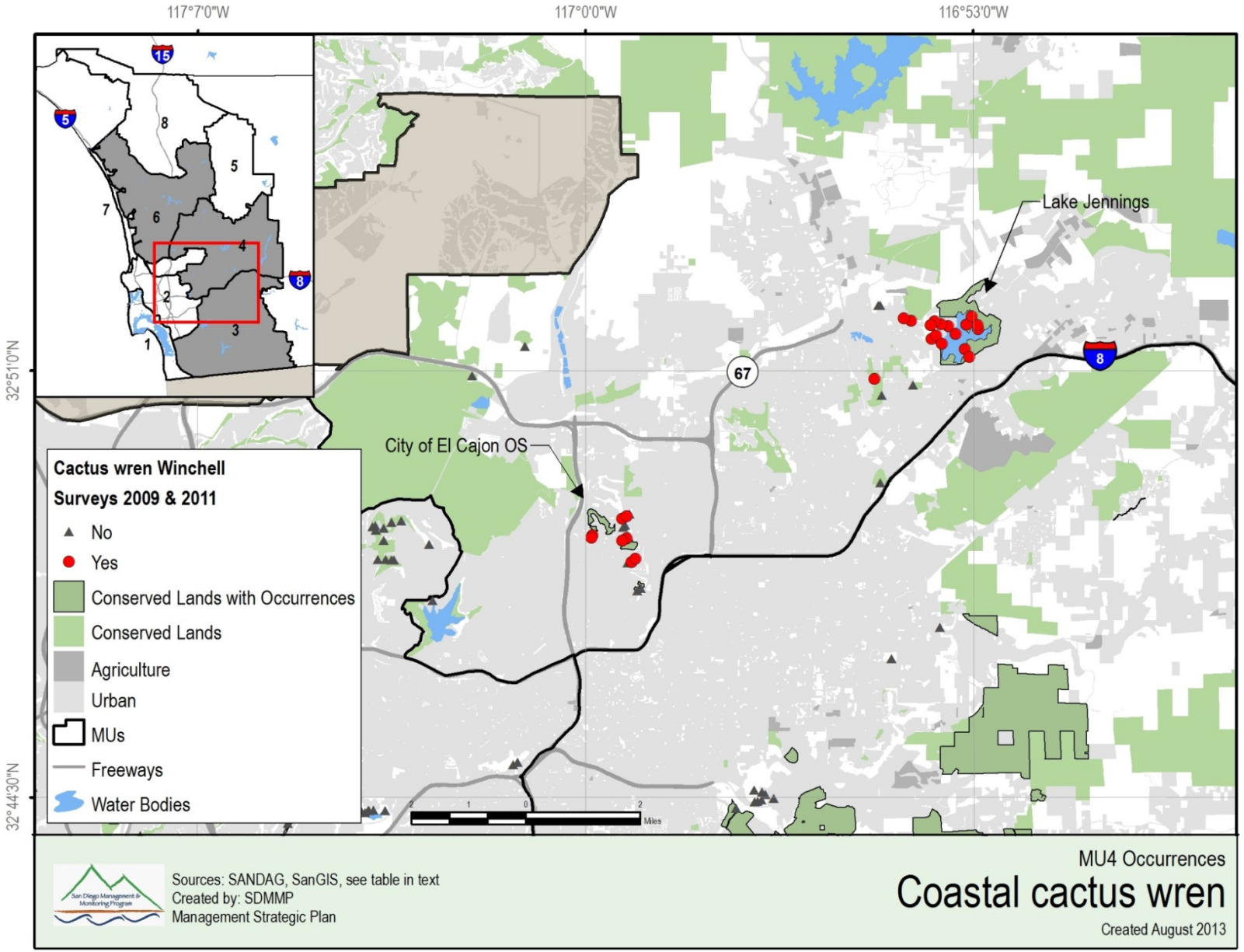


Figure 2-2.15. Distribution of coastal cactus wren on Conserved Lands in MU4.

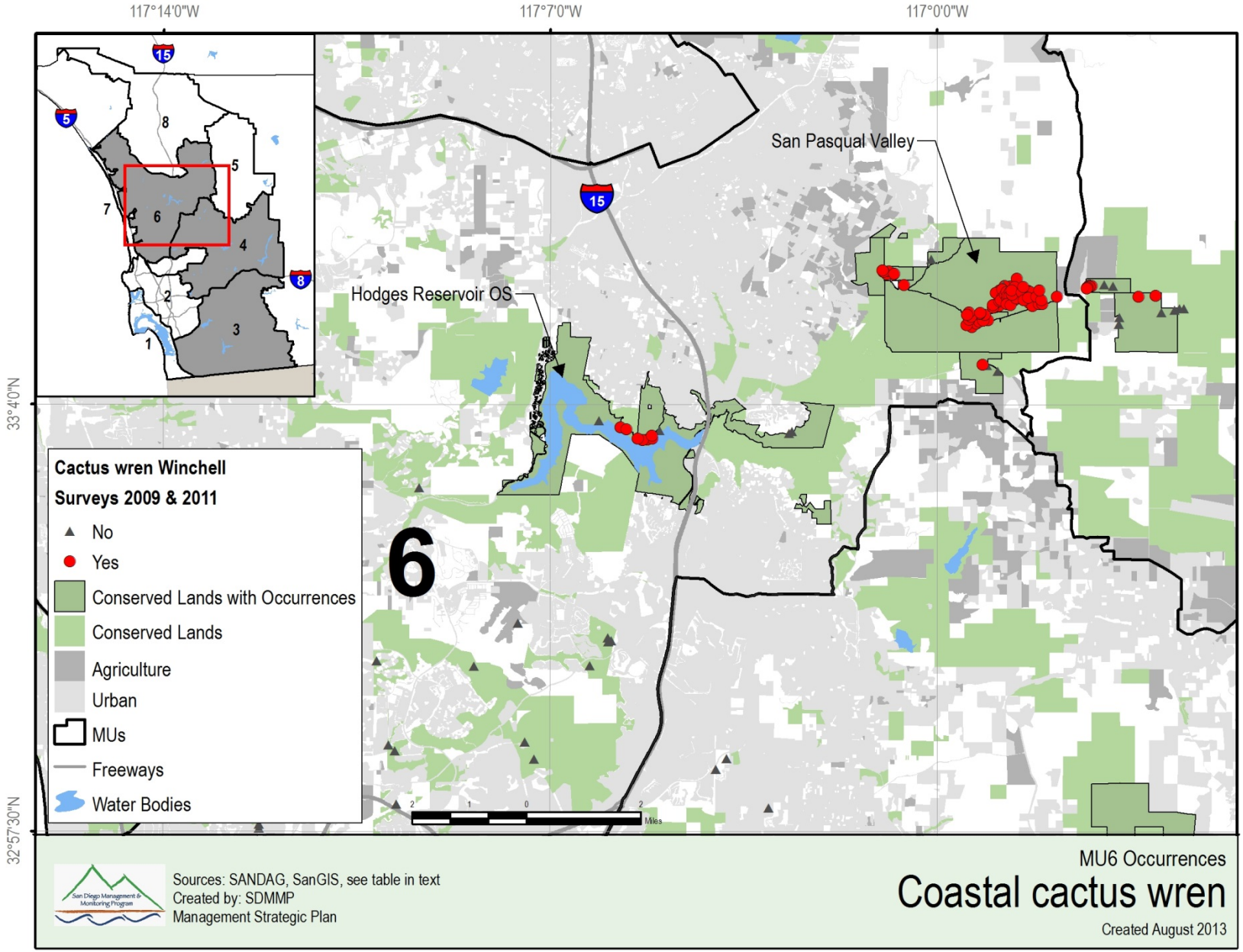


Figure 2-2.16. Distribution of coastal cactus wren on Conserved Lands in MU6.

Table 2-2.9. Management goals and objectives for coastal cactus wren.

Regional Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within and between the recently identified coastal cactus wren genetic clusters to increase the effective occurrence size to a sustainable level (e.g. 50/500; see Vol. 3, Section 5), provide habitat connections to allow for movement within genetic clusters and potentially between the San Diego/El Cajon and Otay genetic clusters, and prioritize management in areas with low predation pressures to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MU3 Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the Otay River and San Diego/El Cajon genetic clusters to expand the occurrences to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5), enhance habitat connectivity throughout the Otay River Valley, and potentially connect this occurrence to the San Diego/El Cajon genetic cluster (depending on results of the in-progress study on historic genetic structure) to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MU4 Management Goal: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the San Diego/El Cajon genetic cluster to expand the occurrence to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5) and enhance habitat connectivity within the genetic cluster to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

MUs 5 and 6 Management Goals: Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the San Pasqual genetic cluster to expand the occurrence to a sustainable effective size to avoid inbreeding (see Vol. 3, Section 5) and enhance habitat connectivity within the genetic cluster to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years).

Type	Objectives	MUs	Actions
PIP; Regional	In 2014, prepare an implementation plan for enhancing and restoring cactus scrub habitats on Conserved Lands in MUs 3 and 4 in order to expand the Otay and San Diego/El Cajon cactus wren genetic clusters and enhance connectivity.	3,4	• Use the historic genetic analysis to determine if connectivity should be restored between the San Diego/El Cajon and Otay genetic clusters to enhance genetic diversity and reduce the potential for inbreeding, and to increase resilience to demographic stochasticity. • Construct dynamic occurrence viability models incorporating the landscape matrix of urban development and natural lands, habitat suitability and existing cactus scrub, fire risk, and wren occurrences, demography and dispersal capabilities. Use this model to compare alternative restoration scenarios connecting and enhancing cactus scrub habitat for the San Diego/El Cajon and Otay River genetic clusters in MUs 3 and 4. • Conduct site visits to potential cactus scrub enhancement and restoration sites and collect information on current wren occupancy, condition of cactus scrub, cover of invasive plant species, potential threats, and identify management needs. Map suitable areas for cactus scrub enhancement and restoration that avoid impacting sensitive plant and animal species. • Prioritize suitable habitat for enhancing and restoring cactus scrub to expand the occurrence and to increase connectivity within genetic clusters. • If it is determined by the historic genetics study that connectivity should be improved between the San Diego/El Cajon clusters, evaluate and prioritize sites for restoration between these genetic clusters that would enhance connectivity.

Type	Objectives	MUs	Actions

	(continued from previous page)		• Identify cactus sources that can be salvaged for transplanting of pads and entire plants into restoration and enhancement. Identify sites for harvesting vegetative cuttings that can be grown at the cactus nursery and later planted as entire plants or segments at the restoration and/or enhancement sites. • Specify BMPs for cactus harvest and salvage, cactus scrub restoration, restoration site selection, restoration and maintenance. • Develop ASMDs to reduce the exotic/invasive plant cover and to provide bare ground for foraging cactus wrens. • Develop ASMDs to reduce predation pressure and other threats to cactus wrens. • Prepare an implementation plan that takes into account the above factors and specifies total acreage and prioritized locations for restoration and enhancement of cactus, source material including availability of large cactuses, reduction of predation pressures, elimination of riparian and urban runoff from habitat historically xeric areas to reduce predation pressures and argentine ant occupation of cactus wren habitat, protection from wildfire, and decrease in invasive/exotic plant cover and creation open areas/bare ground.
NU; Regional	Starting in 2014, develop and maintain two cactus nurseries at approved facilities in MU3/4 and in MU6 and grow cactus pads, segments, and entire plants sufficient for restoration projects in the South County and the San Pasqual Valley as identified in cactus restoration implementation plans.	3,4,6	• Prepare a plan with specifications of BMPs for harvesting and growing cactus at a nursery in preparation for transplant into natural lands. • Develop and maintain a nursery for growing cactus harvested/salvaged from the MUs 2, 3, and 4 for use in restoration projects in the South County. The nursery should be set up to grow and supply cactus pads, segments and entire plants from locally harvested native cactus and the composition of species should reflect those found in that geographic area. • Develop and maintain a nursery for growing cactus harvested/salvaged from MUs 5, 6, and 8 for use in restoration projects in the North County. The nursery should be set up to grow and supply cactus pads, segments and entire plants from locally harvested native cactus and the composition of species should reflect those found in that geographic area. The amount and type of cactus will be determined by the South County implementation plan and by the ongoing restoration projects in the San Pasqual Valley. • Submit to the SC-MTX website portal the cactus nursery plans and annual reports documenting number, size class (pad, segment, entire plant), and type of cactus that were harvested by source site, planted at restoration sites, and that are at the nursery and available for planting.

Type	Objectives	MUs	Actions
FWP; Regional and/or Local	In 2014 and 2015, implement pre-fire management actions identified in the Strategic Fire Plan in order to reduce the effects of an altered fire regime on coastal cactus wrens and cactus scrub habitats on Conserved Lands in MUs 3, 4, 5, and 6.	3,4,5,6	• Perform pre-fire actions applicable to coastal cactus wrens and cactus scrub in the Strategic Fire Plan, including specific actions to protect cactus scrub from high intensity fires and recurrent fires. • Submit management data to the SC-MTX website portal.
IEX, RS; Local	In 2014 continue the ongoing cactus scrub restoration projects for the San Pasqual/Lake Hodges genetic cluster in MU6.	5,6	• Support cactus scrub restoration in the San Pasqual/Lake Hodges genetic cluster. • Support ongoing research into cactus wren abundance, habitat relationships, demographics, and response to restoration.
IIP, IEX; Regional and/or Local	In 2015, begin implementing high priority management actions identified in the implementation plan for the Otay and San Diego/El Cajon genetic clusters in MUs3/4 and continue to manage existing and restored cactus scrub habitat occupied by cactus wrens to allow for the continued growth and expansion of cactus by reducing invasive plant cover to ≤25% absolute cover, increasing the amount of bare ground to 50% cover, and removing predator opportunities and/or prioritizing management in areas with reduced predation pressure.	3,4,5,6	• Implement high priority management actions, including enhancing and restoring cactus scrub habitats as detailed in the implementation plan. • Implement ASMDs at existing occurrences to reduce the exotic/invasive plant cover and to provide bare ground for foraging cactus wrens. • Implement ASMDs at existing occurrences with high risk of predation to reduce predation pressure on cactus wrens.

Appendix B.

Status of Otay River Valley Cactus Wrens – Monitoring and Management Options

Appendix B. Status of Otay River Valley Cactus Wrens –
Monitoring & Management Options

Prepared by K Preston, San Diego Management & Monitoring Program, 7/9/14

Historic Cactus Wren Surveys Conducted at Otay Ranch from 1988 to1992

- Comprehensive cactus wren surveys were conducted in 1988, 1989 & 1992 throughout Otay Valley (Fig. 1; Dudek & Associates 1995). 1988 & 1989 survey methods unknown except that they were different from 1992 (Table 1).

- 1988 & 1989 surveys compiled to reduce "double-counting". Three survey years considered "baseline" to compare with future monitoring data.

- > 2.5- fold increase in cactus wrens in 1992 compared with 1988 & 1989 (Fig. 1; Dudek & Associates 1995). 1992 surveys documented 64 pairs & 16 single individuals, whereas 1988 & 1989 birds were all considered paired.

- Population increase attributed to end of prolonged drought occurring during 1980s (Fig. 2). It is unknown how differences in survey methods/effort between years affect territory estimates.

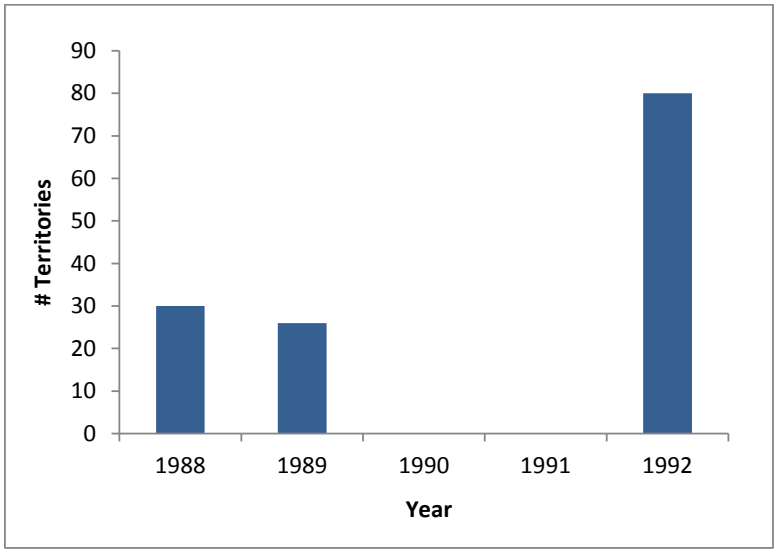


Fig. 1. Number of cactus wren territories estimated in the Otay Valley in 1988, 1989 and 1992.

Impacts to Cactus Wren Habitat

- Compiled all available survey data & overlaid it with GIS layers for conserved lands, urban development, agriculture & parcel boundaries. Cactus wren locations appear directly impacted by agriculture, highway construction & urban development since 1992. A total of 68 cactus wren locations recorded in 1992 are on conserved or future conserved lands.

- In 1994 a fire burned through south end of Salt Creek & northeast edge of Otay Valley impacting two 1992 wren locations. These locations were occupied during 2009 & 2011 surveys.

Table 1. Survey entity, survey effort, method & type of population estimate for different sites surveyed for cactus wren in the Otay Valley between 1988 & 2014.

Year	Poggi Canyon (Entity/Method/Est)	Upper Wolf Cyn (Entity/Method/Est)	Lower Wolf Cyn (Entity/Method/Est)	Otay River Valley (Entity/Method/Est)	Johnson Cyn (Entity/Method/Est)	Salt Creek (Entity/Method/Est)
1988	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs	ASI/unknown method & effort/ # prs
1989	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs	RECON/unknown method & effort/ # prs
1992	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males	Dudek/1 focused survey in 100-acre plots/# prs & single males
1994				? for SR-125 / unknown method & effort/# prs		
2000	? in CNDDB database/ unknown method & effort/# territories				SDNHM in SanBios/unknown method & effort/# territories	
2009	USFWS/2 surveys at established pts/ occupancy	USFWS/2 surveys at established pts/ occupancy		USFWS/2 surveys at established pts/ occupancy		USFWS/2 surveys at established pts/ occupancy Dudek/3 surveys/# territories
2010						RECON/1 survey & photomonitoring pts/ # pairs & single indivs
2011	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs			USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs	USFWS/2 surveys at established pts/ occupancy USGS/survey & band/# prs & single indivs
2012		USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs.			USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs	USGS; 2 surveys all USFWS points & adjacent habitat; Est # prs & single indivs
2013		USGS/1 check of 2012 occupied locations/partial est # territories			USGS/1 check of 2012 occupied locations/partial est # territories	USGS/1 check of 2012 occupied locations/partial est # territories
2014	SDMMP/1 habitat assessment visit/presence	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs	USGS surveys pending	USGS surveys pending	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs	USGS/2 surveys at all USFWS points & adjacent habitat/ # prs & single indivs

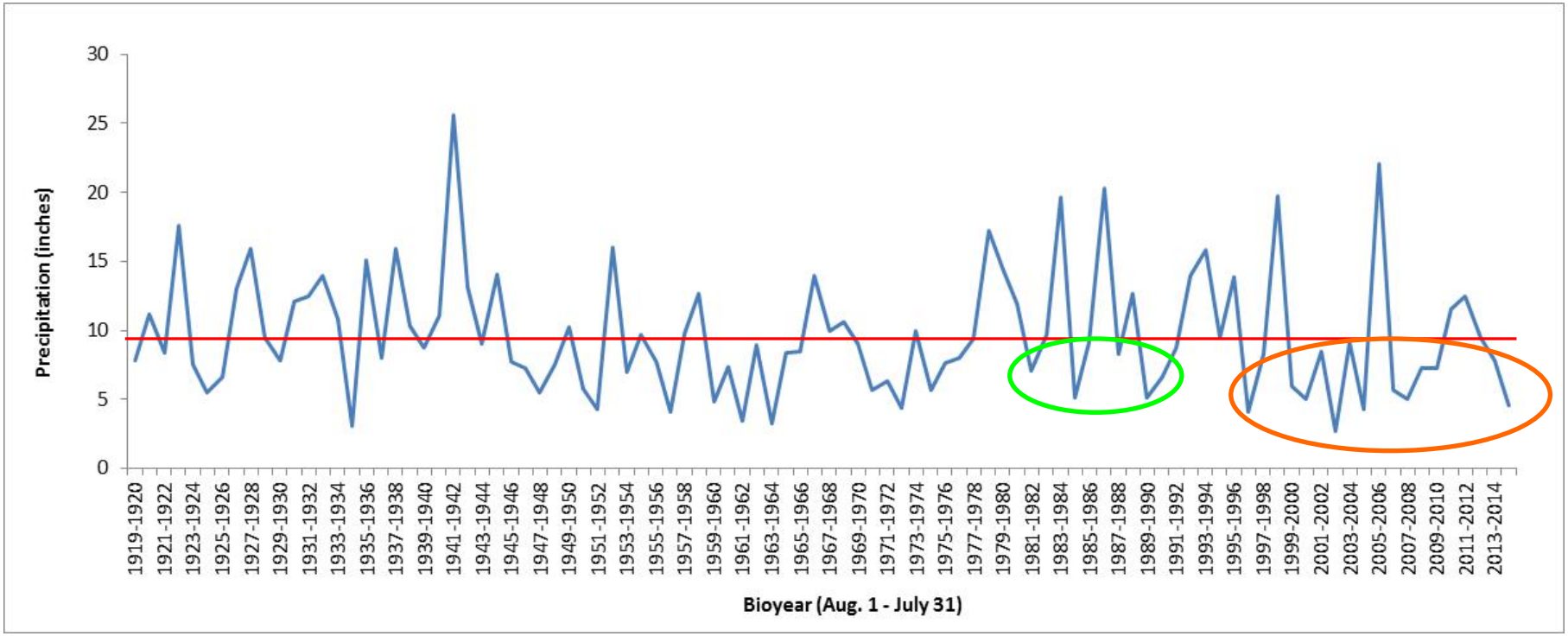


Fig 2. Bioyear precipitation in Chula Vista from 1921-2013. The red line represents average bioyear rainfall, the green circle shows drought years in the 1980s, and the orange circle highlights drought years from the mid-1990s to 2014.

Current Otay Cactus Wren Population Status

- Surveys were conducted from 2009 to 2014 on conserved lands at different sites in the Otay Valley. Methods, survey effort & types of data collected differ among surveys (Table 1). Surveyers typicallly provided an estimate of the number of territories. I developed an estimate in cases when there were multiple entities surveying the same site in the same year or an estimate was not provided by the surveying entity. The number of territories each year represents an estimate based on available data that includes mapped wren locations over time, banding records & pairing /reproductive information.

- The total estimated number of territories on undeveloped lands at 3 consistently surveyed sites (Wolf Canyon, Salt Creek, Johnson Canyon) shows a peak in 1992 with 53 territories (Fig. 3). The next highest years were 1988 & 2009 with 25 territories and the low was in 2014 with 14 territories (12 pairs & 2 single males). Between 2009 & 2014 the estimated number of territories decreased by 40%.

- Salt Creek declined from an estimated 41 territories in 1992 to 15 in 2009 & to 7 in 2014 (Fig. 4). Most of the decline was in the northern half of the canyon (Fig. 5 & 6). Johnson Canyon was more stable with 6-9 territories, although in 2014 two of the 6 territories had single males rather than pairs (Fig. 4 & 7). Upper Wolf Canyon typically supports 1-2 pairs, with 1 pair in 2014 (Fig. 4 & 8). No GIS survey data were available after 1992 for the privately owned, future conserved lands in lower Wolf Canyon and along the Otay River Valley (Fig. 4, 8 & 9).

- Based on 2-3 surveys/territory between April and June, productivity was unusually low in 2014. Three territories (21%) produced single fledglings, 8 exhibited no successful reproduction and 3 had unknown reproductive success.

Factors Associated with Population Dynamics of Songbirds in Southern California Shrublands

- In arid ecosystems, the timing and amount of precipitation drives primary productivity which affects plant and arthropod food source available for birds and small mammal populations. In southern California arthropod abundance and biomass were significantly reduced during an extreme drought year (Bolger et al. 2005).

- Food availability and nest predation are two primary drivers of avian productivity and have been shown to be important in southern California shrubland nesting songbirds (e.g., Morrisonand Bolger 2002, Bolger et al. 2005, Preston and Rotenberry 2006 a,b).

- In southern CA drought induced food limitation has resulted in low productivity and even total reproductive failure among shrubland birds (Bolger et al. 2005, Preston and Rotenberry 2006 a,b). However, nest predation may still play a role as food limitation and nest predation were shown to have equal and independent effects on productivity in an extreme drought. Songbirds respond to reduced food availability by not breeding, delaying nesting, attempting fewer nests, having smaller clutches and fewer broods.

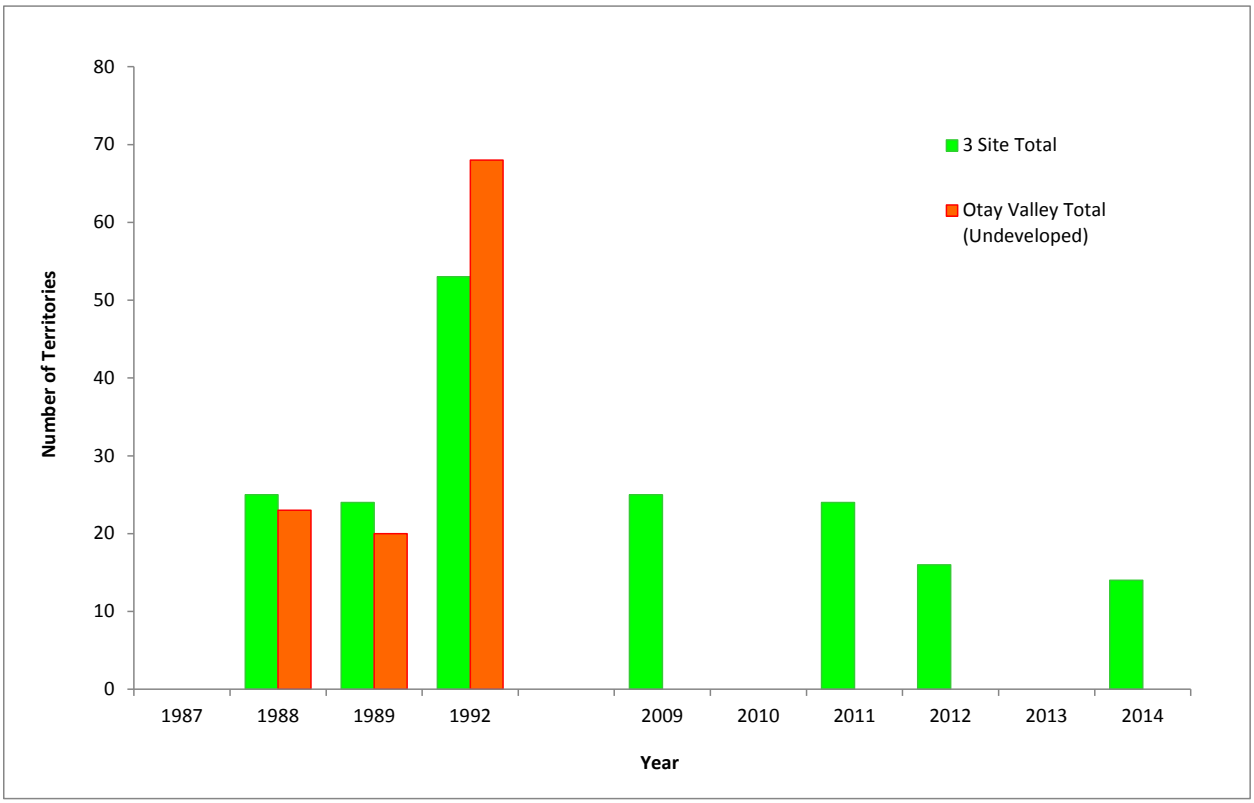


Fig. 3. Estimated total number of undeveloped cactus wren territories and combined total number of territories at three sites (upper Wolf Canyon, Johnson Canyon and Salt Creek) consistently surveyed in the Otay Valley between 1988 and 2014.

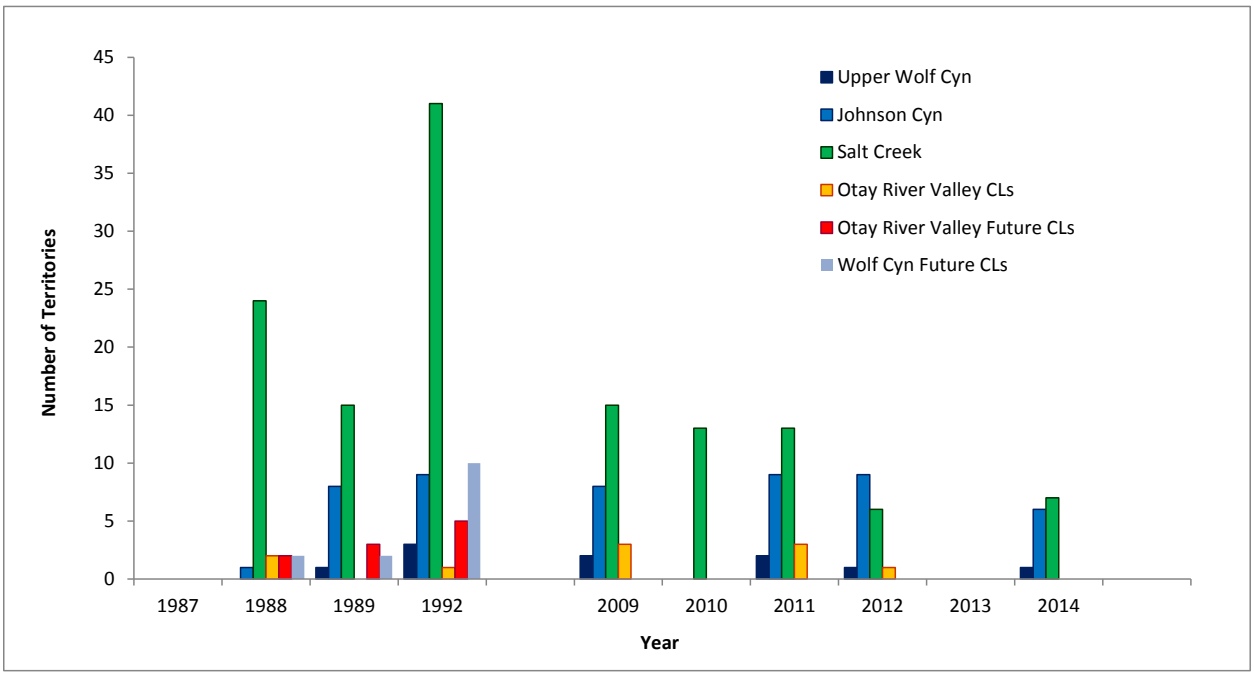


Fig. 4. Estimated number of cactus wren territories between 1988 and 2014 at various sites within the Otay Valley.

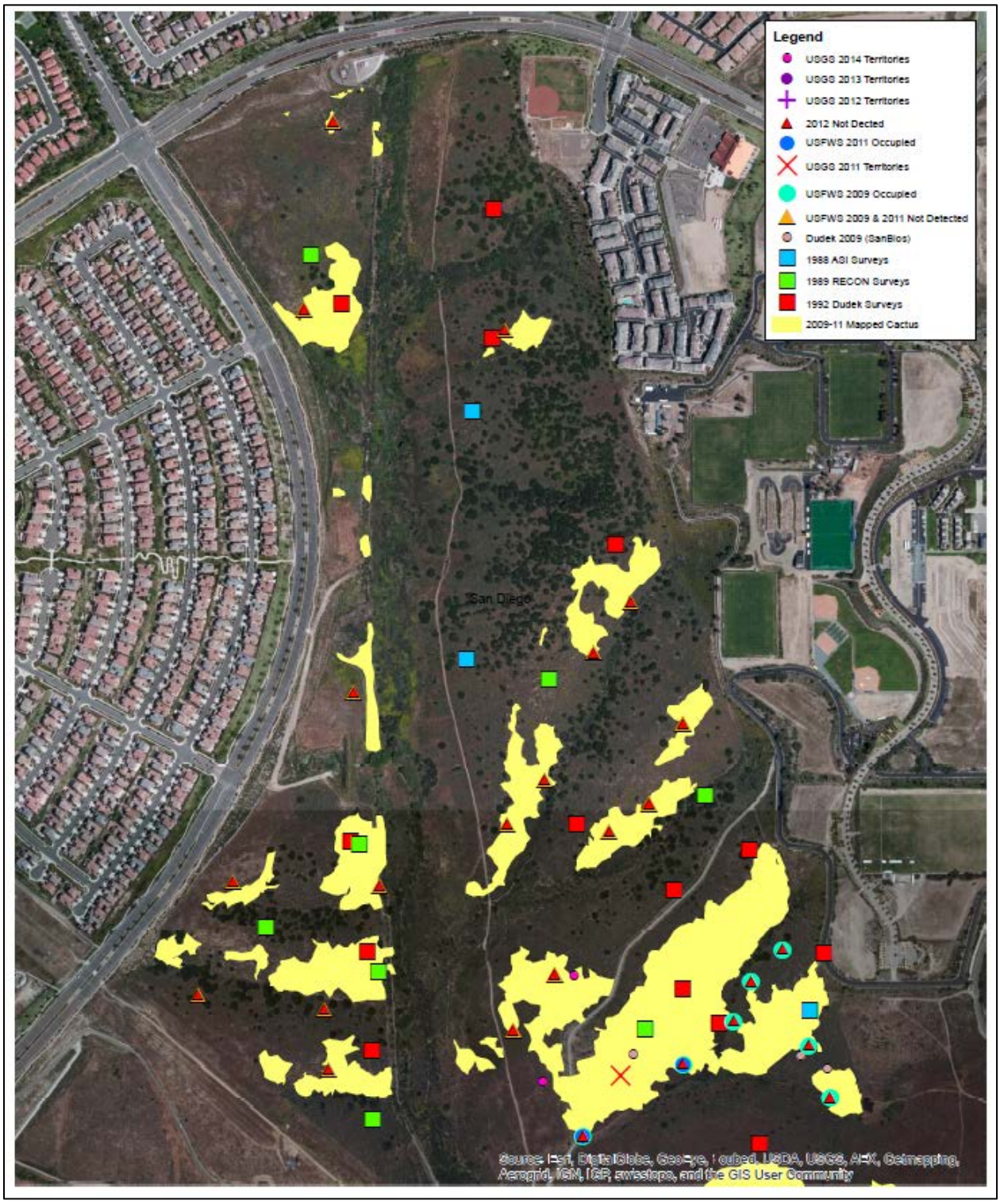


Fig. 5. Distribution of cactus wren territories from 1988 to 2014 in northern Salt Creek.

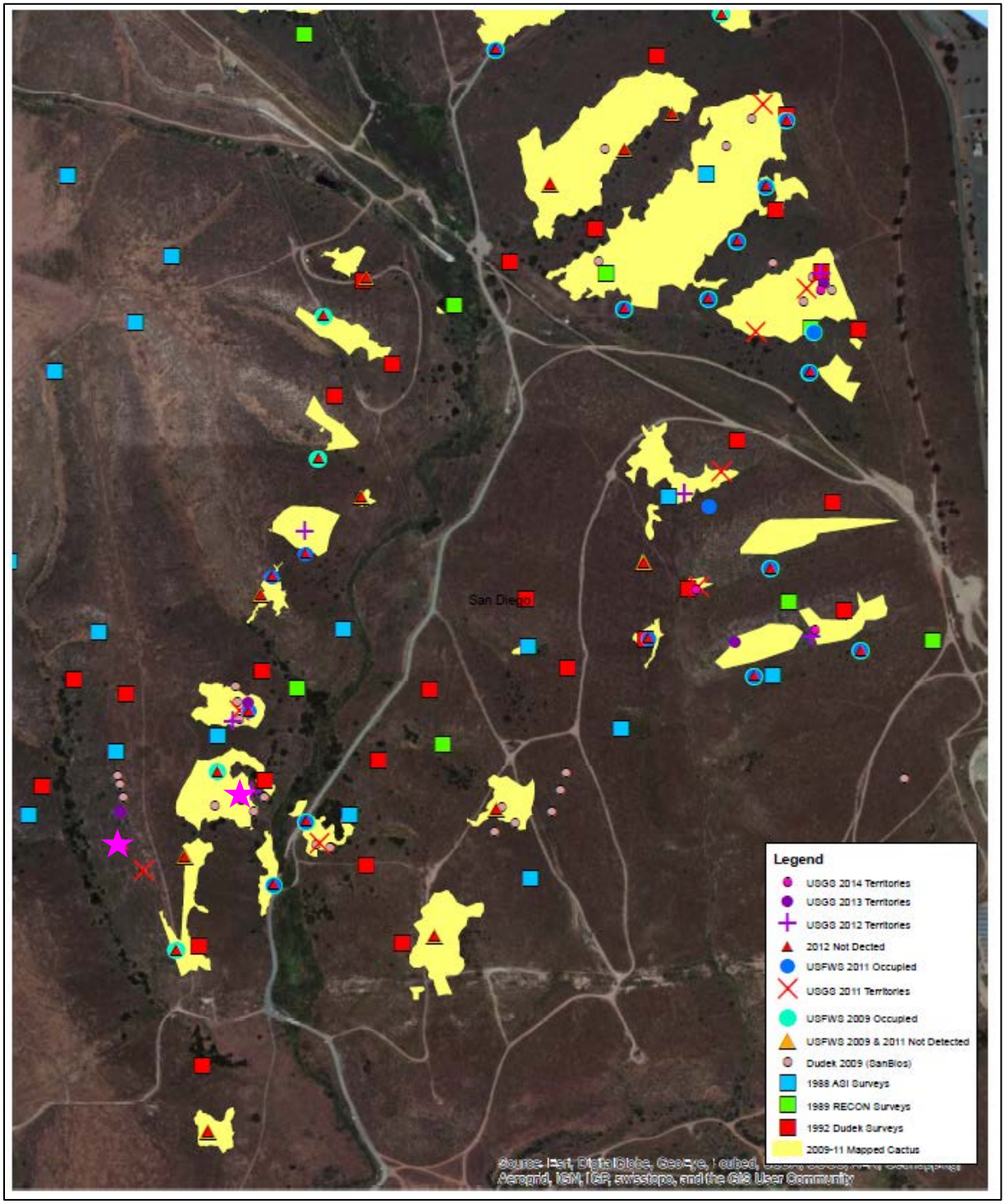


Fig. 6. Distribution of cactus wren territories from 1988 to 2014 in southern Salt Creek. Pink stars represent two pairs producing single fledglings in 2014.

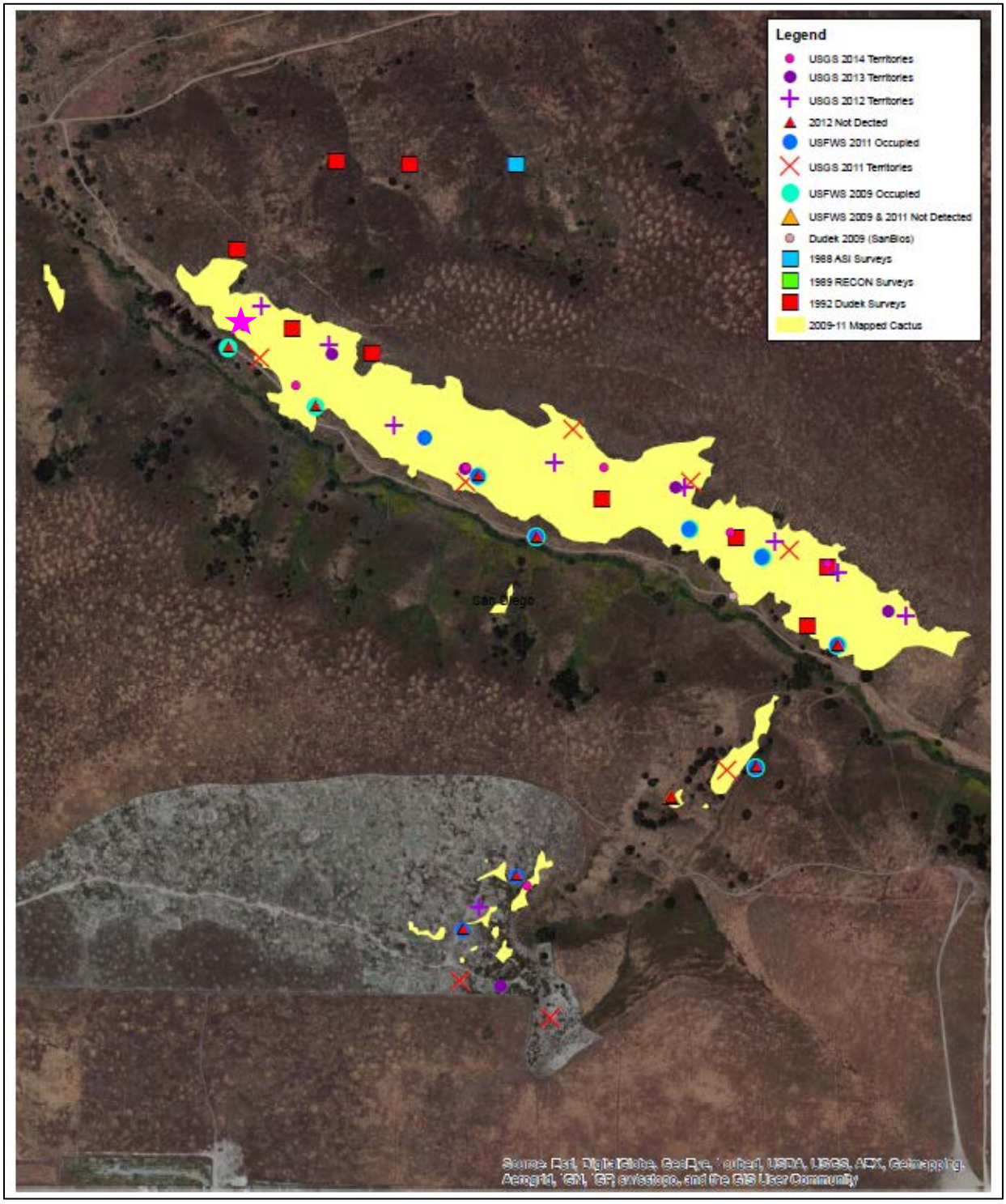


Fig. 7. Distribution of cactus wren territories from 1988 to 2014 in Johnson Canyon. The pink star represents a pair that produced a single fledgling in 2014.

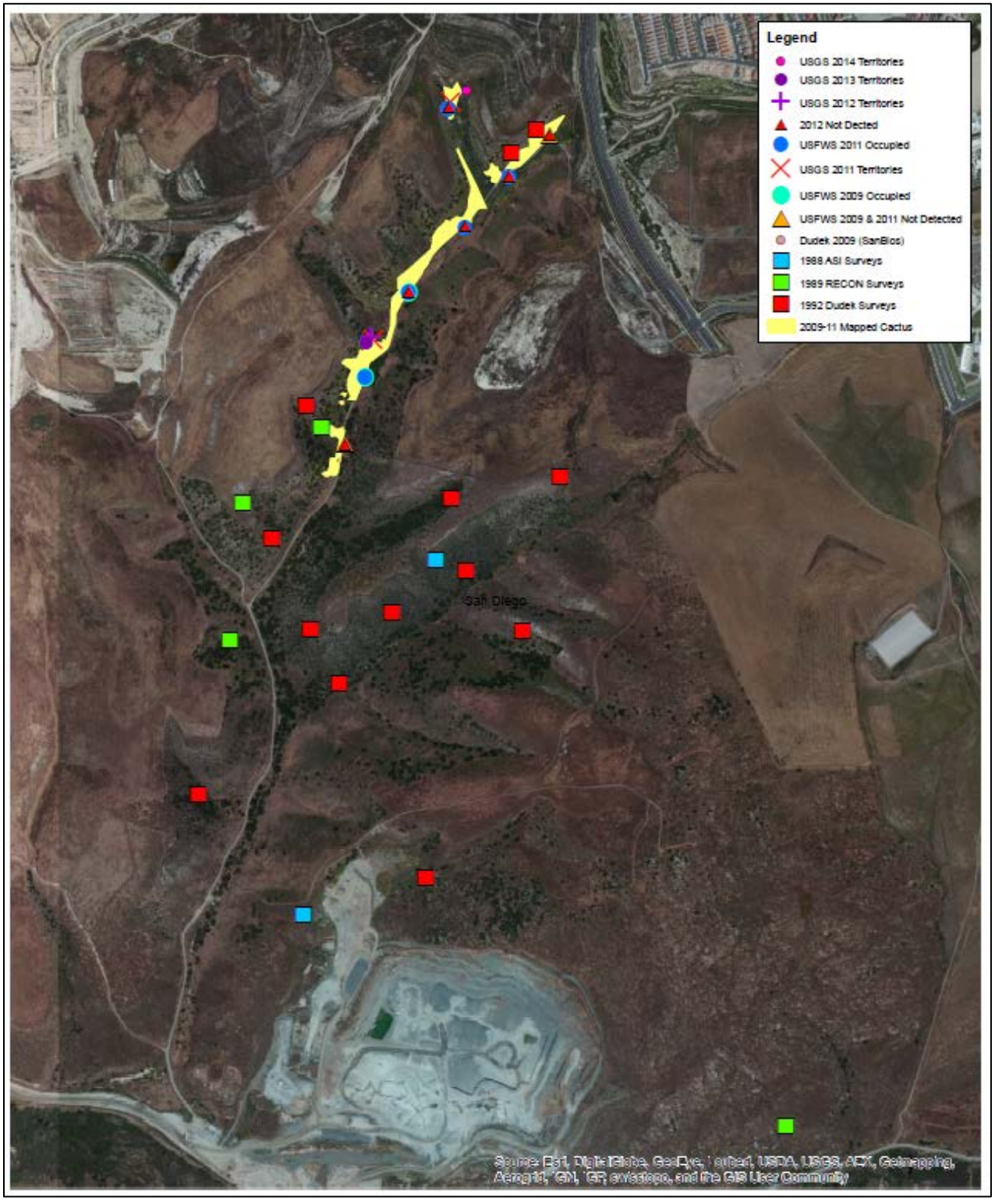


Fig. 8. Distribution of cactus wren territories from 1988 to 2014 in Wolf Canyon.

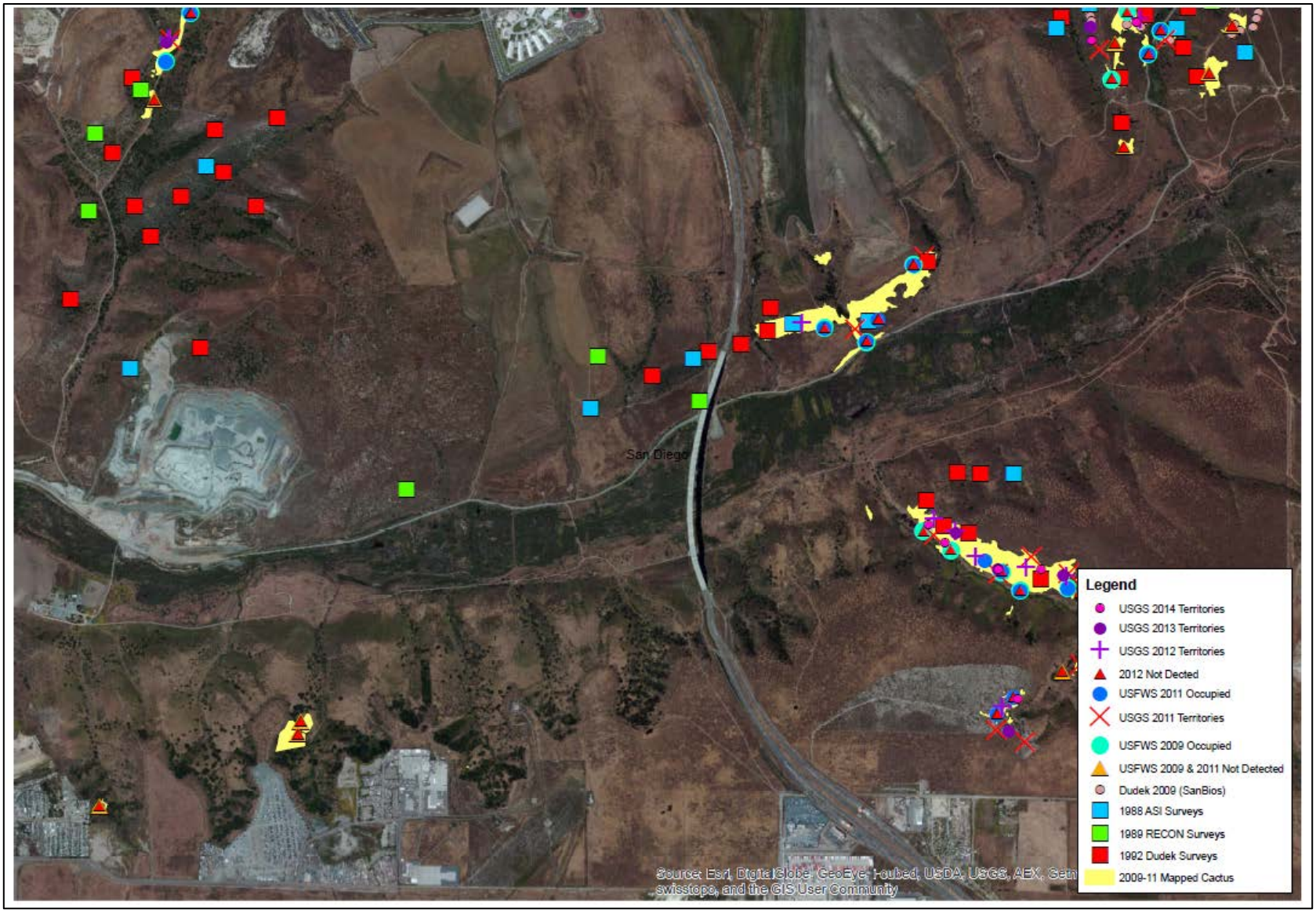


Fig. 9. Distribution of cactus wren territories from 1988 to 1992 along the Otay River Valley.

Factors Associated with Cactus Wren Population Declines

- Habitat loss to development and catastrophic wildfire are considered primary drivers of cactus wren population declines. However, a 5-year study monitoring cactus wren reproduction, dispersal and survival indicate that there are also other factors that influence wren population dynamics (Preston and Kamada 2012, Preston unpub. data). These include small isolated populations with insufficient habitat, limited ability to disperse through fragmented habitat, low productivity (# fledglings/pr/yr) related to rainfall and nest predation, high juvenile mortality with low levels of recruitment into the breeding population, high levels of predation in some habitat fragments and habitat degradation.

- Cactus wren populations declined by more than 80% in the Nature Reserve of Orange County's (NROC) Coastal and Central Reserves, as a result of catastrophic wildfires in 1993 and 2007 (Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009). Wildfires have also affected wren populations in San Diego County over the last decade (e.g., Hamilton 2009).

- Cactus wren productivity at NROC was low from 2009-2013 and was positively associated with January to April precipitation indicating the importance of food availability (Table 4 and Fig. 10 a-d; Preston unpub. data). Productivity is also positively related to elevation (most productive site was at highest elevation) and negatively associated with first egg lay date (earlier nesters can produce more broods) and presence of corvids (nest predators).

- Drought is associated with cactus wren population declines. Substantial population reductions following 2002 and 2007 droughts at NROC's Coastal Reserve indicate decreased productivity and/or survival during droughts (Hamilton 2004, Mitrovich and Hamilton 2007, Preston and Kamada 2012). Multiple years of drought may be associated with smaller population size in the Otay Valley in the late 1980s (Dudek 1995) and more recently (Fig. 2).

- The current drought is affecting cactus and there is dead or dying cholla at some sites in south San Diego County (Fig. 11). There are indications cacti were dying in 2009 in parts of Salt Creek (Preston unpub. data), which could be a factor in the loss of wrens from this area.

- Small populations are vulnerable to local extinction. At NROC, sites with <4 territories were highly variable in occupancy between 1999-2004 (Hamilton 2004), whereas sites with more birds tended to remain occupied over time. During the extreme 2007 drought birds disappeared from sites with small numbers of pairs and most sites were not re-colonized (Table 3).

- Cooper's hawk predation is likely associated with increased mortality and rapid decline in small populations, especially in urban fragments (Preston and Kamada 2012, Preston unpub. data).

Table 3. Disappearance of cactus wrens from sites with small numbers of birds at the Coastal Reserve of Orange County during the 2007 drought.

Site	Original # Territories	Year	Year Disappeared	Association with drought	Connected to Other Sites?	Recolonized?
Boat Canyon	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	Yes (2011)
Bonita Reservoir	2	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
El Moro Ridge	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
Emerald Ridge	1	2006	2007	Disappeared year of extreme drought (32% of average rainfall)	Yes	No
James Dilley	8	2002	2008	4 of 6 years <average rainfall (2 extreme years @ 32% and 40% of average)	Yes	No (Translocated 9 birds but all left/died after 2 years)

- Habitat quality may influence food availability, with high thatch cover of invasive non-native grasses altering cactus wren foraging ability and potentially arthropod composition and abundance. A study is underway by the University of California at Irvine, NROC and the Irvine Ranch Conservancy to relate cactus wren productivity to arthropod community composition and abundance in different species of shrubs, cactus, forbs, native and non-native grasses and bare ground. Fecal samples from nestlings wrens were collected to determine what arthropods they were fed. The results of this study will be useful in developing habitat management criteria to improve productivity by enhancing habitat quality and food availability.

- In southern California there is little connectivity among cactus wren populations that are isolated by urbanization and habitat fragmentation (Barr et al. 2012, 2013). Cactus wren are poor dispersers and isolated populations are becoming less genetically diverse. Genetic analyses show the Otay population has little recent connectivity with wrens to the north, even though they are only several km apart.

Table 4 General least squares models predicting minimum number of cactus wren fledglings/pair/ year. Models include exponential spatial-temporal correlation structure to account for spatial and temporal autocorrelation.

Model Parameters	K	Δ_i	ω_i	Evidence Ratio ω_i/ω_1
Year, Pair Density Occupied Cactus, PCorvids, Julian 1st Egg, Jan to Apr Precip, Min Jan & Feb Temp, Elevation, Topographical Heterogeneity, % Cactus 200m	**11**	**0.0000**	**0.9980**	
Year, Pair Density Occupied Cactus, Pcorvids, Julian 1st Egg, Jan to Apr Precip, Min Feb Temp, Max Mar & Apr Temp, Topographical Heterogeneity, Northness, % Urban 1km, % Cactus 200m	13	8.9990	0.0020	499.00
Year, # Territories, PCOHA, Julian 1st Egg, Jan to Apr Precip, Min Jan & Feb Temp, Max Mar & Apr Temp, Topographical Heterogeneity, Northness, % Slope, % Cactus 200m	13	13.1796	0.0004	2,495.25
Year, Pair Density Occupied Cactus, PCorvids, Julian 1st Egg, Jan to Apr Precip, Min Apr Temp, Max Apr Temp, Elevation, Topographic Heterogeneity, Northness, % CSS 1km, % Urban 1km, % Cactus 200m	15	21.4090	0.0000	24,952.50
Year, Pair Density All Cactus, PAll Predators, Julian 1st Egg, Biological Rainfall Yr, Min Jan & Feb Temp, Max Mar & Apr Temp, Elevation, Topographic Heterogeneity, Northness, % Slope, NDVI, % Cactus 25m	15	26.0594	0.0000	332,700.00

Rationale for Potentially Triggering Management Actions to Maintain Population of Otay Cactus Wrens

- Lindermayer et al. (2013) equates a 20% decline over 5 generations as a catastrophic decline that triggers research into threats and increased surveillance (Fig. 11). If threats are known then management of threats should be implemented.

- Southern California is in the midst of a prolonged and extreme drought, with only 4.6" of rain measured in Chula Vista during the 2013-14 bioyear. The Otay cactus wren population at 3 surveyed sites has declined 40% over 6 years. We have reached a trigger point where we need to decide if we are sufficiently comfortable with our knowledge of threats that we can undertake management actions. We have enough t knowledge to understand that drought is a factor in the decline of cactus wren populations. We know that cactus wren productivity is related to rainfall and this relationship was further confirmed by the very low productivity of the Otay population in 2014. What is currently unknown is the degree to which drought affects survival. Low rainfall is associated with reduced arthropod abundance and biomass, which means that food is limited (as is supported by the lack of productivity). There is concern that some cactus wrens may lack

sufficient arthropod and plant food resources to survive as the drought progresses through the summer into the fall. Unfortunately, populations are becoming small enough that there is insufficient time or number of birds to study if drought is affecting survival. Survival data from NROC will be analyzed to see if there is a link between rainfall and survivorship. However, at this point any individual mortality makes the population more vulnerable to loss. Concerns are that without management to enhance survival, the population is on a downward trajectory that could eventually result in the loss of cactus wrens in the Otay Valley.

- If wrens are lost from Otay Valley, it would be unlikely they could be re-established. The Otay population is isolated from other wren populations as indicated by the genetic study. So natural immigration from other populations is unlikely. There are currently no wren populations in the region with sufficient populations to serve as a source of wrens to be re-established through translocation. Translocation would also be very expensive.

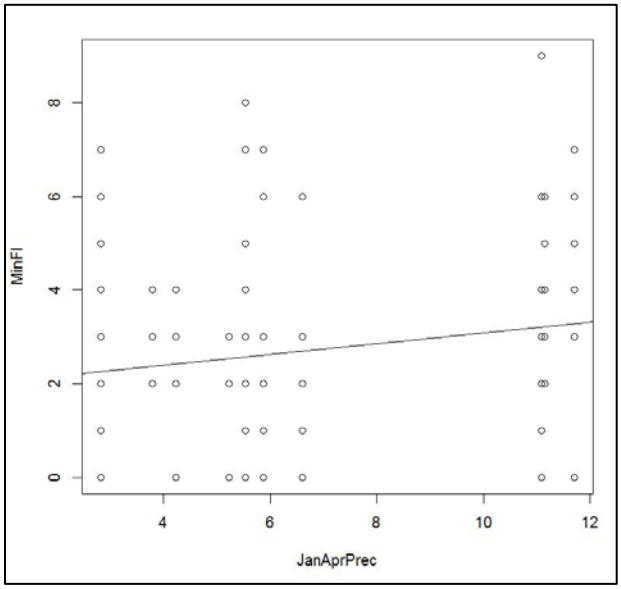
- The importance of food availability in cactus wren reproductive success has been documented in two studies. A study of cactus wrens breeding in the desert found significant differences in reproductive success and nesting phenology between years that was related to the availability of grasshoppers, the primary food source for nestlings (Marr and Raitt 1983). In a second study of desert cactus wrens, food supplemented nestlings and fledglings survived at a higher rate in one of two years and productivity was increased (Simons and Martin 1990).

- The effect of food limitation on survival is unknown in cactus wrens, although loss of wrens during drought periods indicate a reduction in survivorship is occurring (Table 2). Potential management actions to enhance survival in times of limited food availability is to provide supplemental food. This has been done for endangered populations of translocated and naturally occurring songbirds on islands. Food supplementation was shown to enhance survival of 2 of 3 species of translocated songbirds in New Zealand(Armstrong et al. 2002, Chauvenet et al. 2012). One species declined despite the supplemental food because of a fungus prevalent in the habitat. The populations for the two other species increased and after several years led to density dependent reductions in juvenile survivorship in one case and decreased recruitment into the breeding population in the other. A fourth study found that food supplementing an endangered robin during the breeding season resulted in significantly more offspring surviving to 1 year of age (Komdeur 1996).

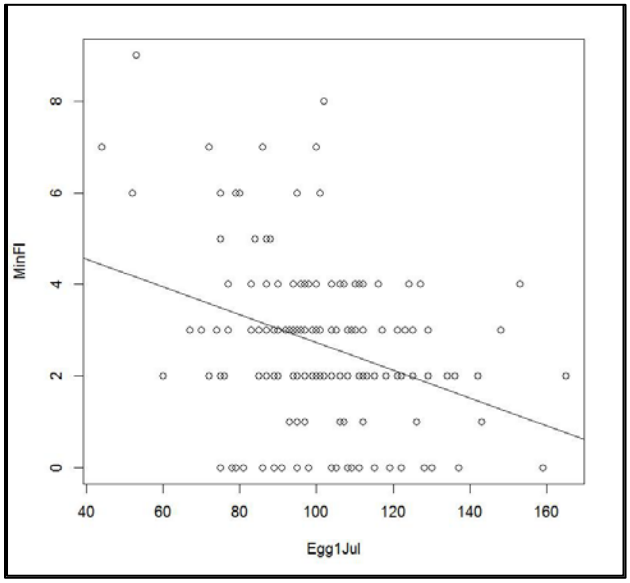
- One course of actions is to survey the Otay River Valley and lower Wolf Canyon sites to document the number of birds in the entire Otay population. We are attempting to obtain access to do this and there is currently sufficient funding to cover this. If there are at least 10 pairs of wrens in the Otay River Valley/lower Wolf Canyon, this would equal a population of 24 and be comparable to the 1989 population level of 26 pairs. A survey should be conducted later this summer to determine if the wren population is stable. If there are fewer individuals, then food supplementation would be an option to try and reduce further loss during the remainder of the drought. Food supplementation has been successfully implemented with cactus wrens in NROC's Coastal Reserve (Kamada and Mitrovich 2013).

- It is important to monitor productivity and survival of Otay cactus wrens over the next few years to better understand the mechanisms underlying the decline and to identify threats to persistence. This will require banding birds and conducting periodic surveys to document survival and production of fledglings.

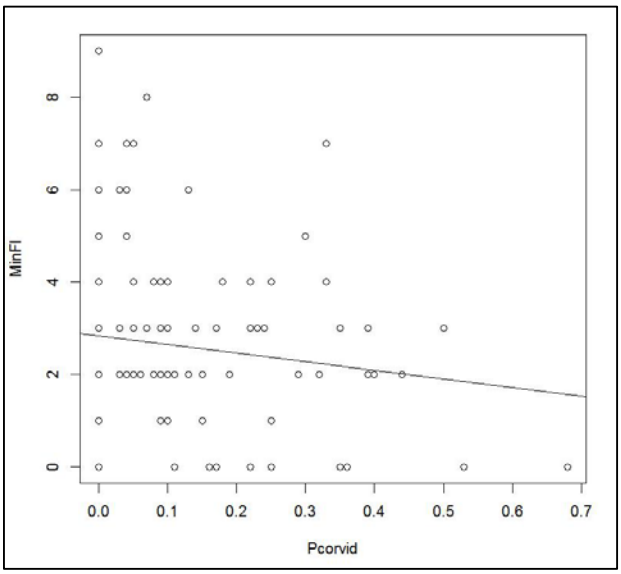
- The Otay population is small and should be managed for increased abundance. Habitat restoration appears to be working at all three sites as birds are using restored sites and the habitat appears of good quality. Continued habitat enhancement and restoration is needed to provide sufficient habitat to accommodate larer more stable population. The current die-off of cholla at various locations in southern San Diego County warrants more attention. The drought is thought to be the major factor in the deteriorating condition of cholla, but disease could also be involved. Management to reduce competition for water where shrubs are overgrowing the cactus has been shown to improve the overall condition of cholla (M. Dodero, pers. comm.). The results of the cactus wren foraging and arthropod study, when available, should be incorporated into the design of cactus scrub enhancement and restoration projects to increase the availability of arthropod food resources.



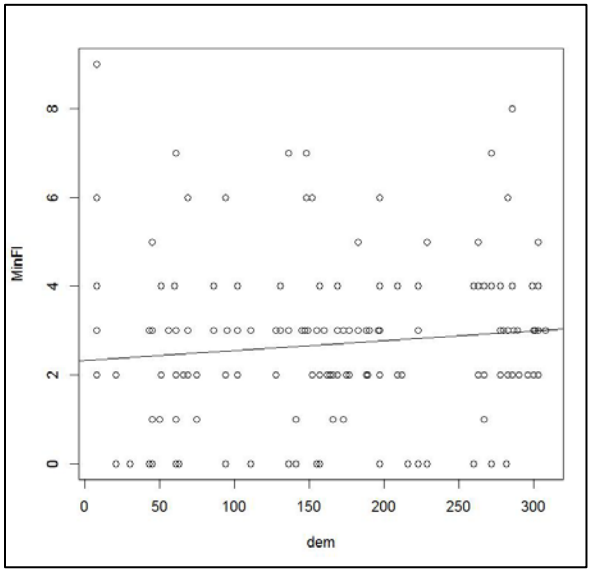
a. January to April precipitation



b. Egg lay date



c. Proportion of corvids detected



d. Elevation

Fig. 10. Factors showing significant positive and negative associations with cactus wren productivity (#fls/pr/yr) at the Nature Reserve of Orange County from 2009 to 2013.

Fig. 11. Drought stressed cactus in southern San Diego County in 2014.

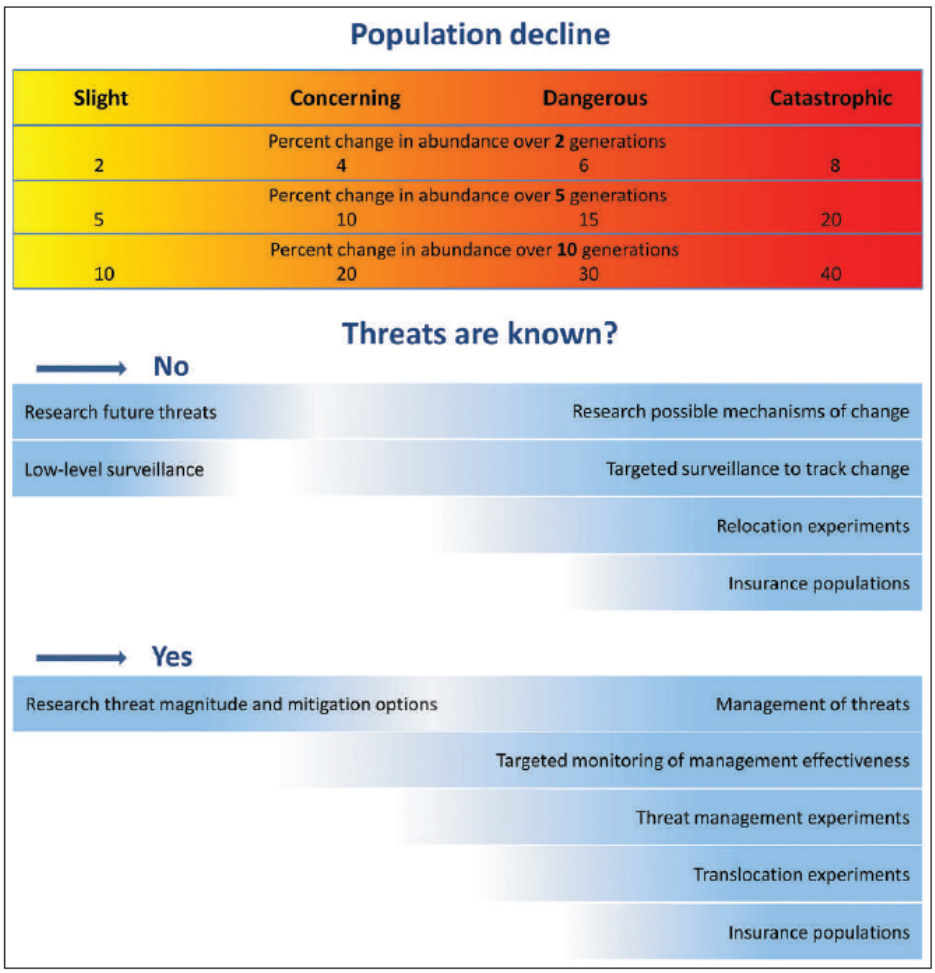


Figure 4. *Planning a response to monitoring. The length of the blue bars indicates the range of declines over which a particular management response might be appropriate, including seeking more information through research, targeted monitoring, or surveillance monitoring. The percent population declines (red panels) provide an indication of the levels of decline that would trigger particular actions (blue panels).*

From Lindenmayer et al. 2013

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Appendix C.

Coastal Cactus Wren Habitat Suitability Model

Appendix C. Coastal Cactus Wren Habitat Suitability Model

Spatially explicit habitat suitability models can be important tools for conserving, monitoring, and managing rare species (Maes et al. 2005, Guisan et al. 2006, 2013, Marcer et al. 2013). These models can be used to increase our understanding of a species' habitat requirements, prioritize areas to survey for new populations, delineate areas important for conservation, and identify potential sites for population translocation. More recently, habitat suitability models have also been used to identify restoration opportunities to enhance habitat for species of conservation interest (Bartel and Sexton 2009, Funk et al. 2013). Habitat suitability or niche models calculate environmental variables with Geographic Information Systems (GIS) and use associations between species locations and environmental variables to identify potentially suitable habitat.

The San Diego Management and Monitoring Program (SDMMP) developed a coastal cactus wren habitat suitability model for southern California. This model is used to assess potential sites for cactus restoration in order to meet an important management objective of the Management Strategic Plan for Conserved Lands in Western San Diego County (SDMMP 2013). The objective is:

"*Protect and enhance suitable cactus scrub and coastal sage scrub habitat within the Otay River and San Diego/El Cajon genetic clusters to expand the occurrences to a sustainable effective size to avoid inbreeding, enhance habitat connectivity throughout the Otay River Valley, and potentially connect this occurrence to the San Diego/El Cajon genetic cluster (depending on results of the in-progress study on historic genetic structure) to provide for coastal cactus wren persistence in the strategic plan area over the long-term (>100 years)*."

Methods

Study Area and Coastal Cactus Wren Datasets

The southern California study area includes San Diego, Riverside, San Bernardino, Orange, Los Angeles and Ventura Counties and encompasses more than 8,148,121 hectares (>20 million acres). We compiled cactus wren location data from throughout coastal southern California. We removed spatially redundant records so that all wren locations used in constructing and evaluating models were at least 150 m apart. Sources of cactus wren location records included:

- US Geological Survey southern California cactus wren surveys and collection of genetic material from 2012 to 2013
- Nature Reserve of Orange County cactus wren surveys from 2006 to 2008
- Western Riverside County Multiple Species Habitat Conservation Plan cactus wren location records from 2006, 2007 and 2011
- U.S. Fish and Wildlife Service cactus wren surveys in San Diego County in 2009 and 2011
- The Nature Conservancy, Sea and Sage Audubon, and California Department of Fish and Wildlife volunteer surveys for cactus wrens in Orange, LA and Ventura Counties from 2009 to 2012
- California Natural Diversity Database cactus wren locations from 2000 to 2012
- SANBIOS cactus wren locations for San Diego County from 2000 to 2009

We also used 1981-1999 CNDDB records available for Orange and San Diego Counties to identify historically occupied suitable habitat where there are no current wren observations. For Los Angeles, Ventura, Riverside, and San Bernardino Counties, we relied on Solek and Szijj (2004) for historically occupied sites where wrens were reported in the late 1980s and early 1990s. Desert populations of cactus wren were not included in the habitat modeling, as the focus was on characterizing suitable habitat for populations on the west side of the Peninsular Mountain ranges.

GIS-based Habitat Variables

Using GIS and digital spatial layers, we calculated topographic, climatic, vegetation, and land use variables to represent environmental conditions across southern California. We created a grid of points that encompassed the study area, with each point falling within the center of a 150 m x 150 m grid cell. We calculated values for various environmental variables at each point in the grid (Table C-1). To characterize the environment used by wrens, we used ArcGIS to spatially join every wren location to the closest grid point with calculated environmental attributes. If two cactus wren records fell within 150 m of each other, then one was removed from the modeling datasets.

Cactus wrens are obligates of cactus scrub habitat in southern California. However, we lack comprehensive mapping of the coastal cactus scrub vegetation community for much of the study area. Cacti have a patchy distribution within the larger and more widespread coastal sage scrub plant community. To characterize suitable conditions for cacti, we developed a habitat model for the widespread and abundant coastal prickly pear cactus (*Opuntia littoralis*). We developed and compared alternative models following methods detailed in Preston et al. (2008). We selected the best performing model and included habitat suitability predictions for prickly pear in selected cactus wren habitat models. Similarly, we modeled an important coastal cactus scrub shrub, California sagebrush (*Artemisia californica*), and included it as a predictive variable in one of our candidate models.

Partitioned Mahalanobis D^2 Modeling Approach

We constructed partitioned Mahalanobis D^2 models for cactus wrens in southern California (Dunn and Duncan 2000, Rotenberry et al. 2002, 2006). Mahalanobis D^2 is the standardized distance between the multivariate mean for environmental variables calculated at locations where a species occurs and values calculated for the same set of environmental variables at a point in the landscape. The more similar environmental characteristics are at a point in the landscape to the species' multivariate mean, the more suitable the habitat is for the species. The D^2 distance is scaled following a chi-squared distribution and ranges from 0 to 1.0. These rescaled values form a Habitat Similarity Index (HSI), with 1.0 indicating environmental conditions identical to the species' multivariate mean (i.e., most suitable) and 0 indicating conditions that are highly dissimilar (i.e., unsuitable).

Mahalanobis D^2 can be divided into independent components or partitions using principal components analysis (PCA; Rotenberry et al. 2002, 2006). Each partition represents an independent environmental relationship. The last partition with the smallest eigenvalue (measure of variance) represents the linear combination of environmental variables that vary the least.

Table C-1

Environmental Variables Used in Coastal Cactus Wren Habitat Suitability Modeling

Variable(s)	Scale(s)	Description
Elevation	At point	Computed elevation (m) using ArcGIS to extract values from a 10m USGS digital elevation model raster at each point.
Topographical Heterogeneity	30m x 30m area	Computed topographic heterogeneity, a measure of topographic ruggedness (Sappington et al. 2007), using ArcGIS and the elevation raster to calculate a median value for a 30m neighborhood centered on each point.
Slope in Degrees	At point	Computed slope (º) using ArcGIS to extract values from the elevation raster at each point.
Northness	At point	Northness is a measure of northerly aspect. Used the "Aspect" tool in ArcGIS to calculate the cosine of aspect from the elevation raster using the "Raster Calculator" at each point.
Eastness	At point	Eastness is a measure of easterly aspect. Used the "Aspect" tool in ArcGIS to calculate the sine of aspect from the elevation raster using the "Raster Calculator" at each point.
Precipitation: Annual (rainfall year: August 2 to July 31); October to January; February to May	At point	Computed precipitation variables (mm) for monthly, seasonal and annual time periods at each point using ArcGIS and a raster with 1981-2010 precipitation averages downloaded from the PRISM Climate Group (http://www.prism.oregonstate.edu)
Temperature: January Minimum; July Maximum	At point	Computed monthly minimum and maximum temperature (°C) for each point using ArcGIS and rasters with 1981-2010 minimum and maximum monthly temperature averages downloaded from the PRISM Climate Group.
Vegetation/Land Use: % Coastal Sage Scrub % Chaparral % Urban	150m x 150m, 1 km x 1 km	Subregional vegetation maps were merged together from western Riverside County (2005), western San Diego County (2014), southern (2013) and central/coastal (2013) Orange County, NAS Miramar (2012-14), MCB Camp Pendleton (2003) and NWS Fallbrook (2010). The 2010 Fire Resource Assessment Program Vegetation Map for California was used for areas in southern California without subregional mapping. Calculated % of vegetation or land use type within 150m grid cells and 1 km neighborhoods.
Normalized Difference Vegetation Index (NDVI)	At point	Extracted NDVI values from MODIS satellite imagery at each grid point for images taken 5/28 to 6/2/2012. Imagery resolution is 1 pixel = 250 m.
Habitat Suitability Coastal Prickly Pear HSI California Sagebrush HSI	At point	1,741 calibration and 747 validation records used to develop prickly pear habitat model. Median validation HSI = 0.7. 196 calibration and 105 validation records to develop California sagebrush habitat model. Median validation HSI = 0.6.

A partition with a larger eigenvalue indicates an increase in the amount of variance in environmental relationships represented by that partition. The underlying idea is that those environmental relationships that vary the least are the most limiting and indicative of suitable habitat, whereas environmental relationships that are highly variable are less informative. Partitions are additive and together add up to the original D^2. Partitions are added by starting with the last partition with the smallest variance and adding that to the next higher partition with the next lowest variance and so on. The more partitions retained, the greater the variability in environmental conditions specified by the model. Combinations of partitions with low variance represent ecological minimums for a species, while combinations that retain more partitions and higher variability represent habitat relationships that are not as limiting for a species distribution.

Determining the number of partitions to retain in a model depends on the modeling objectives, an analysis of eigenvalues, and an evaluation of model performance using calibration and validation datasets. Median HSI values are calculated for calibration and validation datasets and used compare alternative models with different combinations of environmental variables and selected partitions. To further evaluate model performance, 1000 points were randomly selected from the southern California study area grid and classified as pseudo-absences. HSI values for these random absences were compared with values for occupied points by developing a Receiver Operating Curve (ROC) and determining the Area Under the Curve (AUC) value (Fielding and Bell 1997). AUC values range between 0 and 1.0 with no predictive power for models with an AUC of ≤ 0.5. An AUC value of ≥ 0.7 is considered acceptable in terms of model performance, with higher AUC values representing greater model performance. Once a model and partition were selected, an HSI value was calculated for every point in the grid across the study area, resulting in a habitat suitability map.

Cactus wrens are patchily distributed across southern California, with some areas supporting substantially more wrens than others. To avoid spatially biased sampling, we used a subsampling strategy to balance spatial representation of cactus wren locations used in model construction (Knick et al. 2013). We divided the study area into 8 geographic areas and randomly subsampled 20 cactus wren locations from each area (i.e., 160 total wren locations) and created a PCA to calibrate the model. We repeated this subsampling and construction of a PCA for 1,000 iterations and then averaged the PCA results to develop the model partitions.

Results

Cactus Wren Habitat Suitability Model

We randomly selected 60% (n = 507) of the 845 spatially distinct cactus wren records to calibrate alternative Mahalanobis D^2 models and used the remaining 40% (n = 338) as a validation dataset to compare among models and partitions. We constructed 11 different habitat models using different combinations of variables (Table C-2). The best performing model (R11, Partition 1) has excellent predictive capability with an AUC of 0.95. The median HSI for the validation dataset was 0.75, while the calibration dataset was slightly lower at 0.72, indicating model over-fitting is not a concern.

Table C-2. Comparison of alternative coastal cactus wren Mahalanobis D^2 habitat suitability models for southern California.

Environmental Variables	R11	R1	R2	R7	R9	R6	R3	R10	R4	R8	R5
Minimum January Temperature	X	X	X	X	X	X	X	X	X	X	X
Maximum July Temperature	X	X	X	X	X	X	X	X	X	X	X
Annual Precipitation (August 1 – July 31)	X	X		X	X	X			X	X	X
October to January Precipitation			X								
February to May Precipitation							X	X			
Elevation	X	X	X	X	X	X	X	X	X	X	X
Northness	X	X	X	X	X	X	X	X	X	X	X
Eastness	X	X	X	X	X	X	X	X	X	X	X
Slope in Degrees	X	X	X	X	X	X	X	X	X	X	X
Topographical Heterogeneity	X	X	X	X	X	X	X	X	X	X	X
% Coastal Sage Scrub –150m x 150m cell	X	X	X	X			X	X	X	X	X
% Chaparral –150m x 150m cell	X	X	X	X			X	X	X	X	
% Urban –150m x 150m cell	X	X	X	X	X		X	X	X		
% Coastal Sage Scrub –1km x 1km cell					X	X					
% Chaparral –1km x 1km cell					X	X					
% Urban –1km x 1km cell						X				X	
NDVI									X		X
Prickly Pear HSI	X			X	X			X		X	
California Sagebrush HSI	X										
Model Results											
Number of Partitions	13	11	11	12	12	10	11	12	12	12	10
Selected Partition	1	1	1	1	1	1	1	1	2	1	1
Eigenvalue of Selected Partition	2.988	2.480	2.467	2.717	2.879	2.781	2.456	2.677	1.824	2.781	2.766
Median - Calibration HSI	**0.719**	**0.728**	**0.704**	**0.734**	**0.679**	**0.714**	**0.745**	**0.725**	**0.704**	**0.698**	**0.640**
Mean - Calibration HSI	0.630	0.639	0.623	0.627	0.622	0.629	0.630	0.620	0.619	0.617	0.584
Standard Deviation - Calibration HSI	0.328	0.314	0.317	0.329	0.303	0.306	0.334	0.327	0.326	0.311	0.289
Median - Validation HSI	**0.752**	**0.740**	**0.726**	**0.724**	**0.728**	**0.705**	**0.734**	**0.685**	**0.712**	**0.674**	**0.610**
Mean - Validation HSI	0.653	0.647	0.643	0.640	0.635	0.631	0.631	0.623	0.618	0.614	0.574
Standard Deviation - Validation HSI	0.303	0.291	0.295	0.301	0.292	0.284	0.309	0.296	0.316	0.297	0.281

Variables in the selected model included minimum January and maximum January temperatures, annual precipitation, elevation, northness, eastness, topographic heterogeneity, percent of coastal sage scrub, chaparral and urban development within 150 m grid cell, and modeled habitat suitability for prickly pear and California sagebrush. Environmental variables that made the greatest contributions to the model included maximum July temperature, elevation, northness and eastness, % coastal sage scrub, and prickly pear and California sagebrush habitat suitability predictions.

Figure C-1 shows predicted habitat for coastal cactus wren in southern California and the distribution of wrens observed between 2000 and 2013. There are large areas of potentially suitable habitat with no recent wren records. The lack of wren observations in predicted habitat can be explained by several factors. One explanation is that some areas may not have been recently surveyed or have been surveyed but the specific location data are unavailable. Throughout the study area there were extensive focused surveys between 2006 and 2013, so considerable habitat has been assessed for wrens. However, in some areas there were no surveys often because access could not be obtained or because the areas were not identified as suitable for wrens. For those areas that have been surveyed, it is important to note that habitat models identify environmental conditions that are similar to occupied habitat. There may be areas of suitable habitat where the species has not yet dispersed to, areas where the species is excluded by competitors, or areas formerly occupied but where the species is now extirpated. Many wren populations are small and local extinction from a site can result from environmental and demographic stochasticity. Cactus wrens are also poor dispersers (Atwood et al. 1998, Preston and Kamada 2012, Kamada and Preston 2013, Barr et al. 2015) and natural habitats in parts of southern California are highly fragmented due to urban development. Thus, wrens may not occupy some areas with suitable habitat as they are unable to disperse to and recolonize isolated sites where local populations went extinct. In addition, the habitat may not be suitable as cacti may be absent or the habitat may be degraded due to land use practices or invasive plants. The model identifies conditions that are suitable for prickly pear cactus but it may not be present. For example, large catastrophic wildfires in the last two decades have destroyed cactus patches over thousands of acres and a significant amount of cactus has not recovered sufficiently to support nesting wrens (e.g., Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009).

Many of the areas in Orange and San Diego County predicted to be suitable were historically occupied between 1981 and 1999 (Figure C-2), but have no wrens or a significantly reduced number of wren observations since 2000. These areas include the Chino Hills, southern Marine Corps Base Camp Pendleton, Bonsall, San Luis Rey River Valley east of I-15, Rancho Santa Fe, coastal lagoons, parts of the San Dieguito River Valley and Lake Hodges, Lusardi Creek, north of Ramona Airport, Rose Canyon, west of Santee, the San Diego River Valley west of Lake Jennings, south of the Sweetwater Reservoir, north of Upper Otay Lake, City of Chula Vista Canyons, parts of the Otay River Valley and adjoining canyons, Dennery Canyon, and canyons south of Otay Mesa. Southern Orange County has large amounts of suitable habitat that is still occupied but for which we did not have specific location information. There are also reports of historic cactus wren populations from the late 1980s to early 1990s for Los Angeles, Ventura, Riverside and San Bernardino Counties in areas identified as suitable habitat but with no current observations (Solek

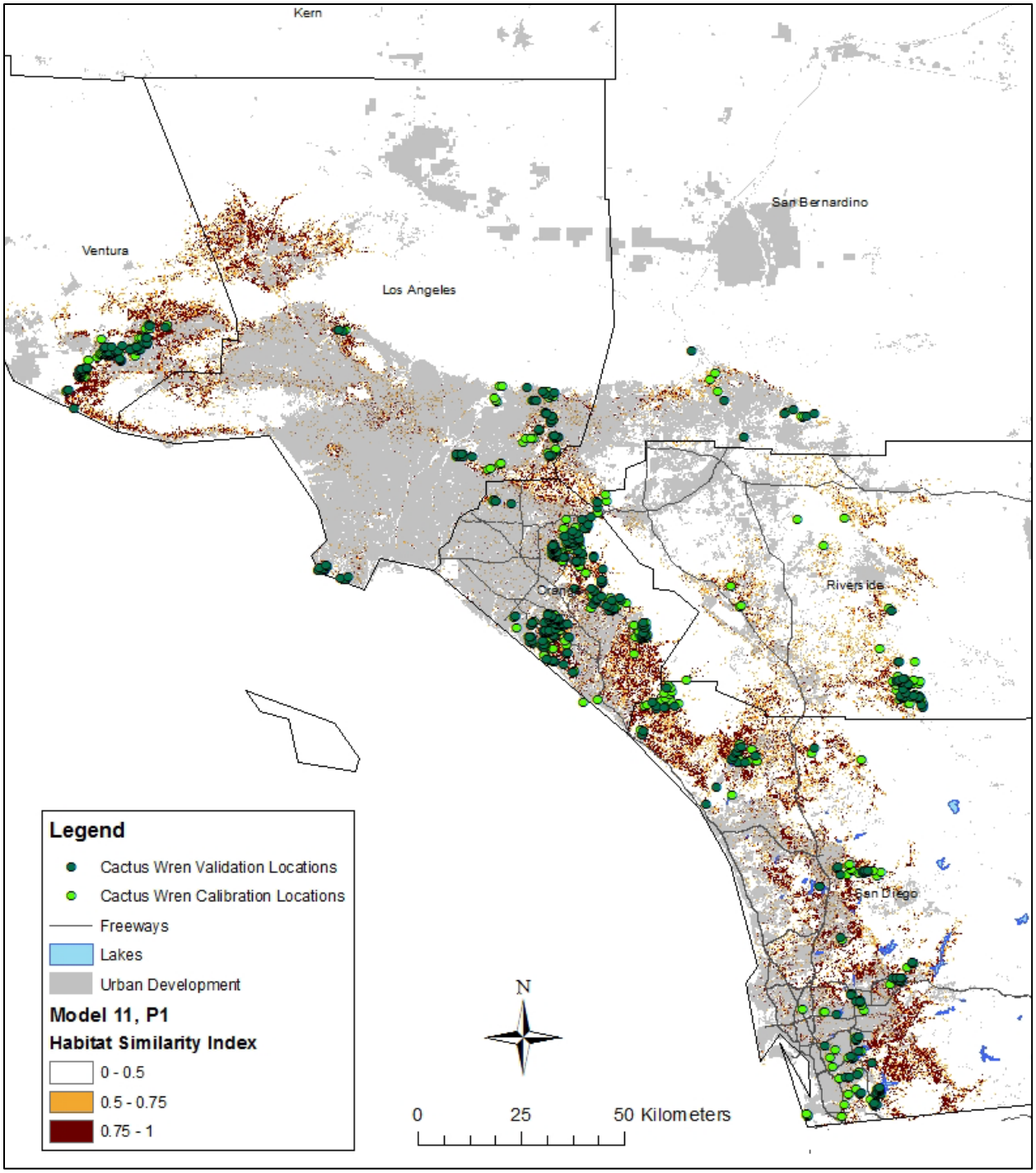

Figure C-1. The recent (2000-2013) distribution of coastal cactus wrens in southern California with potentially suitable habitat predicted by Model R11, partition 1. Highest habitat suitability is indicated by dark brown pixels, intermediate suitability by orange pixels, and low suitability by white pixels.

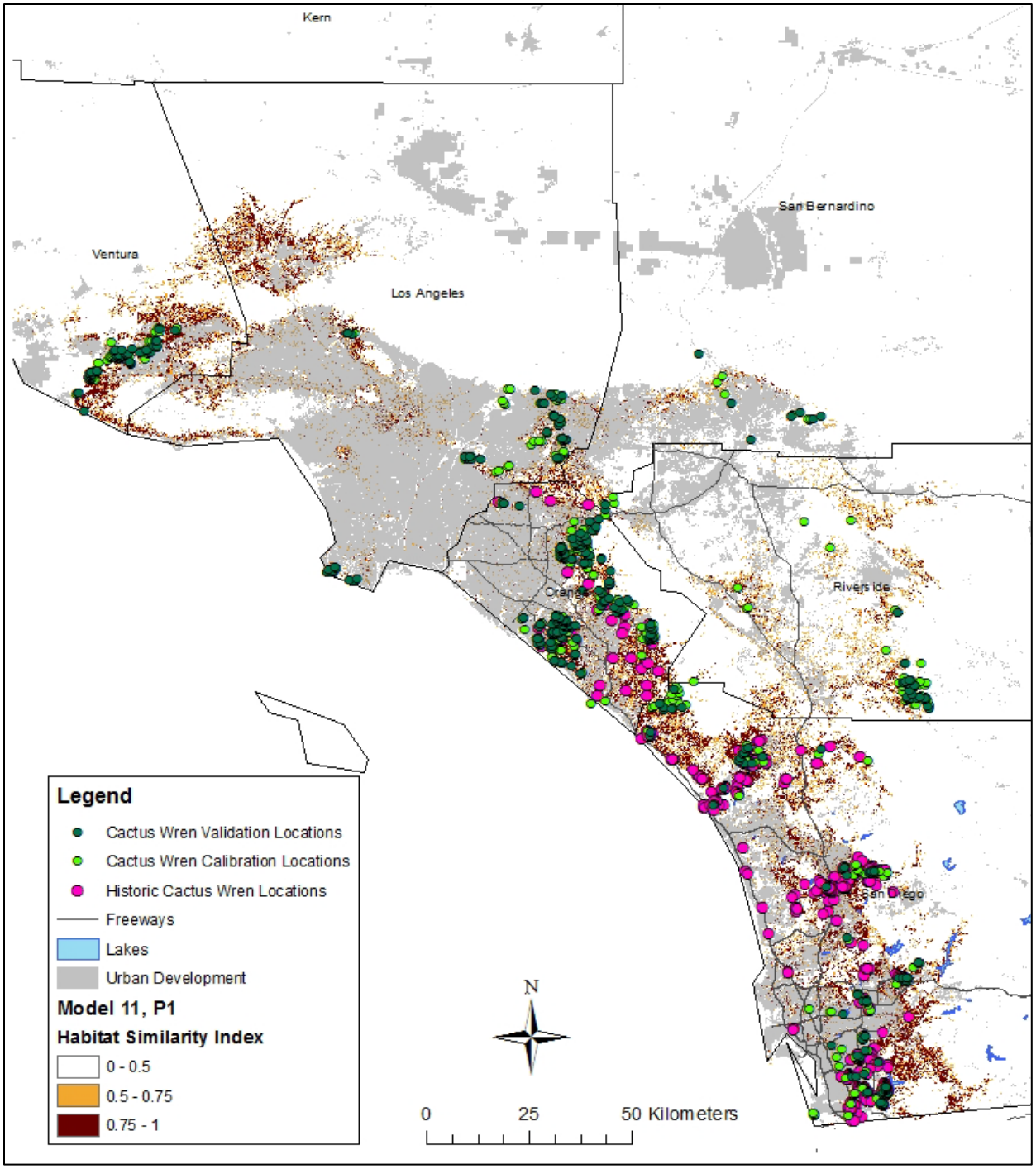

Figure C-2. The recent (2000-2013) distribution of coastal cactus wrens in southern California indicated by green circles and historic distribution (1981-1999) by pink circles with potentially suitable habitat predicted by Model R11, partition 1. Highest habitat suitability is indicated by dark brown pixels, intermediate suitability by orange pixels, and low suitability by white pixels.

and Szijj 2004). Some of these areas include the Santa Clara River east of Santa Clarita, Alamos Canyon north of Simi Valley, Baldwin Hills, Chino Hills, Fontana, Rancho Cucamonga, southwest Beaumont, the Badlands, Temescal Wash, and Santa Rosa Plateau.

Overall, the large amount of suitable habitat predicted by the model for which there are historic records but no recent occurrences is consistent with the significant decline and extinction of coastal cactus wren populations since the 1990s. This decline is attributed to a number of processes, including habitat loss and fragmentation, mega wildfires, extended and severe drought, habitat degradation, and predation (Bontrager et al. 1995, Hamilton 2004, 2009, Solek and Szijj 2004, Mitrovich and Hamilton 2007, Leatherman BioConsulting 2009, Preston and Kamada 2013, Barr et al. 2015).

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Appendix D.

Best Practices for Cactus Scrub Restoration for the Coastal Cactus Wren

Appendix D

Best Practices for Cactus Scrub Restoration for the Coastal Cactus Wren

A Best Practice is the belief that there is a technique, method, process, activity or reward that is more effective at delivering a particular outcome than any other technique, method, or process. The idea is that with proper processes, checks, and testing, a desired outcome can be delivered with fewer problems and unforeseen complications (Global Restoration Network).

The following Best Practices for Cactus Scrub Restoration are based upon the experience of many land managers and restoration practitioners in southern California who have worked to restore habitat for the coastal cactus wren (*Campylorhynchus brunneicapillus*). These practices represent the current state of knowledge on the topic, and are not meant as a mandate or "one size fits all" type of guidance, but rather suggestions for those who are seeking input on their own restoration project.

Indeed, every site and restoration objective is different, and all cactus scrub restoration actions should be tailored to the specific site, management goals, and unique habitat conditions. Over time, these methods may be refined or replaced with alternative methods based on results of adaptive management or experimental programs.

1 Site Selection

Optimally, if the goal is to create new stands of cactus scrub for near-term occupation by cactus wren, the restoration site should be established <1 km from occupied habitat but not more than 4 km. This is based on the average dispersal distance of juvenile cactus wrens (Atwood 1993, Preston and Kamada 2012, Kamada and Preston 2013, Barr et al. 2012, 2013, 2015, Kamada 2014).

Typically, occupied cactus wren habitat is found on south, southwest or west-facing slopes; however, planting on south-east facing slopes with coastal sage scrub or maritime chaparral present (which indicates appropriate soils) may be appropriate and could lessen drought stress, particularly as the climate changes.

Occupied cactus scrub is generally found on slopes <1500 feet in elevation and on flat or slightly sloping hillsides with less than 2:1 slope. However, if there is occupied habitat nearby on steeper slopes, then these criteria may not be as important.

Cactus scrub is often planted within openings in coastal sage scrub or maritime chaparral. The following should be considered when planting within scrub communities:

- Select planting sites with a matrix of bare ground, scrub, grassland and crytpotbiotic soil crust to provide optimal foraging and habitat conditions for the cactus wren;
- Select sites with a diversity of micro-topography – areas with drainages and draws as well as flat areas – to provide a diversity of microclimates and soil moisture conditions;
- Avoid disturbing or planting directly in areas with cryptobiotic soil crusts; these are unique communities that naturally exclude weeds and take many years to recover from disturbance;

- Avoid areas with dense/tall shrubs to minimize shrub crowding and the need for shrub thinning;
- Avoid weedy areas unless you are willing to commit to several years of weed maintenance;
- If you have the time to plan out your restoration, implement a year or two of pre-planting weed control. Weed control may also have the added benefit of promoting other native species (e.g., *Dudleya variegata*).

Check the California Natural Diversity Database and MSP-MOM and conduct spring botanical surveys in advance of site preparation or active planting to ensure that the restoration site does not support rare or other sensitive species that may be impacted by planned enhancement activities.

Ensure that you select cactus planting sites that accessible for maintenance with sufficient buffering from trails to minimize human disturbance.

2 Patch Size

Guidance on how large a restored cactus patch should be to support cactus wrens is evolving. Generally, restoration practitioners have targeted creating cactus scrub patches of at least 1 acre where there is occupied habitat nearby.

Data from cactus wren monitoring efforts in Orange and San Diego counties indicate that a functional patch size ranges from 2-3 acres, although more study is needed. However, when creating stepping stones of habitat between populations, larger habitat patches of 5 acres or greater may be necessary to support more than one pair of cactus wrens. Since small populations are more vulnerable to extinction, a larger stepping stone patch (e.g., several acres) is more likely to support multiple wren territories and persist over time.

In terms of how much cactus is needed in a created patch of cactus scrub, it is generally recommended that cactus cover 40-50 percent of the habitat at maturity. Expanses of cactus scrub dominated by cactus often are packed with cactus wrens, indicating that restored cactus scrub should contain as much cactus as practically feasible.

3 Cactus Salvage

Optimally, cactus propagules should be salvaged from cactus that is planned to be removed by development. The type (*Opuntia* vs *Cylindropuntia*) and proportion of cactus collected and planted should be based upon detailed studies of nearby occupied cactus scrub reference habitat.

If timing allows, cactus propagules should be collected when they are least drought stressed, e.g. not during late fall. However, if the project is urgent, cactus propagules can be collected at any time of year.

When collecting prickly pear cactus, ensure that you are not collecting specimens that have hybridized with the non-native Mission fig (*Opuntia ficus-indica*). Mission fig generally has few or no spines and grows much larger, and is not known to be used for nesting by the cactus wren.

If no source of cactus is readily available from a proposed development site, it is recommended that cactus salvage be performed from unoccupied cactus near the restoration site, with no more than 5 percent of cactus pads/segments removed from any one cactus or patch.

When salvaging from conserved cactus, mature pads/segments should be salvaged from the lower 1/3 of cactus and not from the top of cactus. Cactus collection can be tricky because of the spines, and many practitioners use machetes, pitch forks and tongs to aid in cactus collection.

Cactus should be broken off at joints with a minimum two pads/segments per cutting; larger cuttings with multiple pads/segments are more desirable to promote faster habitat establishment

It is common to end up with many individual pads/segments that have fallen away during salvage/collection. These can be scattered on the ground, either around the outer planting area or below the cactus from where they were salvaged, as they will easily take root.

4 Large Specimen Collection

For more immediate habitat, salvage of large cactus specimens >1 meter in height is desirable. Larger specimens are best taken from areas to be lost to development.

Large cactus salvage is most easily accommodated with large equipment – back hoe, small front end loader, and a flat-bed truck for transport. Ropes, straps, pitch forks and shovels may also be necessary to guide the salvage effort.

Large specimens can be transported “bare root” but you may want to consider boxing large specimens if they are going to sit at the acceptor site for more than a few days. Alternatively, the exposed root ball can be covered with shade cloth or burlap (or soil) at the acceptor site until transplanting.

When salvaging large specimens, it is best performed during the early summer or early winter, when there is some soil moisture in the ground, to facilitate salvage. However, it is recognized that salvage may have to be done during the driest time of the year. When salvaging large specimens, excavate as much of the rootball as you can (2-plus feet) recognizing you will likely only get a portion of the above ground growth, so root pruning will be offset by loss of above ground growth. Large specimens should be irrigated following transplanting. Some temporary staking may also be required after transplanting to keep cactus growing upright.

5 Propagule Selection

Cactus can be established from transplants (discussed above), unrooted cuttings, dry-rooted cuttings or from container/propagated stock. The type of propagule selected depends on funding, lag time between propagule collection and planting date, and urgency to create occupied habitat, among other factors.

Un-rooted cuttings (pads or segments) are the most efficient and cost effective method for establishing cactus scrub. Pads or segments are usually allowed to harden/callus prior to planting, which can take several days or weeks depending on the time of year. Optimally, cactus cuttings should be laid out and allowed to callus in indirect sun, if possible. Shade cloth or burlap can be placed over the cactus to avoid desiccation and sunburn during callusing if necessary. Cactus stems or pads can be placed in the soil or

laid directly on the soil surface to take root. Generally, better results are achieved from planting in the soil, but if there are many small segments left over after planting, simply laying those pads/segments on the ground should be sufficient. To prevent weeds, it is recommended that soil disturbance be minimized; using a hand pick to make a small hole for each cactus cutting is preferred to ripping large swaths of ground with large equipment.

Dry-rooted cuttings involves temporarily planting pads, segments or whole plants in the ground in a nursery type setting for later transplantation to the acceptor/restoration site. This method requires that cuttings be spaced far enough apart to allow for easier harvesting later. Some irrigation can encourage root development and growth prior to out-planting. Once per month irrigation should be sufficient but should only be done when the soil is completely dry. If the cuttings are irrigated, it is likely that weeds will grow as well, so be prepared to perform weed control around cuttings. When ready for out-planting, the rooted cactus should be carefully dug up and stored in indirect sun for a week or so to allow the roots to harden off prior to transplanting. Hardening of roots minimizes the potential for root rot following transplanting. The transplants can be transported bare root (in a flatbed truck or pickup truck) to the restoration site. For ease of planting (if time allows), the planting holes at the acceptor site could be prepared prior to delivery of rooted cuttings. This will minimize the amount of time that the roots are exposed to sun/air at the site.

Container stock (also referred to as "propagated") involves rooting pads or segments or larger cactus specimens in pots for later transplantation to the restoration site. This is often the preferred method for establishing larger, sturdier plants with established root systems that are less susceptible to herbivory. For one gallon sized pots, plant callused cuttings with one to three pads/segments. Place pad/segment at base of cutting at least halfway into soil to keep it upright. Larger cuttings/specimens will require larger pots to keep from falling over. Larger specimens may also require some staking to keep them growing upright. Use potting mix that is fast draining. Do not use topsoil. Propagated/potted cactus will require periodic irrigation. Some pads/segments may fall off during transport, but they can be placed on the ground at the restoration site and allowed to root. Alternatively, you can remove side branches prior to transport and use as additional propagation material.

6 Planting layout

Cactus spacing

Cuttings of cholla and prickly pear can be planted several per square meter, or 2-3 feet on center. This can result in very dense plantings if all the cuttings take root, and some thinning may be necessary later on. However, the "thinned" propagules can be used for additional onsite planting. Cactus planted from containers may be planted further apart. Because prickly pear branches more easily, it can be planted at lower densities, e.g., one per square meter.

Co-plantings

Evaluation of data taken from cactus wren monitoring studies in Orange and San Diego counties have suggested that cactus scrub restoration should avoid and/or minimize the planting of large shrubs such as lemonadeberry (*Rhus integrifolia*), laurel sumac (*Malosma laurina)* and Mexican elderberry (*Sambucus nigra).*

A few scattered Mexican elderberry and lemonadeberry for use as cover or perches are appropriate if they are found in the area. These should be planted sparingly and on the edges of cactus groupings (3-5 meters away).

It is also recommended to plant shrubs that are locally adapted and will not exceed the height of cactus plantings at maturity and may provide good foraging habitat, such as California buckwheat (*Eriogonum fasciculatum*) and California sagebrush (*Artemisia californica*). Shrub plantings should not crowd cactus plantings at maturity. Generally, black sage (*Salvia mellifera*) should be avoided.

Consider delaying seeding of shrubs and forbs until second or third year post cactus planting to allow easier weeding between the cacti during establishment. Delayed seeding may have the added benefit of promoting the germination of the native seed bank in the interim.

Other plantings that could be considered in low numbers and if native to the site include *Jojoba*, *Baccharis sarathroides*, *Brickelia* sp., *Bahiopsis lacianata*, *Acmispon glaber*, *Isacoma menziesii* and *Encelia californica*.

Native forbs and grasses in the cactus scrub understory or in openings between patches could help promote a healthy invertebrate community and could serve as placeholders to help keep weeds at bay. Plant locally adapted native forbs and grasses.

7 Plant protection

Protective above-ground wire mesh cages may be considered for individual or groupings of cactus in areas subject to herbivory. Protective cages can ensure better growth and development of cactus and can generally be removed a year or two after planting.

8 Weed Control

Control of invasive grasses and forbs prior to and following planting of cactus is critical to ensuring successful cactus establishment. Invasive grasses and forbs compete for water, light and nutrients, thereby impeding cactus growth. If invasive grasses and forbs are found on the restoration site, they should be removed prior to planting to ensure that there is good contact between the soil and cactus cuttings.

Once the cactus are planted, ongoing control of invasive plants will be required for several years, either with hand pulling or spot spraying with an herbicide such as glyphosate. Weed control efforts should carefully avoid any native plants that also may be emerging.

9 Supplemental Watering

Supplemental watering should be considered if rainfall is low. Supplemental watering can assist with growth and development of cactus, but should be used sparingly so as not to encourage weeds, rotting, shallow root development or Argentine ant invasion. Studies at the San Diego Zoo Safari Park have demonstrated that cactus watered every four to eight weeks during the first summer following planting experienced increased growth as compared to un-watered cactus. Supplemental watering beyond the first summer is generally not required.

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Figure 1: Study Area Location

Management Unit

Conserved / Public Land*

*Conserved / Public Lands includes lands that are managed by a variety of government agencies, from city to federal, along with lands owned and managed by non-profit conservation organizations. Sources: San Diego Mapping and Monitoring Program; SANDAG Conserved Lands 2014; The Nature Conservancy;

Basemap source: ESRI

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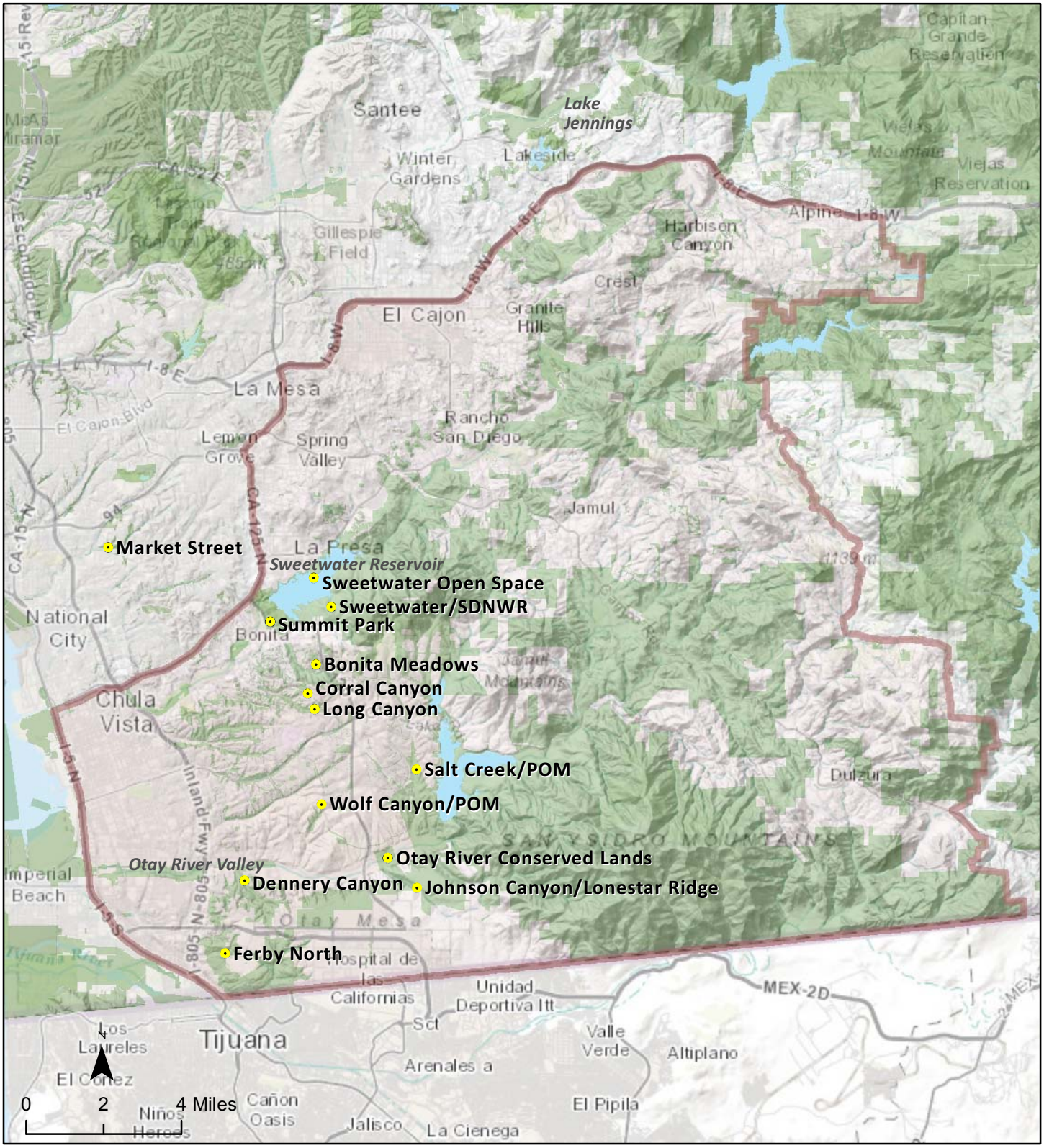
Figure 2: Cactus Wren Study Sites



Management Unit

Conserved / Public Land*

Study Site

Basemap source: ESRI

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Figure 3: 2014 Cactus Wren Detections

Survey Polygon

2014 Cactus Wren Detection

Management Unit

Conserved / Public Land*

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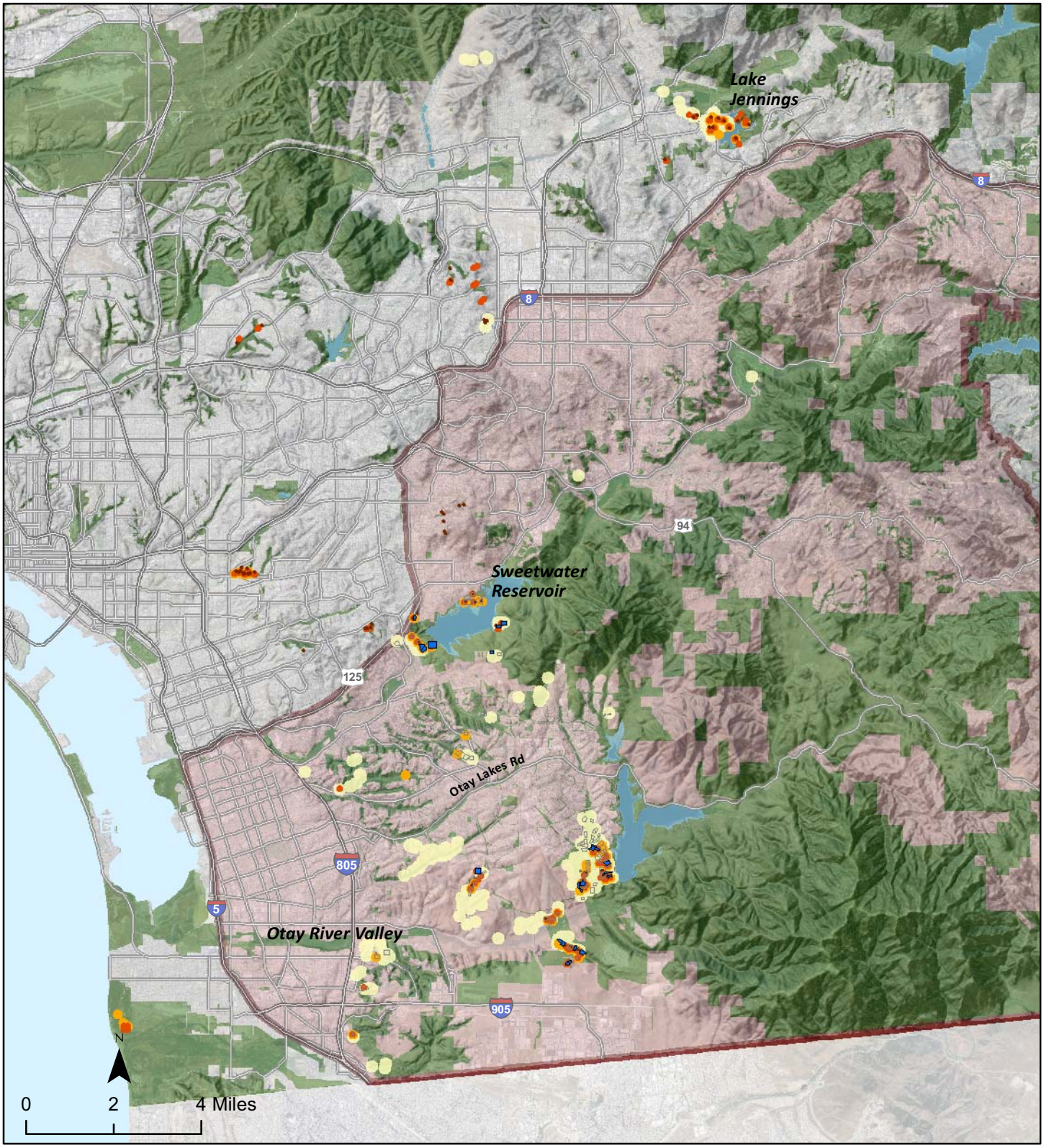
Figure 4: Cactus Wrens in MU 3



2014 Detection, USGS
- Detection
- No Detection

Occupied Territory, Survey Year
- 2012 USGS
- 2011 USGS
- 2009 USGS
- Historic (REGIS)

- Management Unit
- Conserved / Public Land*

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Figure 6: Cactus Wren Connectivity in MU 3 and MU 4

Habitat Suitability Model (R19P1)
- Suitable Habitat, private land
- Suitable Habitat, public or conserved land

Genetic Cluster
- Sweetwater
- Otay

- Potential Connectivity Creation / Restoration
- Potential Connectivity Gap
- Cactus Wren Detection ('09 - '12)
- Cactus Wren Detection ('14)

- Management Unit
- Conserved / Public Land*

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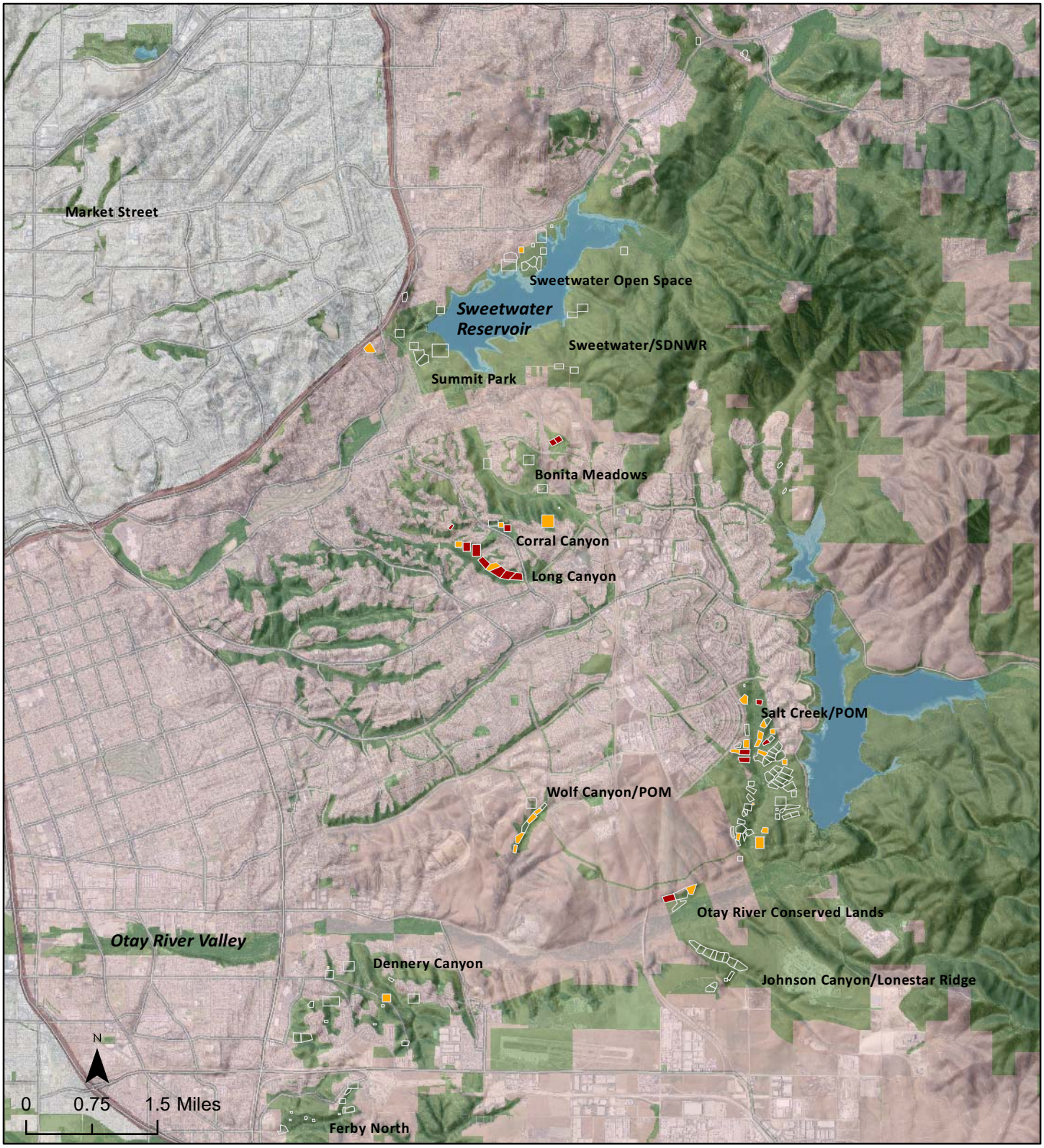
Figure 7: Cactus Scrub Habitat Quality Shrub Crowding



Shrub Crowding

- <25%
- 25%-50%
- >50%

Basemap source: ESRI

- Management Unit
- Conserved / Public Land*

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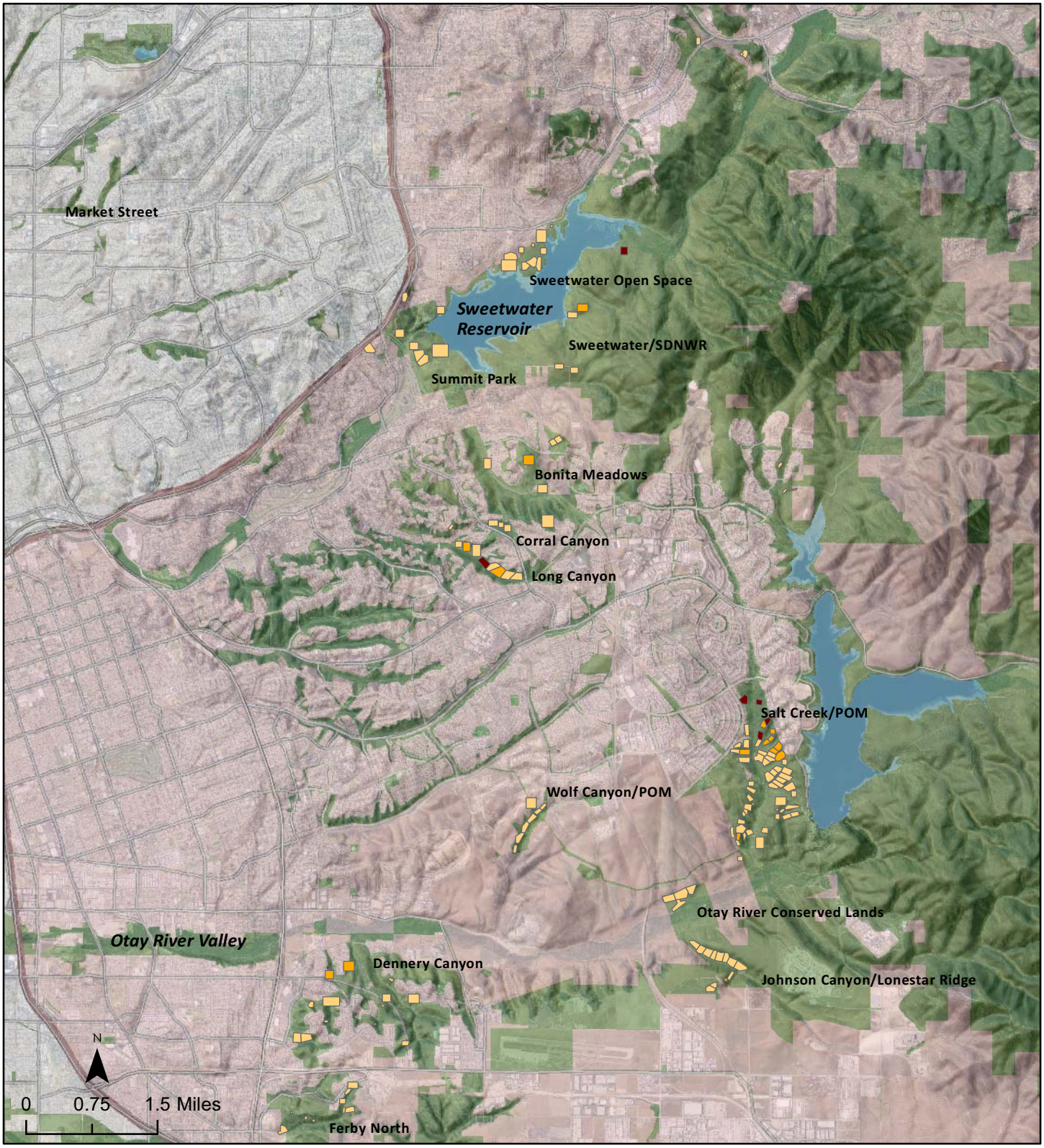
Figure 9: Cactus Scrub Habitat Quality Cactus Die-back



Cactus Die-back

- <25%
- 25%-50%
- >50%

Basemap source: ESRI

- Management Unit
- Conserved / Public Land*

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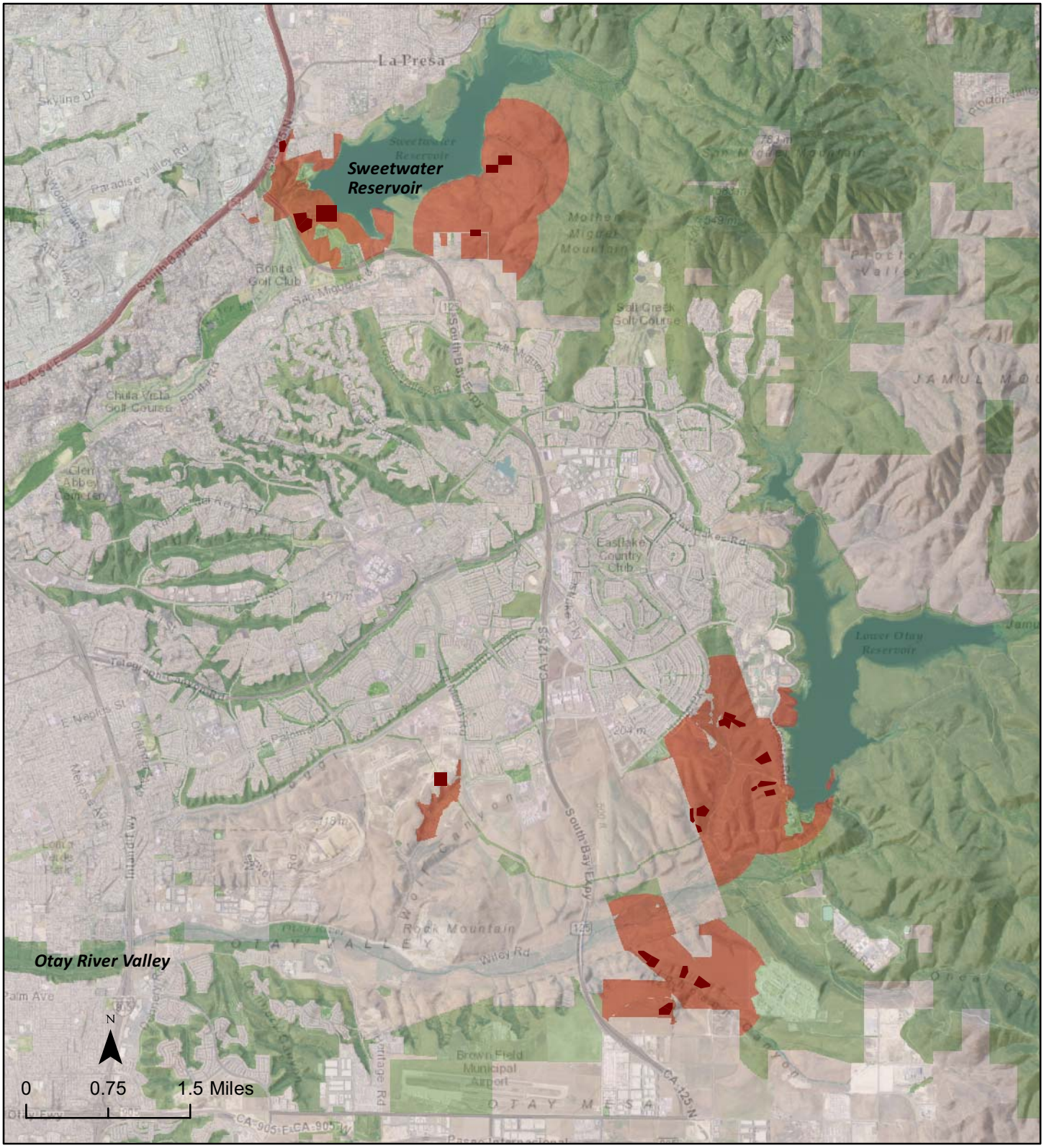
Figure 11: High Priority Locations for Cactus Scrub Restoration and Enhancement



2014 USGS Detection

Priority Restoration Area

Management Unit

Conserved / Public Land*

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Basemap source: ESRI

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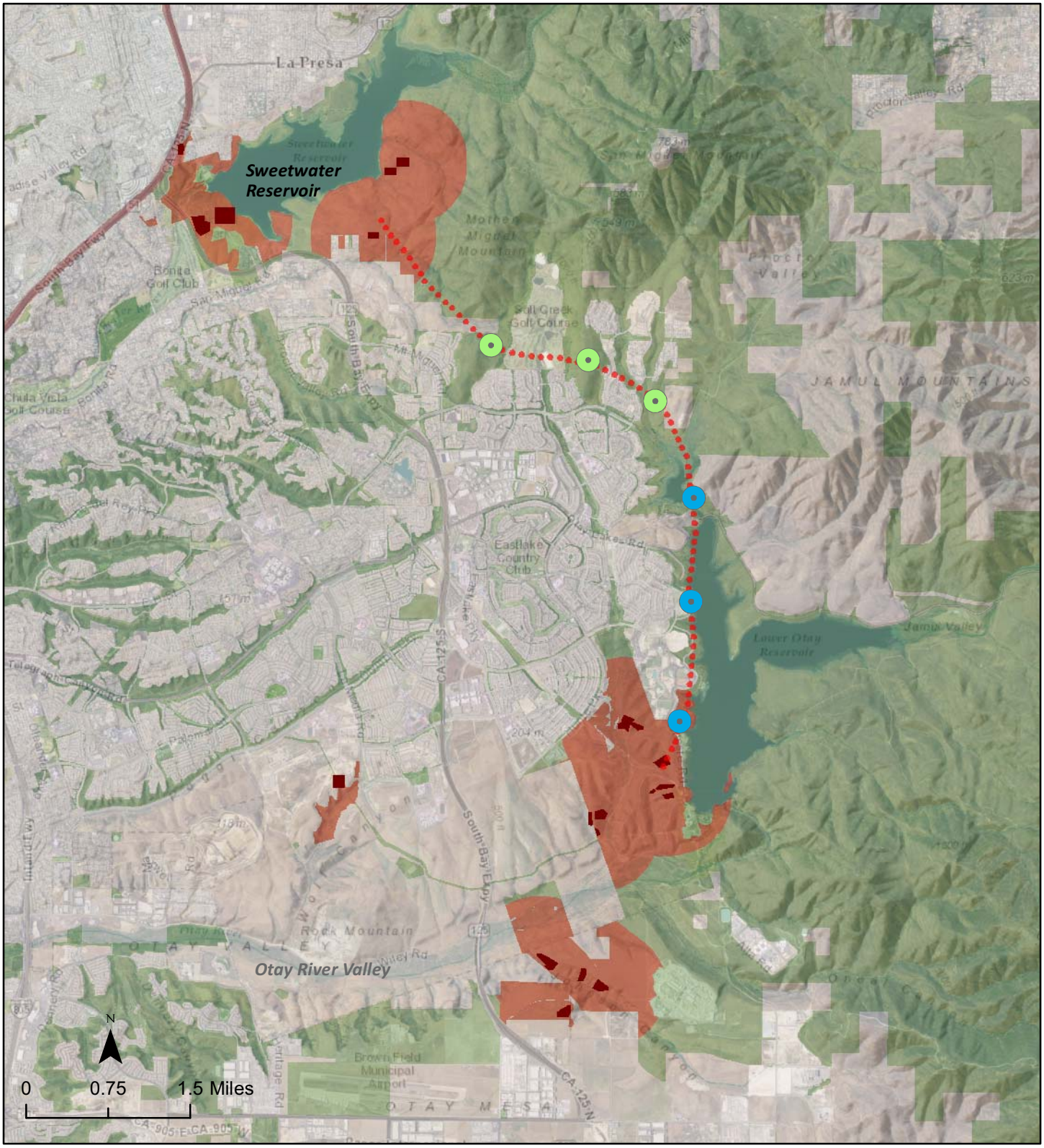
Figure 12: Conceptual Connectivity Design for Sweetwater - Otay Cactus Wren Linkage



2014 USGS Detection
Priority Restoration Area
Linkage Path
Cactus scrub creation
Cactus scrub expansion
Management Unit
Conserved / Public Land*

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Basemap source: ESRI