VOLUME 2B: GOALS AND OBJECTIVES FOR THREATS/STRESSORS

1.0 ALTERED FIRE REGIME

1.1 OVERVIEW

Wildfire is a natural phenomenon in southern California shrublands and forests that affects ecosystem processes and influences the composition and structure of plant and animal communities. Most species are adapted to a natural fire regime; however, humans are altering the frequency of wildfires, which can have adverse effects on natural resources. This overview focuses on fire in coastal sage scrub and chaparral shrublands, as they are highly flammable and carry fire, and are the predominant vegetation communities within the MSPA where wildfire tends to occur. Fires in forested areas have different fire regimes and management needs than shrubland vegetation communities and are not addressed in this plan. Coniferous forest and montane hardwood vegetation communities in the eastern mountainous areas of the MSPA are largely outside the area of the MSP Roadmap management focus and fall under fire management policies developed by the U.S. Forest Service (USFS) and California State Parks.

San Diego County experienced extremely large human-caused Santa Ana wind-driven fires in 2003 and 2007, which caused the catastrophic loss of human life and property. These fires also impacted natural resources across a wide swathe of Conserved Lands within the MSPA. There has been considerable controversy over the last 2 decades about the best ways to reduce wildfire risk and to manage natural resources at risk of an altered fire regime. The fields of fire ecology and management are rapidly evolving as more research is conducted and society gains more experience with large catastrophic wildfires. The intent of this section is to provide a summary of the most recent literature about the southern California fire regime, fire ecology, and fire risk reduction management in order to provide a rationale for managing fire risk to MSP species and natural communities.

1.1.1 Southern California Fire Regime

Southern California's mediterranean climate is characterized by a cool wet growing season followed by a long hot summer and fall with little rainfall. The region's climate, shrublands, and extensive wildland urban interface (WUI) make it one of the most fire hazardous areas within North America (Keeley 2002). There are two primary categories of wildfires in southern California: (1) fires occurring in the summer months under hot, dry conditions and associated with weak onshore winds and (2) fires that typically occur in the fall months and are driven by strong offshore Santa Ana winds (Jin et al. 2014). The current wildfire regime in southern California consists of many small fires with relatively few large, intense stand-replacing crown fires, usually associated with strong Santa Ana winds (Barro and Conrad 1991; Keeley and Fotheringham 2001; Peterson et al. 2011). During the 20th century, fire return intervals averaged around 30–40 years, with high site variability (Keeley and Fotheringham 2001).

Climatic Drivers of the Southern California Fire Regime

Weather conditions and fuel moisture are related to the frequency and size of wildfires in southern California. The frequency of non-Santa Ana fires in southern California increased from 1959 to 2003 and was positively associated with total precipitation during the previous 3 winters, while fire size was negatively associated with relative humidity during the fire event and previous winter-spring precipitation (Jin et al. 2014). Mean daily temperature also had a significant positive effect on burn area for California fires from 1990 to 2006, and this effect was especially evident during winter and in southern California (Baltar et al. 2014).

Santa Ana wind-driven fires occur during extreme weather conditions (Moritz et al. 2004). A study in southwestern California from 1980 through 2009 showed that 64% of the variation in area burned in wildfires was a function of temperature, precipitation, relative humidity, Santa Ana winds, and geography (Yue et al. 2014). From 1959 through 2009, the number of Santa Ana wind-driven fires was highest during conditions of below average relative humidity during the fire event and below average fall precipitation (Jin et al. 2014). The amount of dead standing material as a function of extreme drought has been identified as a contributing factor to extremely large Santa Ana wind-driven fires in southern California (Keeley and Zedler 2009). An accumulation of dead fuels increases burning embers and spot fires driven long distances by strong winds. In the Santa Monica Mountains, total area burned was most strongly associated with the number of ignitions and number of Santa Ana wind events (Peterson et al. 2011), although fuel moisture <77% was an important threshold (Dennison et al. 2008). Spring precipitation (March through May) was strongly correlated with the 77% fuel moisture threshold. Another explanation for the recent increase in fire frequency, intensity, and spread in southern California chaparral is human suppression of fire over the last century that has caused a buildup of dense canopies and increased dead fuels (Minnich and Chou 1997).

High temperatures and severe drought with intense Santa Ana winds have resulted in extremely large wildfires over the last 15 years (Keeley et al. 2004; Keeley et al. 2009; Moritz et al. 2010; Baltar et al. 2014. The number of Santa Ana wind-driven fires surged abruptly since 2003 (Keeley and Zedler 2009; Jin et al. 2014). Eight Santa Ana wind-driven wildfires (>50,000 hectares) were documented from historical records in southern California from the 1870s through 2007, with 4 of these occurring since 2003 (Keeley and Zedler 2009). This rise in recent wildfires is attributed to extreme drought and is consistent with an analysis of large wildfires (>405 hectares) across the western U.S. from 1984 through 2011, in which wildfires increased in size and number over time and in correspondence with severe drought (Dennison et al. 2014).

Human Influence on the Southern California Fire Regime

In addition to climate factors, human activities affect fire regimes in southern California shrublands, with fire frequency increasing over the past few decades. Anthropogenic factors associated with an altered fire regime include development in fire-prone areas creating extensive WUI (Syphard, Clarke, et al. 2007; Syphard, Radeloff, et al. 2007; Moritz et al. 2014), an increase in human-caused fire ignitions (Syphard and Keeley 2015), introduction of invasive nonnative plants that alter flammability (Pausas and Keeley 2014a), and a build-up of fuels in some areas due to fire suppression over past decades (Minnich 2001). Large, intense fires have the potential to increase under global warming and a changing hydrological cycle (Bowman et al. 2011).

In southern California, human-related factors explained 72% of variability in fire frequency and 50% of variability in burn area in 2000 (Syphard, Radeloff, et al. 2007). These anthropogenic factors included the amount of WUI where developed lands intermix with natural vegetation, human population density, and distance to the WUI. The spatial pattern of development is important, with a high frequency of human-caused fires at intermediate levels of development where people and natural vegetation coexist (Syphard, Clarke, et al. 2007; Syphard, Radeloff, et al. 2007). There are few fires in sparsely populated areas where human-caused ignitions are less frequent, although large fires can establish in these areas as fire detection and response times may be delayed in remote areas. Fire frequency is also low in highly urbanized areas where even with high potential for human-caused ignitions, there is little natural vegetation to burn and a quick response to suppress any fires.

Humans have attempted to suppress fires since the early 1900s in southern California chaparral. One viewpoint is that these efforts led to a buildup of fuels and increased fire hazard resulting in unnaturally large fires under extreme weather conditions (Minnich and Bahre 1995; Minnich and Chou 1997; Minnich 2001). This altered fire regime is in contrast to a more natural fire regime in northern Baja California characterized by frequent small to medium, slow-moving fires in a fine-grain patchy age class of fuels that result from a lack of fire suppression. The alternative viewpoint is that there is no strong relationship between fuel age and the likelihood of burning and that the natural fire regime includes infrequent but large Santa Ana wind-driven fires, including the largest fire recorded in California that burned through San Diego and Orange Counties in 1889 (e.g., Keeley and Fotheringham 2001; Moritz et al. 2004; Keane et al. 2008; Keeley and Zedler 2009; Price et al. 2012). Regardless of the historical fire regime, the recent surge in extremely large fires has resulted in a landscape that is increasingly dominated by younger age fuels (see Fire Regime in MSPA section, below).

Starting with the arrival of the first Spaniards in California, humans have introduced a variety of nonnative plants into the natural ecosystems. Among these early invaders were European annual grasses and forbs (Minnich and Dezanni 1998). Southern California shrublands are susceptible to type conversion to nonnative invasive annual grassland through repeated fire (Minnich and Dezzani 1998; Keeley 2002; Keeley and Brennan 2012; Pausas and Keeley 2014a). Conversion of shrublands to nonnative grasslands has a positive feedback on increasing fire frequency as a result of fine fuels that ignite easily and readily carry fire.

Global warming under a high emission pathway is predicted to increase burned areas in California 36% to 74% by 2085, with the greatest increases in the northern part of the state (Westerling et al. 2011). The primary factors driving this upsurge in fire are warmer temperatures increasing evapotranspiration and a reduction in precipitation. Modeling of climate change and predicted fire risk indicate that future fire risk in southern California depends on future precipitation levels; fire risk could increase with higher precipitation and increased vegetation biomass and decrease with lower precipitation and availability of fine fuels (Westerling and Bryant 2008). More recent modeling indicates that global warming has the potential to double the area burned in southwestern California by 2046–2065 under a scenario of moderate growth in greenhouse gases (Yue et al. 2014). A longer fire season is also predicted by the mid-21st century due to warmer, drier weather and Santa Ana wind conditions shifting into November and December (Miller and Schlegel 2006; Yue et al. 2014). However, models also show that while conditions will be hotter and drier, the frequency of Santa Ana winds could decrease by 20% by the mid-21st century (Hughes et al. 2011).

1.2 FIRE REGIME IN THE MSPA

Large areas of land have burned within the MSPA since 2000 (Figure V2B.1-1). A total of 661,550 acres (37%) of developed and undeveloped lands burned at least once between 2000 and 2014 in the 1,765,148-acre MSPA (Table V2B.1-1). The burned area includes 564,246 acres (48%) of undeveloped lands, of which 98,577 acres burned at least twice during this period. Fifty percent of Conserved Lands have burned since 2000 totaling 339,228 (51%) of the acres that burned. Management unit (MU)10 had the largest area burned between 2000 and 2014 with 150,419 acres, followed by MUs 4, 5, and 3. At least 65% of Conserved Lands burned in these 4 MUs.

Exceptionally large and intense human-caused Santa Ana wind-driven wildfires occurred in the MSPA in 2003 and 2007 (Figure V2B.1-2). In 2003, the Cedar, Paradise, Roblar, and Otay/Mine fires simultaneously burned a combined total of 369,619 acres during extreme Santa Ana wind conditions in late October (Figure V2B.1-3a). This scenario was repeated again in late October 2007 when 8 fires, including the Witch Creek, Poomacha, Harris, and Rice fires, simultaneously burned over 314,508 acres. Across the MUs, 95,076 acres (26%) of land that burned in 2003 also burned in 2007. MUs 3, 5, and 10 had over 25,000 acres burned in both fires, with MU5 having the highest proportion of land reburned. More land burned in MUs 4 and 10 during the 2003 wildfires, while MUs 3 and 5 were most affected by the 2007 wildfires. Acres of Conserved Lands burned in the 2003 and 2007 wildfires totaled 210,204 and 141,523 acres, respectively. Conserved lands in MUs 3, 4, 5, and 10 were most affected by the 2003 and 2007 fires (Figure V2B.1-3b). A total of 57,165 acres (27%) of Conserved Lands that burned in 2003 also burned in 20017.

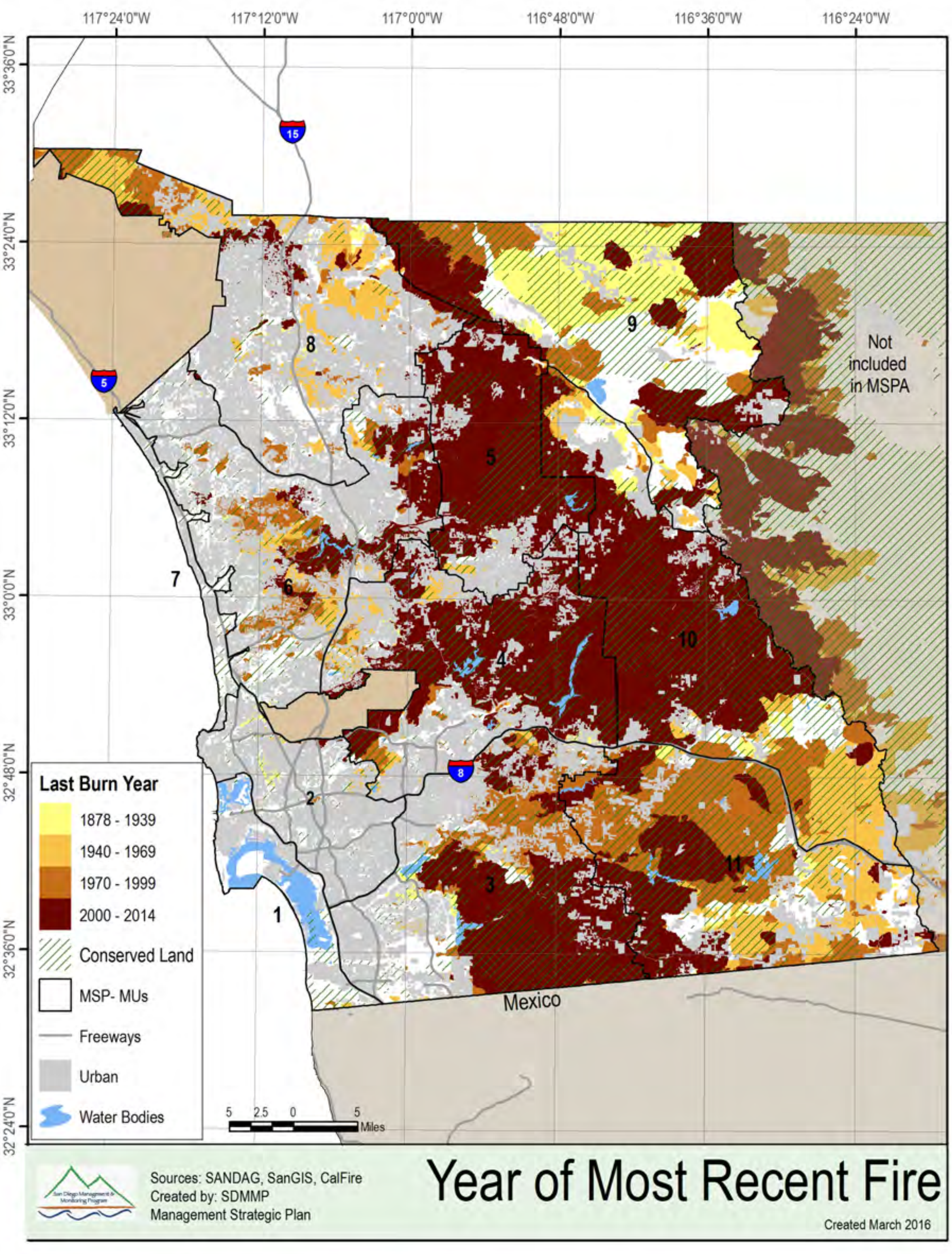

Figure V2B.1-1. Categories of time since most recent fire for Conserved Lands in the MSPA.

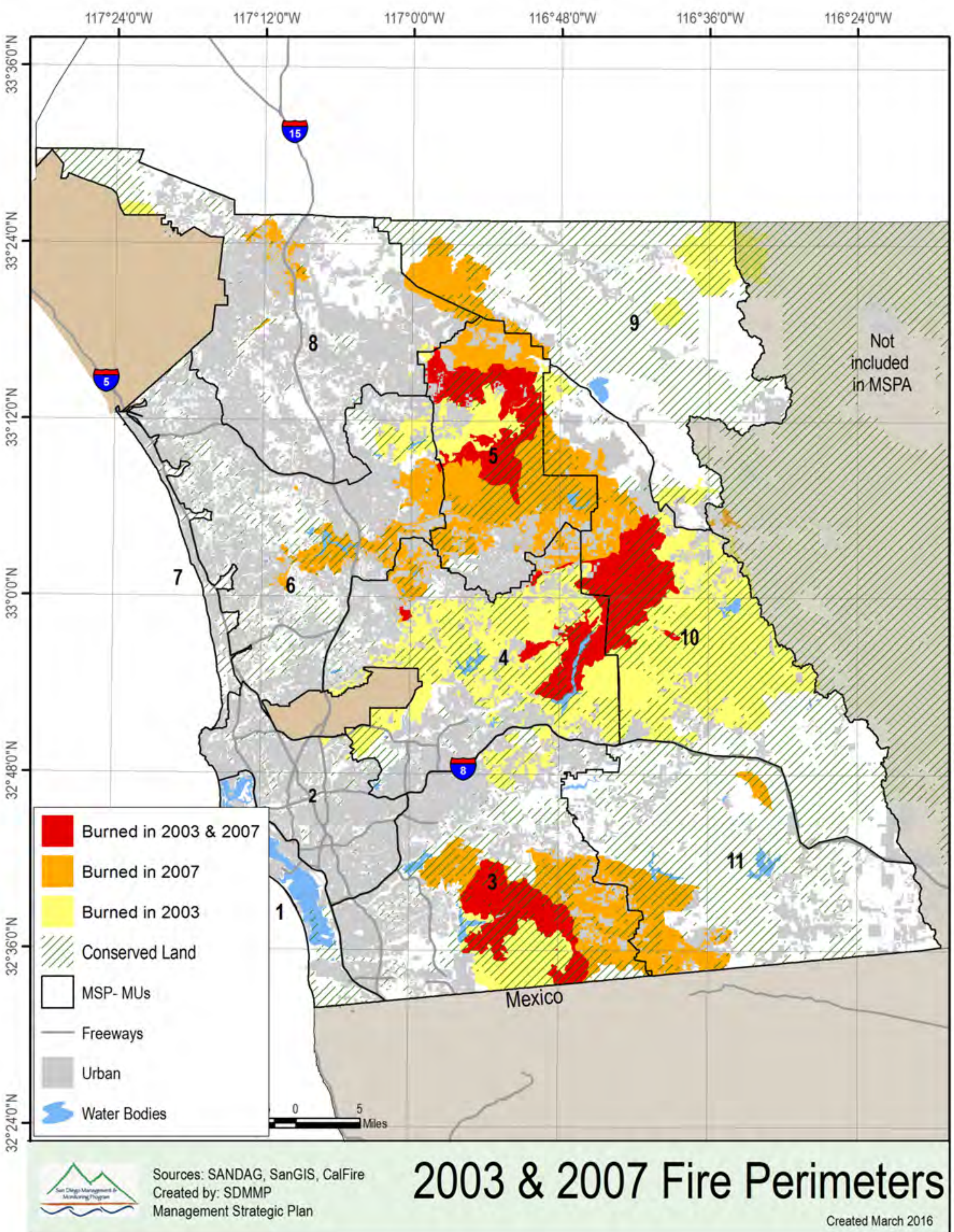

Figure V2B.1-2. Conserved Lands burned in the large-scale 2003 and 2007 wildfires in the MSPA.

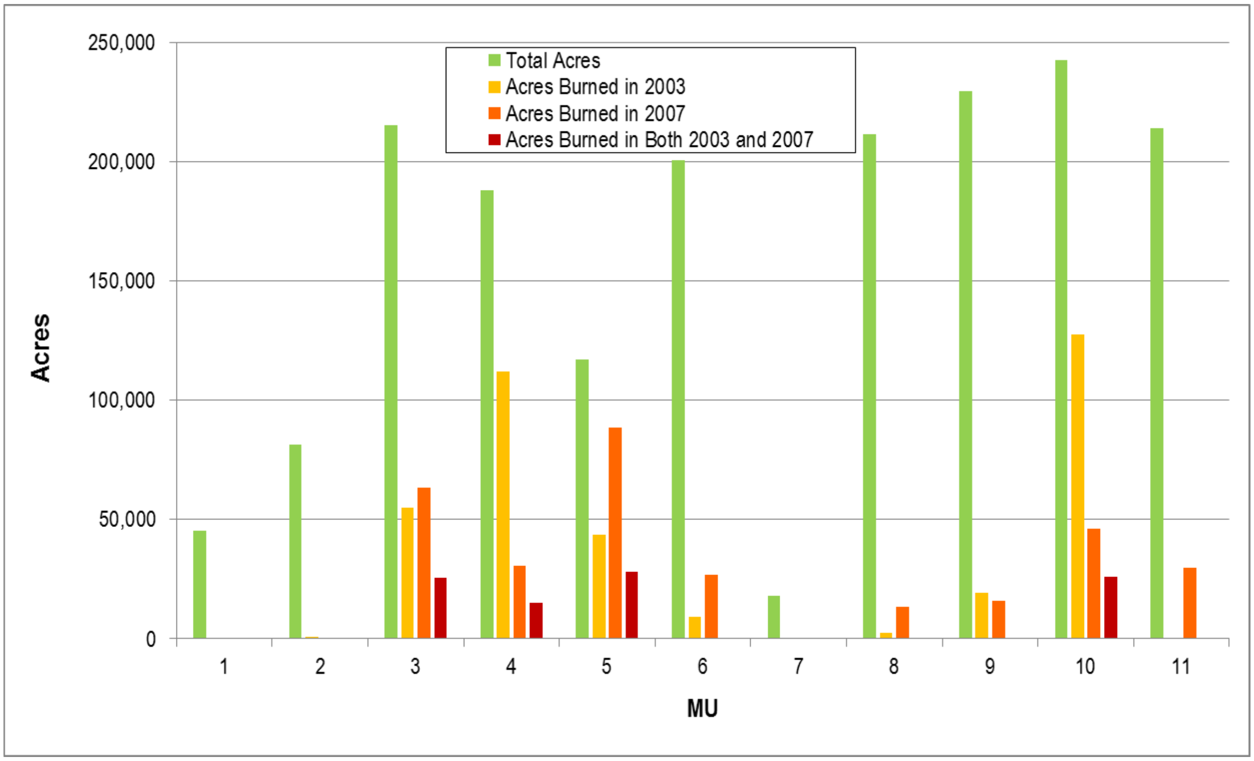

Figure V2B.1-3a. Acres of land by MU and that burned in 2003, 2007, and in both 2003 and 2007.

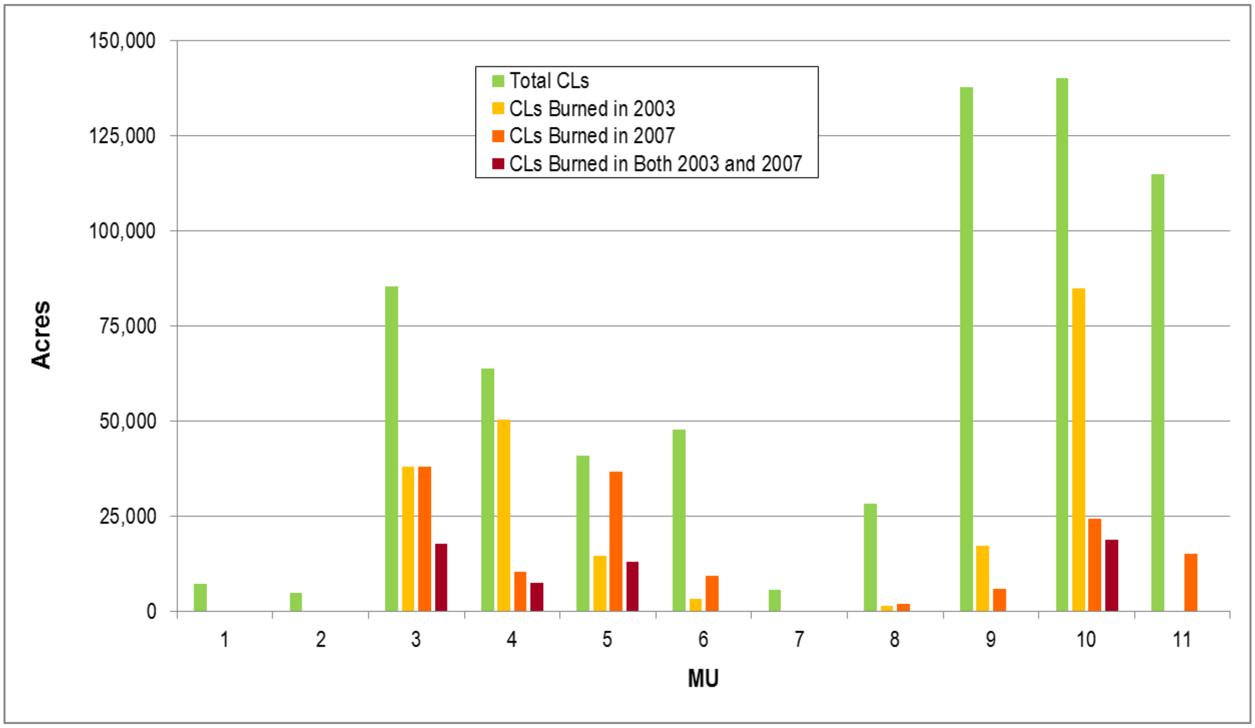

Figure V2B.1-3b. Acres of Conserved Lands (CLs) by MU and that burned in 2003, 2007, and in both 2003 and 2007.

In 2014, several relatively small Santa Ana wind-driven fires burned atypically in May, west of Interstate (I-) 15 near the coast in the Carlsbad, San Marcos, and Fairbanks Ranch areas (MUs 4, 6, and 8). Drought and extremely low fuel moisture, accumulation of dead shrubs causing high dead fuel loads, and Santa Ana wind events have been associated with the 2003 and 2007 wildfires (Keeley et al. 2004; Keeley et al. 2009; Moritz et al. 2010) and contributed to the unusual 2014 May fires.

Conserved Lands with no burn record are situated near the coast in MUs 1 and 7, while most inland areas have burned at least once since fire perimeter mapping began in San Diego County in 1910 (Figure V2B.1-4). Some areas have burned as many as 5 to 11 times, primarily in the central and southern foothill regions and the northwest corner of the MSPA. More recently, 84% of the total area burned between 2000 and 2014 burned once, while 15% burned twice, and less than 1% burned 3 or 4 times (Table V2B.1-1).

Table V2B.1-1. Acres of land and acres of Conserved Lands by MU that burned 1 to 4 times between 2000 and 2014 (CAL FIRE 2014). For each MU, the value for "Acres Burned in MU" is equal to the sum of "Acres Burned in MU by Fire Frequency Class."

MU	Total Acres in MU	Acres Burned in MU	% MU Burned	Acres of Conserved Lands in MU	Acres of Conserved Lands Burned in MU	% Conserved Lands Burned in MU	Fire Frequency in MU	Acres Burned in MU by Fire Frequency Class	% of Area Burned in MU by Fire Frequency Class
1	45,357	0	0	7,164	0	0	0	0	0
2	81,576	864	1	4,791	115	2	1	864	100
3	215,567	97,190	45	85,375	61,348	72	1	68,983	71
							2	27,294	28
							3	913	1
4	188,192	126,313	67	63,742	52,171	82	1	110,231	87
							2	15,015	12
							3	932	<1
							4	135	<1
5	117,275	104,379	89	40,991	38,328	94	1	76,046	73
							2	28,333	27
6	200,813	37,201	19	47,723	12,977	27	1	37,043	100
							2	158	<1
7	18,170	0	0	5,689	0	0	0	0	0
8	211,719	20,309	10	28,408	4,565	16	1	20,110	99
							2	199	1

MU	Total Acres in MU	Acres Burned in MU	% MU Burned	Acres of Conserved Lands in MU	Acres of Conserved Lands Burned in MU	% Conserved Lands Burned in MU	Fire Frequency in MU	Acres Burned in MU by Fire Frequency Class	% of Area Burned in MU by Fire Frequency Class
9	229,778	62,095	27	137,999	40,675	29	1	61,330	99
							2	765	1
10	242,560	150,419	62	140,355	90,878	65	1	123,149	82
							2	27,182	18
							3	88	<1
11	214,140	62,779	29	115,085	38,170	33	1	59,823	95
							2	2956	5
MSPA	1,765,148	661,550	37	677,322	339,228	50	1	557,579	84
							2	101,902	15
							3	1,933	<1
							4	136	<1

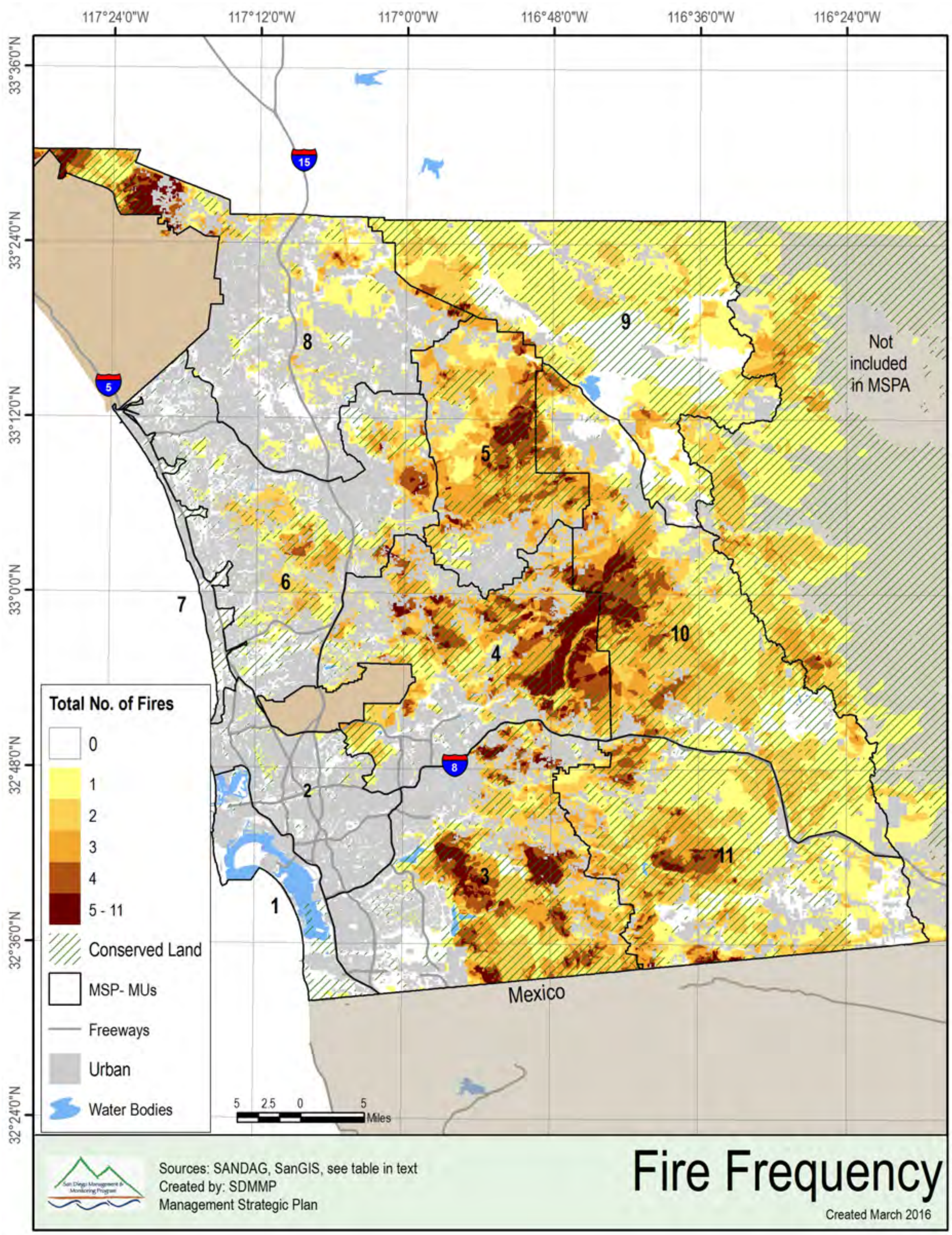

Figure V2B.1-4. Fire frequency on Conserved Lands in the MSPA between 1910 and 2014.

Coastal sage scrub and chaparral are the 2 dominant vegetation communities in the MSPA and are prone to wildfires. Coastal sage scrub is a focus of regional conservation planning and was heavily impacted by wildfires in 2003 and 2007, with over 124,152 of 221,798 acres (56%) burned at least once. MUs 3 and 4 support the greatest amount of coastal sage scrub and were most impacted by these fires (Figure V2B.1-5a). A total of 34,442 acres (51%) of coastal sage scrub that burned in 2003 also burned in 2007. MU3 had 14,538 acres of coastal sage scrub burn in both 2003 and 2007, followed by MU10 with 10,950 acres and MU10 with 7,686 acres. There are 107,042 acres of coastal sage scrub on Conserved Lands and 67,112 acres (30%) burned at least once in the 2003 and 2007 wildfires. MUs 3, 4, and 11 have the most conserved coastal sage scrub (Figure V2B.1-5b). Coastal sage scrub in MUs 3 and 4 was most affected by these fires. A total of 23,681 acres of coastal sage scrub on Conserved Lands burned in both 2003 and 2007.

Chaparral vegetation comprises 709,021 acres of habitat in the MSPA, with 291,880 acres (41%) burned at least once in 2003 and 2007. In 2003, 203,570 acres of chaparral burned and in 2007, 129,084 acres of this vegetation community burned. MUs 9, 10, and 11 each have over 120,000 acres of chaparral (Figure V2B.1-6a), with MUs 9 and 11 having only smaller amounts of chaparral burned in 2003 or 2007. MU10 had over 60,000 acres of chaparral burn in 2003 and MU5 had the most chaparral (46,000 acres) burned in 2007. Over 41,000 acres (20%) of chaparral burned in 2003 and also burned in 2007. MUs 9, 10 and 11 each have over 80,000 acres of conserved chaparral (Figure V2B.1-6b). MU10 had the most chaparral burned on Conserved Lands in 2003, while MU5 had the most chaparral on Conserved Lands burned in 2007. A total of 25,156 acres of chaparral on Conserved Lands burned in both 2003 and 2007.

Figure V2B.1-7 shows departures from historical median fire return intervals across the MSPA (also see Vol. 3, App. 4), with negative values indicating areas burning more frequently than the historical regime and positive values less frequently. Most of the County has burned too frequently, especially in the inland valleys and foothills. Areas that have burned less frequently than the historical record include higher mountain slopes at the east edge of the MSPA in MUs 10 and 11, areas of MUs 6 and 8, and fragments within the urban matrix in MUs 2, 3, and 6.

The ignition probability for fires is based upon modeling by Syphard and Keeley (2015) and shows the classes from ±1 to ±2.5 standard deviations (std dev) from the mean and is greatest (+2.5 std dev) along roads throughout the MSPA, at the margins of urban areas where there is undeveloped land and semi-rural development (Figure V2B.1-8). Risk of ignition is especially high in MU3 followed by MUs 4, 6, 8, and 9. According to the Fire and Resource Assessment Program's (FRAP) GIS database (CAL FIRE 2012), the risk of fire is greatest along the eastern edge of MU3, throughout MU11, the southeastern and northern portions of MU5, in central and northern MU8, and over much of MU9 (Figure V2B.1-9).

1.2.1 Effects of Fire on Southern California Ecosystems

Fire is a natural part of shrubland and forest ecosystems in the mediterranean climate region of southern California. In general, many plant species have evolved adaptations to fire that allow them to recover in place through soil seed banks and vegetative resprouting (Barro and Conrad 1991; Keeley et al. 2005a). In contrast, animal species may be more vulnerable to fire intensity and size and, if they do not survive within a fire perimeter, will need to recolonize from surrounding unburned areas (van Mantgem et al. 2015). Anthropogenic disturbances to the natural fire regime can alter ecosystem processes and have a negative impact on even fire-adapted plant and animal species and natural communities.

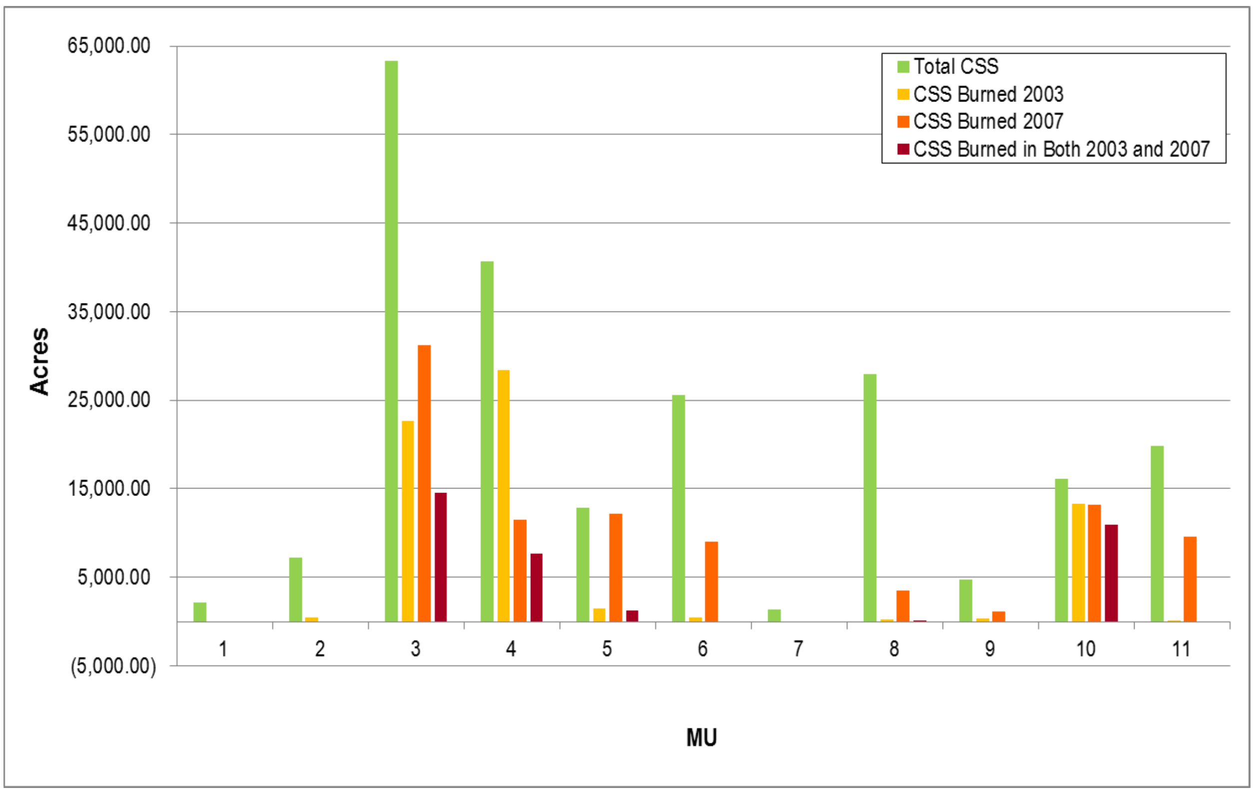

Figure V2B.1-5a. Acres of coastal sage scrub by MU and that burned in 2003, 2007, and 2003 and 2007.

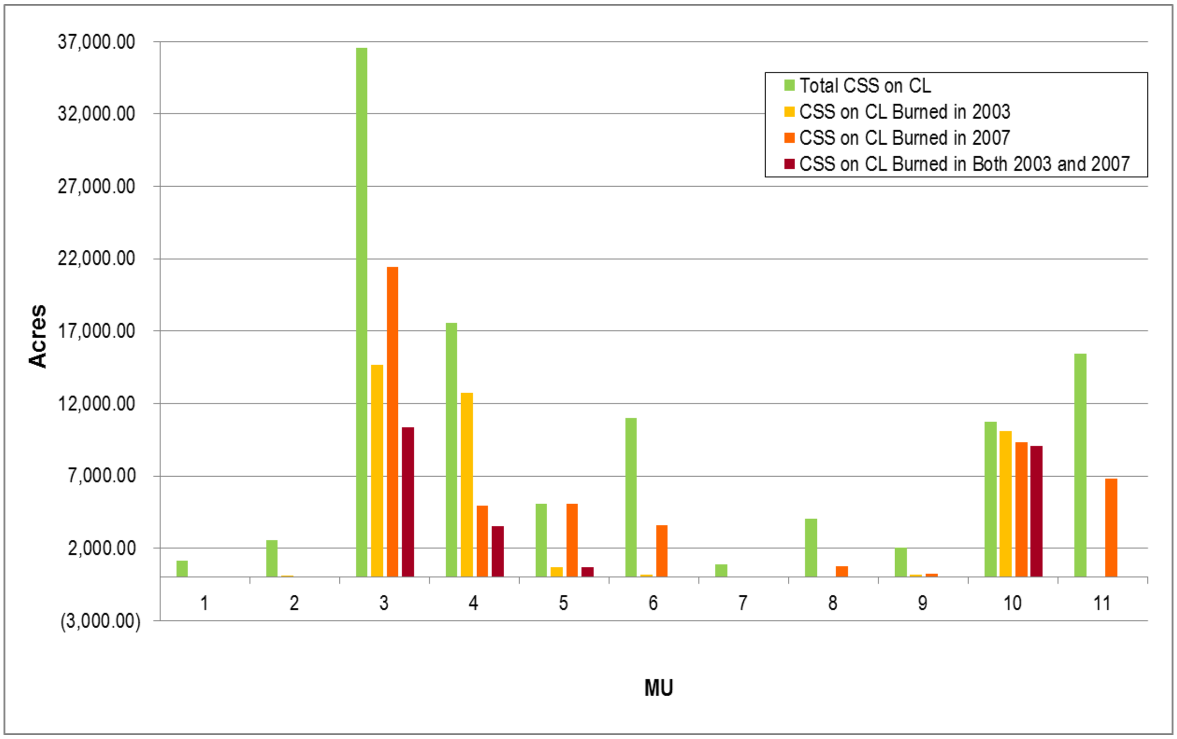

Figure V2B.1-5b. Acres of coastal sage scrub on Conserved Lands by MU and that burned in 2003, 2007, and in both 2003 and 2007.

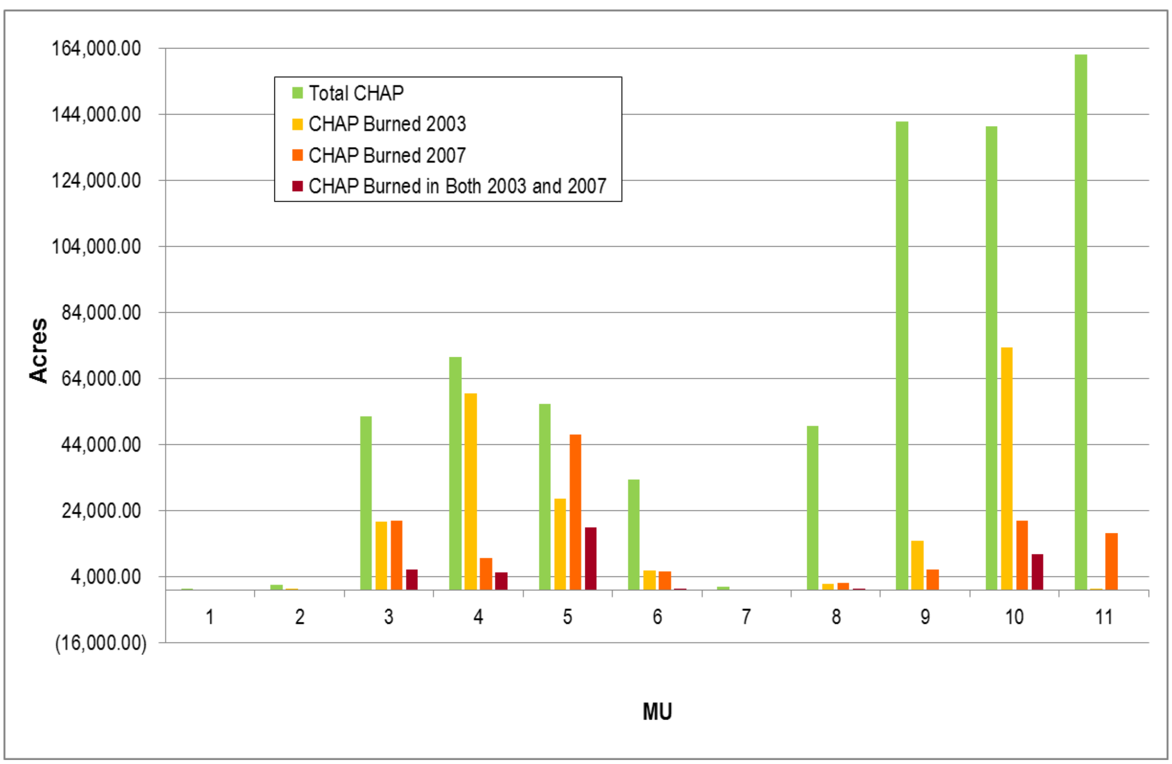

Figure V2B.1-6a. Acres of chaparral by MU and that burned in 2003, 2007, and in both 2003 and 2007.

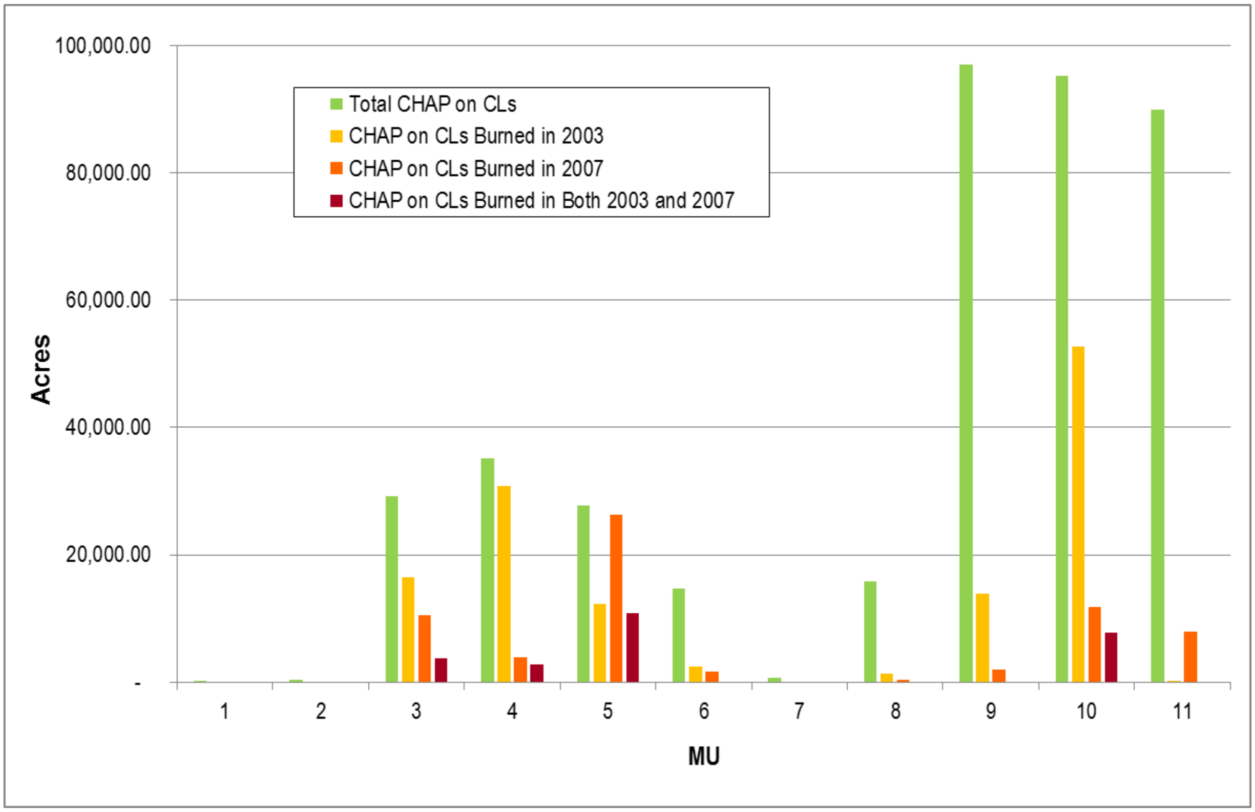

Figure V2B.1-6b. Acres of chaparral on Conserved Lands by MU and that burned in 2003, 2007, and in both 2003 and 2007.

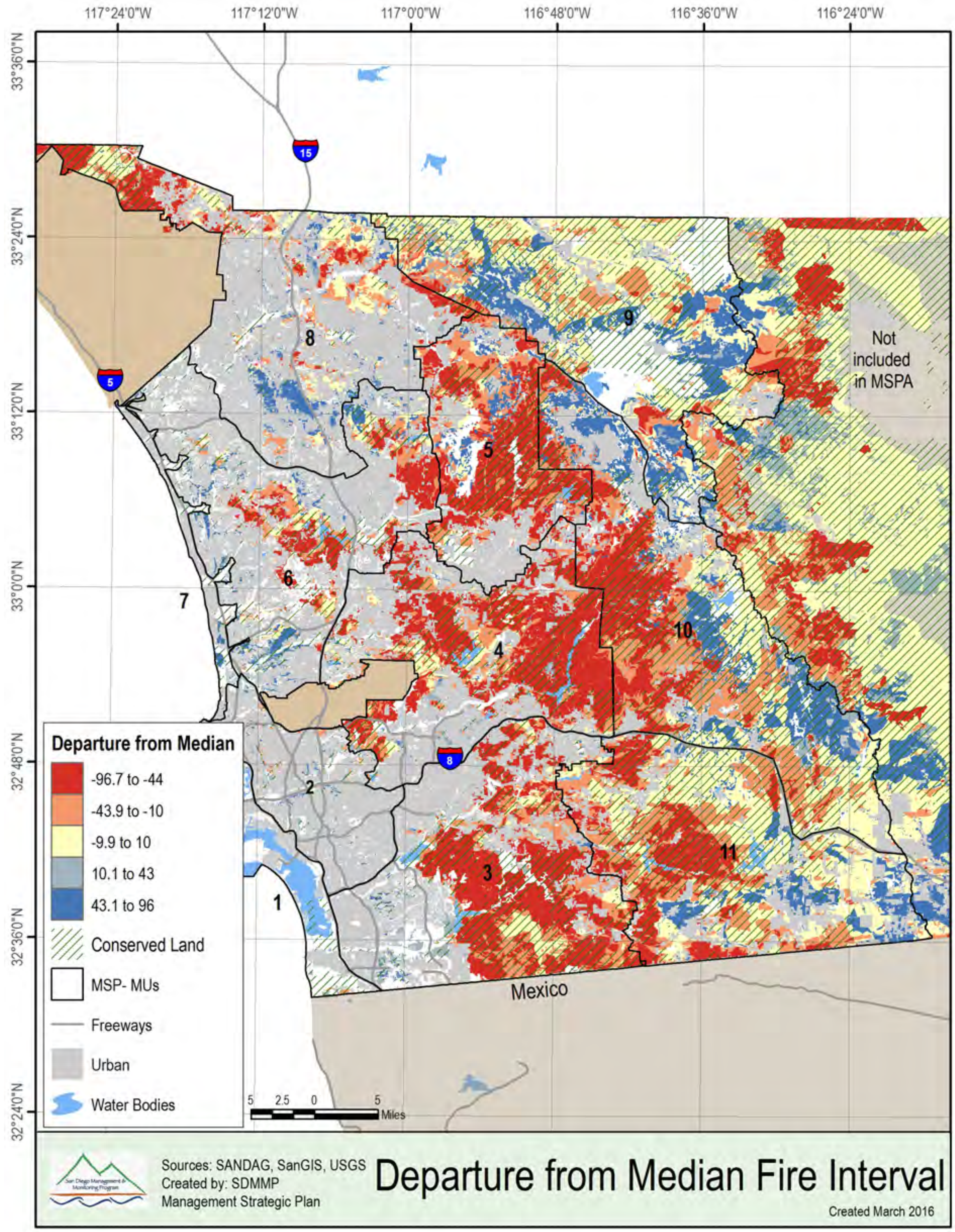

Figure V2B.1-7. Departure from median fire return intervals on Conserved Lands in the MSPA.

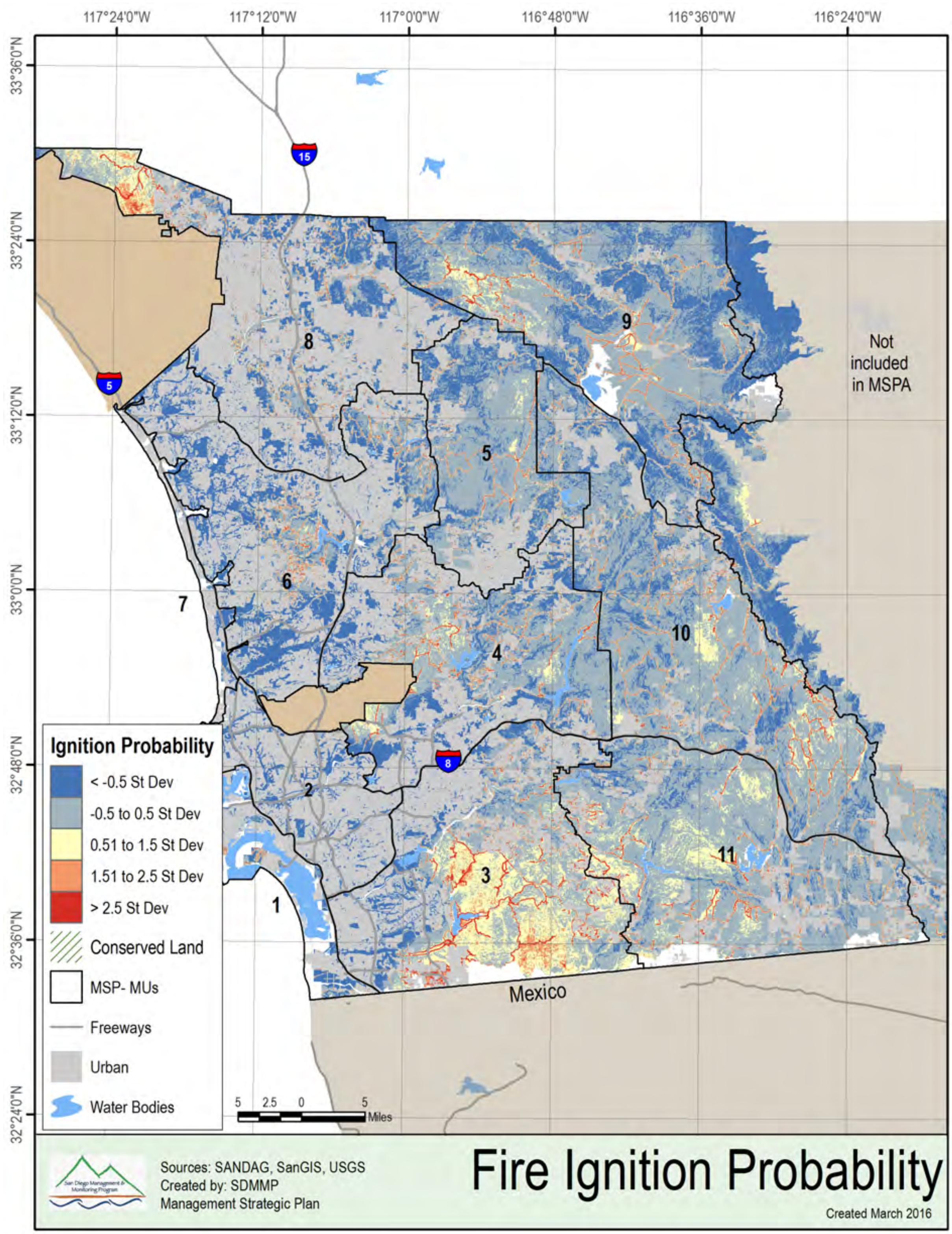

Figure V2B.1-8. Probability of wildfire ignition for Conserved Lands in the MSPA.

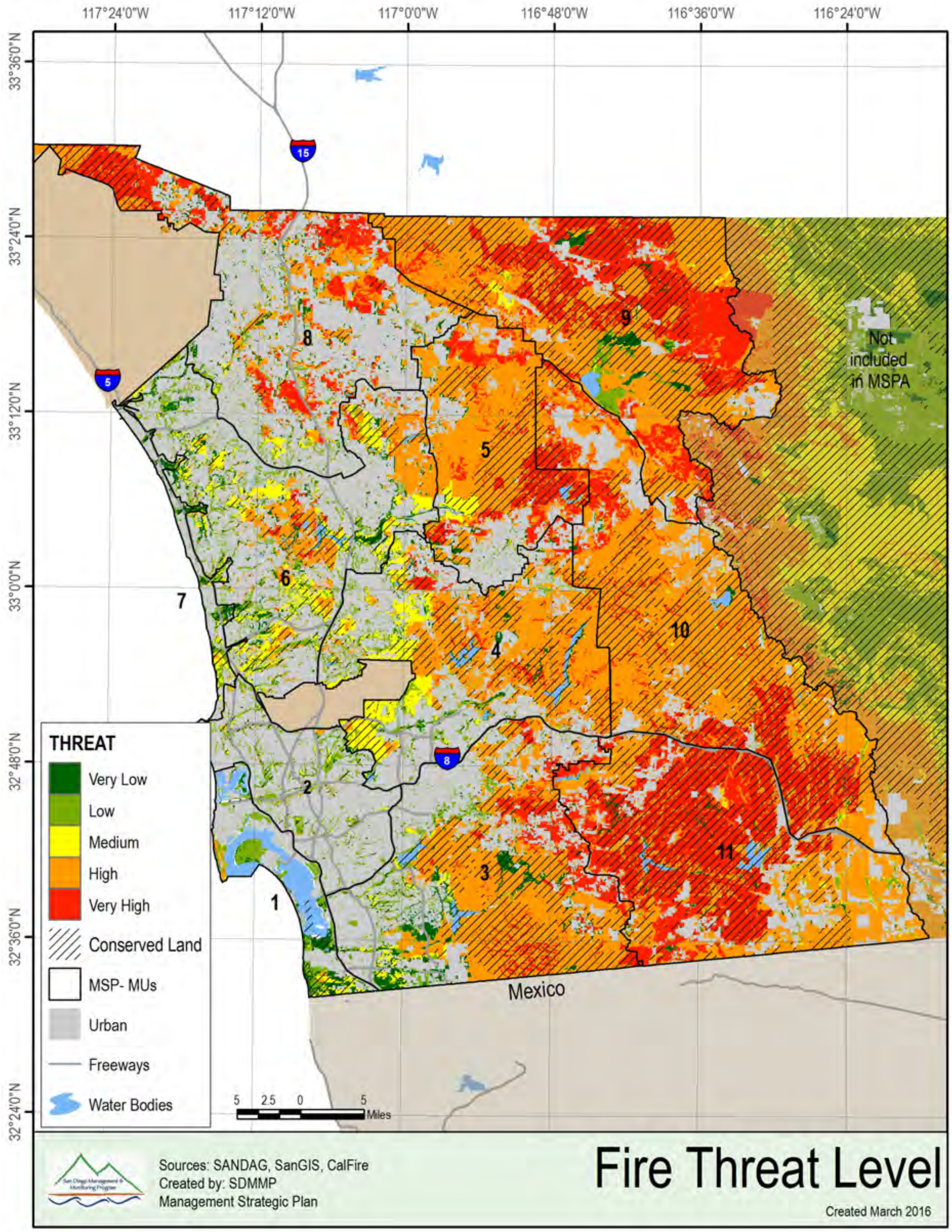

Figure V2B.1-9. Fire threat on Conserved Lands in the MSPA (CAL FIRE 2012).

Effects of Fire on Erosion

Post-fire debris flows and transport of sediment, trace metals, and pollutants can significantly impact aquatic ecosystems in southern California. Wildfires often remove vegetation and destabilize soils, which can result in debris flows, especially following rainfall events (Cannon et al. 2008; Gartner et al. 2008). In southern California, debris flows can occur with little or no moisture, with most flows occurring during low intensity storms that last 5 to 33 hours (Cannon et al. 2008). In the western United States, debris flow volumes are dependent on the area of the basin with slopes greater than or equal to 30%, burn severity, and total storm rainfall amount (Gartner et al. 2008). During the first rainy season following a wildfire, large amounts of sediment, nutrients, heavy metals, and other contaminants can be discharged into aquatic ecosystems (Stein et al. 2012; Warrick et al. 2012; Bladon et al. 2014). In southern California, water discharge can be an order of magnitude greater and sediment export 10 times greater in burned watersheds compared with unburned (Coombs and Melack 2013). Post-fire concentrations of trace metals, including lead, cadmium, copper and zinc, can be orders of magnitude greater in burned watersheds (Stein et al. 2012; Burke et al. 2013). Precipitation during the first rainfall season following fire is positively associated with sediment loads due to increased erosion processes such as rilling and mass movements of soil (Warrick et al. 2012). Within the MSPA, post-fire erosion potential is greatest in the foothills and mountains of MUs 3, 5, 8, 9, 10, and 11 (Figure V2B.1-10).

Effects of Fire on Southern California Plant Communities

Plant species in fire-prone areas are adapted to specific fire regimes that influence the evolution of plant traits and can shape biodiversity patterns (Keeley and Fotheringham 2003; Keeley et al. 2011; Pausus and Keeley 2014b). Changes to the fire regime, such as changes in fire frequency, can pose a threat to species persistence (Pausas et al. 2004; Keeley 2005; Syphard, Clarke, et al. 2007; Keeley et al. 2011).

Post-fire succession in southern California chaparral and coastal sage scrub is largely determined by species that survived the fire via vegetative structures or soil-stored seed banks, by fire severity, and by post-fire precipitation (Keeley et al. 2005a,b; Pausas and Keeley 2014b). There is greater pre- and post-fire similarity in chaparral communities that are dominated by resprouting shrubs, whereas communities dominated by obligate and facultative seeding shrubs are initially

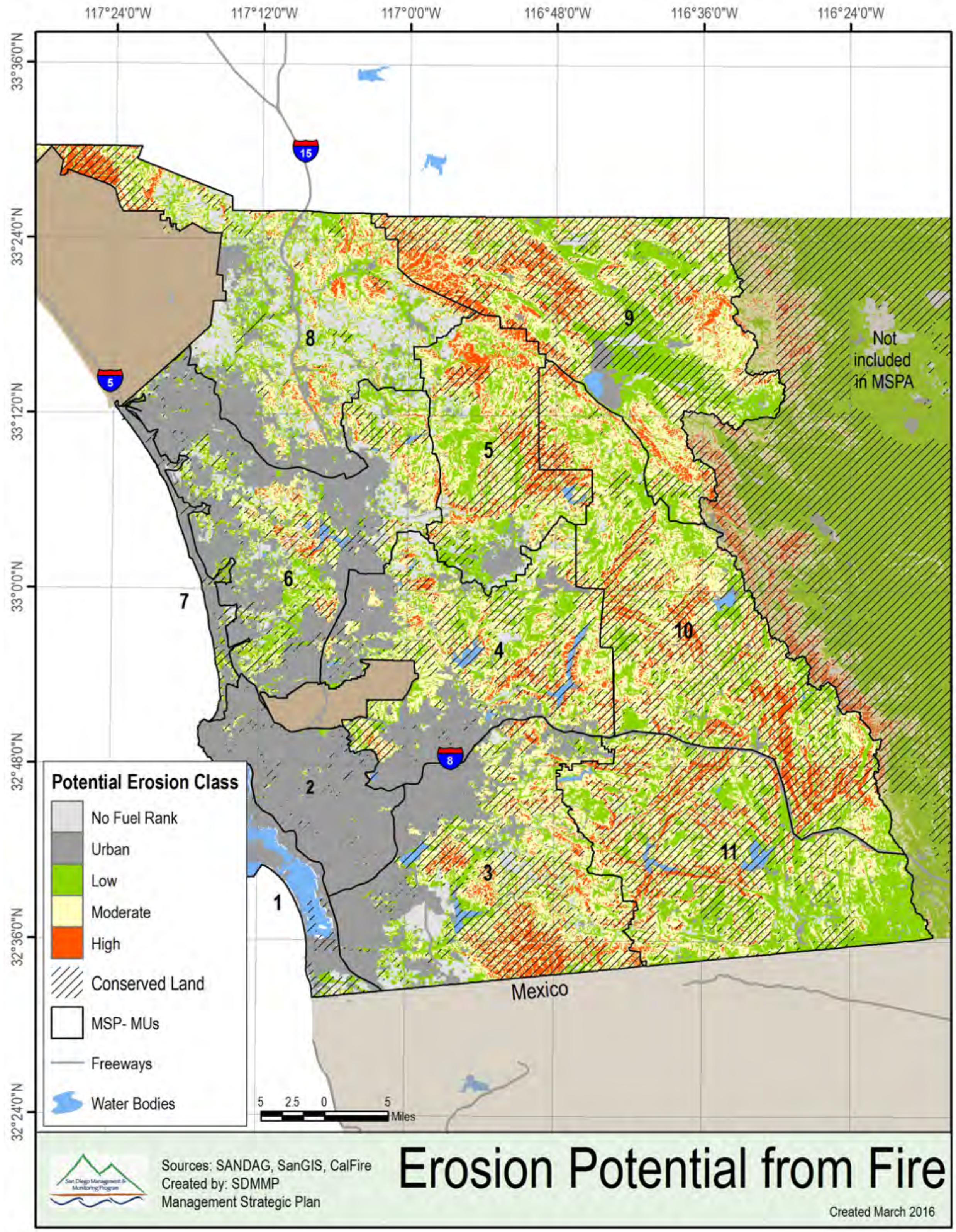

Figure V2B.1-10. Erosion potential following fire for Conserved Lands in the MSPA.

different in density and composition until years later in succession when canopy closure thins out shrubs and the community is more similar to pre-fire conditions. Coastal sage scrub dominated by resprouting subshrubs shows a different pattern in that the subshrubs grow quickly and there is extensive seedling recruitment the second year post-fire, so that pre- and post-fire densities can be much different (Keeley et al. 2005a). Inland sage scrub vegetation dominated by seeders recovers more slowly than coastal associations dominated by resprouters (e.g., California brittlebush [*Encelia californica*], Sawtooth goldenbush [*Hazardia squarrosa*]) (Keeley et al. 2005a). Post-fire diversity is also determined by precipitation, especially for annuals, including those fire endemics that are dormant in the soil seedbank until triggered to germinate by fire (Keeley et al. 2005b). Chaparral species differ in their sensitivity to fire intensity and subsequent seedling production, which can influence post-fire composition and diversity (Moreno and Oechel 1991; Keeley et al. 2005b). Post-fire herb communities are also influenced by aspect, soil characteristics; and elevation (O'Leary 1988).

Short fire return intervals as a result of anthropogenic ignitions are affecting native coastal sage scrub and chaparral vegetation in southern California and causing type conversion to nonnative annual grassland (Minnich and Dezanni 1998; Syphard et al. 2006, Syphard, Clarke, et al. 2007; Diffendorfer et al. 2007; Keeley and Brennan 2012). Obligate seeding shrubs are more vulnerable to local extinction under short fire return intervals than obligate resprouting species or facultative seeders that can employ both modes of post-fire regeneration (Syphard et al. 2006; Keeley and Brennan 2012; Enright et al. 2014). Drought can enhance this vulnerability and, under a warming and drying climate with more frequent fire, could pose a threat to persistence of obligate seeders (Lawson et al. 2010; Enright et al. 2014). Drought and nitrogen deposition have been shown to significantly slow post-fire recovery in coastal sage scrub and to facilitate type conversion to nonnative grassland (Kimball et al. 2014). Wildfire and nonnative plant invasion can also have significant impacts on soils (Dickens and Allen 2014). In chaparral vegetation, invasive grasses increased soil C/N ratio, pH, and N cycling rates and reduced NO_3N availability before fire. After fire, invasive nonnative plants slowed succession above and below ground.

Sensitive plant species can respond to fire in different ways based upon their ecological and life history attributes and to the response of introduced invasive weeds (see Rochester and Fisher 2014). Specific post-fire responses of rare plants within the MSPA are provided in the species goals and objectives (use links found in Table V2B.1-4).

Effects of Fire on Southern California Animal Communities

Animal species can survive fire by remaining in the fire area in a diapause state (e.g., invertebrates); by using refugia such as burrows, rock outcrops, riparian areas, or unburned patches to shelter in place during the fire; or by escaping the fire to unburned areas and then recolonizing burned sites during the post-fire recovery period. Direct effects of fire include animal behavioral responses to the fire (e.g., sheltering in place in refugia or escaping and recolonizing) and whether an individual survives, whereas indirect effects involve post-fire recovery in burned areas over time (Van Mantgem et al. 2015). Fire severity and size affect individual survival and post-fire recolonization, with differential effects depending on the animal species.

A meta-analysis of vertebrate species responses to fire worldwide showed that the effect of fire on species richness and community composition was largely due to the type of fire (Pastro et al. 2014). Prescribed fires tended to increase species richness, whereas wildfires did not show this effect. Prescribed fires had lower species turnover between pre- and post-fire communities compared with wildfires, which enhanced diversity in assemblages. This meta-analysis did not support the idea that there is greater species diversity with intermediate levels of disturbance or with a patch mosaic pattern of burning.

Information on the effects of fire on invertebrate, amphibian, reptile, bird, and mammal communities within the MSPA is presented below. More detailed information on the effects of fire on MSP species is provided within the Species-Specific Approach discussion in Sec. 1.5.2 (below) and in corresponding species goals and objectives (use links found in Table V2B.1-4).

1.3 RESULTS OF FIRE STUDIES IN THE MSPA

Following the 2003 and 2007 wildfires, a number of studies were conducted within the MSPA to evaluate the effect of these fires on animal communities and individual species. A summary of the effects of fire on animal communities is presented here with more detailed information and reports in Vol. 3, App.4. Specific information on the response of individual MSP species to fires is provided in the corresponding species sections.

Vegetation

The size of the 2003 and 2007 wildfires had little impact on post-fire recovery of vegetation as regeneration has been through in situ resprouting and dormant seed banks (see Rochester and Fisher 2014). Vegetation communities in the MSPA are also tolerant of a wide range of fire severities. However, too frequent fire can facilitate the invasion of nonnative annual grasses that can inhibit post-fire recovery of native vegetation (Keeley and Brennan 2012). Studies were conducted after the 2007 wildfires in the MSPA that compared recovery of chaparral with pre-fire stand ages of 3 and 24 years and of sites that burned once in a 4-year period compared with sites that burned twice. Chamise populations were substantially reduced after fire in stands of 3-year-old shrubs compared to 24 years old and there was significantly higher nonnative plant cover and lower plant diversity at the younger age sites. Sites that burned twice in 4 years had significant increases in annual plants with nonnative annuals much more abundant than native species. Nonnative annuals were negatively associated with woody plant cover. While woody plants recovered well after the first fire, they declined after burning a second time 4 years later. An altered fire regime of too frequent fire led to a loss of native diversity and, in some locations, communities began to change from woody shrublands to nonnative herbaceous dominated systems.

Pre- (1995–2002) and post-fire (2005–2012) studies of coastal sage scrub, chaparral, woodlands, and grasslands in the MSPA (MUs 3, ,4 and 9) found that chaparral and coastal sage scrub had reduced shrub and tree canopy cover 9 years after fire and had changed in overall community structure (Rochester, Mitrovich, et al. 2010; see Rochester and Fisher 2014). Post-fire community structure was more similar to that found in grasslands. There were no differences in species richness or community composition in grasslands or woodland/riparian. Nonnative grass was abundant across all plots before and after fire. California sagebrush and California buckwheat declined substantially in burned coastal sage scrub with little to no signs of recovery. Chamise, Tecate cypress, and pines also declined, although they showed some post-fire recovery. An altered fire regime with short fire return intervals is simplifying shrublands in the MSPA and could convert them to nonnative grassland.

Fire facilitates the rapid spread and widespread establishment of the invasive giant reed (*Arundo donax*) into MSPA riparian habitats and can require management in order for native vegetation to recover (see Rochester and Fisher 2014). In the absence of invasive plants, riparian systems can recover rapidly, although precipitation and fire severity can influence this process. Within 5 years post-fire, there is recovery of native understory and mid-canopy vegetation but the upper-canopy requires more time to reestablish.

Invertebrates

The rare Hermes copper butterfly is found in coastal sage scrub habitats supporting the host plant, spiny redberry (*Rhamnus crocea*), in southern and central San Diego County (Marschalek and Deutschman 2008). The range of this species has been reduced as a result of urban development (Marschalek and Klein 2010). Significant portions of Hermes copper habitat burned in 2003 and 2007, causing the loss of 13 populations and further restriction of the species range. Hermes copper butterfly larvae occur in spiny redberry and are killed by fires that burn through the vegetation. Only 2 sites that burned in 2003 have been colonized by the butterfly; 1 site was occupied prior to the fires and the other is a newly discovered population whose pre-fire status is unknown (Marschalek et al. 2016). Genetic analyses indicate that, historically, movement was possible across the landscape. Current dispersal appears limited, particularly in peripheral areas, as a result of landscape fragmentation from urban development and wildfire. Large fires can cause the loss of multiple populations, while it is suggested that small fires that reduce fuel buildup can create refugia (T. Oberbauer, pers. comm.). The bulk of the remaining populations in the southeastern portion of the range are highly vulnerable to extirpation from another large wildfire event.

Ant species diversity declined slightly 2 to 3 years after the 2003 wildfires (Matsuda et al. 2011). Ant community structure varied among coastal sage scrub, chaparral, woodland, and grassland vegetation communities, with coastal sage scrub showing the largest difference between pre- and post-fire species composition. This difference was due to significant decline in 1 ant species and a significant increase in another. Scorpions and solifugids were largely unaffected by the fires in shrublands (Brown et al. 2010). They sheltered in place within burrows in the soil and rocks and could remain underground for long periods during the post-fire period without eating or needing shade during the day.

Amphibians and Reptiles

Herpetofaunal species diversity declined after the 2003 and 2007 wildfires in coastal sage scrub and chaparral and there were significant shifts in overall community structure (Rochester, Brehme, et al. 2010). Shrub and tree cover showed an average decrease of 53% in chaparral and 75% in coastal sage scrub after 2 and 3 years post-fire. Post-fire herpetofauna community structure at burned sites was more similar to that of grasslands. There was no change in herpetofaunal diversity or community composition in woodlands or grasslands. At the species level, western fence lizard was the most abundant reptile before and after fire, with increases in western whiptail, Blainville's horned lizard, and side-blotched lizard in burned chaparral and orange-throated whiptail, and side-blotched lizards in coastal sage scrub. Western toad was detected at significantly fewer burned plots in chaparral. There were also declines in garden slender salamanders, southern alligator lizards, racers, common kingsnakes, gopher snakes, and striped racers in chaparral and coastal sage scrub. Continued monitoring through 2012 (9 years post-fire) showed that changes in post-fire community structure persisted, with specific taxa such as salamanders and small snakes not recovering in burned areas (see Rochester and Fisher 2014). It is hypothesized that this decline was to a post-fire loss of organic material on the ground that resulted in a continued loss of soil moisture. A continued fire regime of unnaturally short fire return intervals will result in simplification of reptile and amphibian communities (Rochester, Brehme, et al. 2010).

<u>Birds</u>

Bird species diversity in chaparral, oak woodland, riparian, and grassland vegetation was monitored 2 years before and 2 years after the 2003 wildfires at a high and a low elevation site in San Diego County (Mendelsohn et al. 2008). Bird species diversity remained unchanged after the fire, except at the low elevation coastal sage scrub site where it was greater. Post-fire cover of trees and shrubs was significantly reduced in coastal sage scrub and chaparral at the low elevation site but not at the high elevation site. There were significant differences in post-fire bird community assemblages in low-elevation chaparral and coastal sage scrub and in high-elevation grassland. Changes in bird community assemblages were associated with changes in vegetation due to the fire. The relative abundance of some species (e.g., lazuli bunting, horned lark) significantly increased after the fire, while other species decreased (e.g., Anna's hummingbird, wrentit, bushtit). Spotted towhee increased in burned chaparral but declined in burned coastal sage scrub at the low elevation site. The ability of bird species to recover from fire is attributed to the availability of unburned refugia, post-fire vegetation characteristics, and the ability to disperse and recolonize burned areas.

Bird communities surveyed from 2002 through 2008 in burned and unburned chaparral and forest habitats in southern California showed substantial variation in species responses to fire (Hargrove and Unitt, in prep.). Overall, breeding bird communities consisted of 16 "fire follower" species, 30 neutral or "fire resilient" species, and 33 "fire fugitive" species. During the nonbreeding season, this changed to 8 "fire followers," 23 "fire resilient," and 33 "fire fugitives." Fire followers included lazuli bunting, Costa's hummingbird, and rock wren. Those species that were fire fugitives included year-round territorial residents such as wrentits and California thrashers or those in forest habitat that converted to chaparral such as mountain chickadee, pygmy nuthatch, Steller's jay, and western tanager. Those species most impacted by fire were in restricted coniferous forest habitat, which takes a long time to recover, were patchily distributed, or also faced other threats.

Significant declines have been documented in coastal cactus wren populations following large wildfires in southern California. Wren populations suffer direct mortality from fire and loss of cactus scrub habitat that can take many years to grow back and often does not fully recover to support wrens. In Orange County, the 1994 Laguna fire caused an 87% decline from an estimated 1,473 to 187 occupied acres, even after 12 years of post-fire recovery (Mitrovich and Hamilton 2007). Similarly, the 2007 Santiago fire resulted in an estimated 82% reduction from an estimated 374 to 67 territories in the year following the fire (Leatherman BioConsulting Inc. 2009). In San Diego County, the 2007 Witch Creek Fire burned through the San Dieguito River Valley and impacted more than 60% of the San Dieguito River Park (Hamilton 2009). A survey in 2008 found 33 territories, a 63% decline from the 90 territories estimated in the 1980s and early 1990s. The population east of I-15 in the San Pasqual Valley recovered rapidly, with at least 65 territories documented by USGS 4 years after the fire during a study of cactus wren genetics (Barr et al. 2015). However, wrens west of I-15 largely disappeared and remained only at Bernardo Mountain in small numbers with 2 pairs in 2012 and 3 pairs in 2014 (Mahrdt and Weaver 2015). The 2007 Harris Fire resulted in the disappearance of several wren territories on the San Diego National Wildlife Refuge, in the vicinity of Sweetwater Reservoir and San Miguel Mountain. Cactus wrens are poor dispersers in a fragmented landscape (Atwood et al. 1998; Preston and Kamada 2012; Kamada and Preston 2013; Barr et al. 2015) and frequent wildfires are associated with genetic bottlenecks (Barr et al. 2015).

Coastal California gnatcatcher monitoring from 2004 through 2009 in the MSPA found slow rates of recolonization at sites burned in 2003 wildfires and indications that colonization was more likely near high-quality and very high-quality habitats (Winchell and Doherty 2014). A larger, more comprehensive study of gnatcatcher and coastal sage scrub post-fire recovery following 2003, 2007, and 2014 wildfires is ongoing with monitoring conducted in 2015 and 2016 (USGS unpub. data).

Small Mammals

Small mammal communities in the MSPA showed a more simplified community structure 2 and 3 years after the 2003 wildfires due to a reduction in shrub and tree cover in chaparral and coastal sage scrub plots (Brehme et al. 2011). Small mammal community recovery in woodlands and grasslands was not affected by tree or shrub cover, as these differences were smaller between pre- and post-burned sites and was hypothesized to be influenced by interspecific competition. There were significant increases in the relative abundance of deer mouse and Dulzura kangaroo rat and significant decreases in California mouse, San Diego pocket mouse, desert woodrat, and brush mouse. Continued monitoring of small mammal communities for 9 years post-fire showed some species increased with time, although woodrats remained low in burned areas (see Rochester and Fisher 2014).

Another study of post-fire recovery of small mammal communities in the MSPA was conducted from 13 to 39 months after the 2003 wildfires (Diffendorfer et al. 2012). Small mammal recovery was not influenced by fire severity or distance from unburned habitat; rather, vegetation characteristics, distance to riparian, and rocky substrates were important in species recovery, with different responses depending on species. Small mammal communities differed between burned and unburned sites with a slow increase in similarity over time since fire. Similar to the Brehme et al. (2011) study, California mouse dominated unburned sites but was rare in burned sites while deer mice and kangaroo rats were initially abundant in burned sites with kangaroo rats increasing over time. Species also showed differential responses to annual precipitation. Both studies indicate that too frequent fire will increase invasion of nonnative grasses into shrublands and cause a simplification of the small mammal community, with loss of shrub specialists.

Carnivores

Using track surveys with baited scent stations and remotely triggered camera stations Turschak et al. (2010) investigated the role of the 2003 wildfires on the relative abundance of carnivores in 2 study areas within San Diego. Data were collected during the 2 years preceding the fire and then 3 to 4 years after the fire. Fifteen medium to large mammal species were detected at the 2 sites including mountain lion, mule deer, coyote, bobcat, badger, gray fox, raccoon, striped skunk, spotted skunk, opossum, and long-tailed weasel. There was little evidence that 2003 fires affected relative abundance of carnivore species for which there were sufficient data. Most of the species seemed capable of persisting in the patchwork of burned and unburned habitats. Indirect effects of wildfires such as changes in habitat suitability and predator-prey dynamics were likely responsible for minor changes in the abundance and distribution of carnivore species.

Schuette et al. (2014) also used motion sensor cameras and track plots to measure carnivore occupancy patterns in burned and unburned habitat in the MSPA 3 to 4 years after the 2003 wildfires. Focal species included coyote, gray fox, bobcat, and striped skunk. Gray fox occupancies were highest overall followed by striped skunk, coyote, and bobcat. The 3 species considered as habitat and foraging generalists (gray fox, coyote, and striped skunk) were common in burned and unburned habitats. Occupancy patterns were consistent over time for all species except for coyote, whose occupancies increased with time. Environmental and anthropogenic variables had weak effects on all 4 species and these effects were species-specific. Gray fox occurred at slightly higher rates in burned interior areas and this could be related to competitive displacement and avoidance of coyotes and bobcats.

A suite of analyses of carnivore movement and camera studies indicate that increasing fire frequency and conversion of shrubland to nonnative grassland could lead to a simplification of the carnivore community (Jennings 2012), similar to other taxa described above. A study tracking mountain lion movements in southern California used global positioning system (GPS) collars and found lions had a moderate preference for burned areas over unburned areas, although this varied by individuals (Jennings et al. 2016). Prey kills were inferred from repeated visits to an area over several nights and while more prey was killed in unburned habitats there was a higher than expected proportion of kills in burned habitats. Mountain lions avoided grasslands and areas with low cover and suitable habitat could be lost through repeated fire and vegetation type conversion to nonnative annual grassland. A similar long-term telemetry study of bobcats and coyotes found that landscape connectivity, particularly for bobcats, was substantially constrained when the effects of fire return intervals were factored in (Jennings 2012). An analysis of remote camera data collected over 14 years in southern California suggests that bobcats avoided urban areas and recently burned areas and were a good indicator of the condition of the landscape (Jennings 2012). Gray fox and mountain lions were most sensitive to conversion of shrublands to grassland and mesopredators such as striped skunk, raccoon, and opossum could benefit from type conversion to grassland (Jennings 2012).

1.4 IMPORTANT AREAS TO MANAGE FIRE RISK

To help prioritize areas for general fire management, overall fire risk was calculated across San Diego County (see Vol. 3, App. 4) based upon fire frequency

(Figure V2B.1-4), the departure from median fire return interval (Figure V2B.1-7), and probability of large fire ignition (Figure V2B.1-8). Preserves were identified that fell into high fire risk categories (see Vol. 3, App. 4). MUs 3, 4, 5, 8, 10, and 11 had preserves at high risk of too much fire. All but MU7 had preserves with a high probability of ignition somewhere within their boundaries. MUs 4 and 5 were the only MUs without preserves or parts of preserves that burned less than the median fire return interval.

Fire risk was also evaluated relative to species diversity, to genetic diversity and to combined species and genetic diversity to identify those areas most important for management of those elements (see Vol. 3, App. 4). A Pareto ranking algorithm was used to spatially prioritize areas for monitoring and management based upon fire risk to species diversity, genetic diversity, and to combined species and genetic diversity (Figures V2B.1-11, V2B.1-12, and V2B.1-13). MUs 3, 4, 5, 6, 8, 9, 10, and 11 had preserves that were ranked ≤25th percentile and were considered highest priority to manage fire risk for species diversity and genetic diversity (see Vol. 3, App. 4).

These analyses were refined to identify important management areas (IMAs) for general reduction of fire frequency (Figure V2B.1-14) and fire ignition probability (Figure V2B.1-15). The fire ignition probability IMA based upon the Syphard and Keeley 2015 model, identifies areas that have the highest probability (mean + 2 standard deviations) for ignitions. The fire frequency IMA is based on a cumulative overlay of highest departure from median fire return interval IMAs for SL, SS, and SO species. IMAs for reducing fire risk to individual MSP species are presented in the goals and objectives sections for those species prioritized at risk from fire (see Species-Specific Approach discussion in Sec. 1.5.2).

1.5 MANAGEMENT AND MONITORING APPROACH

The fire management goal for the MSPA is to maintain the long-term integrity and viability of ecosystems, MSP species, and vegetation communities on Conserved Lands in a cost-effective manner by managing the current human altered fire regime to promote a fire regime with lower fire frequency and reduced impacts (direct and indirect) to natural resources.

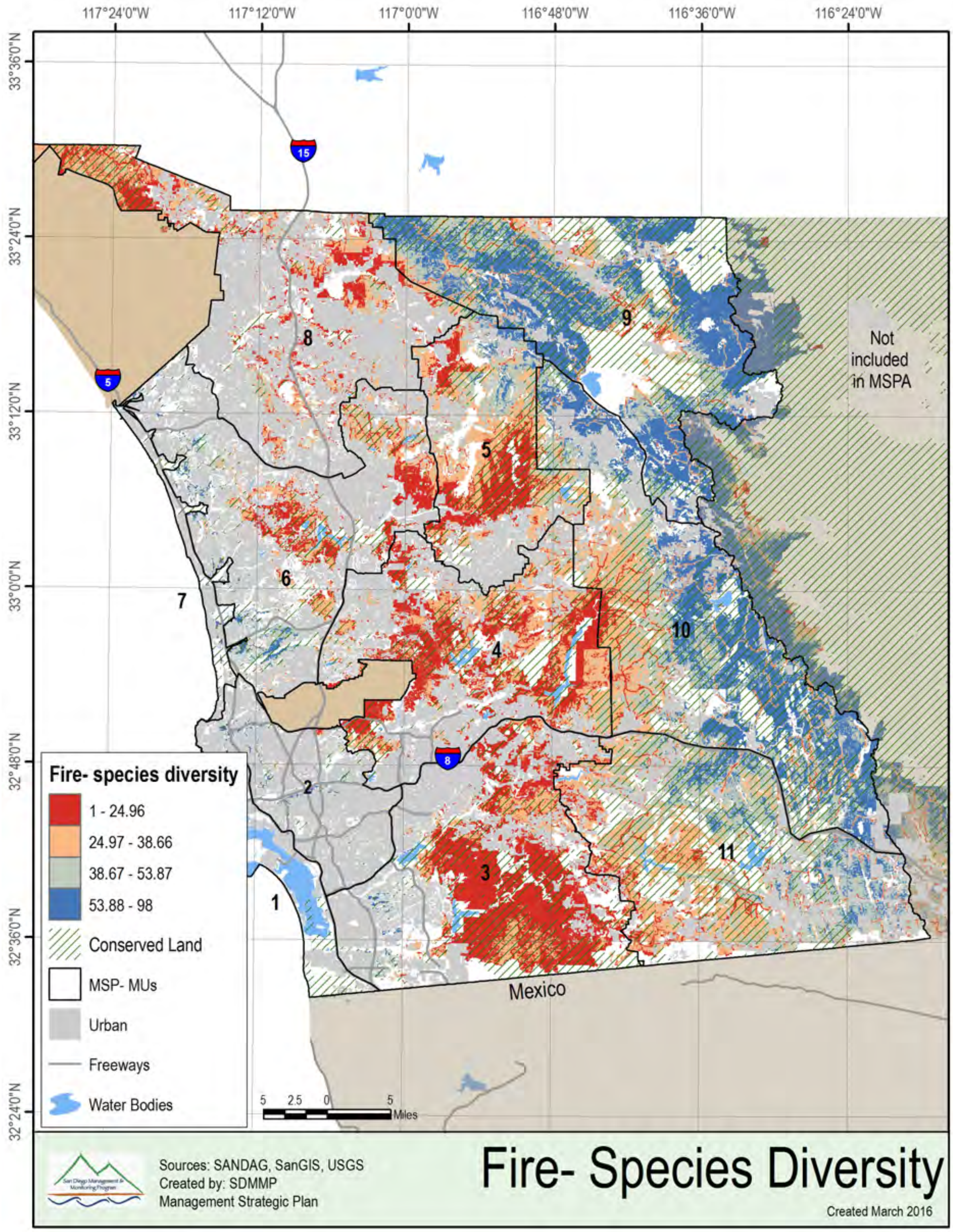

Figure V2B.1-11. Fire and species diversity risk analysis to identify priority areas for management based upon Pareto rankings, the lower the number the higher the priority.

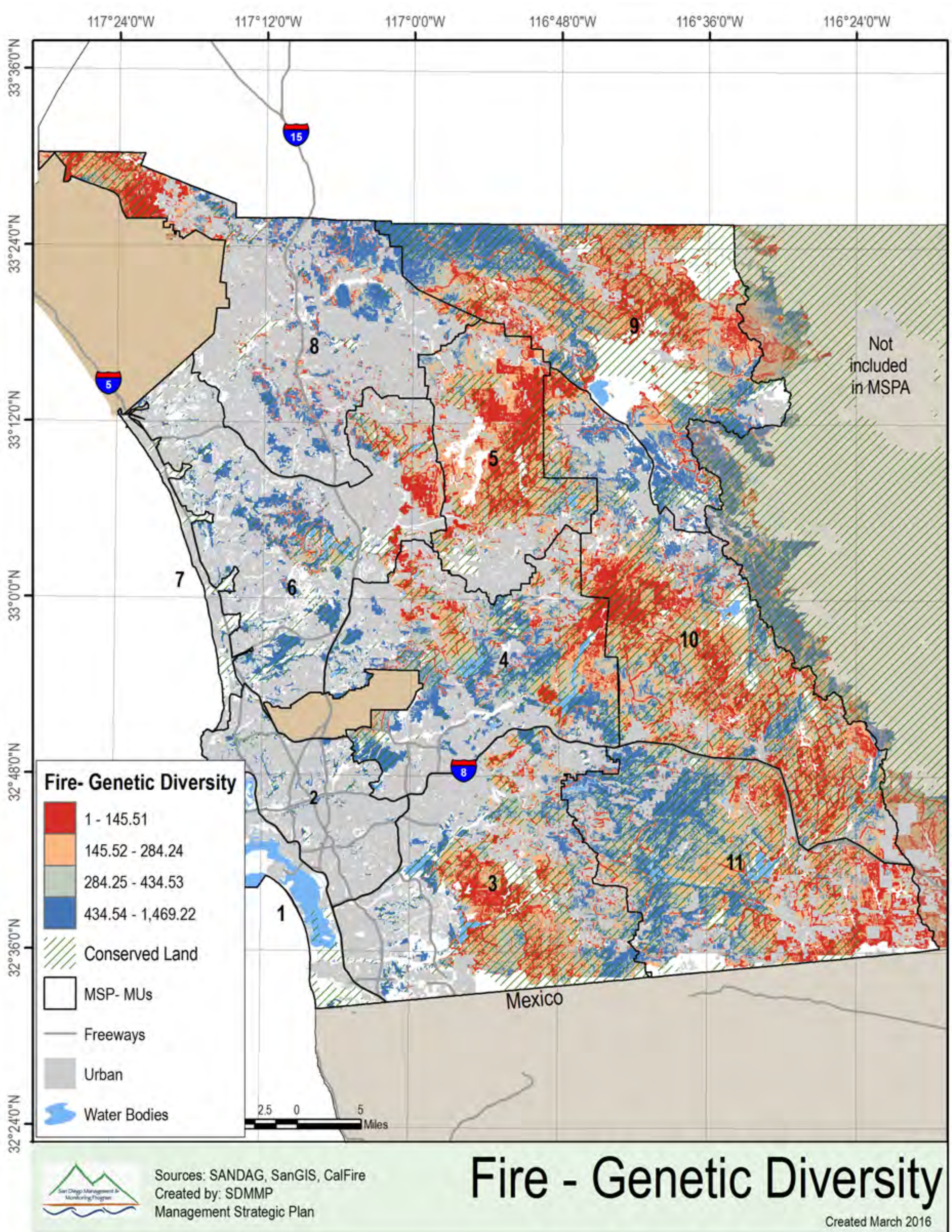

Figure V2B.1-12. Fire and genetic diversity risk analysis to identify priority areas for management based upon Pareto rankings, the lower the number the higher the priority.

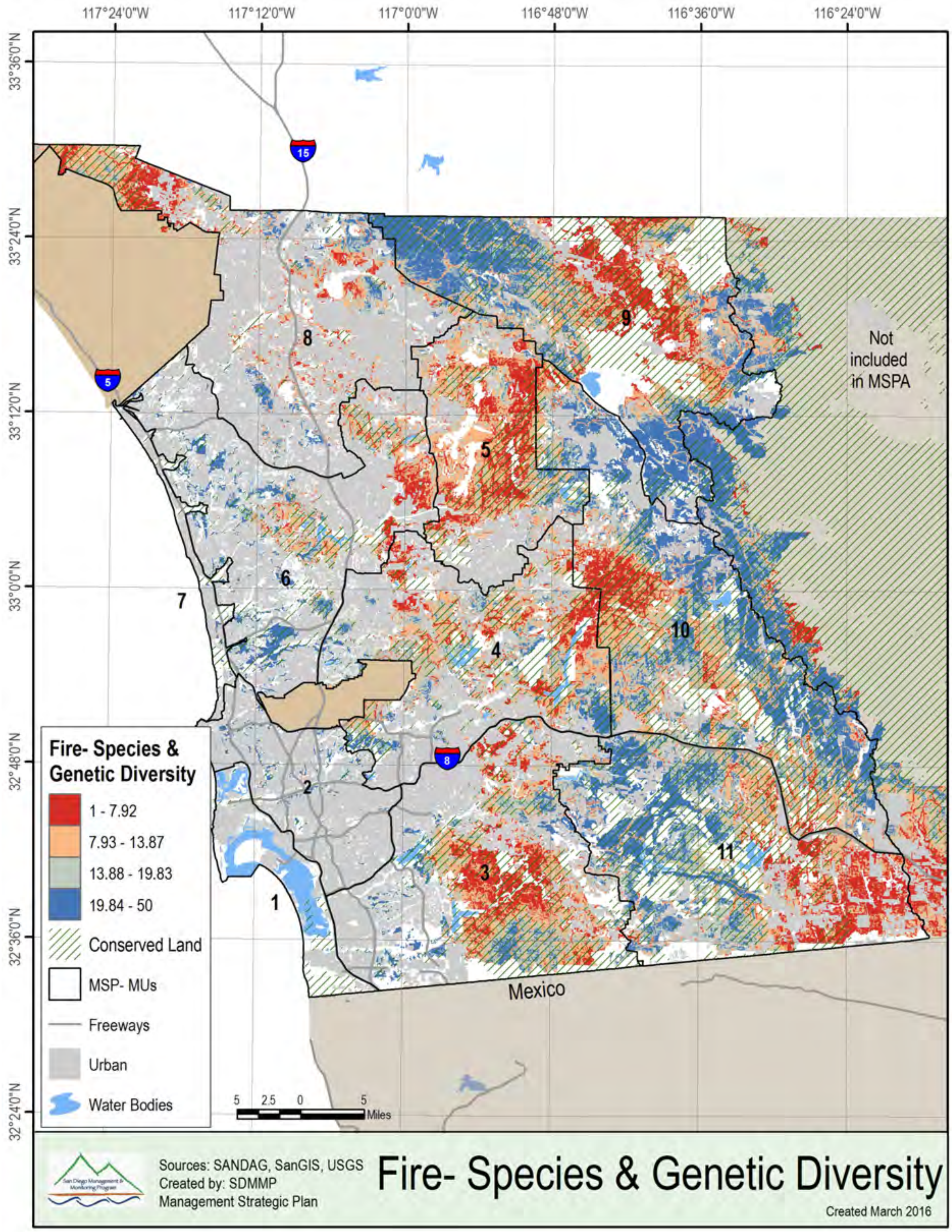

Figure V2B.1-13. Fire, species diversity, and genetic diversity risk analysis to identify priority areas for management based upon Pareto rankings, the lower the number the higher the priority.

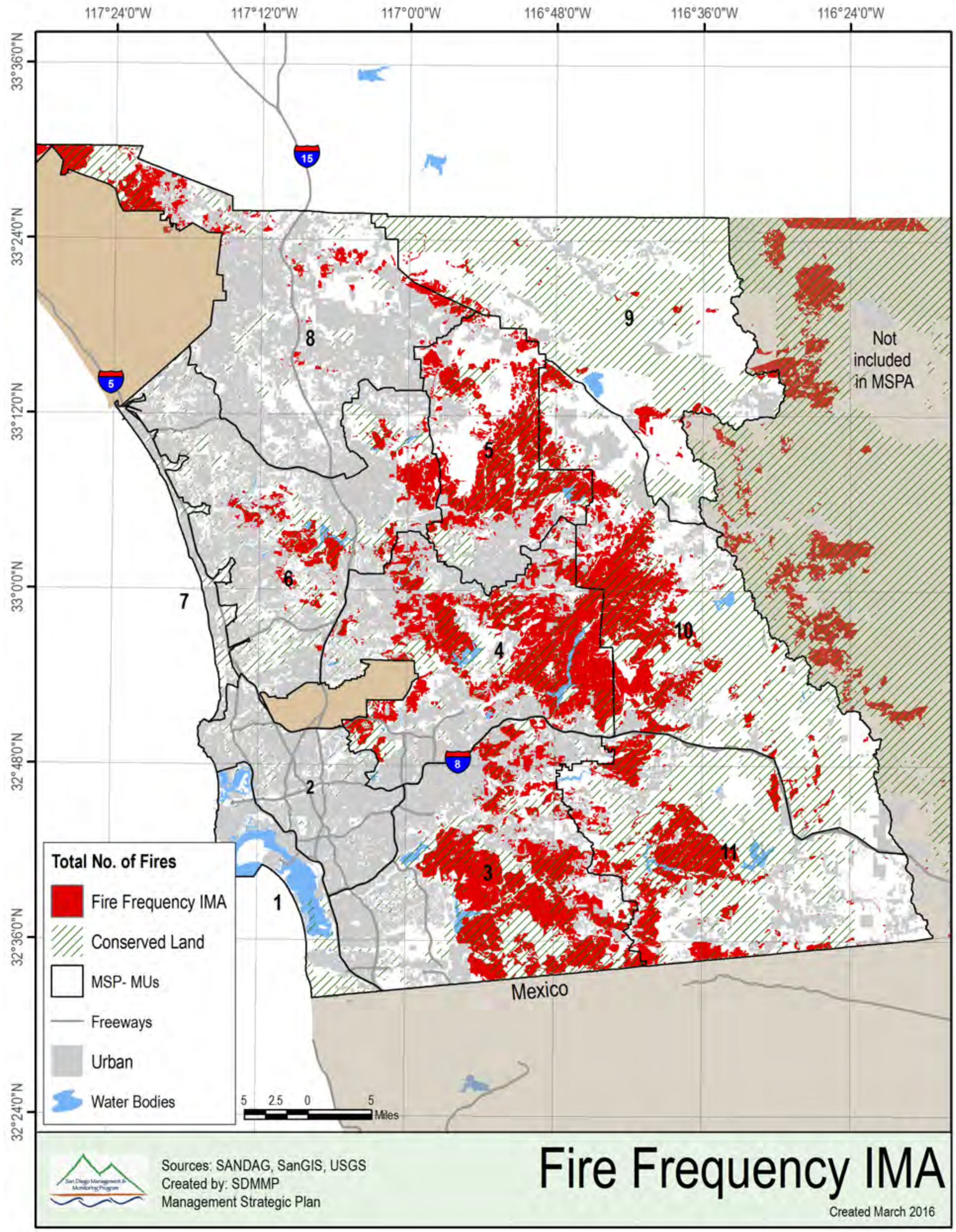

Figure V2B.1-14. Important Management Areas (IMAs) for reducing fire frequency on Conserved Lands in the MSPA.

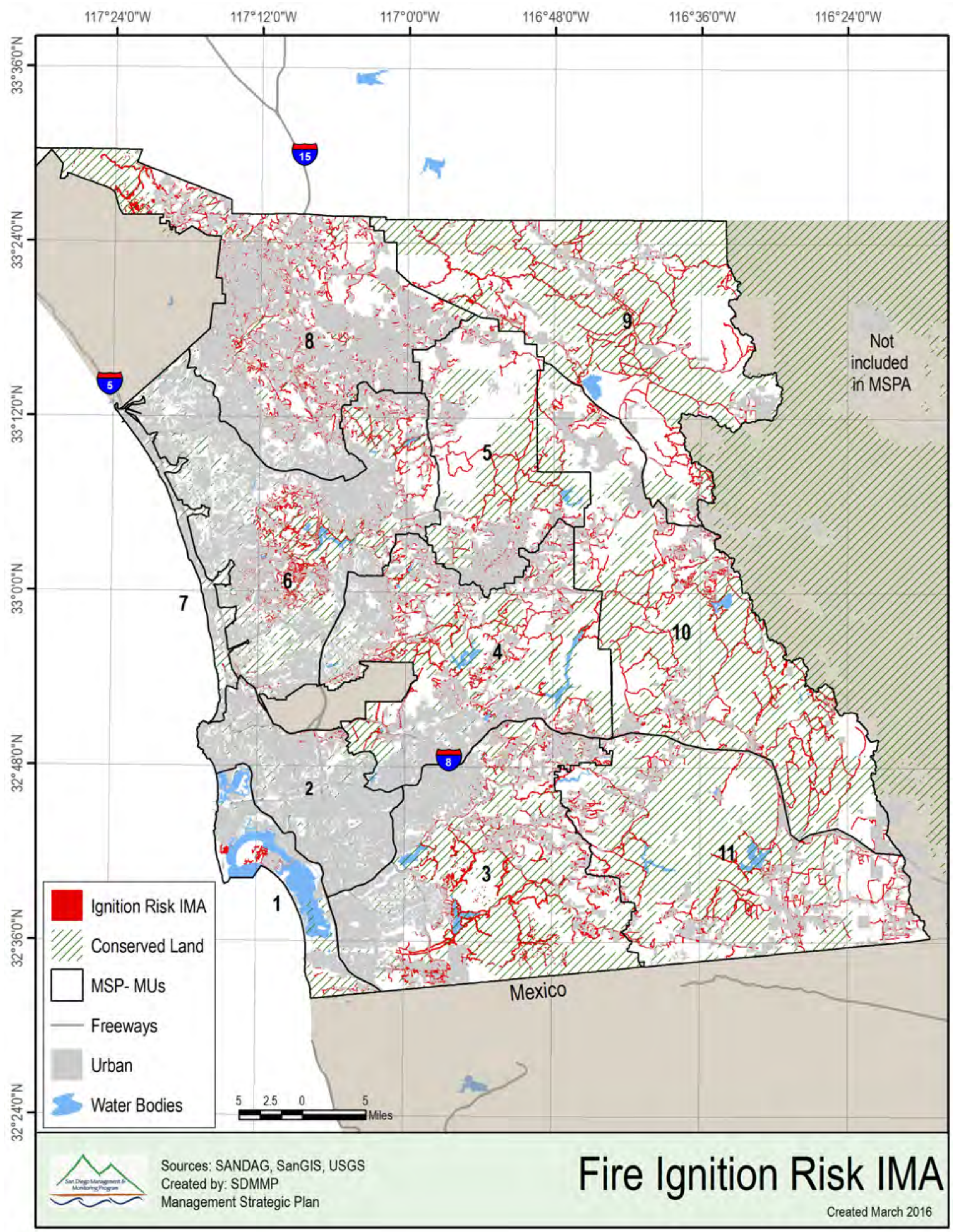

Figure V2B.1-15. Important Management Areas (IMAs) for reducing fire ignition probability in the MSPA.

1.5.1 Reducing Fire Risk to Natural Resources

Early fire detection and sufficient firefighting resources devoted to early suppression are important to reduce the risk of large and catastrophic wildfires, especially during severe fire weather (Fried et al. 2008; Cary et al. 2009; Peterson et al. 2011; Calkin et al. 2013, Penman et al. 2015). Managing fire ignitions is a method to reduce fire frequency to more natural, historical levels in a region where 95% of ignitions are human-caused (Syphard and Keeley 2015).

Fuel management to reduce fire risk to natural resources is complicated and challenging in southern California shrublands and often ineffective for Santa Ana wind-driven fires, when the majority of Conserved Lands burn. Pre-fire fuel management is most effectively targeted at the WUI interface to reduce the destruction of human life and property (Price and Bradstock 2012; Calkin et al. 2013; Syphard et al. 2014). Especially important in southern California shrublands is the creation of defensible space immediately adjacent to homes and other structures in the WUI (Calkin et al. 2013; Syphard et al. 2014). Managing Santa Ana wind-driven fires through reduction of shrubland fuel loads in the interior of preserves, away from the WUI, is more problematic and less successful. Unlike in many forest ecosystems, there is not a strong relationship between fuel age and fire probability in California shrublands (Price et al. 2012; Moritz et al. 2014). Prescribed fire to reduce fuel loads has not been shown to be effective in a number of biomes worldwide, including southern California shrublands (Price et al. 2012; Price et al. 2015). Fuel reduction across large areas of the landscape intended to reduce wildfire intensity, severity, and spread has not stopped wildfires under extreme weather conditions (Keane et al. 2008; Blodgett et al. 2010; Price and Bradstock 2012; Price et al. 2012). As an example, the 2007 wildfires in San Diego County burned through more than 95,000 acres (25%) of land that burned 4 years previously in the 2003 wildfires (see Sec. 1.2, Fire Regime, in the MSPA; Keane et al. 2008; Blodgett et al. 2010).

A study of the 2003 Cedar fire in San Diego County by Blodgett et al. (2010) used very fine spatial resolution imagery to compare burn patterns in areas within the burn perimeter subjected to Santa Ana wind conditions and to areas that burned under non-Santa Ana weather conditions. Pre-fire stands older than 6 years for Santa Ana wind portions of the burn and more than 10 years in the non-Santa Ana wind burn areas had little effect on the pattern of remaining unburned vegetation. This indicates that the mosaic of different age classes did not prevent fire from burning in either the Santa Ana or non-Santa Ana wind conditions. However, Blodgett et al. (2010) found that pre-fire shrub structure and composition did affect localized fire behavior, with chamise chaparral having the least amount of remaining unburned vegetation irrespective of fire weather. Fire severity did not differ between Santa Ana and non-Santa Ana wind portions of the burn as fire may have burned longer but at a lower intensity within the non-Santa Ana wind burn areas. The authors concluded that Santa Ana wind-driven fires would be difficult to control with traditional fuel management techniques of fire breaks and prescribed burning.

Fuel breaks are more effective in managing fires that are not driven by strong winds blowing embers ahead of the fire and where it is safer for fire management personnel to implement fire suppression. Fuel breaks to stop the spread of fire were effective 46% of the time in fires over a 28-year period in shrublands of the Las Padres National Forest in California (Syphard et al. 2011a). Fuel breaks were most effective when they enabled firefighter access to conduct suppression activities (Syphard et al. 2011a,b). Fuel breaks were also more effective in small fires and when the fuel breaks were longer in length. Other important factors in the success of fuel breaks in stopping fires were fire weather and fuel break maintenance that allowed firefighters to access the fires (Syphard et al. 2011b). Environmental conditions vary making the strategic location of fuel breaks important in their usefulness and proximity for access near communities is important for fire protection.

Fuel management to control fire risk is often associated with an increase in the spread and abundance of invasive, nonnative plants, particularly grasses and forbs. Nonnative plant abundance was 200% greater along fuel breaks in the Los Padres National Forest than in nearby untreated areas (Merriam et al. 2006). Fuel breaks made by bulldozers had greater impacts with greater nonnative cover, more bare ground and less canopy cover, litter, and duff. Mechanical fuel treatments in southern California chaparral to reduce shrub biomass and decrease fire hazard were found to be short term in effect as shrubs rapidly regrew and resulted in a 5-fold increase in herbaceous fuels (Brennan and Keeley 2015). This increase in native and nonnative highly flammable herbaceous fuels, especially nonnative invasive annual grasses, increases chances of fire ignition. A comparison of fuel reduction methods in northern California chaparral found that mastication had 34% greater nonnative annual grass cover than prescribed fire (Potts and Stephens 2009). Winter and spring prescribed fire were more resistant to grass invasion than fall fires or fall or spring mastication treatments.

In the MSPA, land owners and managers will determine the type of fuel management actions to implement to reduce risk to lives, property and natural resources and to ensure compliance with state and local laws. They may find targeted fuel management most effective at the WUI and the use of fuel breaks at strategic locations where active fire management can reduce fire risks to human life, property, and sensitive resources.

1.5.2 General and Species-Specific Fire Management Approaches

The approach for managing an altered fire regime is divided into 2 parts: general and species-specific. General fire management objectives focus on management actions that benefit natural resources across the MSPA and that are not targeted to particular species. Species-specific fire management objectives are developed for MSP species identified as at risk from fire, in which significant occurrences or even the species themselves could be lost from the MSPA as a result of an altered fire regime.

The general approach is based upon input from a 2-day Fire and Wildlife Strategic Plan Workshop convened by USGS in March 2013. This workshop brought together researchers, fire management personnel, and land managers to review and discuss wildfire impacts to at-risk natural resources and fire management planning (Rochester and Fisher 2014). A summary document was prepared and then reviewed by a Scientific Advisory Panel and it describes the workshop presentations, discussions, and resulting recommendations (Rochester and Fisher 2014). The workshop provided guidance for development of general fire management objectives and actions that identify at-risk resources with implementable management actions falling into 3 categories: pre-fire, suppression, and post-fire. The general goals, objectives, and actions for fire management on Conserved Lands provided in this Fire and Wildlife Element of the MSP include the recommendations from the workshop and are described below and listed on the MSP Portal under the Altered Fire Regime summary page (https://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1448).

Further details on recommended management actions are provided in the 2013 Fire and Wildlife Strategic Plan Workshop summary (Rochester and Fisher 2014).

The species-specific approach for managing and monitoring an altered fire regime is based on follow-up workshops held in October 2015. Although the initial Fire and Wildlife Strategic Plan Workshop in March 2013 provided information on the effects of fire on several MSP species (Rochester and Fisher 2014), there were several MSP species that still needed to be addressed. The workshops in October 2015 focused on prioritizing species by fire risk and developing management recommendations to reduce impacts to plants and animals. See the 2013 Fire and Wildlife Strategic Plan Workshop summary (Rochester and Fisher 2014) for workshop information and summaries. Fire risk prioritizations for plant species are provided in Table V2B.1-2 and for animals in Table V2B.1-3. Fire management approach, rationale, objectives, and actions for at- risk MSP species are presented in the corresponding species sections with goals and objectives on the MSP Portal.

General Approach Objectives

Below is a summary of the management and monitoring objectives for the threat of altered fire regime. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Altered Fire Regime summary page: https://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1448.

Pre-Fire Objectives: Prepare and Implement a Fire Ignition Reduction Plan

USFS, Bureau of Land Management (BLM), and California Department of Forestry and Fire Protection (CAL FIRE) have focused over the years on reducing ignitions through public education and outreach to inform people about fire dangers in risk areas and about measures to prevent ignitions (see Rochester and Fisher 2014). Firefighting agencies have also been effective at early suppression, as most fires are immediately put out and only a small fraction become large, catastrophic fires. Fire management officials suggest that it may not be possible to suppress and contain the remaining 3–5% of fires that grow beyond 10–150 acres. It is this remaining 5% of ignitions that has caused 95% of the impacts to natural resources in San Diego County, and even a small reduction in these large fires would benefit sensitive plant and animal species and their habitats.

To address other sources of wildfire ignition in the MSPA, a Fire Ignition Reduction Plan should be developed that evaluates ignition sources and the spatial distribution and timing of ignitions (see Rochester and Fisher 2014; Syphard and Keeley 2015). A Fire Ignition Reduction Plan for the MSPA should focus on ignition sources on and near Conserved Lands that have the potential to cause catastrophic fires and that do not overly duplicate the efforts of other organizations. The plan should prioritize areas for management that have high risk of ignition and the greatest potential for impact to at-risk MSP species and vegetation communities.

Table V2B.1-2. Fire risk prioritizations for MSP plant species.

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Acanthomintha ilicifolia	San Diego thorn-mint	MSCP, MHCP, NCP	FT/CE	SO	High	High risk of loss of individual populations (especially small ones) due to secondary fire effects of invasive nonnative plant species.
Acmispon prostratus	Nuttall's acmispon	MSCP, MHCP	--/--	SO	Low	
Adolphia californica	California adolphia	NCP	--/--	VG	Low	
Agave shawii var. *shawii*	Shaw's agave	MSCP	--/--	SL	Medium	Low risk of fire but few small populations with only 1 thought to be native.
Ambrosia pumila	San Diego ambrosia	MSCP, MHCP, NCP	FE/--	SO	Medium	Few populations, high risk from invasive plant species puts species at risk of extirpation due to too frequent fire.
Aphanisma blitoides	Aphanisma	MSCP	--/--	SL	Low	
Arctostaphylos glandulosa ssp. *crassifolia*	Del Mar manzanita	MSCP, MHCP, NCP	FE/--	VF	Medium	Resprouts/reseeds after fire. Altered fire regime does not appear to be a threat currently, but should be monitored. Insufficient fire at coastal locations could pose eventual threat from senescence and lack of reproduction.
Arctostaphylos otayensis	Otay manzanita	MSCP	--/--	VF	High	Fire adapted but restricted range with shortened fire return intervals puts species at risk.
Arctostaphylos rainbowensis	Rainbow manzanita	NCP	--/--	VF	Medium	Fire increases germination and this species may require fire to maintain vigorous populations. Too frequent fire poses a risk given the limited distribution.
Atriplex coulteri	Coulter's saltbush	NCP	--/--	VF	Low	
Atriplex parishii	Parish brittlescale	NCP	--/--	VF	Low	

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Baccharis vanessae	Encinitas baccharis	MSCP, MHCP, NCP	FT/CE	SO	High	Known fire follower; however shortened fire intervals put some populations at risk of extirpation due to weed competition/conversion.
Bloomeria clevelandii	San Diego goldenstar	MSCP, NCP	--/--	SS	Medium	Bulb life form life form facilitates protection/recovery from fire; too frequent fire may lead to population reduction due to secondary effects such as invasive grass/forb invasion.
Brodiaea filifolia	Thread-leaved brodiaea	MSCP, NCP	FT/CE	SS	Medium	Populations found in areas with little fire history; corm life form facilitates protection/ recovery from fire; however, fire may lead to secondary effects such as invasive grass/forb invasion.
Brodiaea orcuttii	Orcutt's brodiaea	MSCP, NCP	--/--	SO	Low	
Brodiaea santarosae	Santa Rosa brodiaea	NCP	--/--	SS	Low	Bulb life form life form facilitates protection/recovery from fire; fire may lead to secondary impacts such as invasive nonnative grasse and forbs.
Calochortus dunnii	Dunn's mariposa lily	MSCP	--/--	VG	Medium	Bulb life form life form facilitates protection/recovery from fire; fire may lead to secondary impacts such as invasive nonnative grasses and forbs.
Ceanothus cyaneus	Lakeside ceanothus	MSCP	--/--	VF	High	Restricted range/few occurrences; shortened fire return interval puts species at high risk of local population extirpation due to fire.
Ceanothus verrucosus	Wart-stemmed ceanothus	MSCP, MHCP, NCP	--/--	VF	Medium	Reseeds after fire. Altered fire regime does not appear to be a threat currently in coastal locations but should be monitored for populations along 1-5 that have burned since 2000.
Centromadia parryi ssp. *australis*	Southern tarplant	NCP	--/--	VF	Low	

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Chloropyron maritimum ssp. *maritimum*	Salt marsh bird's-beak	MSCP	FE/CE	SL	Low	
Chorizanthe orcuttiana	Orcutt's spineflower	MHCP, NCP	FE/CE	SL	Low	
Clinopodium chandleri	San Miguel savory	MSCP, NCP	--/--	SL	High	Low population numbers, shortened fire return intervals, few occurrences puts at high risk of extirpation due to too frequent fire.
Comarostaphylis diversifolia ssp. *diversifolia*	Summer-holly	MHCP, NCP	--/--	VG	Low	
Cylindropuntia californica var. *californica*	Snake cholla	MSCP	--/--	VF	Medium	Too frequent fires (< 10 years) could threaten this species, which is restricted in distribution in the MSPA.
Deinandra conjugens	Otay tarplant	MSCP	FT/CE	SS	High	Few occurrences and shortened fire return intervals may pose a risk of reduction/loss for some occurrences. Fire may lead to population declines due to secondary effects such as nonnative grass/forb invasion that should trigger active management/invasive control post-fire.
Dicranostegia orcuttiana	Orcutt's birds-beak	MSCP	--/--	SL	Low	
Dudleya blochmaniae	Blochman's dudleya	MHCP	--/--	SL	Low	
Dudleya brevifolia	Short-leaved dudleya	MSCP, NCP	--/CE	SL	Low	
Dudleya variegata	Variegated dudleya	MSCP	--/--	SS	High	Corm life form facilitates protection/recovery from fire; shortened fire return intervals at some locations may lead to secondary effects such as invasive nonnative grasses and forbs.
Dudleya viscida	Sticky dudleya	MSCP, NCP	--/--	SS	Medium	Corm life form facilitates protection/recovery from fire; shortened fire return intervals at some locations may lead to secondary effects such as invasive nonnative grasses and forbs.

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Ericameria palmeri ssp. *palmeri*	Palmer's goldenbush	MSCP	--/--	VF	Low	
Eryngium aristulatum var. *parishii*	San Diego button-celery	MSCP, NCP	FE/CE	VF	Low	
Erysimum ammophilum	Coast wallflower	MSCP	--/--	SL	Low	
Euphorbia misera	Cliff spurge	MHCP	--/--	VF	Low	
Ferocactus viridescens	San Diego barrel cactus	MSCP, MHCP, NCP	--/--	VF	Medium	Occurrences in grasslands may have hard time recovering post-fire.
Fremontodendron mexicanum	Mexican flannelbush	None	FE/--	SL	High	Restricted range/few occurrences (4) with low population numbers put species at high risk of extirpation due to fire.
Hazardia orcuttii	Orcutt's hazardia	MHCP	--/CT	SL	High	Likely fire adapted, but only 1 natural occurrence puts species at high risk of extinction due to fire (e.g., invasive plants, suppression actions).
Hesperocyparis forbesii	Tecate cypress	MSCP	--/--	VF	High	Restricted range/few occurrences with decreasing population size due to shortened fire intervals puts species at high risk.
Iva hayesiana	San Diego marsh-elder	MHCP	--/--	VG	Low	
Lepechinia cardiophylla	Heart-leaved pitcher sage	MSCP	--/--	SL	High	Fire follower; however, single occurrence with low numbers is at risk from too frequent fire.
Lepechinia ganderi	Gander's pitcher sage	MSCP	--/--	VG	High	Fire follower; however, distribution is restricted and shortened fire return intervals puts species at risk.

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Monardella hypoleuca ssp. *lanata*	Felt-leaved monardella	MSCP, NCP	--/--	VF	Medium	Fire could be a problem at some sites due to invasive nonnative plant species.
Monardella stoneana	Jennifer's monardella	None	--/--	SL	High	Restricted range/few occurrences with low population numbers and shortened fire intervals puts species at high fire risk.
Monardella viminea	Willowy monardella	MSCP	FE/CE	SL	High	Restricted range/few occurrences with low population numbers and some occurrences with shortened fire intervals puts species at high risk from secondary effects of erosion and invasion of nonnative grasses and forbs.
Navarretia fossalis	Spreading navarretia	MSCP, MHCP, NCP	FT/--	VF	Low	
Nolina cismontana	Chaparral nolina	NCP	--/--	SL	High	Resprouts/reseeds after fire, but species at risk of loss/extirpation at sites that burn frequently.
Nolina interrata	Dehesa nolina	MSCP	--/CE	SO	High	Resprouts/reseeds after fire, but species at risk of loss/extirpation at sites that burn frequently.
Orcuttia californica	California orcutt grass	MSCP, MHCP	FE/CE	SL & VF	Low	
Packera ganderi	Gander's ragwort	NCP, MSCP	--/--	SO	High	Restricted range/few populations puts species at risk of extirpation/degradation if too frequent fires causes invasion of nonnative plants.
Pinus torreyana ssp. *torreyana*	Torrey pine	MSCP, MHCP	--/--	VF	High	Few natural occurrences put species at high risk due to fire, especially given recent mortality from drought and bark beetles.
Pogogyne abramsii	San Diego mesa mint	MSCP	FE/CE	VF	Low	
Pogogyne nudiuscula	Otay mesa mint	MSCP	FE/CE	SL & VF	Low	
Quercus dumosa	Nuttall's scrub oak	MHCP, NCP	--/--	VF	Low	

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Management Category[3]	Overall Fire Risk Category[4]	Categorization Rationale
Quercus engelmannii	Engelmann Oak	MHCP, NCP	--/--	VF	Medium	Risk of fire dependent on age of tree: Poor fire response for seedlings < 3 years; while older large trees subject to increased mortality probability with repeat fires.
Rosa minutifolia	Small-leaved rose	MSCP	--/CE	SS	Low	
Tetracoccus dioicus	Parry's tetracoccus	MSCP, MHCP, NCP	--/--	SS	Medium	Dioecious; regenerates readily post fire, initially; but shortened fire return interval at some locations may cause extirpation due to competition with invasive nonnative plants.

[1] Species covered in a Natural Community Conservation Plan does not denote a priority management area. MHCP = Multiple Habitat Conservation Plan; MSCP = Multiple Species Conservation Plan; NCP = North County Plan

[2] Federal State Designation: FE = Federally Endangered; FT = Federally Threatened; BESA = Federally Protected under the Bald Eagle Protection Act of 1940, as amended; CE = California State Endangered; CT = California State Threatened; CSP = California Specially Protected; CSC = California Species of Special Concern; FP = California Fully Protected Species.

[3] MSP Management Categories are described in detail in Vol. 1, Sec. 2.0. Codes are as follows: SL = Species at risk of loss from MSPA; SO = Significant occurrence(s) at risk of loss from MSPA; SS = Species more stable but still requires species-specific management to persist in MSPA; VF = Species with limited distribution in MSPA or needing specific vegetation characteristics requiring management; VG = Species not specifically managed for, but may benefit from vegetation management for VF species.

[4] Overall Fire Risk Categories: Low, Medium or High risk of impact from fire based on 1st Order, 2nd Order Short Term and 2nd Order Long Term risk evaluations.

Table V2.B1-3. Fire risk prioritizations for MSP animal species.

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
INVERTEBRATES									
Branchinecta sandiegonensis	San Diego fairy shrimp	MSCP, NCP	FE/--	SO & VF	Low	Low	Low	Low	
Euphyes vestris harbisoni	Harbison's dun skipper	MHCP, NCP	--/--	SL	Medium	Medium	Low	High	Moderate potential for direct loss of individuals and host plants during extreme fire events. Loss of oak canopy would reduce potential habitat. Longer term, concern is combined impact of drought, fire and invasive plants on the overall quality of habitat.
Euphydryas editha quino	Quino checkerspot butterfly	NCP	FE/--	SL	Medium-High	Medium	Medium	High	Direct loss of larvae and habitat can occur in an extreme fire event but studies also indicate known locations will support QCB following wildfire (2003-2005 USFWS study). Short term possible moderate positive benefit (0-5 years) canopy opens and provides potential sites for larval plants and allows for easier dispersal of adults across the landscape. Long term concern would be invasion of nonnative grasses and filaree. Disturbance could displace cryptogrammic crusts and allow invasive species to outcompete native plant species.
Lycaena hermes	Hermes copper	NCP	--/--	SL	High	High	Medium	High	Impacted by direct mortality and short term habitat loss. Moderate long term risk due to low recolonization after fire. Mature spiny redberry is not a requirement for eggs/larvae. Long term concern is habitat type conversion and

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
									loss of spiny redberry/California buckwheat association.
Callophrys thornei	Thorne's hairstreak butterfly	MSCP	--/--	VF	High	High	Low	High	Potential for high mortality during extreme fire events. Short term loss of habitat, but decreases as Tecate cypress recovers. Longer term threat depends on recovery of Tecate cypress, which is hampered by short fire return intervals. Fire can benefit by germination of host plants and expansion of occupied habitat if source populations are not extirpated.
Panoquina errans	Wandering skipper	MSCP, MH	--/--	VF	Low	Low	Low	Low	
Streptocephalus wootoni	Riverside fairy shrimp	MSCP, MH NCP	FE/--	VF	Low	Low	Low	Low	
FISH									
Gila orcuttii	Arroyo Chub	NCP	--/CSC	SL	Low	Medium-High	High	High	Does not seem to suffocate with ash during fire. Short term there could be significant mud or sediment flows that fill in ponds. Benefits from invasive plant removal by fire. Long term, invasive plant species return and population contracts.
AMPHIBIANS									
Anaxyrus californicus	Arroyo toad	MSCP, NCP	FE/CSC	SO	Low	Low	High	High	Species is underground during fall fires. A spring fire may cause direct mortality. Short term, invasive plants are cleared and species responds positively. Long term, invasive plants return and populations contract.

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
Spea hammondii	Western spadefoot toad	MHCP, NCP	--/CSC	VF	Low	Medium	Medium-High	High	Species is underground during fall fires. A spring fire may cause direct mortality. Some impacts from fire suppression have been observed. Long term, species will suffer from sedimentation of vernal pools.
Taricha torosa	California newt	NCP	--/CSC	VF	Low	High	Medium-High	High	Species lives in very shallow ponds. Debris flow immediately flowing fire could fill in pond. Long term, some occurrences will likely have no real effect but problems with siltation and invasive plants could arise for others.
REPTILES									
Aspidoscelis hyperythra	Orange-throated whiptail	MSCP, MHCP, NCP	--/CSC	VG	Low	Low	Low	Low	
Crotalus ruber	Red diamond rattlesnake	NCP	--/CSC	VG	High (Spring) ; Low (Fall)	Low	Medium-High	High	Risk of mortality is low in a fall fire and high in a spring fire. Snakes are seen immediately after a fire hunting and most likely benefit from an increase in prey. Suppression activities do pose risk to individuals.
Emys pallida	Southwestern pond turtle	MSCP, MHCP, NCP	--/CSC	SL	High	High	High	High	During the fall, species moves away from ponds so fire will result in direct mortality. Short term, there is a risk of siltation and burial of habitat. Long term the species is so limited in distribution that a single fire could elimate all viable populations.
Phrynosoma blainvillii	Blainville's horned lizard	MSCP, NCP	--/CSC	VF coastal & VG inland	Low	Low	Low	Low	
Thamnophis hammondii	Two-striped garter snake	NCP	--/CSC	VG	Low	Low	Low	Low	

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
BIRDS									
Accipiter cooperii	Cooper's hawk	MSCP, MHCP	--/--	VG	Low	Low	Low	Low	
Agelaius tricolor	Tricolored blackbird	MSCP, NCP	--/CSC	SL	Low	Low to Medium	Low	High	Likely only low adult mortality during a fire, although a spring fire could cause nestling mortality. Fire beneficial in creating early successional marsh habitat favored for breeding and open habitat for foraging. Negative short-term impacts could include siltation of breeding ponds and attraction of competitors and predators. During the breeding season pulling water from ponds for firefighting aircraft could impact nesting blackbirds. Not sure long-term indirect impacts on food availability (grasshoppers) or the best fire return interval for maintaining early successional habitat.
Aimophila ruficeps canescens	Southern California rufous-crowned sparrow	MSCP, MHCP, NCP	--/--	VG	Low	Low	Low	Low	
Ammodramus savannarum perpallidus	Grasshopper sparrow	NCP	--/CSC	VF	Low	Low	Low	Low	
Artemisiospiza belli belli	Bell's sparrow	MHCP, NCP	--/--	VF	High	High	Low	High	Mortality is likely high during fire events. Species is declining in coastal San Diego County so fire-related mortality is an issue. Short term, during the first 2 years following fire habitat is degraded (Hargrove and Unitt 2015). As habitat recovers then species increases. Natural fire regime likely benefits this

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
									species by opening up dense shrub canopy.
Aquila chrysaetos canadensis	Golden eagle	MSCP, MHCP, NCP	BEPA/FP	SO	Low	Low	Low	Low	
Athene cunicularia hypugaea	Western burrowing owl	MSCP, NCP	--/CSC	SL	Low	Low	Low	Low	
Branta canadensis	Canada goose	MSCP	--/--	VG	Low	Low	Low	Low	
Buteo regalis	Ferruginous hawk	MSCP	--/--	VG	Low	Low	Low	Low	
Buteo swainsoni	Swainson's hawk	MSCP	--/CT	VG	Low	Low	Low	Low	
Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	MSCP, MHCP, NCP	--/CSC	SO	High	High	High	High	One of the more fire sensitive bird species in southern California (Hargrove and Unitt, in prep.). Occurrences have declined substantially following fire both from mortality and loss of habitat. Cactus can burn severely and may not recover or else take a long time to grow back. Invasive annual plants can degrade habitat, particularly after multiple fires.
Charadrius nivosus nivosus	Western snowy plover	MSCP, MHCP	FT/CSC	SL	Low	Low	Low	Low	
Circus cyaneus	Northern harrier	MSCP, NCP	--/CSC	SO	Low	Low	Low	Low	
Egretta rufescens	Reddish egret	MSCP	--/--	VG	Low	Low	Low	Low	
Empidonax traillii extimus	Southwestern willow flycatcher	MSCP, MHCP, NCP	FE/CE	SL	Low	High	Medium	High	Mortality unlikely unless late spring or early summer fire. Fire at any time of year could destroy nesting habitat along upper San Luis Rey River where most of population occurs. This could

Scientific Name	Common Name	Plans Covered By[1]	Fed/State Desig[2]	MSP Mgmt Cat[3]	1st Order Fire Risk Cat[4]	2nd Order - ST Fire Risk Cat[5]	2nd Order – LT Fire Risk Cat[6]	Overall Fire Risk Cat[7]	Fire Risk Categorization Rationale
									have a devastating short term effect on persistence in southern California, since there are few other pairs elsewhere. Longer term effects could include slow habitat recovery dependent on available water flow and invasion by nonnative plants such as *Arundo donax.*
Falco peregrinus anatum	American peregrine falcon	MSCP, MHCP	--/ FP	VG	Low	Low	Low	Low	
Haliaeetus leucocephalus	Bald eagle	MSCP	--/CE, FP	VG	Low	Low	Low	Low	
Icteria virens	Yellow-breasted chat	MHCP, NCP	--/CSC	VG	Low	Low	Low	Low	
Numenius americanus	Long-billed curlew	MSCP	--/--	VG	Low	Low	Low	Low	
Pandion haliaetus	Osprey	MHCP	--/--	VG	Low	Low	Low	Low	
Passerculus sandwichensis beldingi	Belding's savannah sparrow	MSCP, MHCP	--/CE	VF	Low	Low	Low	Low	
Passerculus sandwichensis rostratus	Large-billed savannah sparrow	MSCP, MHCP	--/CSC	VG	Low	Low	Low	Low	
Pelecanus occidentalis californicus	California brown pelican	MSCP, MHCP	--/FP	VG	Low	Low	Low	Low	
Plegadis chihi	White-faced ibis	MSCP, MHCP, NCP	--/CSC	VG	Low	Low	Low	Low	
Polioptila californica californica	Coastal California gnatcatcher	MSCP, MHCP, NCP	FT/CSC	VF	Low	Medium	Medium	Medium	Recovery of habitat and recolonization following wildfire appears relatively slow for recent large-scale wildfires in San Diego County. Potential long term

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									effects of fire, particularly repeated fire, include degradation of coastal sage scrub and type conversion to nonnative grassland.
Rallus obsoletus levipes	Ridgway's rail	MSCP, MHCP, NCP	FE/CE, FP	SO	Low	Low to Medium	Low	Medium	Main threat is run-off during rainy period that could transport heavy metals from burned areas downstream into the salt marsh.
Sialia mexicana	Western bluebird	MSCP, MHCP	--/--	VG	Low	Low	Low	Low	
Sternula antillarum browni	California least tern	MSCP, MHCP	FE/CE, FP	SO	Low	Low	Low	Low	
Thalesseus elegans	Elegant tern	MSCP, MHCP	--/--	VG	Low	Low	Low	Low	
Vireo bellii pusillus	Least Bell's vireo	MSCP, MHCP, NCP	FE/CE	VF	Low	Low	Low	Low	
MAMMALS									
Antrozous pallidus	Pallid bat	NCP	--/CSC	SL	Low	Low	Medium	Medium	Bats can escape fire and in short term fire opens up habitat for insect foraging. long term, fire can result in loss of roost sites and degradation of foraging habitat by invasive nonnative plants.
Chaetodipus fallax fallax	Northwestern San Diego pocket mouse	MHCP	--/CSC	VG	Low	Low	Low	Low	
Dipodomys stephensi	Stephens' kangaroo rat	MHCP, NCP	FE/CT	VF	Low	Low	Low	Low	

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Lepus californicus bennettii	San Diego black-tailed jackrabbit	MHCP, NCP	--/CSC	VF	High	High	Low	High	Vulnerable to mortality from fire and to short term impacts to habitat from loss of shrub cover.
Odocoileus hemionus fuliginata	Southern mule deer	MSCP, MHCP	--/--	VG	Low	Low	Low	Low	
Plecotus townsendii pallescens	Townsend's big-eared bat	NCP	--/CSC	SO	Low	Low	Medium	Medium	Bats can escape fire and in short term fire opens up habitat for insect foraging. Long term, fire can result in loss of roost sites and degradation of foraging habitat by invasive nonnative plants.
Puma concolor	Mountain lion	MSCP, MHCP, NCP	--/--	SL	Low	Low	Medium	Medium	Initial risk of mortality is low overall but high impact to population if there is loss of even 1 lion. Short term, fire opens up habitat, possibly enhancing food availability. long term can be a moderate risk if there is type conversion of shrubland to grassland.
Taxidea taxus	American badger	MSCP, NCP	--/CSC	SL	Low	Low	Low	Low	

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3 MSP Management Categories are described in detail in Vol. 1, Sec. 2.0. Codes are as follows: SL = Species at risk of loss from MSPA; SO = Significant occurrence(s) at risk of loss from MSPA; SS = Species more stable but still requires species-specific management to persist in MSPA; VF = Species with limited distribution in MSPA or needing specific vegetation characteristics requiring management; VG = Species not specifically managed for, but may benefit from vegetation management for VF species.

4 1st Order Fire Risk Categories: Low, Medium or High risk of mortality from fire.

5 2nd Order Short-Term Fire Risk Categories: Indirect impact from fire such as Low, Medium or High risk of short-term habitat loss or degradation.

[6] 2nd Order Long-Term Fire Risk Categories: Indirect impact from fire such as Low, Medium or High risk of long-term habitat loss or degradation.

[7] Overall Fire Risk Categories: Low, Medium or High risk of impact from fire based on 1st Order, 2nd Order Short-Term and 2nd Order Long-Term risk evaluations.

Power equipment is the most common ignition source for fires in San Diego County and the leading cause of large fires (Syphard and Keeley 2015). The Fire Ignition Reduction Plan should include measures to reduce power equipment ignitions such as public education and outreach about the risk of fire ignitions from power equipment. It should also include implementing the Project Activities Level (PAL) fire danger rating system across the MSPA to regulate use of power equipment during periods of high fire danger (see Rochester and Fisher 2014).

The second most common source of wildfire ignitions in San Diego County is powerlines (Syphard and Keeley 2015). San Diego Gas and Electric (SDG&E) already has a plan to reduce powerline ignitions and is undertaking a variety of measures, such as monitoring the likelihood of fires using a comprehensive weather network, clearing vegetation around utility poles and trimming trees near powerlines, replacing wood poles with steel poles in fire-prone areas, and temporarily depowering lines during extreme Santa Ana wind events (SDG&E 2013). As a result of SDG&E's management of powerline ignition risks, the Fire Ignition Reduction Plan can focus on other causes of wildfire ignitions.

A majority of fires in San Diego County are also started near roads (Syphard and Keeley 2015) and the Fire Ignition Reduction Plan should identify and prioritize areas to reduce roadside ignitions with actions like strategic road hardening, flashy fuel management, and public education and outreach. Ignitions are also greatest in WUIs with intermediate levels of development (Syphard, Clarke, et al.; Syphard, Radeloff, et al. 2007; Price and Bradstock 2014). The plan should also provide recommendations for reducing fire ignitions from target shooting. BLM recently identified recreational shooters using steel shot as an ignition source that could be managed during periods of high fire danger and through outreach and education to reduce accidental ignitions (see Rochester and Fisher 2014). The plan should also include provisions to increase efforts at public outreach and education about wildfire prevention and the importance of defensible space to reduce ignitions and spot fires within residential areas in the WUI.

The Fire Ignition Reduction Plan should also include specifics on developing a volunteer Fire Watch Program modeled after Orange County Fire Watch (OC Fire Watch 2016) to reduce human-caused wildfires. This program sends highly trained volunteers to specific locations with highest probabilities of ignition during periods of high fire danger. These volunteers serve as visual deterrents, report dangerous or suspicious activities to authorities, and assist with early detection and reporting of ignitions. The plan should also include specific ignition reduction measures for at-risk MSP species, as described in species-specific goals and objectives (use links found in Table V2B.1-4). Upon completion of the Fire Ignition Reduction Plan, ignition management actions should be implemented over time, starting with highest-priority actions.

Pre-Fire Objectives: Prepare a Guidebook for Preserve Fire Management Plans

Within the MSPA, there is a need to plan for fires at the preserve level and to integrate this planning into the existing fire management system. Marine Corps Installations (MCI) – West Camp Pendleton has identified the following steps of fire management planning: (1) identify resources at risk, (2) gather data, (3) prioritize those risks, and (4) develop an action plan to protect resources (see Rochester and Fisher 2014). It is important for land owners and managers to coordinate with their responding fire management agencies to develop Preserve Fire Management Plans that determine specific pre-fire, suppression, and post-fire management actions. As part of fire planning, it is critical to acknowledge that, while efforts will be made to avoid impacts to biological resources during fire suppression, the most important priority during extreme fire conditions is human safety and it takes precedence when there is a conflict between protecting natural resources and protecting human life and property (see Rochester and Fisher 2014)

A guidebook with guidelines for developing Preserve Fire Management Plans should be developed collaboratively with input from land owners, land managers, fire management agencies, scientists, and other relevant stakeholders. The purpose of the guidebook is to provide fire and natural resource management recommendations and to ensure plans are consistent with one another in terms of the type of information provided, formatting, symbology, and terminology. This will help reduce confusion when a fire is being suppressed across multiple preserves and by several fire management agencies, including those from out of the area and unfamiliar with the preserves. An inventory should be made of existing Preserve Fire Management Plans and these plans should be evaluated to determine what types of information to include in the guidebook. The guidebook should include recommendations for pre-fire fire risk reduction and post-fire monitoring and rehabilitation of conserved species and vegetation communities. The Santa Monica Mountains National Recreation Area has a fire plan that could also serve as a model in developing the guidebook (NPS 2012).

The guidebook for Preserve Fire Management Plans should include recommendations for identifying pre-approved fire suppression staging areas, identify what suppression actions are appropriate, and identify the type of areas to

Table V2B.1-4. MSP plant and animal species with specific altered fire regime management and monitoring objectives.

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=32426&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=183764&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Bloomeria clevelandii	San Diego goldenstar	SS	https://portal.sdmmp.com/tracker.php?Target=species&Species=509575&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=565077&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Cylindropuntia californica var. californica	Snake cholla	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=913470&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/tracker.php?Target=species&Species=780273&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Dudleya variegata	Variegated dudleya	SS	https://portal.sdmmp.com/tracker.php?Target=species&Species=502182&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Ericameria palmeri ssp. palmeri	Palmer's goldenbush	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=527914&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Euphorbia misera	Cliff spurge	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=28104&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Ferocactus viridescens	San Diego barrel cactus	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=19801&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Fremontodendron mexicanum	Mexican flannelbush	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=21581&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Hazardia orcuttii	Orcutt's hazardia	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=502882&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Lepechinia cardiophylla	Heart-leaved pitcher sage	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=32553&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Monardella stoneana	Jennifer's monardella	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=832834&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=833060&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Nolina cismontana	Chaparral nolina	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=507567&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Nolina interrata	Dehesa nolina	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=42992&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Packera ganderi	Gander's ragwort	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=565357&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=19329&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=779299&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=707282&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Lycaena hermes	Hermes copper	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=777791&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=773514&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=668677&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Phrynosoma blainvillii	Blainville’s horned lizard	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=208819&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=175408&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=917698&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Polioptila californica californica	Coastal California gnatcatcher	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=925072&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

avoid or minimize fire suppression activities to protect sensitive natural resources. It should provide examples of how to evaluate sensitive resources in relation to wildfire risk and to the potential impacts from fire suppression activities. For some resources, it may be best to provide no fire management and let the resource burn as impacts from suppression are sometimes greater than impacts from fire. For other species, it may be most beneficial to employ fire suppression actions to keep the fire from burning the resource.

The guidebook should provide recommendations on pre-fire management actions, such as ignition risk reduction and fuel management to reduce fire risk to protect natural resources. Fuel management objectives should have a goal of minimizing the introduction of invasive nonnative annual plants that can increase flashy fuels and fire ignition risk and that can expand to invade and degrade native vegetation communities. The guidebook should also include recommendations for species-specific fire management actions (see Sec. 1.5.2.2, Species-Specific Approach) and post-fire monitoring and management actions to ensure recovery of conserved species and vegetation communities.

Once the guidebook is completed, Preserve Fire Management Plans should be developed for preserves that have no plans or need to update their plans. Preserves that make up Preserve Complexes that are in proximity and share many of the same resources and fire risks may choose to develop joint Fire Management Plans to coordinate fire management across their boundaries.

Pre-Fire Objective: Integrate Resource Avoidance Area Maps into Fire Management Agency GIS Wildland Decision Support Fire Systems

The "Resource Avoidance Areas Map" from Preserve Fire Management Plans should be made available to fire management agencies in a format that is compatible with their GIS Wildland Fire Decision Support Systems and that includes standardized symbology and mapping criteria adopted by these agencies. This map could also include elements of the *Border Agency Fire Council – Natural Resource Protection Guidebook for Fire Management and Law Enforcement Officers* (BAFC 2010), which has information on property ownership, access, points of contacts, and preferred suppression guidelines for preserve lands. The maps should identify preapproved fire suppression staging areas and identify what suppression actions are appropriate for a site, and areas to avoid or minimize fire suppression activities to protect sensitive resources.

Pre-Fire Objective: Establish a Wildland Fire Resource Advisors Program (WFRAP)

Wildland Fire Resource Advisors (READs) are called in for large fires to provide information to Incident Management Team (IMT), specifically the Operations Chief and Logistics Chief, on resource protection during fire suppression (see Rochester and Fisher 2014). READs are included in the fire incident management team and provide information to the Incident Command on sensitive resources that should be protected. The READs are responsible for providing GIS layers to fire management agencies if they are not already included in GIS Wildland Fire Decision Support Systems and should also have hard copy maps available as backup. The fire agencies need to know where the sensitive resources are, what resources have priority, and what actions are most appropriate to protect these resources. READs help to reduce conflicts between fire suppression and resource protection, with the consideration that human safety is of the highest priority. The READs also coordinate with local U.S. Fish and Wildlife Service (USFWS) and California Department of Fish and Wildlife (CDFW) staff regarding threatened and endangered species issues. The most important role of the READ is to provide a unified, clear message about priority resource protection during fire suppression activities. After the fire, the READs often provide guidance on rehabilitation of fire suppression impacts, such as repairing dozer lines.

Most READs belong to federal or state agencies, and in large fires multiple READs will confer and coordinate to develop a unified message on resource avoidance or mitigation measures to the IMT (Rochester and Fisher 2014). There is a need to develop and coordinate READ participation by local jurisdictions and to integrate this effort into the state and federal READ structure. A group of READs should be (a) established and trained to respond to fires on non-federal and non-state lands, (b) authorized to work across lands held by multiple land owners, and (c) integrated into existing fire response programs. Local READs should be assimilated into a team to work collaboratively with the state and federal READs on fires that cross state, federal, and locally owned lands. Local jurisdiction READs will be required to meet National Wildfire Coordination Group requirements. These include red card certification in fire training, a physical exam, and a work capacity test to ensure minimum requirements for wildland firefighter access. The local READs will also require training in fire command structure and procedures; operating procedures and constraints of the GIS support team providing maps during fires; procedures for providing GIS data and incorporating recommendations for local lands with those of the federal and state READs; and the process for delivering a simple, unified message to the IMT.

An important aspect of fire planning is communication and coordination between land owners and managers, READs, and fire management agencies (Rochester and Fisher 2014). It is important to delineate roles and responsibilities beforehand and to use the wildland fire decision support system for planning, decision making, and responding to fires (see Rochester and Fisher 2014). Meetings should be held between land managers and responding fire management personnel at least annually and more often as needed to develop working relationships and coordinate fire management (Rochester and Fisher 2014). These meetings would help to clarify roles and responsibilities; inform land managers about fire management procedures; familiarize fire agency personnel with the preserve and sensitive resources; and provide guidance on areas to avoid, staging areas for suppression efforts, and areas where firefighting activities are not constrained by sensitive resources.

It is important to increase land manager and READ participation in fire safety organizations such as the California Wildland Fire Coordination Group, in order to foster coordination with fire management personnel (Rochester and Fisher 2014). Providing opportunities to develop personal relationships and learn from one another's experiences will improve collaboration and transfer of knowledge among fire and natural resource management personnel. Wildland fire management is most successful when roles and responsibilities are clearly delineated, there is coordination and communication between all parties, and there is a management strategy based upon known capabilities (see Rochester and Fisher 2014).

Pre-Fire Objectives: Identify and implement priority pre-fire monitoring and management actions for at-risk MSP species occurrences

The MSP Roadmap has species-specific monitoring objectives that are based upon determining population status (e.g., abundance, percent area occupied, distribution, areal extent, etc.) and characterizing habitat associations, and assessing the level of threats at species occurrences. This information should be evaluated to determine which species and occurrences are most at risk from a fire, including species that do not have species-specific fire objectives. Fire risks to consider include invasion of nonnative plants from nearby source populations and accumulation of dense and dead fuels that could severely impact and potentially lead to extirpation of a species' occurrence. Monitoring data should be used to develop a map of those species occurrences most at risk from potential post-fire expansion of invasive nonnative plants. Based upon the monitoring assessment, management actions should be identified and prioritized by the degree of threat invasive plants pose to the species and to individual occurrences. The evaluation should also determine whether fuels management can effectively reduce risk to particular species occurrences vulnerable to extirpation from fires of high severity or large extent. For some MSP species, there may be occurrences where targeted fuel management is warranted to reduce fire severity, although follow-up management may be required to control invasive plants.

Following the evaluation and prioritization, management recommendations should be implemented for those species and occurrences at highest risk from fire.

Suppression Objective: Implement Wildland Fire Resource Advisor Program

During significant wildfire events on local jurisdiction lands, the WFRAP should be implemented with READs representing local jurisdictions participating on the fire incident team. These READs would work with federal and state READs to provide a unified clear message about natural resource protection priorities across land ownerships.

Post-Fire Objective: Monitor and implement post-fire management to promote recovery of at-risk MSP species and vegetation communities

Post-fire recovery of at-risk MSP species and vegetation communities should be monitored over multiple years to inform best management practices (BMPs) and to provide for adaptive management as needed. This includes 3 years of post-fire surveys of MSP species occurrences to track recovery and determine management needs. The monitoring should include mapping of MSP species occurrences, especially mapping the extent of rare plant species occurrences that occur under the canopy of shrubs and are difficult to detect. The surveys will determine if post-fire management of invasive nonnative plants is warranted. Invasive plant control should be conducted for 3 years or longer until control is achieved.

<u>Species-Specific Approach</u>

While wildfire causes direct impacts (i.e., mortality) to MSP species, fire can also have significant effects on their post-fire recovery, both short and long term. Many MSP species and vegetation communities are fire-adapted and may depend on fire or can readily recover following fire. However, an altered fire regime is negatively impacting many MSP species and vegetation communities. In particular, increased fire frequency, size, and intensity, in concert with invasive annual grasses and forbs, is converting native shrublands to nonnative grassland (Keeley and Brennan 2012).

General pre-fire and post-fire monitoring and management objectives described above are applicable to MSP species at risk from fire. Also, there are additional species-specific pre-fire management objectives that include implementing pre-fire ignition reduction measures for at-risk occurrences establishing nurseries to grow native cacti and selected plants for immediate post-fire habitat recovery, enhancing and establishing multiple spatially distinct occurrences for a species to reduce impacts from a single fire, and pre-planning to collect and salvage individuals during a fire event. During a fire, species measures include rescuing individuals from the direct impacts of fire. Post-fire monitoring could include studies to determine mechanisms of post-fire recovery and effects of fire on species and their habitats. Post-fire management could include invasive plant and animal control, habitat enhancement and restoration, and translocations to reestablish occurrences impacted by fire. Descriptions of fire management approach and rationale and goals, objectives, and actions for at-risk MSP species are presented in the corresponding species sections. Links to species-specific fire objectives are provided in Table V2B.1-4. Use the MSP Portal for the most updated list of species with Altered Fire Regime objectives.

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2.0 ALTERED HYDROLOGY

2.1 OVERVIEW

Altered hydrology refers to any anthropogenic disruption in the hydrologic and fluvial processes in the river system (Rosenberg et al. 2000). Changes in the river function can have significant impacts on the habitat for riparian species (Sakaris 2013). Threats to habitat include changes in the amount and timing of stream flow (Dunne and Leopold 1978; Trimble 1997; White and Greer 2002), geomorphological changes like widening and incising (Trimble 1997; Modrick and Georgakakos 2014; Taniguchi and Biggs 2015), and the establishment and persistence of pollutants (Paul and Meyer 2001) and invasive species (Ficetola et al. 2007; Ficetola et al. 2010). Stream channels collect water, sediment, and pollutants from the entire watershed and are highly affected by upstream land uses, especially urbanization.

Stream flow can change drastically as a watershed urbanizes. The increase in upstream impervious surface prevents infiltration and generally reduces evapotranspiration (Dunne and Leopold 1978; Trimble 1997; McBride and Booth 2005). This leads to an increase in the amount of surface flow and ultimately an increase in stream flow. Urban runoff is also faster flowing than natural surface flow, resulting in a reduced time between precipitation and peak stream flow (Dunne and Leopold 1978; Ossola et al. 2015). Changes in the stream flow dynamics can impact the stream morphology and vegetation characteristics.

Dams and stream channelization can alter the riparian vegetation by disrupting the natural stream ecosystems (Sakaris 2013). Dams have varying effects on downstream rivers depending on the timing of water releases and the type of dam (top over v. stream level discharge). Concrete stream channelization can prevent or slow the erosion of the stream channel but removes usable stream habitat and reduces the water infiltration, which many riparian species depend on (Richardson et al. 2007).

2.2 ALTERED HYDROLOGY IN THE MSPA

In the MSPA, the main threats from altered hydrology include aseasonal flow, geomorphological changes to the stream channel, and vegetation community changes in the riparian system.

2.2.1 Aseasonal flow

In urban watershed, there has been an increase in the overall stream flow of San Diego rivers. A study of Los Peñasquitos Creek demonstrated an increase in the minimum, median, and maximum flows from 1960 through 2000, with the minimum increasing faster than then median or maximum. In addition, the dry season runoff increased faster than the annual average, with only a slight increase in precipitation over the same period (White and Greer 2006).

Stream flow is significantly altered during the dry season due to the addition of water in the system from urban uses (Walsh 2000). Under natural conditions, San Diego streams occasionally dried completely during the summer, depending on winter precipitation (Brodie 2013; City of San Diego 2013). Instead, urban runoff from outdoor landscaping or other outdoor uses, creates a system that maintains flow year-round (called aseasonal flow). This change has allowed for the persistence of invasive aquatic species like crawfish and bullfrogs (Ficetola et al. 2007; Ficetola et al. 2010).

2.2.2 Geomorphology

Stream systems have also experienced a change in morphology due to urbanization. The expansion of impervious surface in the watershed increases the rate of channel erosion (Dunne and Leopold 1978; Trimble 1997). An increase in impervious surface concentrates the flow energy on the stream system, causing channels to increase in size. Channels can become either wider or deeper depending on a number of factors; see Sec. 2.3, Results of Altered Hydrology Studies, below.

2.2.3 Vegetation changes

Vegetation changes have resulted from stream flow and geomorphological changes. Portions of Los Peñasquitos Creek changed from a broad and braided channel (1928 and 1945 aerial images) to an incised channel beginning in 1969 (White and Greer 2006). In the same reaches, the acreage and density of riparian vegetation increased from 1928 to 2000. Pieces of the stream that were visible from aerial imagery in 1945 were completely covered by vegetation in 2000. The increase in vegetation consisted mainly of willows growing in previously unoccupied stream banks (White and Greer 2006).

2.3 RESULTS OF ALTERED HYDROLOGY STUDIES IN THE MSPA

Hydrological studies in the MSPA have focused on aseasonal flow originating from urban sources. The USGS recently began a several-year study to identify stream channels vulnerable to aseasonal flow and determine a threshold for the amount of urbanization that leads to a year-round flow (Brown et al. 2015). This study deployed 56 Stream Temperature, Intermittency, and Conductivity (STIC) loggers, which are sensors that record temperature and relative conductivity (water presence). An additional 64 STIC sensors have been placed in arroyo toad habitat in order to relate water presence with the presence of arroyo toads and invasive aquatics. Initial results indicate that there could be a positive relationship between urban areas and the number of days with water present in the stream (C. Brown, pers. comm., September 14, 2016).

Geomophorical studies have focused on the stream channel dimension's relationship to upstream urban and agriculture land uses (Dunne and Leopold 1978; Trimble 1997; Biggs et al. 2010; Tanaguchi and Biggs 2015). In 2015, 80 sites throughout San Diego County, with data from 2001 through 2014 were used to analyze the impact of upstream urbanization on stream channel size and dimensions (Tanaguchi and Biggs 2015). This research found that the majority of urban channels were enlarged, with sand-bedded channels enlarged mainly through incising, and experienced the largest increase in bankfull dimensions. This relationship is also influenced by the age of the development and the stream soil type, with sandy soils more likely to incise and cobbly soils more likely to widen.

2.4 MANAGEMENT AND MONITORING APPROACH

The altered hydrology management and monitoring goal is to reduce the impact of urban runoff and aseasonal flow on the highest-priority MSP species and riparian habitat so that species can persist over the long term (>100 years) in areas upstream and downstream of urban land uses.

The approach for managing an altered hydrologic regime is divided into 2 parts: general and species-specific. General altered hydrology management objectives focus on management actions that benefit natural resources across the MSPA and that are not targeted to particular species. Species-specific altered hydrology management objectives are developed for MSP species identified as at risk from altered hydrology, in which significant occurrences or even the species themselves could be lost from the MSPA as a result of an altered hydrologic regime.

2.4.1 General Approach Objectives

Below is a summary of the management and monitoring objectives for the threat of altered hydrology. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Altered Hydrology summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1449.

Continue USGS Research Using STIC Sensors

Management for aseasonal flow should be directed by continued monitoring of STIC sensor locations. This study should focus on identifying the relationships between watershed size, percent of watershed urbanized, and the number of days with stream flow. The analysis could also consider water temperature changes and the presence of invasive species.

Prepare a Comprehensive Hydrologic Management Plan

The results of the STIC analysis should be used in a comprehensive management plan. The plan should include identification of areas vulnerable to aseasonal flow, priority channels with covered MSP species at risk, and management actions to reduce the water flow or the damages caused by the change in water flow.

2.4.2 Species-specific Approach Objectives

Descriptions of altered hydrology management approach and rationale, and the goals, objectives, and actions for at-risk MSP species are presented in the corresponding species sections. Links to species-specific altered hydrology objectives are provided in Table V2B.2-1. Use the MSP Portal for the most updated list of species with Altered Hydrology objectives.

Table V2B.2-1. MSP plant and animal species with specific altered hydrology management and monitoring objectives.

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Atriplex coulteri	Coulter's saltbush	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=20523&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Atriplex parishii	Parish brittlescale	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=20554&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Centromadia parryi ssp. australis	Southern tarplant	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=780715&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Eryngium aristulatum var. parishii	San Diego button-celery	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=528066&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Fremontodendron mexicanum	Mexican flannelbush	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=21581&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Monardella stoneana	Jennifer's monardella	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=832834&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=833060&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Navarretia fossalis	Spreading navarretia	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=31328&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Orcuttia californica	California orcutt grass	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=41970&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Pogogyne abramsii	San Diego mesa mint	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=32639&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Pogogyne nudiuscula	Otay mesa mint	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=32643&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=19329&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Branchinecta sandiegonensis	San Diego fairy shrimp	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=624043&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=707282&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Panoquina errans	Wandering skipper	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=706557&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Streptocephalus wootoni	Riverside fairy shrimp	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=624020&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=773514&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Spea hammondii	Western spadefoot toad	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=206990&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=668677&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Agelaius tricolor	Tricolored blackbird	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=179060&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

Scientific Name	Common Name	Management Category	Goals Objectives Actions Page Link
Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=917698&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Empidonax traillii extimus	Southwestern willow flycatcher	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=712529&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Passerculus sandwichensis beldingi	Belding's savannah sparrow	VF	https://portal.sdmmp.com/tracker.php?Target=species&Species=179325&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Vireo bellii pusillus	Least Bell's vireo	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=179007&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Antrozous pallidus	Pallid bat	SL	https://portal.sdmmp.com/tracker.php?Target=species&Species=180006&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit
Plecotus townsendii pallescens	Townsend’s big-eared bat	SO	https://portal.sdmmp.com/tracker.php?Target=species&Species=203457&MonMgtObjType=&ActionStatus=&ManagementUnit=&ObjectiveType=&Year=&Preserve=&Short=Long&submit=Submit

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3.0 CLIMATE CHANGE

3.1 OVERVIEW

Global climate is changing as a result of human activities that emit greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O; IPCC 2014). Greenhouse gases trap heat in the atmosphere and are produced from the burning of fossil fuels; burning of trees, wood products, and solid waste; cement production; livestock and agricultural practices; decay of organic waste in landfills; and other industrial activities (EPA 2017). CO_2 makes up 81% of greenhouse gases, followed by CH_4 at 11%, N_2O at 6%, and fluorinated gases at 3%. There is a historical record of global anthropogenic emissions for CO_2 emissions, but not for the other gases. CO_2 has increased from approximately 2 to nearly 40 gigatonnes (Gt) of CO_2 per year since the mid-1800s, with 50% of that increase in the last 40 years (IPCC 2014). Of these emissions, 40% stayed in the atmosphere, 30% were stored in the land in plants and soil, and 30% were absorbed into the ocean. CO_2 is absorbed by plants and used in photosynthesis as part of the biological carbon cycle (EPA 2017). Gases in the atmosphere are trapping heat and have led to an average increase of 0.85 degrees Centigrade (°C) in combined land and sea surface temperatures between 1880 and 2012, with the last 3 decades warmer than any preceding decade since 1850 (IPCC 2014). The ocean is storing heat and beginning to warm as energy accumulates and it is also acidifying with the increase in CO_2.

Climate projections for the future depend on the amount of greenhouse emissions from human activities. Recently, the Coupled Model Intercomparison Project Phase 5 (CMIP5) was completed with predictions averaged across 32–39 different global climate change models and dependent on Representative Concentration Pathways (RCPs) reflecting different emission scenarios (IPCC 2014). The models project an average global temperature increase of 1 to 4°C (1.8 to 7.2 °F) by 2100 depending on the RCP, with steep reductions in CO_2 emissions associated with the smallest temperature increases and increases in emission production leading to the highest temperature increases. However, some areas will be warmer than the global average temperature increase. The southwestern United States, including southern California, and northern Mexico, is considered a persistent climate change hotspot (Diffenbaugh et al. 2008). In this area, the relative changes in climate will be highest and due more to changes in the annual variability of climate variables rather than to changes in long-term means. In southern California, the changes are largely due to variability in precipitation.

CMIP5 highest emission models for the Los Angeles Basin predict that, in 2100, June through October temperatures will be more than 5°C (9°F) hotter than the warmest baseline months between 1980 to 2000 (Sun et al. 2015). There will be a predicted 60–90 more days a year with extreme heat of >35 °C (95 °F). This will shift the Los Angeles climate into a new climate state that is only 50% similar to the baseline climate, with the least amount of change from December through February. Warming is also expected to be greater in summer than winter periods (Cayan, Maurer, et al. 2008).

Global climate change models for the southwestern United States indicate that the region is making a rapid transition to a drier climate (Seager et al. 2007; Cayan et al. 2010). There is greater uncertainty about how precipitation might change in southern California, particularly from Los Angeles south to San Diego; with areas to the north having higher certainty of increased precipitation (Sun et al. 2015). However, there is a growing consensus that southern California will become drier and more vulnerable to drought (Cayan et al. 2010; Franco et al. 2011). Recent modeling indicates that southern California will be drier as it is in the transition zone of increased rain in the mid to high latitudes and decreased rainfall in the tropics (Neelin et al. 2013; Diffenbaugh et al. 2015). The amount of rainfall will be dependent on the Pacific jet stream steering storms toward the California coast. Global climate change models indicate that California will maintain a mediterranean climate, with precipitation largely in the cooler winter months and hot dry summers (Cayan, Maurer, et al. 2008; Franco et al. 2011). Temperature increases will be more extreme in inland areas greater than 50 kilometers from the coast (Messner et al. 2011). More extreme precipitation events in the form of droughts and floods are forecast for the future (Berg and Hall 2015; Diffenbaugh et al. 2015; Monier and Gao 2015).

Droughts are likely to become more frequent and intense as increases in temperature coincide with dry periods (Diffenbaugh et al. 2015). Analysis of historical climate records for California found lower rainfall was 2 times more likely to lead to drought when temperatures were warm and that the occurrence of drought was greater in the last 20 years than in the preceding 100 years (Diffenbaugh et al. 2015). The recent 2012–2014 drought was caused by the co-occurrence of warm and dry conditions (Griffin and Anchukaitis 2014; Diffenbaugh et al. 2015). While low levels of precipitation were important in the 2012–2014 drought, human-caused global warming is estimated to have contributed 8–27% of the increase in drought severity for 2012–2014 and 5–18% for 2014 (Williams et al. 2015a). An increase in global warming means there is 100% probability that increased risk of severe drought will occur in the future (Diffenbaugh et al. 2015). Warming temperatures increase evapotranspiration and the loss of soil moisture and will amplify soil moisture deficits beyond those caused by reductions in precipitation, contributing to an increase in the frequency, duration, and intensity of future droughts (Cayan et al. 2010; Diffenbaugh et al. 2015).

Based on an analysis of a portion of the drought period that extended from 2012–2016, it was found that 2012–2014 was the most extreme drought documented in southern California over the last 1,200 years based on tree ring data and precipitation reconstruction (Griffin and Anchukaitis 2014). The accumulated moisture deficit in 2014 was greater than any previous year. A reanalysis of these data, using spatially based averages to account for differences in precipitation data grid sizes, found that 2 droughts from the years 800 through 2006 were more severe than 2014, but that the 2012–2014 drought period was the most severe and represented a 10,000-year event (Robeson 2015). Extending the drought period to 2015 finds the drought was so severe there is no precedent in previous drought records and that the return interval for a similar drought is incalculably large (Robeson 2015). There is also finer-scale variation in the impact of the 2012–2015 drought within California, with coastal cities being mildly impacted, whereas, inland, more rural areas faced much more severe impacts (Swain 2015).

Based on the CMIP5 global climate models and the “business as usual” RCP, extreme precipitation events leading to flooding are likely to be 3 times more frequent in California from 2060–2100 (Berg and Hall 2015). This increased flooding is due to increased variability as well as increases in average precipitation levels for California as a whole. The CMIP5 climate models indicate there could be 2 times more extreme El Niño events globally due to a warming over the eastern equatorial Pacific that is faster than in surrounding ocean waters (Cai et al. 2014). An extreme El Niño occurred in 2015 but was not associated with higher than normal precipitation in southern California. There was an anomalous high amplitude ridge system associated with the precursor to the El Niño that diverted storm troughs to the northeast United States and away from California (Wang et al. 2014). This ridge is associated with anthropogenic warming during the 2013–2014 winter.

In addition to changes in precipitation, climate change could affect coastal low cloudiness or fog. A decrease in coastal low cloudiness was seen from 1950 to 2012 along the Pacific Coast from Alaska to southern California and was linked to increasing sea temperatures linked to the Pacific Decadal Oscillation (Schwartz et al. 2014). Since the mid-1900s, fog trends have been spatially variable at 24 airports in southern California due to differences in nighttime warming due to the amount of surrounding urban area creating a heat island effect (Williams et al. 2015b).

Coastline and estuaries in San Diego County have started to see an increase in sea level and this will be sharply intensified by 2100. A study of San Diego tidal gauges by Cayan, Bromirski, et al. (2008) found there had been an approximately 2 centimeters/decade average rise in sea level since the 1980s (Cayan, Bromirski, et al. 2008). It is anticipated that sea level will increase to 11–72 centimeters above the historic mean by 2070–2099, depending on the global climate change model and carbon emission scenario considered. The study found that, since the early 1970s, there has been a sharp increase in the number of high sea level events in San Diego. Sea level rise will increase the impacts from high tides and storms, with an upsurge in frequency and intensity of extreme events.

A changing climate may interact with multiple stressors to impact or potentially impact conserved MSP species, vegetation communities, and ecosystem processes. Information on the impacts or potential impacts of climate change on conserved resources and objectives for monitoring and managing the threat of climate change are detailed in sections of Vols. 2A, 2C, and 2D where climate change has been identified as a threat. Specific sections of Vol. 2B have information on other threats that climate change may interact with. Examples of potential impacts include the effects of climate on fire regimes; invasion dynamics of nonnative plants and animals; species responses to novel pests and pathogens; demographic responses of plants leading to changes in community composition and declines in rare plants; decreased surface water flows; rising sea level; changing food webs; phenological mismatches; disruptions of ecosystem services such as pollination; and habitat loss and fragmentation limiting the ability of species to shift their distributions in response to climate change.

3.2 CLIMATE CHANGE IN THE MSPA

Given the scale of climate change, the current and future climate conditions described above for southern California also apply to the MSPA. A specific assessment of future climate change impacts in 2050 for San Diego County was prepared by a team of over 40 scientists and experts as part of the San Diego Foundation's Regional Focus 2050 Study (SDF 2008a,b). If the region does not reduce the current trend in greenhouse gas emissions by 2050 then sea level will be 12–18 inches higher, the climate will be hotter and drier, and wildfires will be more frequent and intense (SDF 2008 a,b). Rising sea levels will mean the reduction and loss of beaches, disappearance of tide pools, increasing high waves, and flooding. Average temperatures will increase approximately 1 to 3°C, heat waves and drought will increase in frequency, intensity, and duration (SDF 2008a,b). The fire season will start earlier with warmer spring temperatures, drought will reduce fuel moisture and increase fire risk, Santa Ana winds may occur over longer portions of the fire season and exacerbate extreme fire conditions, and extreme weather for severe fires will increase by up to 20% (SDF 2008a,b). All of these changes will affect MSP plant and animal species, vegetation communities, and ecosystem processes. Some species may be able to migrate to more suitable conditions, others may disappear (SDF 2008a,b). A significant die-off of trees is expected, entire ecosystems will be stressed, and novel conditions could emerge.

3.3 RESULTS OF CLIMATE CHANGE STUDIES IN THE MSPA

The results of climate change studies in the MSPA are described in the preceding sections. These studies are summarized in the San Diego Foundation's 2015 climate impact assessment (SDF 2008a) and include modeling of future climate conditions under different emission scenarios; an examination of historical sea level rise data and modeling of future conditions; documentation of an increase in fire frequency due to changing climate conditions, including very large Santa Ana wind driven fires; modeling of suitable habitat under climate change and documented impacts to native plant and animals species, including several MSP species; and reductions in the biodiversity of San Diego's ocean habitats.

3.4 MANAGEMENT AND MONITORING APPROACH

The management and monitoring approach to respond to the threat of climate change currently has 5 components for the 2017–2021 and subsequent planning cycles.

The first component is information gathering and analyzing data to evaluate potential responses of conserved natural resources to climate conditions. This involves measuring climate across the MSPA using remote, automated weather stations (see Vol. 2A); monitoring species to document distribution, status, habitat and threat covariates (see Vol. 2D); monitoring vegetation communities to determine composition, structure, and ecological integrity (see Vol. 2C); monitoring ecosystem processes (see Vol. 2A and Vol. 2B); and monitoring various threat covariates that may interact with climate change (see Vol. 2B). Monitoring data will be analyzed to determine the relation between climate variables and measured aspects of MSP species, vegetation communities, ecosystem processes, and threats. An understanding of these relationships is important in developing management strategies to manage threats to promote resilience and adaptation of MSP species, vegetation communities, and ecosystem processes to climate change impacts.

A second component is to model the range in predicted responses of species and vegetation communities to potential future climate conditions, as determined by ensemble habitat models, global climate models, and various RCPs. Potential threats, such as land use change, invasive species, and altered fire regime, can be added to these models to more broadly represent the range in potential future conditions. This information will help to gauge the potential impact of changing climate and other threats on conserved natural resources and to identify potential future refugia. Related to this is an evaluation of the MSPA to determine areas that are projected to see the greatest change in climate versus those areas that remain more similar to current climate and to identify non-analog climates. This modeling can be used to inform future management strategies for MSP species, vegetation communities, and ecosystem processes.

The third component is to manage MSP species, vegetation communities, and ecosystem processes to increase resilience to short-term climate impacts by implementing management actions that reduce the level of other threats (e.g., targeted enhancement and restoration to improve habitat quality, such as controlling nonnative invasive species, enhancing food webs, and improving pollinator services).

The fourth component is to develop longer-term management strategies to facilitate adaptation of MSP species and vegetation communities to changing climate conditions. Examples of potential adaptation actions include using modeling of potential future conditions to manage for connectivity to allow for distributional shifts and potentially assisting migration of species to more suitable habitat and managing for increased genetic diversity to facilitate adaptation to changing conditions.

The fifth component is to monitor resilience and adaptation management actions to determine short-term and long-term effectiveness and improve management strategies.

3.4.1 General Approach Objectives

Below is a summary of the monitoring objectives for climate change in the 2017–2021 planning cycle. There are no general climate change management objectives in the current planning cycle. For the most up-to-date objectives and actions, refer to the MSP Portal Climate Change summary page: https://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1450.

The overall climate change management goal is to maintain and enhance the long-term ecological integrity, resilience, and viability of ecosystems, MSP species, and vegetation communities on Conserved Lands and to facilitate range shifts in species and vegetation communities as necessary for long-term persistence in the region.

There are 2 general approach monitoring objectives for climate change in the 2017–2021 planning cycle. The first objective is to develop habitat suitability models for plant and animal species and vegetation communities under current and future climate scenarios. This will include modeling the influence of other threats, such as altered fire regimes, projected sea level rise, and potential habitat for invasive nonnative species. The range in model predictions can be evaluated to identify where species and vegetation communities may be predicted to persist and where they may need to migrate to more suitable future conditions. The second objective is to establish a long-term monitoring network of remote, automated weather stations and soil moisture/temperature sensors on Conserved Lands across the MSPA. These should be co-located as feasible at permanent, long-term vegetation monitoring plots.

3.4.2 Species-Specific and Vegetation Approach Objectives

Descriptions of climate change management approaches, rationale, goals, objectives, and actions for at-risk MSP species and vegetation communities are presented in the corresponding species, threats, and vegetation sections.

Species-specific and vegetation objectives that address climate change are often combined with other threat objectives to reduce threat impacts and improve resilience of populations to enhance continued persistence. Objectives that pertain to climate change include monitoring to determine the effects of climate variables on various aspects of species and vegetation communities and management to enhance population resilience. These management actions can include controlling invasive nonnative species, restoring habitat to specifically provide more abundant food resources in drought, enhancing linkages to accommodate species range shifts, and creating habitat to escape rising sea levels. There are also climate change-specific objectives to model future conditions for MSP species. Monitoring and management objectives and actions that relate to climate change are presented in the corresponding species and vegetation sections. Links to species-specific and vegetation objectives that apply to climate change are provided in Table V2B.3-1. Use the MSP Portal for the most updated list of species and vegetation communities with Climate Change objectives.

Table V2B.3-1. MSP plant and animal species, and vegetation communities with specific climate change management and monitoring objectives.

Scientific Name	Common Name	Management Category	Summary Page Link
Plants			
Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/view_species.php?taxaid=32426
Acmispon prostratus	Nuttall's acmispon	SO	https://portal.sdmmp.com/view_species.php?taxaid=820047
Aphanisma blitoides	Aphanisma	SL	https://portal.sdmmp.com/view_species.php?taxaid=20679
Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/view_species.php?taxaid=183764
Brodiaea filifolia	Thread-leaved brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=42806
Brodiaea orcuttii	Orcutt's brodiaea	SO	https://portal.sdmmp.com/view_species.php?taxaid=42815
Chloropyron maritimum ssp. maritimum	Salt marsh bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834234
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/view_species.php?taxaid=565077
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/view_species.php?taxaid=780273
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834156
Eryngium aristulatum var. parishii	San Diego button-celery	VF	https://portal.sdmmp.com/view_species.php?taxaid=528066
Erysimum ammophilum	Coast wallflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=22928
Hazardia orcuttii	Orcutt's hazardia	SL	https://portal.sdmmp.com/view_species.php?taxaid=502882
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/view_species.php?taxaid=833060
Navarretia fossalis	Spreading navarretia	VF	https://portal.sdmmp.com/view_species.php?taxaid=31328
Nolina interrata	Dehesa nolina	SO	https://portal.sdmmp.com/view_species.php?taxaid=42992
Orcuttia californica	California orcutt grass	SL	https://portal.sdmmp.com/view_species.php?taxaid=41970
Pogogyne abramsii	San Diego mesa mint	VF	https://portal.sdmmp.com/view_species.php?taxaid=32639
Pogogyne nudiuscula	Otay mesa mint	SL	https://portal.sdmmp.com/view_species.php?taxaid=32643
Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
Tetracoccus dioicus	Parry's tetracoccus	SS	https://portal.sdmmp.com/view_species.php?taxaid=28420

Scientific Name	Common Name	Management Category	Summary Page Link
Invertebrates			
Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/view_species.php?taxaid=707282
Lycaena hermes	Hermes copper	SL	https://portal.sdmmp.com/view_species.php?taxaid=777791
Panoquina errans	Wandering skipper	VF	https://portal.sdmmp.com/view_species.php?taxaid=706557
Amphibians			
Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
Spea hammondii	Western spadefoot toad	VF	https://portal.sdmmp.com/view_species.php?taxaid=206990
Birds			
Athene cunicularia hypugaea	Western burrowing owl	SL	https://portal.sdmmp.com/view_species.php?taxaid=687093
Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/view_species.php?taxaid=917698
Charadrius nivosus nivosus	Western snowy plover	SL	https://portal.sdmmp.com/view_species.php?taxaid=824565
Empidonax traillii extimus	Southwestern willow flycatcher	SL	https://portal.sdmmp.com/view_species.php?taxaid=712529
Passerculus sandwichensis beldingi	Belding's savannah sparrow	VF	https://portal.sdmmp.com/view_species.php?taxaid=179325
Polioptila californica californica	Coastal California gnatcatcher	VF	https://portal.sdmmp.com/view_species.php?taxaid=925072
Rallus obsoletus levipes	Light-footed Ridgway's rail	SO	https://portal.sdmmp.com/view_species.php?taxaid=176211
Sternula antillarum browni	California least tern	SO	https://portal.sdmmp.com/view_species.php?taxaid=825084
Vireo bellii pusillus	Least Bell's vireo	SO	https://portal.sdmmp.com/view_species.php?taxaid=179007
Mammals			
Taxidea taxus	American badger	SL	https://portal.sdmmp.com/view_species.php?taxaid=180565

Scientific Name	Common Name	Management Category	Summary Page Link
Vegetation Communities			
Chaparral	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_3
Coastal Sage Scrub	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_1
Grassland	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_2
Oak Woodland	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
Riparian Forest & Scrub	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7
Salt Marsh	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_6
Southern Interior Cypress Forest	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_9
Torrey Pine Forest	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_8
Vernal Pool/Alkali Playa	NA		https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_4

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4.0 HERBIVORY AND PREDATION

There are no objectives for Herbivory and Predation in the 2017-2021 planning cycle. This section will be included in future planning cycles.

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5.0 HUMAN USE OF THE PRESERVES

5.1 OVERVIEW

Human use of preserves refers to the various activities that humans undertake on a preserve that may have a negative impact on natural resources. These activities primarily include certain types of outdoor recreation described below (e.g., off road vehicles, encampments, shooting, trail use), but also agriculture, some types of reserve management activities (e.g., disking soils, creating fire breaks), and biological surveys, which can all lead to the unintentional spread of invasive plant species. Additionally, humans have intentionally released nonnative species on or adjacent to Conserved Lands (e.g., pigs) that have resulted in significant impacts to MSP species.

Participation in outdoor recreation and the rates of visitation to protected areas are increasing rapidly in the United States (Cordell 2008) and around the world (Balmford et al. 2009). While outdoor recreation is often thought to be compatible with species protection (Reed and Merenlender 2008), there is a growing awareness that even quiet, nonconsumptive recreational activities, such as hiking and wildlife viewing, can affect the distribution and abundance of certain species within protected areas (Reed et al. 2014). Recreation activity has been linked to declines in wildlife species occupancy, changes in spatial or temporal habitat use (George and Crooks 2006; Cardoni et al. 2008), increased physiological stress (Arlettaz et al. 2007), reduced reproductive success (Finney et al. 2005), and behavioral effects such as increased vigilance and flight (Taylor and Knight 2003). Thus, certain types of recreational activities may not be compatible with achieving species conservation goals in the preserves. A growing body of research demonstrates the negative impacts of outdoor recreation on plant and animal communities (Liddle 1997), with recreation the second-leading cause of endangerment to species on U.S. federal lands (Losos et al. 1995). California has the greatest number of listed species threatened by recreation (Czech et al. 2000).

While the impacts from human use in preserve systems can be alarming, outdoor recreation does have many health (Frumkin 2001) and economic benefits (Goodwin 1996). Due to this, it is important that land and wildlife managers find the balance between the benefits of outdoor recreation and its potentially negative effects on species and habitat (Reed et al. 2014). When considering the impacts from recreation, the most important factors are amount of use, type and behavior of use, timing of use, resistance and resilience of the environment, and the spatial distribution of use (Cole 2004).

In San Diego, key objectives of the MSCP and MHCP preserves are to provide passive recreation and educational opportunities, while providing adequate protection for biological resources (The City of San Diego et al. 1998; AMEC Earth & Environmental, Inc. et al. 2003). The plans allow riding and hiking trails within appropriate portions of the preserves to provide passive recreational opportunities for the public. Other passive activities such as photography, bird watching, scientific research, and public education programs are also encouraged. However, excessive or uncontrolled access can result in habitat degradation through trampling and erosion (e.g., along trails) and the disruption of breeding and other critical wildlife functions at certain times of the year. Passive recreational activities (e.g., hiking, bird watching) are generally compatible with the plans' conservation goals. In general, passive activities pose a significant threat to biological resources when the level of recreational use becomes too intense or in areas of sensitive resources.

Therefore, enforcement programs are needed to ensure compliance with land use plans and restrictions to ensure that recreational uses are compatible with preserve goals. Preserve owners and managers should continue providing public education programs to explain open space conservation goals, the natural resources protected, and the regulations in the area (The City of San Diego et al. 1998).

5.1.1 Off-Road Vehicles

The large increase in use of off-road vehicles (ORVs) since the 1960s has generated concern over the negative environmental effects (Baldwin and Stoddard 1973; Brander 1974; Webb and Wilshire 1983, all cited in Boyle and Samson 1985). Recent studies in the Southwest have demonstrated severe effects of ORVs on wildlife of arid regions through direct mortality, harassment, noise, and habitat destruction (Webb and Wilshire 1983, cited in Boyle and Samson 1985). ORV use has been linked with population declines of the desert tortoise and Couch's spadefoot in California (Berry 1980; Bury 1980, both cited in Boyle and Samson 1985). Other studies have shown decreases in density and diversity of desert birds and mammals where use of ORV use was extensive (Busack and Bury 1974; Bury 1978; Luckenbach 1978). Additional adverse effects from ORVs include reductions in air quality due to automotive exhaust and creation of dust, soil erosion and sedimentation into local waters, petrochemical pollutants entering watersheds, transporting and dispersing exotic weed seeds, and illegally dumping trash (Dillingham and Miner 2009). Disturbance from ORVs can also disrupt breeding activities.

Due to the numerous negative impacts from ORVs, they are banned from many preserves in the MSPA. In North County, the MHCP prohibits the use of ORVs. In the South County, ORV use is incompatible with preserves and linkages in the MSCP, except on designated roads and as provided for in the subarea plans.

5.1.2 Encampments

Transients and migrant workers sometimes maintain shelters and living areas illegally within habitat areas (AMEC Earth & Environmental, Inc. et al. 2003). Such living areas have a detrimental effect on native vegetation and wildlife use, including an increase in refuse, poaching of wildlife, increased fires, and raw sewage disposal that can pollute water resources. The volume of refuse generated attracts black rats, which contribute to the decline of native rodent populations. Scattered living areas are difficult to control, but villages of transients are incompatible with the preserve areas and linkages and should be removed (AMEC Earth & Environmental, Inc. et al. 2003) in collaboration with local law enforcement and public welfare agencies.

5.1.3 Shooting

The noise of shooting is known to cause animals to flee from an area and change behavior (Anderson 1995). Birds in particular may break flight formation and become disorganized (Wiseley 1974; Anderson 1995). There are also instances where the sound from shooting has caused geese to fly up and hit transmission lines, buildings, or windows as they try to escape the noise (Anderson 1995). Shooting and other human-caused noise also can cause animals to avoid habitats.

Shooting in the South County has the potential to start fires. Other impacts from recreational target shooting can include destruction of native vegetation; disturbance to wildlife; visual disturbance from natural objects destroyed and landscapes scarred; and visual disturbance from the targets, shells, and ammunition left behind (Tuell 2016). When irresponsible shooters use electronics as targets, they can leave behind cadmium, arsenic, selenium, and mercury. These heavy metals persist in the soil and can contaminate surface or subsurface water.

While lead ammunition is severely restricted in California, a full ban on lead ammunition will not take place until July 1, 2019, as phase 3 of Assembly Bill 711

(CDFW 2016) wraps up. Numerous studies have documented the adverse effects of lead exposure to waterbirds and scavenger species, like eagles and hawks, as well as reptiles and small mammals near shooting ranges (Live Science Staff 2008). Lead poisoning causes behavioral, physiological, and biochemical effects, and often death. Spent ammunition can also slowly dissolve and enter the groundwater, negatively impacting plants, animals, and even people if it enters a water body or is taken up by plants used for consumption.

5.1.4 Trail Use

Trails in the MSPA are used for various types of nonconsumptive recreational activities, including walking, running, biking, wildlife viewing, and equestrian riding. While certain recreation activities are permissible on the preserves, they are not without impacts to native flora and fauna. Trail creation alters the microclimate of the ecosystem, which can lead to decreased nesting near trails; altered bird species composition near trails; and increased nest predation by cowbirds, skunks, raccoons, and foxes using the clearings as corridors (Jordan 2000).

Recreation activities have immediate and long-term impacts on wildlife, with exposure to recreational activities particularly high in urban systems (George and Crooks 2006). A George and Crooks (2006) study assessed activity for bobcat, coyote, mule deer, humans, and domestic dogs along paths in the Nature Reserve of Orange County. In this reserve, the probability of detecting deer during the day was lower with increasing levels of human recreation. Results also suggested that bobcats, and to a lesser degree coyotes, exhibited both spatial and temporal displacement in response to human recreation. Bobcats were detected less frequently and appeared to shift their activity patterns to become more nocturnal in areas with high human use.

Behavioral changes in animals in response to recreation may also include increased time spent vigilant and decreased time resting and foraging; as was the case for caribou in a Canadian ecotourism study (Duchesne et al. 2000). Besides changes in activity patterns, recreation can impact density and community composition of wildlife. In a Reed and Merenlender study (2008), they determined that the presence of dispersed, nonmotorized recreation led to a 5-fold decline in the density of native carnivores and a substantial shift in community composition from native to nonnative species. Results from a Boulder County study suggest that recreational trails may also affect habitat selection of some raptor species in grassland ecosystems (Fletcher Jr. et al. 1999).

High levels of human activity can also impact an animal's alert distance as a Cooper et al. study revealed. They determined that eastern grey squirrels in areas of low human activity had much shorter alert distances than those with high human use (Cooper et al. 2008). However, some animals may simply avoid the areas in and around the trail system due to human use of preserves. This appeared to be the case for pronghorn antelope in Antelope Island State Park, where antelope distanced themselves from the trails following the introduction of human recreation. Over a 3-year trail study, there appeared to be no habituation to recreational users (Fairbanks and Tullous 2002).

While hiking, walking, and jogging may be popular recreational activities in preserves, mountain biking and equestrian riding are additional uses allowed in certain preserves. Mountain biking can impact the habitat and wildlife in ways unlike hiking. Trampling is a major concern for mountain biking that may occur off-trail and when on developed trails, erosion is a major concern. Since mountain bikes travel more swiftly and silently then other forms of recreation, they can have a more pronounced impact on certain animals due to the 'sudden encounter' effect (Chernoff and Quinn 2010). Compared to hikers and runners, horses cause greater compaction of the soil and leaf litter (Dawson et al. 1974; Whittaker 1978). Horses were also found to destroy 8 times as much cover and created an order of magnitude more bare ground than hikers (Nagy and Scotter 1974, cited in Jordan 2000). Additionally, horse manure can be a dispersal mechanism for exotic species in nature preserves (Benninger 1989, cited in Jordan 2000).

Dogs are often brought on trails by humans either on-leash or off-leash. In a Boulder County open space study, in areas that allowed dogs, deer activity was decreased within 100 meters of trails, twice the distance of deer on trails with recreational activity without dogs (Lenth et al. 2006). In addition to mule deer, a Miller et al. study (2001) found sparrows (*Pooecetes gramineus*), western meadowlarks (*Sturnella neglecta*), and American robins (*Turdus migratorius*) all showed elevated sensitivity and flushing distances when dogs accompanied hikers, particularly when off-trail.

5.1.5 Biological Surveys

Human use in the preserves by organizations conducting species and vegetation monitoring and use of preserves by the public can contribute to invasive species spread. Seeds on clothing and shoes can be left in native habitat and aid invasive species in spreading to previously unoccupied areas. Additionally, walking/biking/riding through areas with biologically active soils can disturb the soil crust and provide an invasion opportunity for invasive species from adjacent areas.

5.2 RESULTS OF HUMAN USE STUDIES IN THE MSPA

An increasing number of studies and projects address human use of the preserves in the MSPA. The results and progress of a few of these studies are summarized below, with full descriptions provided in Table V2B.5-1.

Beginning in 2010, the County of San Diego Sheriff's Department and CDFW wardens participated in an Open Space Enforcement Program, funded by SANDAG, to implement an aggressive multi-agency enforcement effort for conservation and management of open space. Goals of the project were to prevent and reduce habitat damage, prevent take of MHCP and MSCP "covered species," reduce preserve management and remediation costs, and support volunteer patrol activities on preserves. This pilot program was viewed as a success by land managers and SANDAG and was continued through 2015.

Several projects funded by TransNet Environmental Mitigation Program (EMP)7 grants resulted in the installation of a steel vehicle barrier in concrete footings with gates along Proctor Valley Road in Jamul. The goal was to prevent trespass by ORVs and prevent the further degradation of sensitive habitats on the property. This Proctor Valley parcel is owned and managed by the City of San Diego Public Utilities Department, and is part of the larger USFWS San Diego National Wildlife Refuge. The barrier was continued through an additional TransNet grant by CDFW and the California Wildlife Foundation. This vehicle barrier has allowed the native habitat to recover and a vernal pool restoration project is now underway.

The City of San Diego Department of Park and Open Space conducted an access study specifically aimed at documenting patterns and trends in use of both open and closed trails within the Del Mar Mesa Preserve. Information from the study directed management and enforcement activities by highlighting problematic areas and periods of highest use. Data showed that increased enforcement resulted in a change in use of closed trails before and after enforcement. Additionally, illegal mountain bikers were the highest user type pre-intervention, but they were no higher than other user groups post-intervention.

[7] Go to www.keepsandiegomoving.org for more information on the *TransNet* EMP.

Table V2B.5-1. Summary of relevant studies on Human Use of Preserves.

Topic/Species	Publication(s)	Summary
Open Space Enforcement Program	San Diego Sheriff's Department Off-Road Enforcement Team, CDFW	An Open Space Enforcement Program to coordinate and implement an aggressive multi-agency enforcement effort for conservation and management of open space in the region. Goals of the project were: (1) Prevent/reduce habitat damage, (2) Reduce/prevent take of MHCP and MSCP "covered species," (3) Reduce preserve management and remediation costs, and (4) Support volunteer patrol activities on preserves. The Off-Road Enforcement Team will provide increased technical and administrative law enforcement services, via overtime from County of San Diego Sheriff's Department and California Department of Fish and Wildlife Game Wardens, to reduce negative impacts on the environment.
Off-road Vehicle Barrier Project Proposal for Proctor Valley Road	CDFW, (City of San Diego Public Utilities Dapartment 2011)	Several TransNet EMP grant projects to prevent trespass by off-road vehicles and the further degradation of sensitive habitats managed by the California Department of Fish and Wildlife and San Diego Public Utilities Department within Proctor Valley. Grant funding led to the installation of steel vehicle barriers in concrete footings with gates along Proctor Valley Road in Jamul. The Chaparral Lands Conservancy also used TransNet grant funds to complete the fencing on private lands where there was a gap between public land parcels.
Access Study Plan for Del Mar Mesa Open Space	City of San Diego	An access study specifically aimed at documenting patterns and trends in use of both open and closed trails within the Del Mar Mesa Preserve. Information from this study directed management and enforcement activities by highlighting problematic areas and periods of highest use. The study also determined that increased enforcement resulted in a change in use of closed trails before and after enforcement. Trail use during and after enforcement was significantly different than the use pre-enforcement. Additionally, illegal mountain bikers were the highest user type pre-intervention, but they were no higher than other user groups post intervention.
Wildlife Response to Human Recreation on NCCP Reserves in San Diego County	Reed et al. 2014	An applied research project to complement existing species and habitat monitoring efforts in San Diego County. The study developed a program to assess the possible effects of human recreation on wildlife populations. Specific objectives were to: (1) Develop recommendations for research studying the effects of recreation on wildlife species; and (2) Test methods for monitoring recreation and complete a pilot field study. First, researchers implemented a systematic review of studies examining the impacts of recreation on wildlife, in

Topic/Species	Publication(s)	Summary
		order to assess what has been studied and where knowledge gaps remained, which species are particularly vulnerable, and what types of effects are the most prevalent. Second, they acquired and augmented a GIS database to facilitate field site selection and spatial analysis. They worked with SDMMP staff members to select 51 reserves for the expert opinion survey and 18 reserves for the pilot field study. Third, they conducted an expert opinion survey to assess relative levels of visitation to a subset of NCCP reserves. Fourth, they implemented a pilot field study to test methods for monitoring recreation visitation and provide a more precise quantitative estimate of actual visitation rates at 18 NCCP reserves. They found that remotely-triggered cameras were the most efficient and cost-effective technique for counting visitors to reserves. They provided recommendations for a research design to study potential impacts of recreation on wildlife species in NCCP reserves and next steps for communicating the results of the project to scientists, land and wildlife managers, and the public.

A Reed et al. (2014) study developed a program to assess the possible effects of human recreation on wildlife populations. Researchers implemented a systematic review of studies examining the impacts of recreation on wildlife. They acquired and augmented a GIS database to facilitate field site selection and spatial analysis. Researchers worked with SDMMP staff members to select 51 reserves for the expert opinion survey and 18 reserves for the pilot field study. Lastly, they implemented a pilot field study to test methods for monitoring recreation visitation and provide a more precise estimate of visitation rates at 18 NCCP reserves. They found that remotely triggered cameras were the most efficient and cost-effective technique for counting visitors. From their assessment, they provided recommendations for a research design to study potential impacts of recreation on wildlife species in NCCP reserves, as well as recommendations for communicating the results of the project to scientists, land and wildlife managers, and the public.

5.3 MANAGEMENT AND MONITORING APPROACH

The goal for managing human use of preserves is to understand and reduce the impacts of human uses on Conserved Lands where human use is reducing the population levels and/or viability of MSP species populations. The approach for managing human use of the preserves is divided into 2 parts: general and species-specific. General objectives focus on supporting research and enforcement programs across the MSPA. Species-specific objectives have been developed for those MSP species identified as at highest risk from loss due to human use in the preserves, and for which specialized objectives are required to ensure their persistence in the MSPA.

In addition to the MSP Roadmap general and species-specific objectives, the MHCP has preserve management recommendations for various recreation types. The MHCP prohibits recreational activities that require the construction of new facilities or roads. When new trail construction is required, design standards should address the avoidance of sensitive species, unique habitats, wildlife corridors, erosion control, and access to major features. Preserve managers should also construct trails to any prominent features or viewpoints that are likely to attract hikers, thereby preventing extensive trampling and compaction.

5.3.1 General Approach Objectives

The general approach for managing the human use in the preserves is to continue supporting recreation research and jurisdictions that are developing enforcement programs, as described below. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Human Use summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1452.

5.4 CONTINUE SUPPORTING ONGOING RECREATION RESEARCH

As the Reed et al. (2014) study highlighted, there are still knowledge gaps surrounding the topic of human use and wildlife. The second phase of the recreation and wildlife study led by researchers at Colorado State University and the Wildlife Conservation Society began in 2016. To ensure that the conservation community makes sound decisions involving human use of the preserves, it is important to support the continuing research on recreation and its impacts on wildlife.

5.5 SUPPORT JURISDICTIONS TO DEVELOP AND IMPLEMENT ENFORCEMENT PROGRAMS

As more humans use the preserves, both legally and illegally, it is important to have more enforcement programs in place to protect the preserves. Jurisdictions should be supported as they develop and implement enforcement programs.

5.6 IMPLEMENT BIOSECURITY MEASURES

Biosecurity measures to prevent the spread of invasive species will be developed as part of the invasive plant and invasive animal strategies. These measures should be included in biological surveys and management actions where appropriate.

Restrict Recreation Uses

Depending on the preserve, passive recreation can be a popular use of the preserve, bringing in hundreds of visitors a day during peak days. To limit the impacts of the passive recreation, preserve managers should limit or restrict passive uses within IMAs and/or significant occurrences of MSP species during the breeding season for animals and peak growing season for plants. They should also work to minimize adverse effects of passive recreation, such as trampling vegetation and erosion. Litter control measures, such as closed garbage cans and recycling bins, should be provided at preserve access points.

Establish Recreational Area Patrols

It is important that visitors to the preserves stay on designated trails and out of sensitive habitat. To ensure this, when possible, managers should establish a recreational area patrol to regulate use of the preserve. Patrol groups could also take note of any unauthorized uses in the preserve, including homeless camps, ORV use, trash dumping, illegal trails, and vandalism. Unauthorized use has been documented to cause habitat and species impacts and is more often documented as occurring close to urban areas. Enforcement actions focused at reducing unauthorized use of preserves have been implemented on some preserves and additional monitoring (camera traps, citizen patrols, etc.) would help focus enforcement and education efforts to reduce impacts.

5.6.1 Species-Specific Approach Objectives

The impacts of human use in the preserves on rare and endemic species can vary widely. Some native species may not be impacted at all by human use, while other rare and endemic species are disproportionately affected. Species for which human use goals and objectives have been identified as part of their management and monitoring approach are identified in Table V2B.5-2. Use the MSP Portal for the most updated list of species with Human Use of Preserves objectives.

Table V2B.5-2. MSP plant and animal species with specific human use management and monitoring objectives.

	Scientific Name	Common Name	Management Category	Summary Page Link
Plants				
	Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/view_species.php?taxaid=32426
	Acmispon prostratus	Nuttall's acmispon	SO	https://portal.sdmmp.com/view_species.php?taxaid=820047
	Agave shawii var shawii	Shaw's agave	SL	https://portal.sdmmp.com/view_species.php?taxaid=810342
	Ambrosia pumila	San Diego ambrosia	SO	https://portal.sdmmp.com/view_species.php?taxaid=36517
	Aphanisma blitoides	Aphanisma	SL	https://portal.sdmmp.com/view_species.php?taxaid=20679
	Atriplex coulteri	Coulter's saltbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=20523
	Atriplex parishii	Parish brittlescale	VF	https://portal.sdmmp.com/view_species.php?taxaid=20554
	Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/view_species.php?taxaid=183764
	Bloomeria clevelandii	San Diego goldenstar	SS	https://portal.sdmmp.com/view_species.php?taxaid=509575
	Brodiaea filifolia	Thread-leaved brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=42806
	Brodiaea orcuttii	Orcutt's brodiaea	SO	https://portal.sdmmp.com/view_species.php?taxaid=42815
	Brodiaea santarosae	Santa Rosa brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=810190
	Centromadia parryi ssp. australis	Southern tarplant	VF	https://portal.sdmmp.com/view_species.php?taxaid=780715
	Chloropyron maritimum ssp. maritimum	Salt marsh bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834234

Scientific Name	Common Name	Management Category	Summary Page Link
Chorizanthe orcuttiana	Orcutt's spineflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=21019
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/view_species.php?taxaid=565077
Cylindropuntia californica var. californica	Snake cholla	VF	https://portal.sdmmp.com/view_species.php?taxaid=913470
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/view_species.php?taxaid=780273
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834156
Dudleya blochmaniae	Blochman’s dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502165
Dudleya brevifolia	Short-leaved dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502166
Dudleya variegata	Variegated dudleya	SS	https://portal.sdmmp.com/view_species.php?taxaid=502182
Dudleya viscida	Sticky dudleya	SS	https://portal.sdmmp.com/view_species.php?taxaid=502185
Ericameria palmeri ssp. palmeri	Palmer's goldenbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=527914
Eryngium aristulatum var. parishii	San Diego button-celery	VF	https://portal.sdmmp.com/view_species.php?taxaid=528066
Erysimum ammophilum	Coast wallflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=22928
Euphorbia misera	Cliff spurge	VF	https://portal.sdmmp.com/view_species.php?taxaid=28104
Ferocactus viridescens	San Diego barrel cactus	VF	https://portal.sdmmp.com/view_species.php?taxaid=19801
Hazardia orcuttii	Orcutt's hazardia	SL	https://portal.sdmmp.com/view_species.php?taxaid=502882
Lepechinia cardiophylla	Heart-leaved pitcher sage	SL	https://portal.sdmmp.com/view_species.php?taxaid=32553
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/view_species.php?taxaid=833060

	Scientific Name	Common Name	Management Category	Summary Page Link
	Navarretia fossalis	Spreading navarretia	VF	https://portal.sdmmp.com/view_species.php?taxaid=31328
	Nolina cismontana	Chaparral nolina	SL	https://portal.sdmmp.com/view_species.php?taxaid=507567
	Orcuttia californica	California orcutt grass	SL	https://portal.sdmmp.com/view_species.php?taxaid=41970
	Packera ganderi	Gander's ragwort	SO	https://portal.sdmmp.com/view_species.php?taxaid=565357
	Pogogyne abramsii	San Diego mesa mint	VF	https://portal.sdmmp.com/view_species.php?taxaid=32639
	Pogogyne nudiuscula	Otay mesa mint	SL	https://portal.sdmmp.com/view_species.php?taxaid=32643
	Rosa minutifolia	Small-leaved rose	SS	https://portal.sdmmp.com/view_species.php?taxaid=504824
	Tetracoccus dioicus	Parry's tetracoccus	SS	https://portal.sdmmp.com/view_species.php?taxaid=28420
Invertebrates				
	Branchinecta sandiegonensis	San Diego fairy shrimp	SL	https://portal.sdmmp.com/view_species.php?taxaid=624043
	Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
	Lycaena hermes	Hermes copper	SL	https://portal.sdmmp.com/view_species.php?taxaid=777791
	Panoquina errans	Wandering skipper	VF	https://portal.sdmmp.com/view_species.php?taxaid=706557
	Streptocephalus wootoni	Riverside fairy shrimp	SL	https://portal.sdmmp.com/view_species.php?taxaid=624020
Amphibians				
	Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
	Spea hammondii	Western spadefoot toad	VF	https://portal.sdmmp.com/view_species.php?taxaid=206990

	Scientific Name	Common Name	Management Category	Summary Page Link
Reptiles				
	Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/view_species.php?taxaid=668677
	Phrynosoma blainvillii	Blainville's horned lizard (Coast horned lizard, San Diego horned lizard)	VF	https://portal.sdmmp.com/view_species.php?taxaid=208819
Birds				
	Agelaius tricolor	Tricolored blackbird	SL	https://portal.sdmmp.com/view_species.php?taxaid=179060
	Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/view_species.php?taxaid=175408
	Athene cunicularia hypugaea	Western burrowing owl	SL	https://portal.sdmmp.com/view_species.php?taxaid=687093
	Charadrius nivosus nivosus	Western snowy plover	SL	https://portal.sdmmp.com/view_species.php?taxaid=824565
	Circus cyaneus	Northern harrier	SO	https://portal.sdmmp.com/view_species.php?taxaid=175430
	Empidonax traillii extimus	Southwestern willow flycatcher	SL	https://portal.sdmmp.com/view_species.php?taxaid=712529
	Passerculus sandwichensis beldingi	Belding's savannah sparrow	VF	https://portal.sdmmp.com/view_species.php?taxaid=179325
	Polioptila californica californica	Coastal California gnatcatcher	VF	https://portal.sdmmp.com/view_species.php?taxaid=925072
	Rallus obsoletus levipes	Light-footed Ridgway's rail	SO	https://portal.sdmmp.com/view_species.php?taxaid=176211

	Scientific Name	Common Name	Management Category	Summary Page Link
	Sternula antillarum browni	California least tern	SO	https://portal.sdmmp.com/view_species.php?taxaid=825084
	Vireo bellii pusillus	Least Bell's vireo	SO	https://portal.sdmmp.com/view_species.php?taxaid=179007
Mammals				
	Antrozous pallidus	Pallid bat	SL	https://portal.sdmmp.com/view_species.php?taxaid=180006
	Lepus californicus bennettii	San Diego black-tailed jackrabbit	VF	https://portal.sdmmp.com/view_species.php?taxaid=900973
	Plecotus townsendii pallescens	Townsend's big-eared bat	SO	https://portal.sdmmp.com/view_species.php?taxaid=203457
	Puma concolor	Mountain lion	SL	https://portal.sdmmp.com/view_species.php?taxaid=552479
Vegetation Communities				
	Salt Marsh			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_6
	Torrey Pine Forest			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_8
	Vernal Pool/Alkali Playa			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_4

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6.0 INVASIVE ANIMALS

6.1 OVERVIEW

Invasive animals refer to aquatic and terrestrial animal species, including pests, that are not native to the area and that tend to spread to a degree that causes damage to MSP species and/or the habitats they depend on. Invasive animals "threaten the diversity or abundance of native species through competition for resources, predation, parasitism, interbreeding with native populations, transmitting disease or causing physical or chemical changes to the invaded habitat" (CDFW 2016).

The species composition of natural communities in the San Diego region has undergone significant changes since the area was first settled. Many invasive animals have entered the area through accidental introduction via commercial shipping, small fishing boats, and commercial watercraft (CDFW 2016). Other means of unintentional spread occur when people travel between natural areas, farms, or waterways, carrying the exotic species on their vehicles, boats, equipment, or clothing. Additionally, there have been intentional introduction of animals brought in as sources of food, fur, or pets.

Prevention is the best strategy for managing invasive animal species. While not all nonnative species will survive introduction into a new system, nonnative species that are particularly invasive will be able to establish and become difficult to remove. Once an invasive animal species has been introduced to an area, early detection and rapid response are the best ways to stop the spread of an invasion. The longer an infestation is allowed to progress, the more extensive the damage and costs for control, and the less efficient the control efforts CDFW 2016).

To avoid costly treatments aimed at species eradication, it is imperative to focus efforts on prevention efforts. At least, prevention efforts should include increased education/public information, coordination, and cooperation. Additionally, prevention efforts often require exclusionary policies or apparatuses (technologies, facilities, and personnel) (McNeely et al. 2001; National Invasive Species Council 2001; Wittenberg and Cock 2001). Screening systems, codes of conduct, preclearance, and compliance agreements are also means of biosecurity (Meyerson and Reaser 2002).

6.1.1 Biosecurity

Biosecurity measures are the best way to strengthen and promote prevention efforts. In an ecological context, biosecurity refers to preventative measures intended to reduce the risk of nonnative and invasive species (plant, mammal, invertebrate, etc.) introduction and spread. The costs of nonnative species invasions and the costs to control those species often outweigh the financial costs of limiting or preventing the invasion in the first place. Biosecurity is a means of controlling invasions and may include surveillance programs and networks, identification of specimen to the species level, mandatory restrictions, and more. Biosecurity includes prevention, early detection, and rapid response.

6.1.2 Early Detection Rapid Response

Once a species is beyond prevention measures, time becomes the most important predictor for the significance of its effect (Meyerson and Reaser 2002). Early detection is imperative for reducing the costs for controlling the species and increasing the possibility for eradication. Effective early eradication systems consist of inventory and monitoring programs conducted by knowledgeable surveyors (National Invasive Species Council 2001; Wittenberg and Cock 2001). The ability to accurately identify any intercepted specimen to the species level is essential for early detection system (Armstrong and Ball 2005). High priority should be given to pathways and sites of potential invasion that are of particularly high risk (Meyerson and Reaser 2002).

Once an invasive animal is detected, mechanisms must be in place for a quick response for eradication, control, or containment. Meyerson and Reaser recommend developing a rapid response program, in close cooperation with state and local efforts, to immediately respond to the invasive animal detection. This program would require governments and other bodies to establish emergency action funding, establish or modify policies to support rapid response, and develop and improve techniques to eradicate and control invasives (Meyerson and Reaser 2002).

The key elements of any response include positive identification of the suspect exotic animal; identification of the incursion pathway; establishing the extent of the spread; eradication, containment, or other management actions; consultation; and communications (Pascoe 2002).

6.2 EFFECTS OF INVASIVE ANIMALS ON SOUTHERN CALIFORNIA ECOSYSTEMS

Invasive animals can impact the native species and habitat in a single way or many ways, sometimes directly and sometimes indirectly. A few of those impacts are summarized below.

6.2.1 Agriculture

Invasive pests that destroy native plants can also have large impacts on agricultural plants. The shot hole borer (*Euwallacea* sp. *#1 and Euwallacea* sp. #5) is such a pest and poses a severe threat to the agricultural industry. It uses avocado trees as its reproductive host and has been known to attack 12 other agriculturally important crops (Eskalen et al. 2013). Shot hole borer infestations cause *Fusarium* dieback in infected avocado trees, causing branch dieback and sometimes death of the tree. See further discussion below on impacts of shot-hole borer and *Fusarium* dieback to native vegetation.

6.2.2 Competition for Resources

Competition for resources from invasive animals can have detrimental impacts to native animal species. For example, European starlings (*Sturnus vulgaris*) compete with cavity-nesting birds for nesting sites. Brown-headed cowbirds (*Molothrus ater*) also compete with native birds through nest parasitism, leading to native birds unknowingly rearing brown-headed cowbird chicks instead of their own (Leatherman BioConsulting Inc. 2012). Invasive red-eared sliders (*Trachemys scripta elegans*) will outcompete the native southwestern pond turtle for food, egg-laying sites, and basking sites (Brown et al. 2015).

6.2.3 Disease

Invasive animals can spread bacterial, protozoal, and viral pathogens directly to native species through contact, or indirectly through fleas and other vectors. Cats (*Felis catus*), parrots (various spp.), and opossums (*Didelphis virginiana*) are a few of the nonnative animals in San Diego that could pose disease threats to the native species (Fisher, pers. comm., 2016).

6.2.4 Food Webs

Invasive animals can disrupt food webs in natural areas directly through predation, or indirectly through the consumption of prey species, increasing competition for the native species. Invasive animals can also alter food webs through the disruption of native pollinators and other arthropods. An example of this is the Argentine ant (*Linepithema humile*), which displaces native arthropods that are an important food source for several bird species, the Blainville's horned lizard, and others (Holway and Suarez 2006).

6.2.5 Genetics

While hybridization is less of a concern with animals than with plants, it can still occur in rare cases and present problems for native species genetics. The Sonoran spotted whiptail (*Aspidoscelis sonorae*) is an example of an invasive animal presenting such a problem. This lizard is native to southeastern Arizona, but has recently been found in Orange County. As a parthenogenic species, if this species were to reach San Diego, it is possible for it to hybridize with the native whiptails (Fisher, pers. comm., 2016).

6.2.6 Habitat

In addition to direct impacts on native species, invasive animals can also degrade and reduce the habitat available to native species. For example, rooting by feral pigs (*Sus scrofa*), overturns surface vegetation and below ground plant tissue (Sweitzer and Van Vuren 2008). Additionally, rooting in riparian zones disturbs sensitive vegetation and increases the risk of invasive plant spread.

6.2.7 Reproduction

Invasive animals can hinder reproduction of native species through consumption of their eggs and larvae. For example, the egg masses of the California newt (*Taricha torosa*), are consumed by the invasive swamp crayfish (*Procambarus clarkia*) (Kats et al. 2013). The egg masses contain a neurotoxin that deters most native species; however, the nonnative swamp crayfish are not deterred. Many streams with crayfish have experienced declines or complete elimination of California newts. Argentine ants can also impact the reproduction of San Diego barrel cactus (*Ferocactus viridescens*) by displacing native ants and deterring pollinators, resulting in reduced seed production by the barrel cactus (LeVan et al. 2014).

6.3 INVASIVE ANIMALS IN THE MSPA

Numerous nonnative aquatic and terrestrial animal species are present in the MSPA. While not all are invasive, there are many alien species that qualify as invasive due to their ability to persist in the region and cause harm to the native flora and fauna.

6.3.1 Invasive Aquatic Animal Species

Numerous exotic aquatic species have been introduced into southern California streams, ponds, and rivers. These invasive aquatic animals include red-eared sliders, largemouth bass (*Micropterus salmoides*), brown trout (*Salmo trutta*), black bullhead (*Ameiurus melas*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), mosquitofish (*Gambusia affinis*), African clawed frog (*Xenopus laevis*), American bullfrog (*Rana catesbeiana*), crayfish (*Procambatus clarkia*), and tiger salamander (*Ambystoma tigrinum*). These exotic species prey upon and/or compete for food with MSP species such as southwestern pond turtle and arroyo toad as well as other native amphibians and fish (Madden-Smith et al. 2005).

Historically, most southern California streams and rivers were ephemeral, drying up during the summer drought. However, increasing urbanization in the region has caused many streams and rivers to become perennial or for pools to persist as a result of water transfers between reservoirs, storm event urban runoff, and aseasonal flows from developed areas. This allows establishment and persistence of exotic aquatic species that could not persist when streams and rivers were dry during much of the year (Miller et al. 2012). When more than 8% of a watershed is developed, native amphibian species populations decline (Riley et al. 2005; Miller et al. 2012).

6.3.2 Invasive Terrestrial Animal Species

The terrestrial invasive species of concern include Argentine ants, brown-headed cowbirds, feral pigs, feral cats, the goldspotted oak borer (*Agrilus auroguttatus*), shot-hole borers, and more. A few of these species are described in more detail below.

<u>Argentine Ants</u>

Argentine ant populations are present throughout urban areas in San Diego County. Argentine ants tend to replace native ants by outcompeting them for resources (Suarez, Bolger, and Case 1998; Holway and Suarez 2006). They can also alter the composition and abundance of native arthropod communities; prey upon dependent baby birds and mammals; and eliminate native ant resources for the horned lizard, ground-foraging birds, and other species. Cactus bees spent less time in flowers of San Diego barrel cactus (*Ferocactus viridescens*) that were occupied by the Argentine ant compared to those occupied by the native *Crematogaster californica.* This decrease in the duration of visits is likely the cause for the decrease in seed set per fruit by cacti occupied by Argentine ants, and likely the cause of the production of fewer seeds overall.

Conserved Lands bordering urban areas and riparian corridors are at greatest risk of Argentine ant infestation. Conserved Lands less than 250 meters from an urban or agricultural edge may have significantly higher populations of Argentine ants and reduced native arthropod diversity and abundance, including fewer native ant species (Bolger 2007; Mitrovich et al. 2010). In narrow preserves, little to no portion of the preserve may be more than 250 meters from the urban edge (Figure V2B.6-1), such as the predominate situation found in MU2 where 93% of Conserved Lands are in urban edge (Table V2B.6-1).

Native ants tend to adapt to drought conditions more easily than Argentine ants and extended droughts can eliminate Argentine ants from some areas. Moist/wet conditions, created by urban drool, green waste dumping, irrigation along the edge and within preserves, and mulching within and adjacent to preserves can all contribute to Argentine ant invasion and occupancy of Conserved Lands (Mitrovich et al. 2010). In San Diego County, Argentine ant numbers fluctuate annually, most likely due to rainfall patterns. Global climate change may pose a unique threat to native ants and other invertebrates by changing rainfall patterns and increasing the distance from edge of preserves that Argentine ants occupy (Bolger 2007).

Brown-headed Cowbird

Brown-headed cowbirds are native to the Great Plains where they historically followed herds of grazing bison. However, in the late 1800s, brown-headed cowbirds expanded their range into California (Unitt 1984) due to landscape conversions. They were first recorded in San Diego County in 1862 near Cuyamaca Peak. The first incidence of breeding was reported in 1911 in National City, with eggs found in the nests of the least Bell's vireo. Cowbirds are now widely distributed and abundant as breeding summer residents throughout San Diego County and as localized winter visitors.

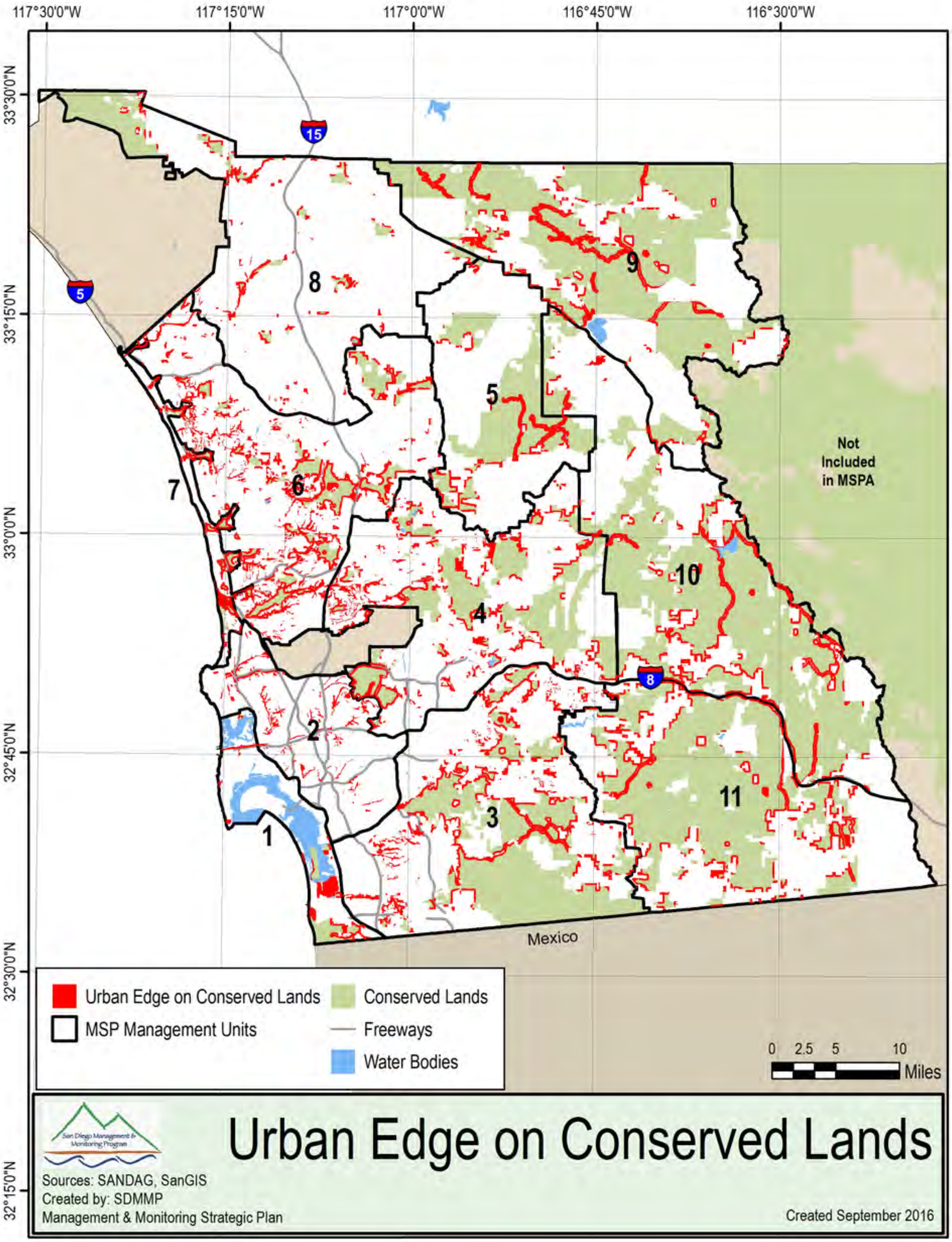

Figure V2B.6-1. Conserved Lands within 250 meters of an urban edge that are at risk of invasion by Argentine Ants.

Table V2B.6-1. Percent of area of Conserved Lands with urban edge.

MU	Acres of Conserved Land in Urban Edge	Total Acres of Conserved Land	Percent of Conserved Land in Urban Edge
1	3,742.4	7,245.6	51.7
2	5,520.7	6,736.2	82.0
3	20,388.5	85,122.9	24.0
4	17,484.5	58,467.2	29.9
5	6,612.5	40,129.2	16.5
6	27,630.5	42,946.3	64.3
7	3,029.5	3,817.8	79.4
8	5,964.3	23,881.6	25.0
9	17,571.1	137,926.2	12.7
10	18,759.7	141,868.2	13.2
11	17,262.3	115,258.8	15.0

Brown-headed cowbirds are obligate brood parasites that lay their eggs in the nests of other bird species, often destroying or expelling the eggs and young of the host species. The cowbirds rely on the host species to incubate their eggs and raise their young (Leatherman BioConsulting Inc. 2012). As a result of this parasitism, noticeable declines in passerine birds have been observed since the 1940s (Grinnell and Miller 1944). Cowbirds are extreme generalists and are known to parasitize over 200 North American bird species (Friedmann and Kiff 1985, cited in Uyehara et al. 2000). Female cowbirds arrive at their breeding sites between mid-April to early-May (Fleischer et al. 1987; Braden et al. 1997), with most females laying eggs in May and June (Uyehara et al. 2000).

While some species from the Great Plains develop behavioral adaptations to deal with the parasitism, most southern California bird species do not recognize the cowbird eggs and will readily accept the egg as their own (Leatherman BioConsulting Inc. 2012). In a parasitized nest, cowbird young often hatch earlier and develop faster than the host young (Rothstein 2004). Cowbird young then outcompete the host nestlings, leading to substantially reduced reproductive success for the host species. Cowbird parasitism presents an additional threat to the federally endangered southwestern willow flycatcher and least Bell's vireo as well as the federally threatened coastal California gnatcatcher (*Polioptila californica californica*); these are species that are already experiencing extreme habitat loss and degradation (Rothstein 2004; California Department of Parks and Recreation [CDPR] 2007).

Brown-headed cowbirds frequently parasitize least Bell's vireos and southwestern willow flycatcher nests (Kus and Whitfield 2005; Sharp and Kus 2006) and have contributed to the decline of these 2 federally-listed species. Vireo nests that occur in high-density understory vegetation are less likely to be parasitized. Cowbird control has been a major focus of management of these 2 species in southern California. Over the past 20 years, trapping and removal of cowbirds has increased productivity of least Bell's vireos, resulting in an 8-fold population increase (Kus and Whitfield 2005). However, flycatchers have not increased in the same manner and may be more affected by other aspects of habitat quality and other unknown factors.

Cowbird trapping and nest monitoring during the nesting season has been an effective short-term, local control strategy for the recovery of vireo populations (McGraw 2006). However, trapping and nest monitoring has not reduced overall cowbird populations and should not be used as a long-term recovery strategy. Additionally, open-ended control of cowbirds may remove the selective pressures that allow the native species to evolve nest parasitism defenses (Kus and Whitfield 2005). These defenses have been observed in least Bell's vireo, a species that has been in contact with the cowbirds for a longer period of time (Parker 1999).

While cowbird removal has been effective at increasing vireo populations, it shifts the emphasis from managing other threats and leads to a long-term dependence on intensive management. If cowbird control is to be effective long term, suitable habitat must exist. An evaluation of alternative management approaches, including the protection and restoration of habitat, as well as the maintenance of natural processes, should be considered. USGS is currently evaluating brown-headed cowbird trapping programs to develop a trapping strategy that addresses recruitment and natural selection, and is cost effective to implement.

Feral Pigs

The first feral pigs in San Diego County were observed in 2006 (SANDAG 2014) and have the potential to severely impact many MSP species. Feral pigs spread rapidly throughout the eastern portion of the county, with the large pig concentrations in the Upper San Diego River area and its tributaries, lands on Palomar Mountain, and lands adjacent to Lake Henshaw (Figure V2B.6-2). Feral pigs threaten San Diego's native ecosystem due to their omnivorous diets and rooting behavior

(California Department of Parks and Recreation 2013). As opportunistic omnivores, pigs primarily eat plants "(roots, tubers, fruit, acorns, etc.), but they will also eat worms, insects, small mammals, eggs, and young of ground-nesting birds and reptiles" (California Department of Parks and Recreation 2013). MSP species particularly susceptible to pig damage include species at high risk of extirpation from the MSPA (e.g., southwestern pond turtle, willowy monardella, and arroyo toad).

Rooting overturns surface vegetation and plant tissue below the ground, exposing the soils to warming, drying, and erosion (Sweitzer and Van Vuren 2008). The soil nutrient process is also affected by rooting due to "the combined effects of aeration, mixing of different soil layers, and increased water infiltration that may leach some nutrients" (Lacki and Lancia 1986; Cushman et al. 2004). Rooting activity also damages seedlings, which is especially problematic for the regeneration of oak woodlands (Sweitzer and Van Vuren 2008). In San Diego, feral pigs root in riparian zones, disturbing sensitive vegetation and increasing the risk of invasive plant spread. Physical destruction of nests and eggs, and the destruction of water quality due to turbidity and bacterial contamination are added concerns (California Department of Parks and Recreation 2013). Apart from the degradation of San Diego's natural habitats, feral pigs also damage agricultural crops and private property. Additionally, there are food safety concerns and the potential for disease outbreak (Kreith 2007).

The San Diego County feral pig population appears isolated from populations in other counties and Baja California, Mexico, making it possible to eradicate the San Diego County population (SANDAG 2014). In 2012, USFS and BLM completed a Wildlife & Botany Biological Evaluation and Assessment for their feral pig management program on the Cleveland National Forest, BLM Lands and Capitan Grande Indian Reservation (Wells 2012). The management areas for the program covered San Diego, Orange, and Northern Riverside Counties and included 423,472 acres of National Forest lands, 179,694 acres of BLM lands, and 15,540 acres of tribal lands. This management program, consisting of census, monitoring, and removal programs, was intended to expand on existing efforts.

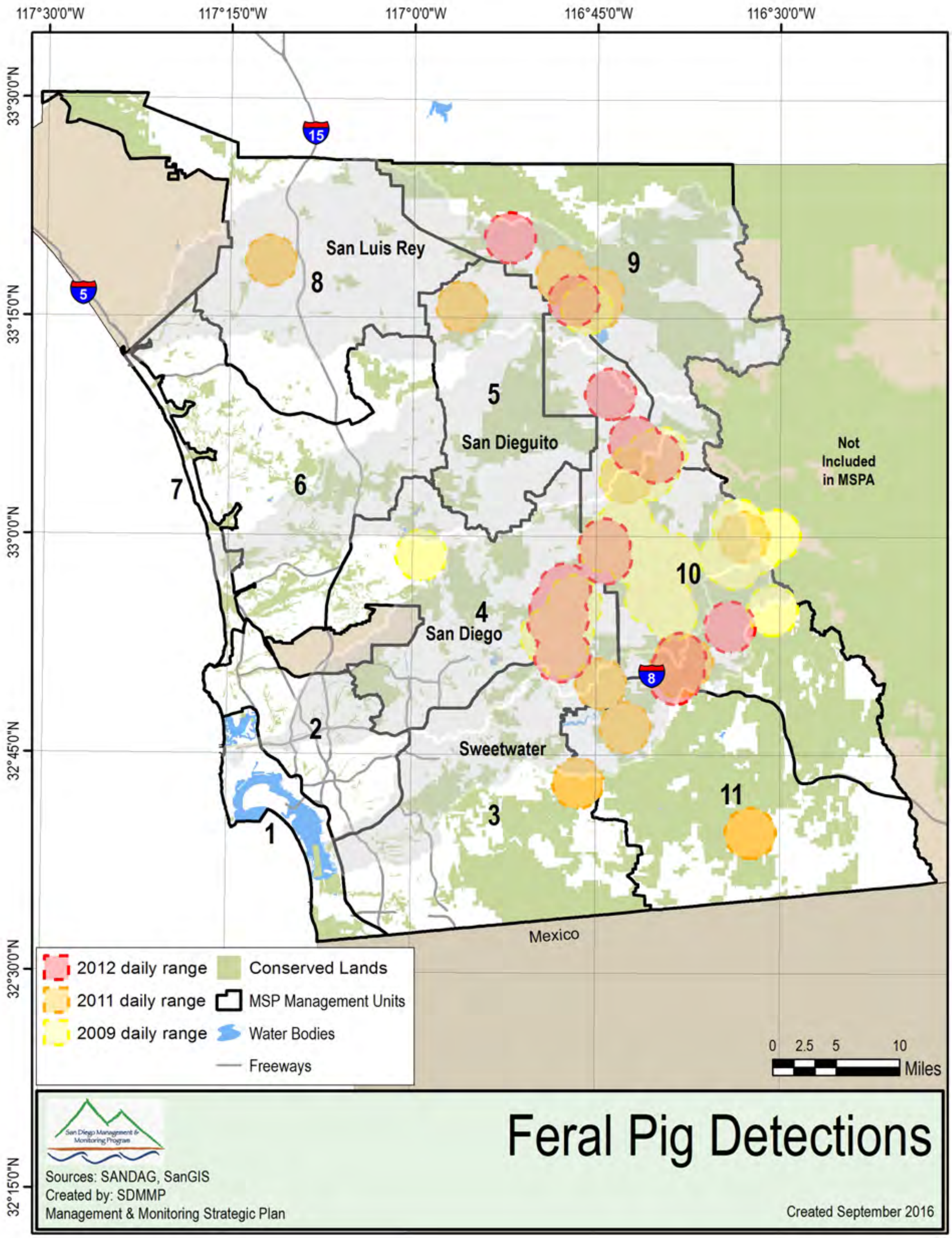

Figure V2B.6-2. Expansion of feral pigs into MSP lands since 2009.

In 2013, the State of California Department of Parks and Recreation completed the Draft Initial Study and Mitigated Negative Declaration Feral Pig Eradication and Control Project for the County of San Diego, with CDFW, City of San Diego, County of San Diego, Vista Irrigation District, and Helix Water District as responsible agencies (CDPR 2013). The primary elements of this project included inventory of pig populations, removal of feral pigs, and monitoring.

A 2014 eradication project by SANDAG and APHIS leveraged federal, state, and regional funding to maximize efficiency and cost sharing (SANDAG 2014). This 2-year project funded APHIS Wildlife Services staff members to monitor and eliminate feral pigs and feral pig sounders. After completion of this project in June 2016, the focus has switched to continued monitoring.

Feral Cats

Globally, domestic free-ranging cats are 1 of the 100 worst invasive animal species (Lowe et al. 2000) and have contributed to multiple wildlife extinctions on islands (Loss et al. 2013). A study by Loss et al. estimates that free-ranging cats kill 1.3–4.0 billion birds and 6.3–22.3 billion mammals annually in the United States These kills are primarily from feral cats rather than free-ranging pet cats. While the prey species preference appears to depend on the landscape type, on average, 33% of the birds killed were nonnative species. This amount of bird mortality from cats is greater than any other mortality source, such as collisions with windows, buildings, communication towers, and vehicles and pesticide poisoning. There are minimal studies on cat predation on reptiles and amphibians, but Loss et al. estimate the loss to be about 228–871 million reptiles and 86–320 million amphibians.

Fragmented habitat in California may be at a greater risk from feral cats, as increased predation is likely to occur in fragments <1.4 square kilometers where there is a higher density of cats (Soule et al. 1988; Crooks 2002). Circumstantial and anecdotal evidence suggests that domestic cats, along with gray foxes, are major contributors in the disappearance of wildlife from canyons (Soule et al. 1988). Cats are particularly detrimental as they will continue to kill wildlife in canyons long after the prey density is too low to sustain native predators; this is often due to their subsidized diet provided by humans.

From a study in an urban Michigan watershed, Ram et al. (2007) explained that cats and dogs contribute to more fecal coliform bacteria contamination than other sources, with cats twice as likely to be the source. From their findings, they emphasize the need for source tracking of cat fecal contamination of stormwater.

In addition to degrading water quality of water bodies on land, fecal coliform bacteria from cats can harm sea mammals, including Pacific harbor seals (*Phoca vitulina richardsi*) and California sea lions (*Zalophus californianus*) (Conrad et al. 2005).

While coyotes help to control the cat populations in canyons (Soule et al. 1988), more control is necessary. Models indicate that 71–94% of a feral cat population must be neutered, and there must not be any immigration, for the population to decline (Andersen et al. 2004; Foley et al. 2005).

<u>Goldspotted Oak Borer</u>

The goldspotted oak borer is a flat-headed borer that was introduced to California via infested firewood from Arizona (Lynch et al. 2013). It was first identified in California in 2004, but extensive oak mortality was not reported until 2008 (Hishinuma et al. 2011). By 2010, an estimated 21,500 trees had been killed, covering 1,893 square miles of San Diego County forests, parks, and residential landscapes (Hishinuma et al. 2011).

Goldspotted oak borer larvae feed under the bark of certain oaks near the phloem and xylem interface, which is the tissue where nutrients and water are conducted. The larvae damage both of these tissue layers, as well as the cambium, a unicellular layer responsible for radial growth (Hishinuma et al. 2011). Infested trees die after several years of injury inflicted by multiple generations of goldspotted oak borer. Trees that are predisposed by other injury, such as drought and root disease, succumb more quickly to the goldspotted oak borer effects (Coleman et al. 2015). In southern California, goldspotted oak borer is known to injure and kill coast live oak (*Quercus agrifolia*); California black oak (*Q. kelloggii*); canyon live oak (*Q. Chrysolepis*); and, in extremely rare cases, Engelmann oak (*Q. engelmannii*) (Hishinuma et al. 2011).

<u>Polyphagus/Kuroshio Shot Hole Borer</u>

Polyphagous shot hole borer, ***Euwallacea sp. #1***, and Kuroshio shot hole borer, ***Euwallacea*** sp. #5, collectively referred to as shot hole borers, are vectors for the invasive plant disease, *Fusarium* dieback. These shot hole borers are invasive ambrosia beetles known to severely damage tree species in riparian communities and urban areas through their symbiosis with *Fusarium* sp. (SANDAG 2016 *draft*). The beetles also pose a severe threat to the agricultural industry where they use avocado trees as a reproductive host. The polyphagous shot hole borer has been known to attack 12 other agriculturally important crops (Eskalen et al. 2013).

Polyphagous shot hole borer was first reported in southern California in 2003 and misidentified as the tea shot hole borer (Eskalen et al. 2012). The first Kuroshio shot hole borer was discovered in San Diego in 2014 (Sloss 2016). Female adult beetles create brood galleries beyond the cambium inoculating the walls of the gallery with the fungus, *Fusarium* sp., as they bore into a host tree species (Eskalen et al. 2013). The fungus will grow and feed both the larvae and adults, eventually blocking the transport tissue of the host (Freeman et al. 2013; Mendel et al. 2012). This prevents movement of water and nutrients to the upper canopy causing associated branch dieback and tree mortality (Freeman et al. 2013; Eskalen et al. 2013; Mendel et al. 2012).

6.4 RESULTS OF INVASIVE ANIMAL STUDIES IN THE MSPA

There are many studies addressing invasive animals in the MSPA. The results and progress of a few of these studies are summarized below, and a more comprehensive list is provided in Table V2B.6-2.

In 2012, USGS began assessing native and nonnative turtles, as well as suitable habitat for pond turtles in coastal northern San Diego County (Brown et al. 2015). Before successful management can be implemented, the distribution and status of pond turtles and aquatic nonnatives had to be determined. USGS determined that nonnative turtles were more abundant than southwestern pond turtles within the study area. Southwestern pond turtles were detected at 2 sites, while nonnative turtles were detected at 18 sites, including the sites with the native turtles. Nonnative centrarchid fishes were detected at 16 sites, American bullfrogs were detected at 12 sites, and red swamp crayfish were detected at 12 of the sites. In contrast, the only native species beside the pond turtle that was detected was the Pacific tree frog. The study provided a summary of monitoring and management guidelines that can be used to sustain and improve pond turtle populations within the coastal watersheds of northern San Diego.

Table V2B.6-2. Summary of relevant Invasive Animal studies.

Topic/Species	Publication(s)	Summary
Parasitism, productivity, and population growth: response of least bell's vireo and southwestern willow flycatchers to cowbird control	Kus and Whitfield 2005	Cowbird control is a major aspect of recovery-oriented management for the endangered southwestern willow flycatcher and the least bell's vireo. Twenty years of cowbird trapping have reduced parasitism at the least Bell's vireo and southwestern willow flycatcher breeding sites. This trapping led to an 8-fold increase in vireos, but little change in abundance was observed for the flycatchers. Cowbird control interferes with the evolutionary processes necessary for establishment of genetically based natural defenses. From the study analysis, researchers suggest shifting away from long-term control programs and toward practices that emphasize restoration and maintenance of natural processes on which species depend.
Factors influencing the incidence of cowbird parasitism of least bell's vireo	Sharp and Kus 2006	Microhabitat is the most important habitat feature influencing the incidence of brood parasitism of least Bell's vireos. Dense cover may shield parental activity from the searching cowbirds. Habitat management should focus on increasing the density of understory vegetation.
Parasitism and gnatcatcher nest fates	Braden et al. 1997	Predation had a greater influence on gnatcatcher nest fates than parasitism. Approximately half of the potential impacts of nest parasitism on gnatcatcher nest fates were negated by depredation of parasitized nests. The modest gains in nest success from cowbird trapping were overwhelmed by a large decrease in nest success. The decrease in nest success was likely due to nest abandonment unrelated to parasitism.
The impact of free-ranging domestic cats on wildlife in the United States	Loss et al. 2013	A systematic review and quantitative estimate on mortality caused by cats in the United States.
Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands	Soule et al. 1988	Evidence from the study suggests that chaparral-requiring birds in isolated canyons have very high rates of extinction partially due to their low ability to move from place to place.
Use of matrix population models to estimate the efficacy of euthanasia versus trap-neuter-return for management of free-roaming cats	Anderson et al. 2004	Effective cat population control is achievable by euthanizing at least 50% of the population or by neutering greater than 75% of the population annually.

Topic/Species	Publication(s)	Summary
Variable effects of feral pig disturbances on native and exotic plants in a California grassland	Cushman et al. 2004	Study results indicated that feral pig disturbance had substantial effects on the community. Soil disturbances by pigs increased both exotic and native plant species richness. Pig disturbance led to a 69% reduction in biomass of exotic annual grasses in tall patches and a 62% increase in short patches. Native, nongrass monocots exhibited the opposite pattern. Native forbs were unaffected, but exotic forb biomass increased by 79%. Vegetation changes were likely due to the clearing of space by pigs.
Rooting and foraging effects of wild pigs on tree regeneration and acorn survival in California's oak woodland ecosystems	Sweitzer and Van Vuren 2002	Long-term study of the ecological effects of wild pigs on oak woodland ecosystems in California using multiple control plots using paired control plots. Soil disturbance significantly higher in areas of high pig density. Rooting significantly reduced aboveground plant biomass in oak woodland and may reduce forage availability. Rooting may significantly reduce survival of tree seedlings, limiting oak woodland regeneration.
Southwestern pond turtle study for TransNet grant	Brown et al. 2015	Pond turtles were detected at 2 sites while red-eared sliders were detected at 18 of the 62 sites surveyed. Six other nonnative species were detected in the study. Nonnative aquatic species were detected at 37 sites compared with the 5 sites where natives were detected. Threats from nonnative aquatic animals result in low population recruitment.
Joint estimation of habitat dynamics and species interactions: disturbance reduces co-occurrence of nonnative predators with an endangered toad	Miller et al. 2012	Results support that disturbance and species responses post-disturbance structure differences in co-occurrence of native toads with nonnative predators among sites in the stream systems studied.
Floral visitation by the Argentine ant reduces pollinator visitation and seed set in coast barrel cactus	LeVan et al. 2014	Floral visitation by ants affects pollination services when the invasive Argentine ant replaces a native ant species in a food-for-protection mutualism with the coast barrel cactus. Cactus bees spent less time in flowers of cacti occupied by the Argentine ant compared to those occupied by the native *Crematogaster californica.* The decrease in the duration of visits is likely the cause for the decrease in seed set per fruit by cacti occupied by Argentine ants, and the production of fewer seeds overall.

USGS researchers conducted a study that tracked the trends in breeding populations of arroyo toad within 3 occupied drainages to develop management action recommendations and evaluate the effectiveness of those actions (Brehme et al. 2011). This research and monitoring effort developed a probability of detecting arroyo toads that used a nonnative index as one of the inputs. Mosquitofish, bullfrogs, crayfish, and predatory fish were all detected threats to the arroyo toad, decreasing detection probability.

In a USGS study, scientists examined the relationship of vegetation surrounding nests and of vireo behavior near nests to the incidence of parasitism (Sharp and Kus 2006). Monitoring occurred annually at a long-term study site on the San Luis Rey River in southern California for 3 seasons between 1999 and 2003. Their data provide information for designing recovery strategies to minimize parasitism of the least Bell's vireo. From their study, they determined that microhabitat cover is the most important habitat feature influencing the incidence of brood parasitism of least Bell's vireos. Additionally, large trees can provide vantage points for perched cowbirds, increasing the likelihood of parasitism.

A USGS analysis of published and new information on long-term cowbird trapping programs determined that enhanced seasonal productivity due to cowbird trapping programs have led to an 8-fold increase in least Bell's vireo numbers (Kus and Whitfield 2005). However, southwestern willow flycatcher abundance remained nearly unchanged. Researchers suggest that cowbird control be reserved for short-term crisis management and be replaced, when appropriate, by practices emphasizing restoration and maintenance of natural processes on which the species depends on.

A study by LeVan et al. (2014) examined how floral visitation by ants affects pollination services when the invasive Argentine ant replaces a native ant species in a food-for-protection mutualism with the coast barrel cactus. Researchers discovered that cactus bees spent less time in flowers of cacti occupied by the Argentine ant compared to those occupied by the native *Crematogaster californica.* This decrease in the duration of visits is likely the cause for the decrease in seed set per fruit by cacti occupied by Argentine ants, and the production of fewer seeds overall.

6.5 MANAGEMENT AND MONITORING APPROACH

The overarching goals for addressing invasive animal species in the MSPA are:

(1) Protect intact, unspoiled habitat from new or expanding invasive animal species

(2) Detect new invasive species and new invasions early on and control them before they have a chance to establish

(3) Address invasive species using the response appropriate for the level of invasiveness ensuring higher-priority invasive animal species are addressed first

The approach for managing invasive animals is divided into 2 parts: general and species-specific. General invasive animal objectives focus on early detection and eradication across the MSPA. Species-specific objectives have been developed for those MSP species identified as at highest risk from loss due to invasive animals, and for which specialized objectives are required to ensure their persistence in the MSPA.

6.5.1 General Approach Objectives

Below is a summary of the management and monitoring objectives for the threat of invasive animals. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Invasive Animal summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20161207_1454.

Prepare an Invasive Animal Strategic Plan

In early 2017, SANDAG, USGS, and other agencies will begin developing a regional strategic plan for the management and monitoring of invasive animal species. The Invasive Animal Strategic Plan (IASP) will assess and rank nonnative animals using an assessment process that evaluates abiotic and biotic impacts, invasiveness, and distribution. Evaluating risk to determine the potential pool of taxa that could become direct or indirect risks is vital to the creation of the plan. After the nonnatives have been evaluated, they will be ranked on their threat level. High threat level species need to be addressed immediately for control or eradication, while species with a lower threat level may have a lower priority for removal.

The IASP will look at species at various geographic levels of invasion, including species that are outside of the region with the potential to spread into the region; species that are already in the region but only in the urban setting; and species that are in the region and have entered the wildlands. Some nonnative species may only be in the urban landscape, without a threat of crossing into natural areas, decreasing the urgency in removing them.

Several species outside of the region will be monitored by biologists and evaluated for their potential to spread into San Diego, as well as monitored for their potential threat to the region. These species include, but are not limited to, the following:

- Fox squirrel (*Sciurus niger*) – spreading from Los Angeles; a mostly urban species that also inhabits yards; potential risk to oak and jojoba in maritime succulent scrub habitat
- Sonoran whiptail lizard (*Aspidoscelis sonorae*) – found in parking lots in Orange County; parthenogenic species; risk of it hybridizing with native whiptails if it spreads to natural areas
- Wall lizard (*Podarcis muralis*) – spreading through urban Los Angeles; threat to the El Segundo Dunes blue butterfly (*Euphilotes battoides allyni)*

Assessing these species and their potential impacts, as well as other nonnatives even farther from San Diego, is a key component of early detection and rapid response. In addition, the plan will address biosecurity measures to reduce the unintentional spread of invasive species to Conserved Lands.

The IASP will address the San Diego nonnative wildlife species that are established in urban environments, nonnatives that are in urban environments but with the potential to spread to natural areas, and those that are already in natural areas. While, urban biodiversity includes many nonnatives, not all of those include an apparent risk. A few urban species that have been shown to harm native species include:

- Domesticated and feral cats – disrupt food web; disease transfer
- Opossums – may be passing disease
- Parrots – may be passing disease
- Argentine ants – disrupt food webs; disrupt pollination/reproduction

Some invasive species thrive in urban areas or the wildland urban interface, but many invasive species are completely disconnected from the urban environment. Included are many aquatic species and some terrestrial species, such as bullfrogs, crayfish, red-eared sliders, tiger salamander, invasive fish, wild turkeys (*Meteagris gallopava silvestris*), and feral pigs.

In addition to evaluating nonnative species and assessing their level of threat, the IASP will also identify the responsible parties for each species and at what level that organization is addressing the species. In developing the IASP, the collaboration will determine what species can be managed and which organizations are most appropriate for the management. It is important to work with other counties and urge them to address nonnative species before they spread further. The collaboration will also work with CDFW to update their list of prohibited species.

<u>Implement the Invasive Animal Strategic Plan</u>

The approach for managing invasive animal species is to follow the recommendations provided in the IASP, including adopting and implementing the recommended biosecurity measures. Early Detection and Rapid Response programs are the best way to manage invasive species with limited distributions where eradication is the goal. The goal for species that are abundant in localized areas is eradication within that geographical area (e.g., watershed, MU etc.) where management will significantly benefit MSP species. The goal for abundant and widespread invasive species is eradication in the areas where those species adversely affect narrow endemic plant species, primarily Category SL, SO, SS species.

Monitor Effectiveness of Implementing the Invasive Animal Strategic Plan

Monitoring the effectiveness of the IASP is a critical step in ensuring the most appropriate and effective actions are being implemented. This would include regular surveys and reports on the status of species spread or species reduction, in the case of species being actively controlled. Continued monitoring would allow land managers to update the list of priority species and report to the conservation community when suspected new invasives have entered the MSPA. Additionally, monitoring will determine what, if any, control measures that are not effective at controlling and/or eliminating target species.

Support Feral Pig Eradication Program

The SDMMP will continue supporting the Feral Pig Eradication Program and the partners involved with implementation.

Implement SHB Management Strategy

The approach for managing the shot hole borer is to follow the recommended actions provided in the SHB Management Strategy Plan (SANDAG 2016 *draft*). This includes working collaboratively with land managers, researchers, regulators, and funding agencies to implement common goals. The management strategy goal is to reduce expansion of the shot hole borer into new areas and manage known occurrences of the beetle.

Monitor Success of the SHB Management Strategy

Monitoring the success of the SHB strategy is an important step in determining the effectiveness of the recommended management actions. This information is imperative in adapting BMPs, a vital part of the strategy. Using monitoring data to revise and design new BMPs will allow for more effective control and management actions.

6.5.2 Species-Specific Approach Objectives

The impacts of invasive species on rare and endemic species can vary widely. While some invasive animals have a drastic impact on whole plant communities, some invasives have a disproportionate effect on certain native species. Species for which invasive animal goals and objectives have been identified as part of their management and monitoring approach are identified in Table V2B.6-3. Use the MSP Portal for the most updated list of species with Invasive Animals objectives.

Table V2B.6-3. MSP plant and animal species with specific invasive animal management and monitoring objectives.

Scientific Name	Common Name	Management Category	Summary Page Link
Plants			
Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
Invertebrates			
Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/view_species.php?taxaid=707282
Amphibians			
Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
Reptiles			
Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/view_species.php?taxaid=668677
Phrynosoma blainvillii	Blainville's horned lizard (Coast horned lizard, San Diego horned lizard)	VF	https://portal.sdmmp.com/view_species.php?taxaid=208819
Mammals			
Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/view_species.php?taxaid=175408
Vegetation Communities			
Oak Woodland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
Riparian Forest & Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7
Torrey Pine Forest			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_8

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7.0 INVASIVE PLANTS

7.1 OVERVIEW

The species composition of natural communities in the San Diego region has undergone significant changes since the area was first settled. With the early Spanish explorers and European settlers came livestock and a host of plant species from Europe and Asia. Some species tagged along with the livestock (seeds) and others with trees and shrubs brought in for food, fiber, and to reflect the plant communities the new arrivals had left behind. Over time, some of the introduced annual grasses and forbs became well established on the landscape, often intermixed with native perennial grasses and forbs. Even today, with increased globalization, exotic plant and other species continue to be accidentally or intentionally introduced into our native environments.

Nonnative plants that cause economic, environmental, or human harm are known as invasive plants (Pacific Northwest Research Station 2015). The biological monitoring plan for the San Diego MSCP defines invasive species as aggressive or noxious weed species that are growing or spreading rapidly, outcompeting native species, and difficult to control (Ogden Environmental and Energy Services Co. 1997). Invasive species respond to ecosystem modifications at a landscape level, including removal of native species for development, changes in impervious surfaces and hydrological systems, nitrogen deposition, and global climate change, and other disturbances that land managers cannot control (Cal-IPC, Dendra Inc., and CBI 2012). As an alien species with different growth patterns and without many natural consumers, it is often easy for invasives to outcompete native vegetation. Invasive plants can impact native habitats through direct competition for resources such as sunlight, moisture, nutrients, and space. They can also decrease species diversity, degrade water quality, increase soil erosion, and more (U.S. Forest Service Rangeland Management Botany Program, n.d.).

Today, there are large areas where introduced annual grasses and forbs dominate and they have converted other vegetation types, such as coastal sage scrub and native grassland to nonnative grassland. Nonnative grasses and forbs may also be a significant component of other vegetation types including, maritime succulent scrub, oak-woodland, and riparian. While these nonnative grasses and forbs are addressed as a threat/stressor, the MSP Roadmap addresses their management as part of the vegetation community or specific species' occurrences, such as rare plant occurrences, where they occur.

In addition to invasive grasses and forbs, there are invasive broadleaf plants, shrubs, and trees that negatively impact wildlands. Invasive species can have a localized effect on a particular species, or they can create a cascade of effects that impact whole vegetation communities. Land managers and scientists throughout San Diego have conducted many studies that evaluate different aspects of invasive plant life cycles or management options. Results of those studies and others are invaluable in forming treatment recommendations for invasive plants, similar to those outlined in the Invasive Plant Strategic Plan (IPSP). The IPSP organizes many of San Diego's invasive plants by degree of abundance and manageability. The locations of the invasion, the treatment status, the lead organization, and more are described in the plan. The IPSP, plus the MSP invasive plant objectives, lay the foundation for invasive plant management in the MSPA.

7.2 EFFECTS OF INVASIVE PLANTS ON SOUTHERN CALIFORNIA ECOSYSTEMS

Invasive plants can impact the native habitat in a single way or many ways, with often more than 1 nonnative species invading an area. Some of those impacts are summarized below.

7.2.1 Agriculture

Invasive weeds can invade grazing lands, replacing desirable or native forage with unpalatable and toxic plants. Foliage with toxic properties can harm and even kill livestock that have consumed it. Other plants with thistles, thorns, or spikes can directly injure livestock by lodging in their eyes or mouths.

In addition to livestock damages, there are also economic losses from the impacts of invasive plants on crops. For example, purple loosestrife, *Lythrum salicaria*, has the potential to clog irrigation systems and infect rice fields (Benefield 2000). Other invasive weeds may crowd out crops in addition to consuming the water and fertilizer intended for those crops. Losses from crop yield and treating invasive weeds impacting crops cost the U.S. economy an estimated $27 billion annually (Pimentel et al. 2005).

7.2.2 Soil

Similar to certain native species, the leaf litter and root exudates of some invasive species have allelopathic properties that reduce the germination of native plants.

Other alternations to the soil include salt and nitrogen increases. For example, saltcedar (*Tamarix* spp.) increases soil salinity through salt inputs from the glands on its leaves. This increased salinity inhibits the growth and germination of native riparian plant species. In some cases, increased leaf litter from invasives can increase the nitrogen in the soil, creating a disadvantage for native plants that compete better at lower nutrient levels. Early germination, large numbers of plants, and deep roots are all characteristics that allow invasive plants to outcompete native plants for water stored in the soil. One such plant is giant reed, which forms giant monoculture stands that monopolize the moisture in the soil.

7.2.3 Recreation

Recreation, tourism, and ecotourism suffer substantial losses from invasive plants through the reduction of access; reduction of wildlife or native habitat viewing; and the increased nuisance to boating, swimming, and diving (Charles and Dukes 2007). Yellow starthistle (*Centaurea solstitialis*) is an example of a plant that can limit access to recreational areas. Purple loosestrife (*Lythrum salicaria*) is a wetland plant that can clog waterways and wetlands used for boating and other recreational activities (Benefield 2000).

7.2.4 Shade/Light

Plants that grow vertically along streambanks (e.g., giant reed) provide little to no shade to the surrounding riparian and in-stream habitat in contrast to the native riparian vegetation. This shade reduction increases exposure and water temperature, while reducing the habitat quality for aquatic wildlife such as arroyo toad, California red-legged frog, southwestern pond turtle, steelhead trout, and others (Franklin 1996; cited in Dudley 2000). In addition to removing shade, many invasives can carpet the native landscape, depriving native species of the light needed to germinate, survive, and thrive.

7.2.5 Food Supply

Without adaptation, specialists that rely on a small range of flora or fauna for survival may be harmed by the conversion of their native food source to an invasive one. In a review of 87 articles evaluating the response of arthropods to nonnative invasives, Litt et al. (2014) found that arthropod abundance decreased in 62% of the studies. One invasion that supports these findings is French broom (*Genista monspessulana*), which is responsible for reducing one-third of the arthropod population in Golden Gate National Recreation Area (Langford and Nelson 1992).

When nonnatives grow in monocultures, there may be a reduction of food supply from the limited number of insects that forage on nonnative species. Additionally, foraging and grazing habitat is reduced and degraded when unpalatable, toxic, or harmful invasive plant species replace the native forage species.

7.2.6 Erosion

Invasive plants with shallow root systems can contribute to soil erosion. When invasive species alter the fire regime, increasing fire frequency, this can also contribute to accelerated erosion.

7.2.7 Hydrological Regimes

Saltcedar and giant reed both have high evapotranspiration rates, which can lower water tables, increasing the difficulty of attaining water for native plants (Dudley 2000). Large monocultures of invasive reeds can alter the channel morphology when the monoculture traps and retains large amounts of sediment and constricts flow. This can lead to narrowing of stream channels and more frequent flooding (Graf 1978).

7.2.8 Fire

"*Invasive plants often increase the frequency of fires by providing more continuous fuels that are easier to ignite. After fires, these weedy invaders typically reestablish more rapidly than native plants, suppressing the recovery of the natives and allowing the weeds to expand their range*" (Bell et al. 2009). The dense growth of invasive plants, like giant reed, increases the amount of biomass available as fuel for fires. Nonnative annual grasses increase fire severity by providing continuous fuel for the fire. Unlike native grasses, these grasses complete their lifecycle before summer, leaving large amounts of dried material that can fuel fires throughout the summer and fall fire season (Bell et al. 2009). The intensity of fires caused by giant reed and saltcedar along the riparian zone can eliminate stands of native riparian plants such as cottonwood, sycamore, and willow. For more information on how invasive alter the natural fire regime, as well as how invasives spread after fire events, see Vol. 2B, Sec. 1.0, Altered Fire Regime.

7.2.9 Native Species

"*Invasive species have contributed directly to the decline of 42% of the threatened and endangered species in the United States*" (The Nature Conservancy 2016).

Invasive plant species can displace native species in many ways, often outcompeting native species for light, water, and/or nutrients. Some invasive plants germinate earlier than native species or germinate first following a fire, quickly overtaking the habitat of the native species. If native shrub habitat is converted to nonnative grassland, the habitat value is degraded, depriving species of the plant cover and foraging variety they rely on. When large stands of invasive plant species grow in a once-natural habitat, this can displace the native fauna that depend on native habitat. Nonnatives can lower the species diversity and disrupt native plant diversity. It is also difficult for native seeds to germinate when large patches of invasive plants have displaced the native plant structure and diversity. There are endemic bird species, burrowing animals, and insects that require specific plants or vegetation mosaics for breeding, nesting, and rearing. Removing these natives could be detrimental to those species if they cannot adapt to the invasive plants.

7.3 INVASIVE PLANTS IN THE MSPA

Invasive exotic plants are diverse and widespread. In 2012, there were over 100,000 occurrences of almost 250 invasive plant species in the MSPA (Cal-IPC, Dendra Inc., and CBI 2012). CalWeedMapper, a mapping database maintained by the California Invasive Plant Council (Cal-IPC), has reports of 167 invasive species in San Diego County. There are many types of invasive plants in San Diego County, including annual grasses (*Avena* spp., *Bromus* spp., *Lolium* spp.), perennial grasses (giant reed, pampas grass, crimson fountaingrass), herbaceous broadleaf plants (mustard, fennel, thistles), and woody trees and shrubs (saltcedar, acacias, eucalyptus). According to Cal-IPC, some of the most prevalent invasives with severe ecological impacts are giant reed, *Bromus* spp., and saltcedar. While invasive plant species vary in the degree of effort needed for control or eradication, among the most difficult to eradicate are pampas grass (*Cortaderia selloana*) and giant reed. Giant reed, saltcedar, *Bromus* spp., and pampas grass all occur throughout the MSPA.

Giant reed is the most common invasive plant in riparian areas of southern California (Bell et al. 2009). It is a perennial grass that has invaded areas in central California to Baja California, Mexico (Dudley 2000). It is typically found in riparian, floodplain, or coastal areas below 350 meters, and is most problematic in southern California coastal drainages where it can dominate entire river channels bank to bank (Jackson 1994; Bell 1997; both cited in Dudley 2000). Plants range from 2.5–9 meters tall and can tolerate a range of soil types and a range of fresh to semi-saline water (Dudley 2000). Giant reed spreads vegetatively from rhizomes or plant fragments. Stands of giant reed displace native plant and animal species, with the monoculture of giant reed reducing habitat and food supply by displacing the native vegetation. The reduction in insect populations is especially important for listed species such as the least Bell's vireo, southwestern willow flycatcher, and yellow-billed cuckoo (Frandsen and Jackson 1994; Dudley and Collins 1995; both cited in Dudley 2000). The vertical growth of giant reed reduces shade along riparian areas, increasing in-stream temperatures and decreasing the habitat suitability for listed species like steelhead trout, arroyo toad, and southwestern pond turtle among others. Giant reed has a shallow root system that may promote bank erosion. It can also alter channel morphology, increasing the risk of flooding during heavy rain events. By creating more than double the normal fuel supply, giant reed increases the potential for fire in urbanized areas.

Brome (*Bromus* spp.) are nonnative annual grasses from Europe that, unlike native grass species, germinate in the winter and complete their life cycle before summer (Bell et al. 2009). These nonnative grasses have displaced much of the native grasses throughout California. Few *Bromus* spp. seeds remain dormant each year, making seeds the main source of brome infestation. Due to this, seed bank reduction is the most important aspect of brome management (Hashem and Borger 2016). As a winter annual, the prevalence of *Bromus* spp. is concerning due to the amount of dead fuel left during the summer and fall fire season.

Saltcedar is common in riparian areas where surface or subsurface water is available through most of the year (Lovich 2000). It thrives on saline soils that are uninhabitable for most native woody and riparian plants. The presence of saltcedar is associated with "dramatic changes in geomorphology, groundwater availability, soil chemistry, fire frequency, plant community composition, and native wildlife diversity" (Lovich 2000). The leaf-litter from saltcedar contributes to the increase in fire frequency. Additionally, saltcedar is able to resprout strongly following a fire.

Pampas grass is a perennial grass growing 2–4 meters tall (DiTomaso 2000). In southern California, pampas grass inhabits the banks of sandy and moist ditches in the coastal region. The plants often have a build-up of dry leaves and flowering stocks that increase fire potential. Additionally, pampas grass outcompetes native vegetation. Few control strategies are available for pampas grass and, as a rapid resprouter, burning is not an effective control method (DiTomaso 2000). Hand-pulling of seedlings is effective, but tools are needed to remove the larger plants with established clumps. Detached plants have the potential to take root if left on moist soil, so it is important to remove the entire crown and top section of the roots (Harradine 1991; cited in DiTomaso 2000). Chemical control can be achieved with a spot treatment of post-emergence application of glyphosate. Fall applications result in better control compared to summer applications (Costello

1986; cited in DiTomaso 2000). To reduce the amount of herbicide used, the top foliage can be removed and only the regrowth is retreated.

7.4 RESULTS OF INVASIVE PLANT STUDIES IN THE MSPA

There are many studies addressing invasive plants in the MSPA. Some of these studies focus primarily on rare plants with discussions on specific invasive species threatening those rare plants, and other studies are directly focused on the management and monitoring of specific invasive plant species. The results and progress of some of these studies are summarized briefly below.

RECON's Otay Tarplant and San Diego Thornmint Restoration and Enhancement Project was intended to restore native grassland and clay lens habitat for Otay tarplant (*Deinandra conjugens*) and San Diego thornmint (*Acanthomintha ilicifolia*) in areas currently dominated by weeds (RECON 2012). A goal of the project was to reduce competition with nonnative weeds by controlling nonnative grasses and perennial weeds such as fennel (*Foeniculum vulgare)* and artichoke thistle (*Cynara cardunculus*). Purple needlegrass was planted in areas dominated by nonnative grasses and other weeds.

A Center for Natural Lands Management herbicide application study examined the thread-leaved brodiaea's tolerance to the grass-specific herbicide, Fusilade®, to assess the potential for herbicide treatment of nonnative grasses that occupy thread-leaved brodiaea habitat (Vinje et al. 2009). Other treatment combinations such as dethatch and dethatch with herbicide application were also examined. Researchers found that Fusilade® did not appear to harm thread-leaved brodiaea and plots with herbicide treatment had increased vegetative and flowering numbers. The plots with dethatch and dethatch/herbicide treatments also saw an increase in thread-leaved brodiaea. However, if using dethatching to restore thread-leaved brodiaea habitat, then native forbs and grasses must be planted to fill the open niche.

A study investigated the tolerance of the San Diego ambrosia to herbicide used to control the invasive weeds negatively affecting it (Kelly et al. n.d.). Impacts from the weeds include competition for limited water, blocking sunlight, impeding wind pollination from taller weeds, and loss of genetic variation. With San Diego ambrosia hidden by tall weeds, it would be risky to spray an herbicide for nonnative grass control, since it would be difficult to avoid spraying San Diego ambrosia. Phase I of this 4-part study tested the tolerance of herbicide for San Diego ambrosia in pots. These plants showed no harmful effects from the Fusilade

II® spraying. Phase II assessed the tolerance of 6 native grassland species that are San Diego ambrosia cohorts. Aside from purple needlegrass (*Nassella pulchra*), all other plants showed moderate to severe damage. Phase III was a test of Fusilade® on San Diego ambrosia in the field at Mission Trails Regional Park. There was no apparent damage to San Diego ambrosia and good control of the nonnative grasslands. Additionally, red-stemmed filaree (*Erodium cicutarium*) appeared to be dying after the application. Phase IV further investigated the response of purple needlegrass to Fusilade®.

The extent and dominance of purple false brome (*Brachypodium distachyon*) in San Diego County has grown in recent years, possibly due to reoccurring fires and climatic conditions (CBI 2014). Purple false brome not only decreases native species diversity, but it may also alter the soil composition, vegetation community structure, and natural fire regime. The high density of purple false brome threatens edaphic endemic plants such as San Diego thorn-mint, San Diego goldenstar, thread-leaved brodiaea, Orcutt's brodiaea, Otay tarplant, variegated dudleya, Dehesa nolina, and Parry's tetracoccus. Native grassland and coastal sage scrub communities are also threatened by the high density of purple false brome on restricted soils. To protect conservation target species from purple false brome invasion, CBI developed a study to, among other things, identify variables that may respond to control treatments and be used to develop restoration strategies. The study also predicted areas currently at risk of invasion and under future climate regimes. One major finding of the study was that a single Fusilade ® application per year provided effective control of purple false brome when done in a uniform and timely manner relative to rainfall. The dethatch-herbicide-seeding combination had the highest number of native species.

The South County Grasslands Project, a collaboration initiated in 2011 between the South County Land Managers, CBI, and The Nature Conservancy, developed landscape-scale conservation visions and restoration plans for native grassland and forbland habitats (Land IQ and CBI 2015). The Quino checkerspot butterfly and the Otay tarplant are specifically targeted in this project. This 4-phase project tested restoration methods for controlling invasive grasses and restoring native grasslands and forblands. Quantitative data were used to assess the effectiveness of site preparation methods in the first growing season post-seeding. This project is in the fourth and final phase, using quantitative data from 3–5 years of monitoring to determine the long-term trajectory and success of the experimental restoration treatments.

A conservation vision created by CBI evaluates the status and threats for the endangered Dehesa nolina, prioritizes management actions by population, and identifies survey and research needs (CBI 2015). Invasive species such as purple false-brome, tocalote (*Centaurea melitensis*), and red brome (*Bromus madritensis*) are listed as threats to Dehesa nolina. Of particular concern is purple false-brome because of the potential for widespread invasion following fire or other large-scale disturbances.

7.5 MANAGEMENT AND MONITORING APPROACH

The overarching goals for addressing invasive plant species in the MSPA are to:

(1) Protect Conserved Lands from new or expanding invasive plant species

(2) Detect new invasive species and new invasions early on and control them before the plants have a chance to establish

(3) Address invasive species using the response appropriate for the level of invasiveness (levels 1 through 5) as defined in the IPSP

The approach for managing invasive plants is divided into 2 parts: general and species-specific. General invasive plant objectives focus on early detection and eradication as well as the IPSP recommendations across the MSPA. Species-specific objectives have been developed for those MSP species identified as at highest risk from loss due to invasive plants, and for which specialized objectives (i.e., chemical and manual removal, restoring habitat) are required to ensure their persistence in the MSPA.

7.5.1 General Approach Objectives

Below is a summary of the management and monitoring objectives for the threat of invasive plants. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Invasive Plant summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20161207_1453.

Continue to Implement the Invasive Plant Strategic Plan

In 2012, collaboration between CBI, Dendra, Inc., and Cal-IPC created a regional strategic plan for the management and monitoring of invasive plant species. In the development of the IPSP, 55 nonnative plant species were assessed and scored using a regional plant assessment process that evaluates abiotic and biotic impacts, invasiveness, and distribution. Twenty-nine of those species were addressed in the plan for near-term management and monitoring. Those 29 invasive plant species are considered more recent species arrivals and are divided into 5 management levels (Table V2B.7-1) (Cal-IPC, Dendra Inc., and CBI 2012). Some prevalent invasive plants were not ranked in the IPSP because they have become widely established in the landscape (e.g., bromes, mustard, clover, etc.) and are the primary species in the nonnative grassland vegetation community. Use the following online map to view the invasive plant detections: http://arcg.is/2hYs6xq.

The approach for managing invasive plant species is to follow the recommendations provided in the IPSP. Early Detection and Rapid Response programs are the best way to manage Level 1 and Level 2 invasive species, and eradication is the goal for those species within the MSPA. The goal for Level 3 species is eradication within geographical areas (e.g., watershed, MU etc.) where management will significantly benefit MSP species. The goal for Level 4 and Level 5 species is eradication in the areas where they adversely affect narrow endemic plant species, primarily Category SL, SO, SS species. Future updates of the MSP Roadmap will include an analysis and maps showing the locations where invasive plants are impacting MSP species. Contact the SDMMP for a map of current locations.

The 5 management levels for invasive plants described in the IPSP are:

- **Level 1:** considered eradicated from the MSPA but need ongoing surveillance to detect any reinvasions and trigger a rapid response to prevent them from becoming reestablished
- **Level 2:** very limited in distribution and eradication is possible with a regionally coordinated eradication program
- **Level 3:** may be abundant in localized areas, but can likely be eradicated within focal areas (an MU, watershed, etc.)
- **Level 4:** abundant and widespread
- **Level 5:** very widespread and control is typically of short-term benefit

In December, 2014, the County of San Diego created the Invasive Plant Species Annual Work Plan to focus on the control of Early Detection and Rapid Response species. This work plan included new Level 2 invasive plant species that were not covered in the IPSP 2012. Those 8 new species are:

Table V2B.7-1. Invasive plants by Management Level as listed in the Invasive Plant Strategic Plan (Cal-IPC et al. 2012).

Scientific Name	Common Name	Mgt Level	Priority	Recommended Actions
Cytisus scoparius	Scotch broom	1	Medium	Surveillance
Euphorbia terracina	Carnation spurge	1	Very High	Surveillance
Aegilops triuncialis	Barbed goat grass	2	High	Monitor
Ageratina adenophora	Eupatory	2	High	Fund management
Carrichtera annua	Ward's weed	2	High	Monitor
Centaurea calcitrapa	Purple star thistle	2	Low	Coordinate
Centaurea solstitialis	Yellow star thistle	2	High	Fund management
Centaurea stoebe ssp. *Micranthus*	Spotted knapweed	2	Medium	Fund management
Elymus caput-medusae	Medusahead	2	Very High	Coordinate; fund management
Genista monspessulana	French broom	2	Very High	Fund management
Hypericum canariense	Canary Island St. John's wort	2	High	Fund management
Iris pseudacorus	Yellow flag iris	2	High	Fund management
Lythrum salicaria	Purple loosestrife	2	Very High	Fund management
Retama monosperma	Bridal broom	2	Very High	Fund management
Arundo donax	Giant reed	3	Very High	Fund management
Cortaderia selloana and jubata	Pampas grass (and jubata)	3	High	Fund management
Cynara cardunculus	Artichoke thistle	3	Very High	Coordinate; fund trial

Scientific Name	Common Name	Mgt Level	Priority	Recommended Actions
Ehrharta calycina	Perennial veldt grass	3	Medium	Additional data
Ehrharta longiflora	Long-flowered veldt grass	3	Medium	Additional data
Emex spinose	Devil's thorn	3	Medium	Coordinate; fund trial
Lepidium latifolium	Perennial pepperweed	3	Very High	Fund management; additional data
Oncosiphon piluliferum	Globe chamomile	3	Medium	Additional data
Spartium junceum	Spanish broom	3	Medium	Coordinate; fund management
Agrostis avenacea	Pacific bent grass	4	Very High	Fund management
Brachypodium distachyon	Purple false brome	4	Very High	Fund management
Dittrichia graveolens	Stinkwort	4	High	Additional data
Foeniculum vulgare	Fennel	4	Very High	Fund management
Silybum marianum	Milk thistle	4	High	Additional data
Glebionis coronaria	Crown daisy	5	Medium	Additional data

Enchylaena tomentosa (ruby saltbush)
Limonium duriusculum (European sea lavender)
Limonium ramosissimum (Algerian sea lavender)
Euphorbia virgate (leafy spurge)
Heliotropium supinum (dwarf heliotrope)
Pentameris airoides (annual pentaschistis)
Senecio quadrdentatus (cotton burnweed)
Sesbania punicea (rattlebox)

The County proposed active control work on 3 of those 8 species (*Enchylaena tomentosa, Limonium duriusculum, and Limonium ramosissimum*), with tracking and monitoring of the other 5 species to ensure that treatment work is occurring.

Update the San Diego County Invasive Plant Species Annual Work Plan

To ensure the appropriate species are identified and targeted for management, it is imperative to regularly update the San Diego County Invasive Plant Species Annual Work Plan. The SDMMP will support and work with the County of San Diego Department of Agriculture, Weights, and Measures to update the annual work plan and include those updates in the focal species table in the MSP Invasive Plant section. They will add any new early detection and rapid response (EDRR) species to the watchlist.

<u>Pursue outside funding for Level 3 invasive plants species</u>

Total eradication is unlikely for Level 3 species, but eradication within focal areas is possible. However, due to the abundance of Level 3 species, EMP funding is unlikely, so funding will likely need to come from outside the region. The SDMMP will pursue other funding and grant options, possibly for wetlands and other habitat types.

<u>Create a Biosecurity Plan</u>

Prevention is the first line of defense in invasive species management. Biosecurity measures are the best way to strengthen and promote prevention efforts. In an ecological context, biosecurity refers to preventative measures intended to reduce the risk of nonnative and invasive species (plant, mammal, invertebrate, etc.) introduction and spread. Biosecurity often includes BMPs for preventing the spread of invasive plant material. Implementing BMPs helps reduce future maintenance and costs, herbicide use, and fire hazards, while also protecting native habitat, plant populations, and listed species. Cal-IPC's *Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers* (2012) outlines specific prevention BMPs for land managers working with potentially or known invasive material.

The first prevention principle recommends that land managers take time to conduct a pre-activity assessment of the work areas to determine which activities could spread weeds and which BMPs are applicable (Cal-IPC 2012). Other important BMP areas are:

- *Project material BMPs*: using weed-free source for materials
- *Travel BMPs*: plan travel to reduce invasive spread, integrate cleaning activities into travel
- *Tool, equipment, and vehicle cleaning BMPs*: designated cleaning areas, inspections before entering and leaving the site, etc.
- *Clothing, boots, and gear cleaning BMPs*: wear gear that does not retain soil and plant material, designate cleaning areas, clean clothing, boots, and gear before leaving site
- *Waste disposal BMPs*: ensure invasive material is rendered nonviable while still on-site, designate disposal areas for invasive plants, contain invasive material while in transport to disposal site
- *Soil disturbance BMPs*: minimize soil disturbance, implement erosion control, etc.
- *Vegetation management BMPs*: schedule to maximize control efforts and minimize invasive spread, retain native existing vegetation, etc.
- *Revegetation and landscaping BMPs*: revegetate to optimize resistance to invasive plant establishment, use local materials, revegetate or mulch disturbed soils to decrease invasive establishment
- *Fire and fuel management BMPs*: consider wildfire implication when setting priorities for invasive plant control, reduce disturbance when implementing fuel management, revegetate burned areas to reduce invasive spread, etc.

Recommendations for creating a pre-activity assessment and implementing the other BMP categories are detailed in the plan.

Create an Early Detection/Rapid Response Database and Reporting Tool

"*Early detection and rapid response (EDRR) is a management approach that capitalizes on our ability to most effectively eradicate invasive plant populations when they are smll*" (Cal-IPC 2016). Addressing a new invasive plant population while it is small deprives it of a chance to spread or establish a large seed bank. Early detection of invasive species is imperative for avoiding costly long-term control efforts. EDRR involves well-informed surveillance and immediate reporting, followed by eradication measures.

A regional invasive reporting and tracking website would be beneficial for reporting new invasions, as well as tracking management efforts. The website could serve as a regional occurrence database and could be available for public reporting. The database would include a regional watchlist and invasive plant alerts similar to the one operated by Cal-IPC. Plants found in nearby regions with similar habitat should be included on the watchlist. For the watchlist to be most effective, land managers should be diligent in monitoring their properties and be aware of plants on the watchlist. Important information to incorporate in the database includes all suspected and confirmed invasive occurrences, whether or not and how the occurrence is being addressed, and sites where the species has been eradicated. Land managers could periodically review the website to assess what invasive plants are on or near their lands, determine what plants may be an impending problem, and develop an appropriate management strategy.

For information on current EDRR plants in San Diego County, visit the San Diego Weed Management website: http://www.sandiegocounty.gov/content/sdc/awm/ipm_sdwma/InWeedWatch.html?cq_ck=1462552877418.

Support the Removal of Level 4 and Level 5 Species Threatening MSP Species

It is important to remove Level 4 and Level 5 invasive species where they occur and threaten MSP species. The SDMMP will support land managers conducting the removal of these invasive species.

7.5.2. Species-Specific Approach Objectives

The impacts of invasive plant species on rare and endemic species can vary widely. While some invasive plants have a drastic impact on whole plant communities, there are those invasive plants that have a disproportionate effect on certain native species. Species for which invasive plant goals and objectives have been identified as part of their management and monitoring approach are identified in Table V2B.7-2. Use the MSP Portal for the most updated list of species with Invasive Plants objectives.

Table V2B.7-2. MSP plant and animal species with specific invasive plant management and monitoring objectives.

	Scientific Name	Common Name	Management Category	Summary Page Link
Plants				
	Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/view_species.php?taxaid=32426
	Acmispon prostratus	Nuttall's acmispon	SO	https://portal.sdmmp.com/view_species.php?taxaid=820047
	Agave shawii var shawii	Shaw's agave	SL	https://portal.sdmmp.com/view_species.php?taxaid=810342
	Ambrosia pumila	San Diego ambrosia	SO	https://portal.sdmmp.com/view_species.php?taxaid=36517
	Aphanisma blitoides	Aphanisma	SL	https://portal.sdmmp.com/view_species.php?taxaid=20679
	Atriplex coulteri	Coulter's saltbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=20523
	Atriplex parishii	Parish brittlescale	VF	https://portal.sdmmp.com/view_species.php?taxaid=20554
	Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/view_species.php?taxaid=183764
	Bloomeria clevelandii	San Diego goldenstar	SS	https://portal.sdmmp.com/view_species.php?taxaid=509575
	Brodiaea filifolia	Thread-leaved brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=42806
	Brodiaea orcuttii	Orcutt's brodiaea	SO	https://portal.sdmmp.com/view_species.php?taxaid=42815
	Brodiaea santarosae	Santa Rosa brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=810190
	Centromadia parryi ssp. australis	Southern tarplant	VF	https://portal.sdmmp.com/view_species.php?taxaid=780715
	Chloropyron maritimum ssp. maritimum	Salt marsh bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834234

Scientific Name	Common Name	Management Category	Summary Page Link
Chorizanthe orcuttiana	Orcutt's spineflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=21019
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/view_species.php?taxaid=565077
Cylindropuntia californica var. californica	Snake cholla	VF	https://portal.sdmmp.com/view_species.php?taxaid=913470
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/view_species.php?taxaid=780273
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834156
Dudleya blochmaniae	Blochman's dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502165
Dudleya brevifolia	Short-leaved dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502166
Dudleya variegata	Variegated dudleya	SS	https://portal.sdmmp.com/view_species.php?taxaid=502182
Dudleya viscida	Sticky dudleya	SS	https://portal.sdmmp.com/view_species.php?taxaid=502185
Ericameria palmeri ssp. palmeri	Palmer's goldenbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=527914
Eryngium aristulatum var. parishii	San Diego button-celery	VF	https://portal.sdmmp.com/view_species.php?taxaid=528066
Erysimum ammophilum	Coast wallflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=22928
Euphorbia misera	Cliff spurge	VF	https://portal.sdmmp.com/view_species.php?taxaid=28104
Ferocactus viridescens	San Diego barrel cactus	VF	https://portal.sdmmp.com/view_species.php?taxaid=19801
Fremontodendron mexicanum	Mexican flannelbush	SL	https://portal.sdmmp.com/view_species.php?taxaid=21581
Hazardia orcuttii	Orcutt's hazardia	SL	https://portal.sdmmp.com/view_species.php?taxaid=502882

	Scientific Name	Common Name	Management Category	Summary Page Link
	Lepechinia cardiophylla	Heart-leaved pitcher sage	SL	https://portal.sdmmp.com/view_species.php?taxaid=32553
	Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/view_species.php?taxaid=833060
	Navarretia fossalis	Spreading navarretia	VF	https://portal.sdmmp.com/view_species.php?taxaid=31328
	Nolina cismontana	Chaparral nolina	SL	https://portal.sdmmp.com/view_species.php?taxaid=507567
	Nolina interrata	Dehesa nolina	SO	https://portal.sdmmp.com/view_species.php?taxaid=42992
	Orcuttia californica	California orcutt grass	SL	https://portal.sdmmp.com/view_species.php?taxaid=41970
	Packera ganderi	Gander's ragwort	SO	https://portal.sdmmp.com/view_species.php?taxaid=565357
	Pogogyne abramsii	San Diego mesa mint	VF	https://portal.sdmmp.com/view_species.php?taxaid=32639
	Pogogyne nudiuscula	Otay mesa mint	SL	https://portal.sdmmp.com/view_species.php?taxaid=32643
	Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
	Rosa minutifolia	Small-leaved rose	SS	https://portal.sdmmp.com/view_species.php?taxaid=504824
	Tetracoccus dioicus	Parry's tetracoccus	SS	https://portal.sdmmp.com/view_species.php?taxaid=28420
Invertebrates				
	Branchinecta sandiegonensis	San Diego fairy shrimp	SL	https://portal.sdmmp.com/view_species.php?taxaid=624043
	Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
	Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/view_species.php?taxaid=707282
	Lycaena hermes	Hermes copper	SL	https://portal.sdmmp.com/view_species.php?taxaid=777791

	Scientific Name	Common Name	Management Category	Summary Page Link
	Panoquina errans	Wandering skipper	VF	https://portal.sdmmp.com/view_species.php?taxaid=706557
	Streptocephalus wootoni	Riverside fairy shrimp	SL	https://portal.sdmmp.com/view_species.php?taxaid=624020
Amphibians				
	Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
	Spea hammondii	Western spadefoot toad	VF	https://portal.sdmmp.com/view_species.php?taxaid=206990
Reptiles				
	Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/view_species.php?taxaid=668677
	Phrynosoma blainvillii	Blainville's horned lizard (Coast horned lizard, San Diego horned lizard)	VF	https://portal.sdmmp.com/view_species.php?taxaid=208819
Birds				
	Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/view_species.php?taxaid=175408
	Athene cunicularia hypugaea	Western burrowing owl	SL	https://portal.sdmmp.com/view_species.php?taxaid=687093
	Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/view_species.php?taxaid=917698
	Circus cyaneus	Northern harrier	SO	https://portal.sdmmp.com/view_species.php?taxaid=175430
	Empidonax traillii extimus	Southwestern willow flycatcher	SL	https://portal.sdmmp.com/view_species.php?taxaid=712529

	Scientific Name	Common Name	Management Category	Summary Page Link
	Passerculus sandwichensis beldingi	Belding's savannah sparrow	VF	https://portal.sdmmp.com/view_species.php?taxaid=179325
	Polioptila californica californica	Coastal California gnatcatcher	VF	https://portal.sdmmp.com/view_species.php?taxaid=925072
	Sternula antillarum browni	California least tern	SO	https://portal.sdmmp.com/view_species.php?taxaid=825084
	Vireo bellii pusillus	Least Bell's vireo	SO	https://portal.sdmmp.com/view_species.php?taxaid=179007
Mammals				
	Lepus californicus bennettii	San Diego black-tailed jackrabbit	VF	https://portal.sdmmp.com/view_species.php?taxaid=900973
	Taxidea taxus	American badger	SL	https://portal.sdmmp.com/view_species.php?taxaid=180565
Vegetation Communities				
	Chaparral			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_3
	Coastal Sage Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_1
	Grassland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_2
	Oak Woodland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
	Riparian Forest & Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7
	Salt Marsh			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_6
	Southern Interior Cypress Forest			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_9
	Vernal Pool/Alkali Playa			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_4

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8.0 LOSS OF CONNECTIVITY

8.1 OVERVIEW

Connectivity refers to the degree to which the landscape facilitates or impedes movement of genes, individuals, propagules or populations among resource patches (Taylor et al. 1993; Hilty et al. 2006). Maintaining connectivity between natural areas is widely regarded as essential to maintaining functional landscapes and evolutionary processes (e.g., Noss 1987, 1991; Saunders et al. 1991; Beier and Noss 1998). Connectivity is also viewed as essential to promoting dispersal among habitat patches; maintaining gene flow; facilitating local adaptation; and promoting resilience to many threats, including fire, floods, disease, and climate change (Austin et al. 2004; Anacker et al. 2013).

There are 2 types of connectivity: *structural* and *functional*. *Structural connectivity* refers to the physical relationship between landscape elements, whereas *functional connectivity* describes the degree to which landscapes actually facilitate or impede the movement of organisms and processes (Meiklejohn et al. 2010). Functional connectivity is a product of both landscape structure and the response of organisms and processes to this structure. Thus, functional connectivity is both species and landscape specific. Distinguishing between these 2 types of connectivity is important because structural connectivity does not imply functional connectivity. Protecting and restoring functional connectivity is the goal of the MSP Roadmap.

The loss of connectivity is a major driver in the loss of biodiversity across southern California, including the MSPA. Within the MSPA, roads and urban development have created barriers to species movement, especially for wide-ranging species that need large patches of land. Roads, in particular, fragment habitat and create barriers that impede mobility and result in increased wildlife mortality. In addition, large wildfires in the last 20 years have resulted in loss of habitat and reduced connectivity for some species such as the coastal cactus wren and Hermes copper butterfly. Fragmentation by anthropogenic or natural disturbances can result in genetic isolation, putting some species at risk over the longer term (Trombulak and Frisell 2000; Van der Ree et al. 2011). As habitat becomes fragmented, populations or subpopulations may become separated or even isolated in the remaining smaller habitat patches. Smaller populations are at greater risk of extirpation due to stochastic and anthropogenic events.

The MSCP, MHCP, and future North County NCCP Plans identify blocks of Conserved Lands connected by linkages (Figure V2B.8-1) that are intended to maintain natural processes (e.g., erosion and sediment deposition, organic litter accumulation, etc.) and movement of species between NCCP conserved areas and to Conserved Lands outside of the plan areas. Maintaining connectivity within and among core habitat areas through conservation and management of land is essential for maintaining the biodiversity of the preserve system and ensuring resilience of species and natural communities in the San Diego region and beyond. Connectivity monitoring is a required element of these plans to confirm that linkages are functionally connecting core habitat areas. Monitoring will also aid in the identification of actions to improve or restore connectivity between Conserved Lands.

8.2 CONNECTIVITY IN THE MSPA

Although large blocks of habitat have been conserved in the MSPA, the preserve system in western San Diego County is still being assembled and gaps of unprotected habitat remain between existing Conserved Lands that, if developed, will result in the permanent fragmentation of core and linkage areas. In addition, major highways and arterial roads bisect Conserved Lands and create impediments to wildlife movement. In other areas, habitat degradation caused by invasive plants or altered fire regimes has led to the fragmentation of otherwise connected habitat patches for rare species. On the coast, urban development and roads surround Conserved Lands leaving narrow drainages that connect these otherwise isolated habitat patches. Prioritizing management and monitoring actions for securing connectivity between these assembled Conserved Lands considers the following: (1) maintaining and protecting permeability between Conserved Lands; (2) preventing choke points from becoming severed; and (3) restoring connectivity through habitat restoration or infrastructure improvements.

8.2.1 Core Habitat Areas in the MSPA

Figure V2B.8-2 shows the Cores and Linkages identified by the MSCP and the MHCP for the plan areas in 1997 and 2003, respectively. The Core and Linkage maps were prepared as analytical tools to assist with assessing preserve design criteria and levels of species conservation (Ogden Environmental and Energy Services Co. 1996; AMEC Earth & Environmental, Inc. et al. 2003). In 2011, the Connectivity Monitoring Strategic Plan (CMSP; SDMMP 2011) included updated Core and Linkage areas as shown in Figure V2B.8-3 to assist with prioritizing management and monitoring actions (see 2011 CMSP for rationale; SDMMP 2011).

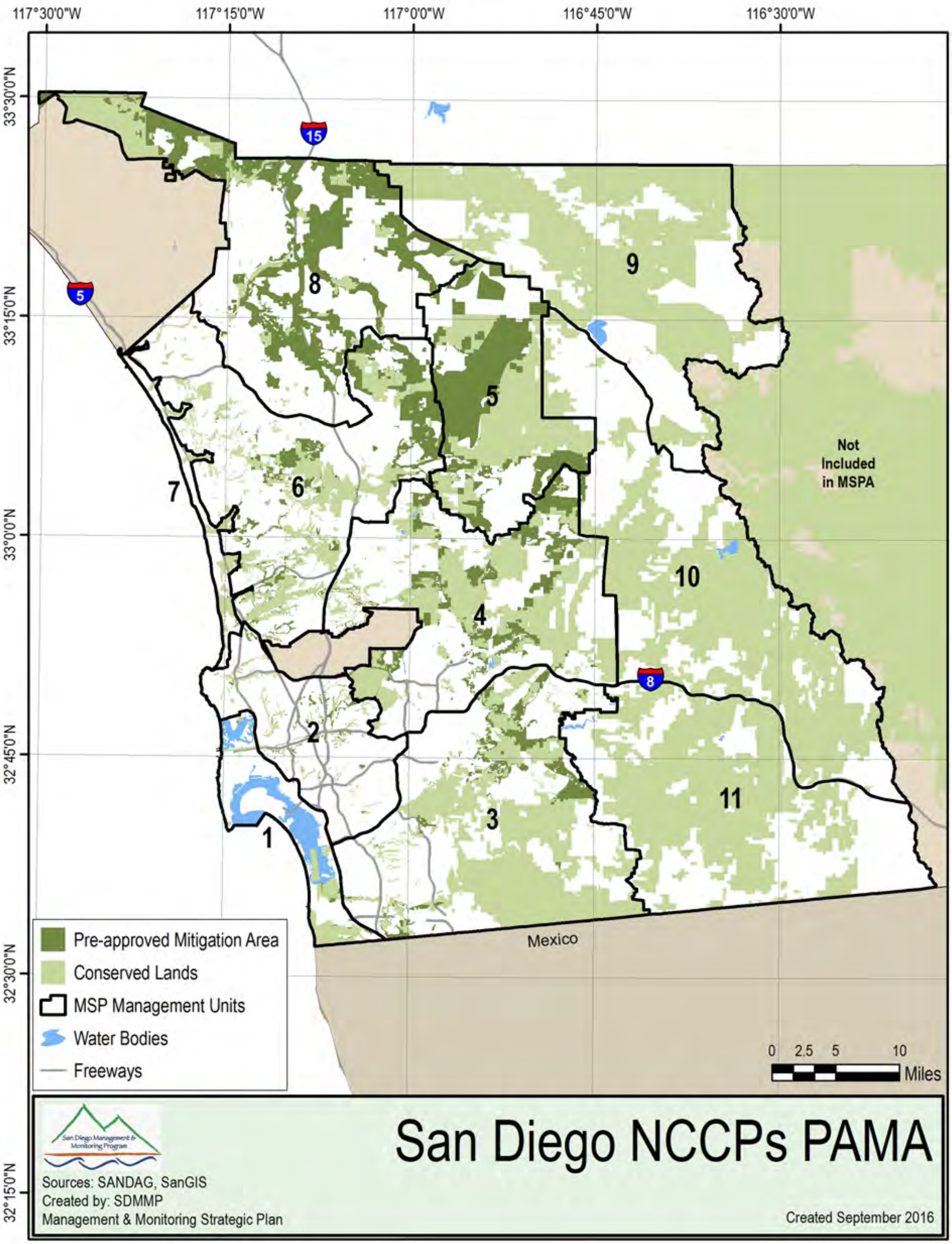

Figure V2B.8-1. Pre-approved Mitigation Areas from the MSCP, MHCP, and future North County NCCP.

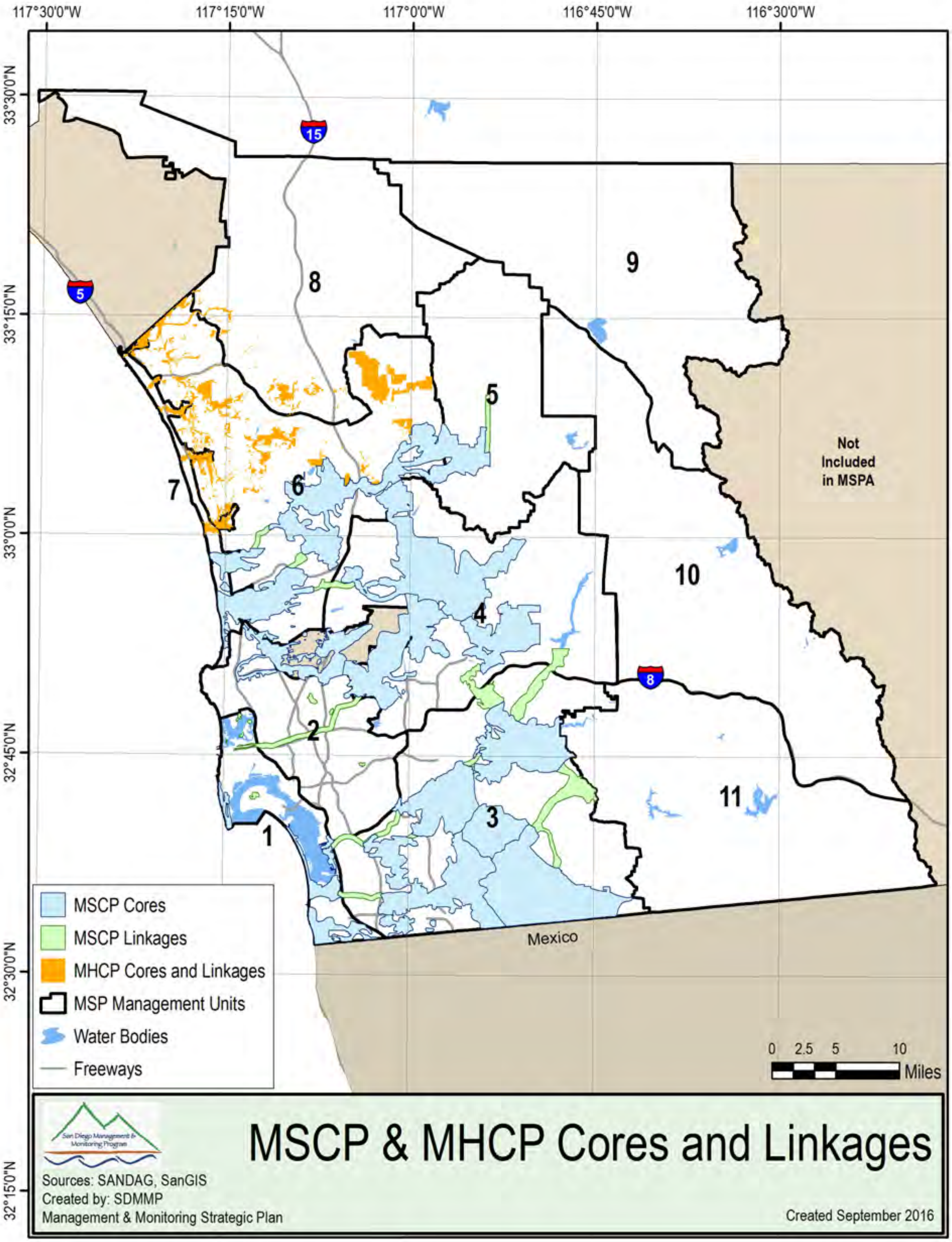

Figure V2B.8-2. MSCP and MHCP Cores and Linkages.

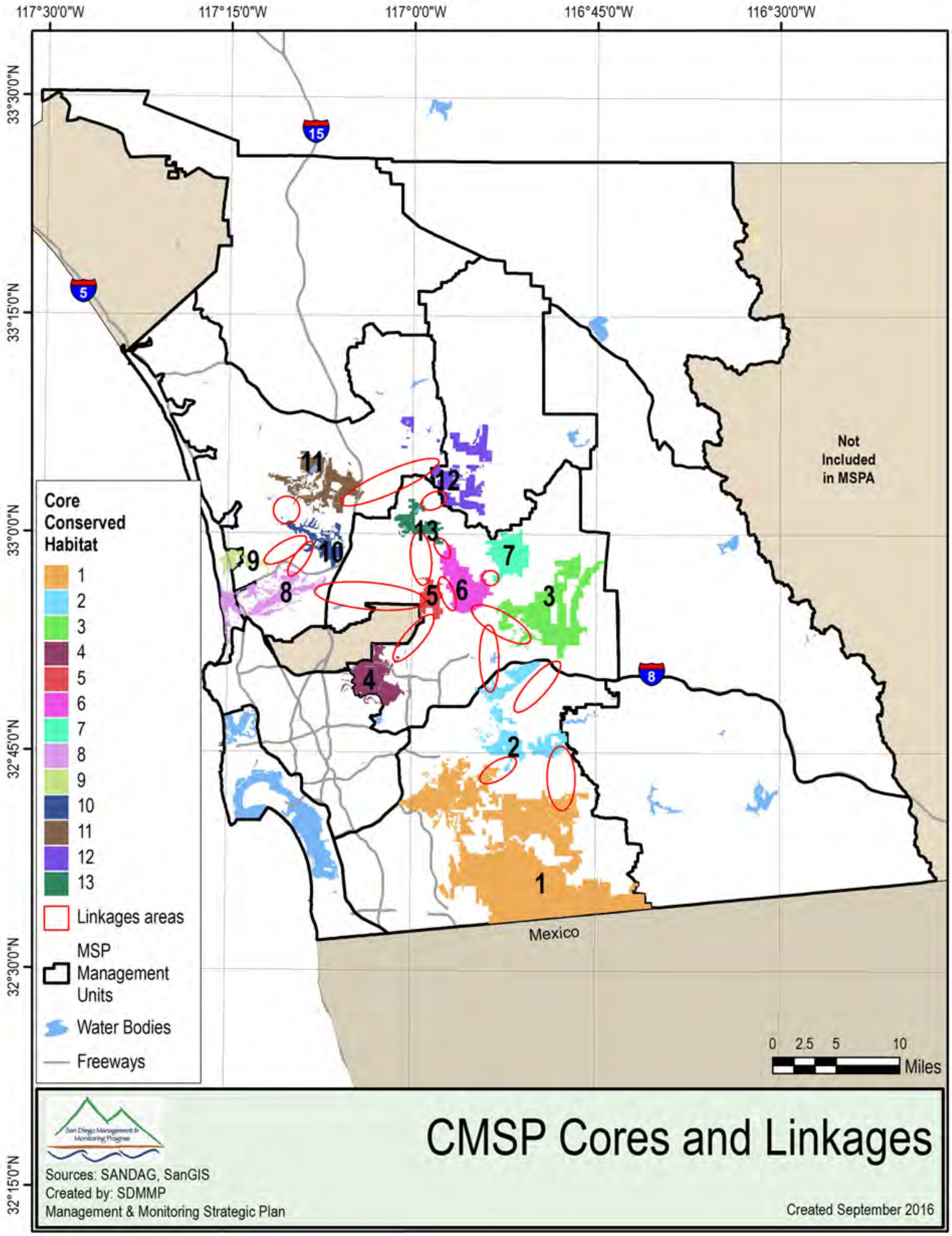

Figure V2B.8-3. CMSP Cores and Linkages.

Because the planning area for the MSPA is much larger than the MSCP and MHCP areas and has been expanded to the east with the MSP update, the approach for identifying cores has been modified to consider the broader landscape context of western San Diego County and adjacent planning areas. For the MSP Roadmap, a Core Habitat Area (also referred to as "Core" or "Core Area") is defined as a contiguous area of relatively intact natural vegetative cover that is at least 1,250 acres in size and with little or no permanent internal fragmentation from human development. In some cases, Core Habitat Areas smaller than 1,250 acres have been included where valuable biological resources exist in localized areas (e.g., lagoons, vernal pools, cactus habitat). In addition to Conserved Lands, Core Habitat Areas may include un-conserved but intact habitat on private lands, military lands, utility lands (e.g., water districts), and tribal lands.

Core Habitat Areas provide many values toward protecting native species and the integrity of natural systems. These values include (Austin et al. 2004): supporting natural ecological processes such as predator-prey interactions and natural disturbance regimes; helping to maintain air and water quality; supporting the biological requirements of many plant and animal species, especially those that require large areas to survive; supporting viable populations of wide-ranging animals by allowing access to important feeding habitat, reproduction, and genetic exchange; and serving as habitat for source populations of dispersing animals for recolonization of nearby habitats that may have lost their original populations.
A total of 27 Core Habitat Areas (labeled A through Z, plus AA) were identified in the MSPA based on the above criteria (Table V2.8-1). Conserved lands within Core Habitat Areas are shown in Figure V2B.8-4 (or view online at: http://arcg.is/2iSQHRJ), which provides an overview of how well Conserved Lands are currently connected and where there are gaps of unprotected habitat between existing Conserved Lands.

Within the broader MSPA, Core Habitat Areas range in size from 1,104 acres to 272,142 acres. The average Core Habitat Area is 49,867 acres. West of I-15, Core Habitat Areas are smaller and largely defined by intense urban development, whereas, in the inland area, Core Habitat Areas tend to be much larger and are usually defined by major highways such as I-8 and State Route (SR) 52, SR 67, SR 76, SR 78 and SR 79.

In terms of level of conservation in each core, the cores with the largest acreage of conserved intact habitat are found in Core C (Eastern Mountain Boundary) followed by Core V (Crestridge-Hollenbeck-McGinty), M (San Vicente/Iron

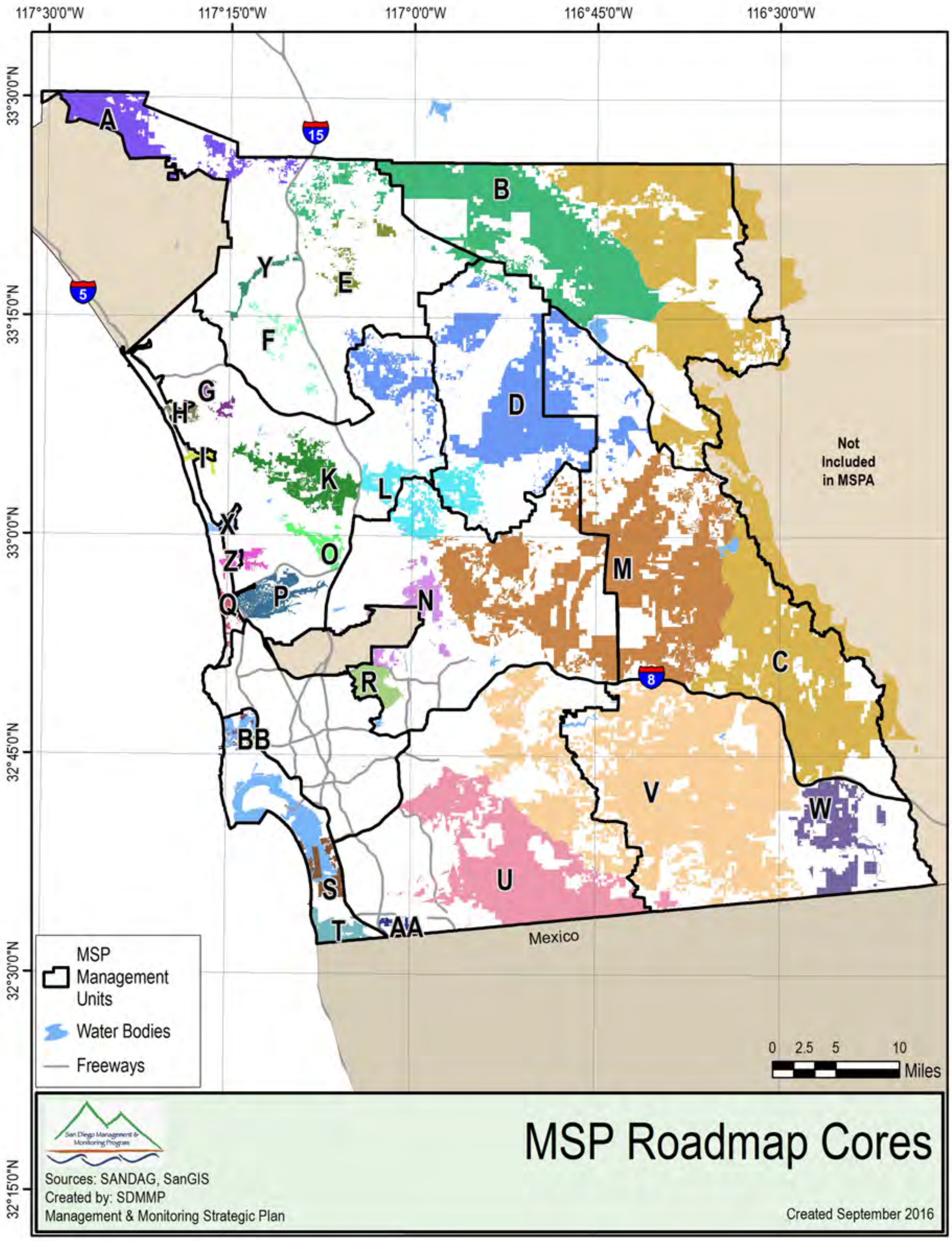

Figure V2B.8-4. MSP Roadmap Conserved Lands in Core Areas.

Table V2B.8-1. Summary of Core Habitat Areas

Core ID	MSPA Core Name	MU(s)	MSCP Core Area ID	Total Core Acres	Total Acres Conserved	Percent Conserved	Total Acres Urban	Percent Urban
A	Santa Ana Mountains	8	N/A	150,020	16,014	11	2,324	2
B	Palomar Mountains	9	N/A	132,152	67,464	51	9,307	7
C	Eastern Mountain Boundary	9,10	N/A	272,142	180,945	66	11,024	4
D	Daley Ranch-Pauma Valley	4	N/A	146,260	51,072	35	12,211	8
E	Lilac Ranch	4	N/A	17,094	1,709	10	1,274	7
F	Merriam Mountain	6	N/A	9,569	718	8	1,549	16
G	Carlsbad Cores 3/5	6	N/A	2,482	1,485	60	114	5
H	Carlsbad 4	6	N/A	1,400	981	70	183	13
I	Carlsbad 8	6	N/A	1,411	928	66	158	11
J	Mission Bay	1	Mission Bay	3,104	137	4	403	13
K	Lake Hodges	6	Lake Hodges / San Pasqual Valley	18,899	10,828	57	2,806	15
L	Ramona/Mt Woodsen	4	Central Poway	27,053	10,793	40	5,714	21
M	San Vicente/Iron Mountain	5	Central Poway/San Vicente, Lake Jennings/Wildcat Canyon/-El Cajon Mountain	177,871	98,258	55	17,120	10
N	Gooden Ranch/Sycamore Cyn	5	Mission Trails/Kearny Mesa/ East Elliot/Santee	29,106	6,122	21	1,107	4
O	Black Mountain	6	Lake Hodges/San Pasqual Valley	4,269	3,075	72	290	7
P	Peñasquitos Canyon	6	Peñasquitos Lagoon, Del Mar Mesa, Peñasquitos Canyon	8,534	5,235	61	1,998	23
Q	Torrey Pines	7	Peñasquitos Lagoon, Del Mar Mesa, Peñasquitos Canyon	2,241	1,596	71	225	10
R	Mission Trails	5	Mission Trails/ Kearny Mesa/East Elliot, Santee	5,370	5,150	96	127	2
S	Silver Strand	2	Silver Strand	8,014	2,710	34	2,342	29
T	Tijuana Estuary	2	Tijuana Estuary	4,791	3,827	80	262	5

Core ID	MSPA Core Name	MU(s)	MSCP Core Area ID	Total Core Acres	Total Acres Conserved	Percent Conserved	Total Acres Urban	Percent Urban
U	Greater SDNWR	3,4	Sweetwater River/ San Miguel Mountain/Sweetwater Reservoir, Marron Valley/Otay Mountain	81,354	56,810	70	4,134	5
V	Crestridge-Hollenbeck-McGinty	3	McGinty Mtn/Sequan Peak-Dehesa	203,912	123,549	61	27,065	13
W	Campo	11	N/A	3,104	137	4	403	13
X	San Elijo Lagoon	8	San Dieguito Lagoon	1,104	955	87	136	12
Y	San Luis Rey River	6. 8	N/A	3,388	1,509	45	398	12
Z	San Dieguito Lagoon	7/6	San Dieguito Lagoon	2,247	2,144	95	205	9
AA	Spring Canyon/Furby North	2	Spring Canyon	2,298	606	26	165	7

Mountain), and B (Palomar Mountain). In terms of percent area conserved, the cores with the lowest percent conserved (in terms of total acreage of unprotected private lands) are Cores C, D, B, M and V. While Cores M and V support large areas of Conserved Lands, these cores are also on the verge of being fragmented into smaller cores as a result of expanding agricultural and urban development. Connectivity monitoring will help assess whether there remain opportunities for maintaining connectivity within these cores and will assist with prioritizing actions, such as land acquisition, to ensure that smaller habitat patches remain connected to larger Core Habitat Areas.

8.2.2 Linkages in the MSPA

A linkage is defined as connected land intended to promote movement of multiple focal species or propagation of ecosystem processes (Beier et al. 2008). Linkages within the MSPA include both *Between*-Core and *Within*-Core linkages. In Figure V2B.8-5 (or view online at: http://arcg.is/2iSQHRJ), Between-Core linkages are assigned letters according to the Core Habitat Areas they are connecting (i.e., A–B, D–E, etc.). Within-Core linkages are identified by the assigned Core letter and a number (i.e., A1, A2, etc.).

In the MSPA, Within-Core linkages are important for maintaining connectivity between habitat patches for species that can persist in smaller habitat fragments, whereas both Within- and Between-Core linkages are important for wide-ranging species that have ranges that extend beyond an individual Core Habitat Area. Mountain lions, for example, occupy ranges that encompass up to 300 square kilometers and disperse distances that average 65 kilometers (much larger than any single core area) and requiring movement between cores to persist in the MSPA.

West of I-15, Core Habitat Areas tend to be smaller and surrounded by roads and development. Linkages west of I-15 are largely Between-Core linkages and often consist of narrow canyons and drainages. A few of these linkages connect coastal lagoons with more inland areas along drainages. These linkages are vital to maintaining lagoon processes and for providing opportunities for species to move with climate change and sea level rise. East of I-15, many linkages are not well defined, and will require further refinement through the linkage evaluation and design process. Linkages east of I-15 often involve crossings of major highways, including SR 67, SR 76, SR 78, SR 79, and SR 94. While most of these are 2-lane highways where they intersect Conserved Lands, they support high traffic volumes

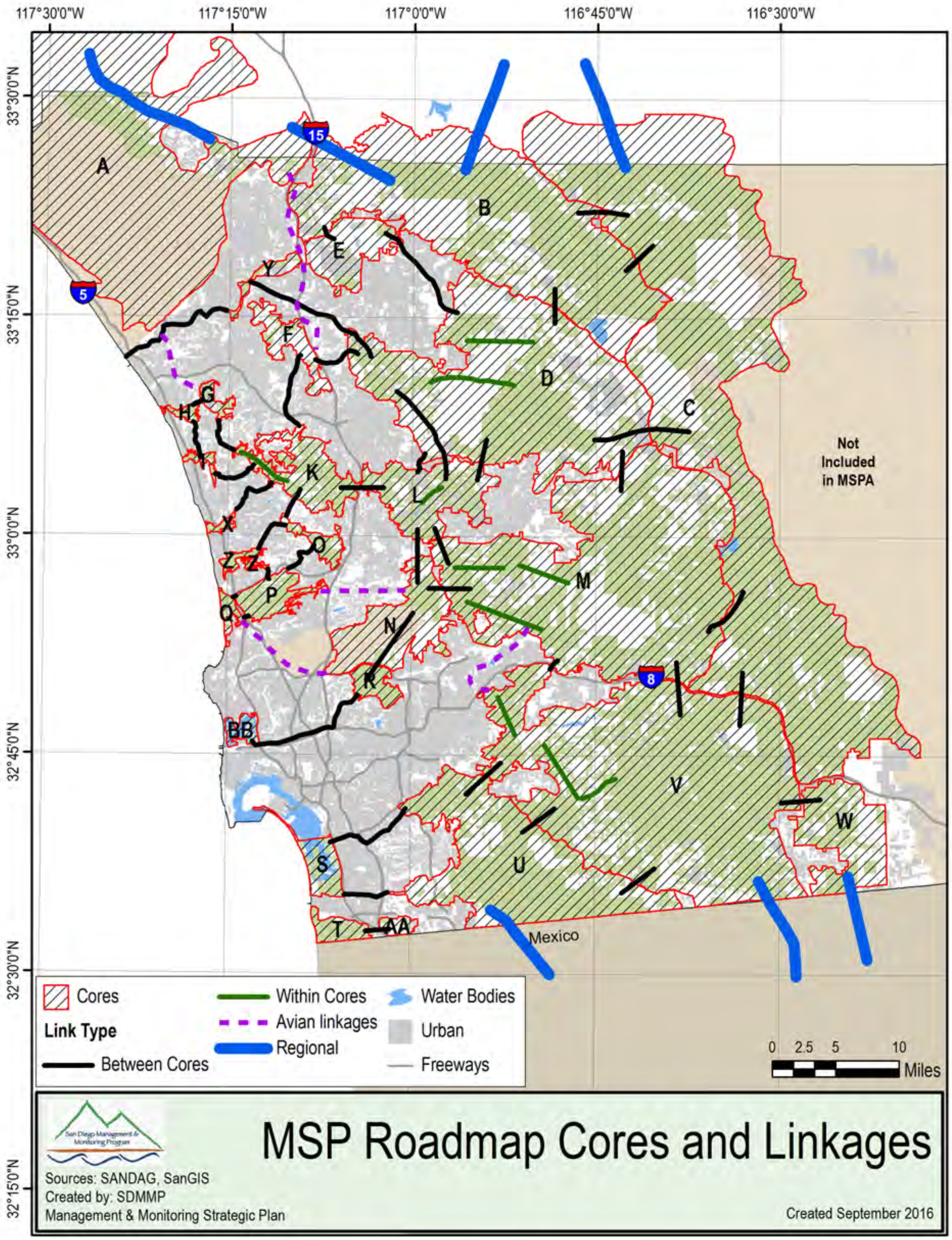

Figure V2B.8-5. MSP Roadmap Between-Core and Within-Core Linkages.

that are expected to rise with increased development in the backcountry. These highways, known for their curves, hill climbs, and narrow line of sight, do not support adequate wildlife crossing structures, both inhibiting wildlife movement and forcing wildlife to cross at-grade (CBI 2015). In anticipation of future highway widening plans, wildlife infrastructure improvement plans have been prepared for SR 94 and are being prepared for SR 67. These plans, informed by wildlife monitoring studies, are being developed to assist with identifying spatially explicit linkages that inform land protection needs and the placement and design of wildlife crossing structures and directional fencing to increase the permeability of these roads for a suite of wildlife species.

Within-Core linkages east of I-15 consist of gaps of unprotected lands between conserved habitat and crossings of busy arterial roads. Gaps in unprotected habitat between Conserved Lands in the southern part of the MSPA are narrowing as a result of urban and rural development and require attention in the next 5 years to ensure that connectivity is maintained. For example, linkages between Sycuan Peak Ecological Reserve (ER), Hollenbeck Canyon ER, and Crestridge ER are increasingly becoming constrained by urban development, and opportunities for maintaining these connections are becoming scarce. Elsewhere, arterial roads such as Barona Road, Wildcat Canyon Road, and Valley Center Road, serve to decrease internal permeability of Core Habitat Areas, as many do not support adequate wildlife crossing infrastructure. Finding the best locations for, as well as solutions to protect, these linkages in the next 5 years is critical, and will require a combination of restoration, land acquisition, and wildlife crossing infrastructure where these choke points involve major roadways.

8.3 RESULTS OF CONNECTIVITY STUDIES IN THE MSPA

Existing identified linkages within the NCCP areas have been monitored for their effectiveness through various early studies (CBI 2002, 2003a and b, 2004; Webb and Campbell 2003). These efforts focused on monitoring the use of identified habitat linkages and choke points by large mammals, primarily deer, bobcats, coyotes, and mountain lions. These studies identified wildlife use of linkages, compared monitoring methods (e.g., cameras, track stations, scent stations) and recommended locations (existing and new) for future monitoring.

Following these studies, the 2011 CMSP included priority objectives for the implementation of several additional connectivity studies for 3 functional groups: large animals (mountain lion, bobcat, badger, and deer), small animals (various), and birds (coastal California gnatcatcher and coastal cactus wren) plus an evaluation of linkages (corridors and choke points) for potential functionality.

While previous studies confirmed the use of linkages and choke points by target species, they did not examine genetic exchange which is necessary for long-term population viability. The 2011 CMSP included objectives for genetic analyses to assess genetic diversity, population structure, effective population size, and levels of inbreeding to identify where roads or development may be interfering with preserve integrity and population viability. Although no priority objectives for invertebrates or plants were included in the 2011 CMSP, genetic studies were completed or are ongoing for several species (e.g., San Diego fairy shrimp, Hermes copper, San Diego thorn-mint). The results of these studies are summarized briefly below and in Table V2.8-2 (see project pages on SDMMP website for full reports, http://portal.sdmmp.com).

8.3.1 Large Animal Studies

Studies of deer and mountain lions in the MSPA identified that major highways are restricting their connectivity (Bohonak and Mitelberg 2014; Vickers et al. 2015). I-5 and I-805 are isolating mule deer populations in the western part of the MSPA, where populations generally correspond to existing reserves and canyons. I-15 in the northern MSPA is restricting genetic connectivity between mountain lion populations, with lions west of I-15 belonging to the Orange County/Santa Ana Mountains subpopulation and lions east of I-15 belonging to the San Diego subpopulation (Vickers et al. 2015). Recent genetic analyses of the Santa Ana Mountain's mountain lion population indicate significant genetic restriction and minimal evidence of migration into this population in recent years. These studies indicate that genetic diversity for the Santa Ana Mountains' lions is very low (Ernest et al. 2014), lower than has been measured anywhere else in the west. In addition to I-15, other roads and highways that appear to be a potential barrier for mountain lions include SR 67, SR 76, SR 78 near Santa Ysabel, Barona Road/Wildcat Canyon Road, and Valley Center Road (Vickers 2014).

Genetic analyses of bobcats in the MSPA showed some degree of genetic differentiation between coastal bobcats west of I-5 with inland animals to the east, but did not indicate subpopulation differentiation has occurred (Jennings and Lewison 2013). This supports the assertion that the coastal and inland areas have some level of connectivity (Jennings and Lewison 2013). However, for species such as bobcat that are sensitive to habitat fragmentation, increasing fire frequency and associated loss of cover may be leading to impaired landscape connectivity. Failure to account for fire return interval departures can result in overestimation of landscape connectivity.

Table V2B.8-2. Summary of relevant Connectivity Studies

Topic/Species	Publication(s)	Summary
Mountain lion movement and genetic studies	Ernst et al. 2014; Vickers et al. 2015	Six of 9 core areas within the MSPA that were evaluated were used regularly by collared mountain lions and 1 core area was used briefly. Of the 11 linkages identified for assessment, only 3 were utilized by collared lions. It is estimated that the MSPA can support 4 to 5 reproductive females. Lions west of I-15 are part of the Orange County lion population, whereas those east of I-15 belong to lion populations that extend east of MSPA. Road mortality and depredation are major causes of mortality in San Diego County. Particular roads of concern include SR 67, SR 78, SR 76, County Road S6, Wildcat Canyon/Barona Road, and San Vicente Road. Camera trap data indicate that the majority of the lions utilizing the study area were captured and collared.
Badger movement studies	Brehme et al. 2016	Badgers were detected in MUs 3, 4, 5, and 8 and to areas east and north of the MSPA, but detections were not consistent between nor within years, which indicates the badger population is sparse, home ranges are large, and individuals likely make large daily and seasonal movements. Roads appear to be a major mortality issue where badgers still exist. Genetic analysis of badger scat is ongoing in an effort to determine feasibility of utilizing scat DNA to identify individual animals and make inferences on movement areas and population size.
Bobcat movement and genetic study	Jennings and Lewison 2013	Genetic analysis from collared and road-killed bobcats showed some degree of genetic differentiation between coastal bobcats west of I-15 and inland animals to the east, but did not indicate subpopulation differentiation has occurred. This supports the assertion that the coastal and inland areas have some level of connectivity.
Southern mule deer genetic study	Bohonak and Mitelberg 2014	The genetic data from the deer fecal analyses indicated deer in the areas analyzed have high family group home range affinity with most female young occupying at least a portion of their mother's home range as adults. Male deer moved farther but did not disperse widely. Genetic structuring of the population is occurring indicating that some linkages may not be functioning for deer. Torrey Pines, Sorrento Valley, Peñasquitos Canyon, Peñasquitos Creek, Carrol Canyon, MCAS Miramar, and Mission Trails can be considered as a separate management unit from those elsewhere in the subspecies range.

Topic/Species	Publication(s)	Summary
Wildlife Linkage Evaluation	Rochester et al., in prep.	Of the 16 linkages identified in the CMSP, 8 are estimated to be functional, having a high likelihood to provide suitable habitat and movement routes to allow wildlife to effectively move back and forth between the conserved areas. The remaining 8 linkages were estimated as nonfunctional, having significant barriers to wildlife movement, so much so that it seems very unlikely that none but the most disturbance-tolerant species will be able to move from 1 area to the next. A wide variety of taxa were detected using monitored wildlife undercrossing locations, including: snakes, lizards, invertebrates, rodents, predators, and deer. Mountain lions were not detected at any of the monitored wildlife undercrossings.
Carlsbad Wildlife Movement Analysis	City of Carlsbad, Environmental Science Associates, Center for Natural Lands Management 2015	This study evaluated connectivity for medium and large animals for over 20 potential wildlife linkages in the Carlsbad Habitat Management Plan area. Potential linkages and pinch points were first inventoried using available aerial imagery and geospatial data, and then each linkage or pinch point was evaluated in the field to document existing conditions and potential constraints to wildlife movement. Use of identified wildlife linkages was then monitored for 12 months via track and camera trap studies. Bobcat and coyote were documented at nearly all studied linkages, while deer were documented at 2 linkages. Surveys identified the need for maintenance of several pinch points that are overgrown or are otherwise unpassable for wildlife due to pooling of water or fencing.
Coastal cactus wren genetic study	Barr and Vandergast 2014	This study found many distinct genetic clusters, relatively small effective population sizes, and low genetic diversity in small populations in San Diego County, particularly in South County. The small effective population sizes for the Otay Valley and the Sweetwater-Lake Jennings populations and the lack of connectivity between these populations are of great concern. This species is in significant trouble and the southern MSPA populations could disappear in the near future without intervention.

Topic/Species	Publication(s)	Summary
California gnatcatcher	Vandergast et al. 2014	Regional genetic studies performed for the California gnatcatcher in Ventura, San Bernardino, Los Angeles, Orange, Riverside and San Diego Counties found that Palos Verdes, Ventura, and Coyote Hills in Orange County composed statistically distinguishable populations, while all other aggregations from the eastern Los Angeles Basin through southern San Diego County formed a single population.
Arroyo toad genetic study	Fisher, Brown (ongoing)	Study is ongoing by USGS to determine the degree of genetic variation within and between populations of arroyo toad in San Diego County.
Southwestern pond turtle genetic study	Fisher et al. 2014	Studies of the southwestern pond turtle performed by USGS throughout southern California using mitochondrial DNA have identified that southwestern pond turtle genetics are distinct between watersheds in southern California.
Small vertebrates	Tracey et al. 2014	The results supported the short-term effectiveness of the added structure treatments on small vertebrate use of underpasses and suggested that these rates changed on the specific side the treatment was applied rather than the entire underpass.
San Diego fairy shrimp genetic study	Bohonak and Simovich 2013	Studies suggest that local pool complexes were historically isolated but are currently homogenized in high use sites.
Hermes copper butterfly	Strahm et al. 2012; USFWS 2013	The genetic study showed there is little genetic differentiation in Hermes copper populations, although some differentiation occurs at the edges of their range (e.g., Meadowbrook Ecological Reserve, Boulder Creek Road, and Mission Trails Regional Park) (Strahm et al. 2012). These results likely represent historical connectivity patterns as, more recently, dispersal appears constrained with few of the 14 sites recolonized following population extinction from the 2003 and 2007 wildfires

Topic/Species	Publication(s)	Summary
Native bees (*Hymenoptera: Anthophila*)	Hung and Holway 2014 (see Vol 3 App. for Connectivity Workshop 2014 Project Summary)	In fragments of scrub habitat <40 hectares in size (e.g., open space parks embedded in urban matrix), native bee species richness and genus richness were roughly 35% lower than those in large, intact patches of scrub habitat >400 hectares in size (e.g., Mission Trails Regional Park), despite similar richness and density of blooming native plant species in the 2 types of habitats.
Stephens' kangaroo rat genetic study	Shier and Navarro 2016	The results of this regional study show the highest genetic variation in terms of allelic richness primarily in northern populations in Riverside County and the lowest in the southernmost populations (i.e., Ramona Grasslands, Rancho Guejito, MCB Camp Pendleton) suggesting that the species may have expanded southward from an ancestral population in the north of the current range. The study implies that recent effects of habitat fragmentation and population isolation in Stephens' kangaroo rat have created a metapopulation-like structure in the species across its current range.
San Diego thornmint genetic study	CNLM 2014	Results from this study indicated that the species has significant genetic structure and that differentiation among populations is consistent with gene flow, decreasing as a function of geographic distance. The overall genetic differentiation observed in San Diego thornmint is slightly lower than mean values reported for endemic annuals, but higher than that reported for other members of the Lamiaceae family. Populations that occur within a geographic region (ca. 20 kilometers) were more genetically similar than populations separated by greater distances.
San Diego ambrosia genetic study	McGlaughlin and Friar 2007	Genetic studies indicate that there is a high degree of genetic variation within 3 sampled San Diego ambrosia populations, hinting that sexual reproduction must have occurred at times in the past (Friar 2005). There is very little gene flow between nearby occurrences, indicating that large populations are necessary to maintain genetic diversity.
MSP rare plant genetic studies	Vandergast ongoing	Genetic studies are underway by USGS for the following 6 MSP rare plant species: Salt marsh bird's-beak, Orcutt's bird's-beak, Encinitas baccharis, Otay tarplant, willowy monardella, and San Diego thornmint.

Surveys conducted during the past 5 years in the MSPA for the American badger have identified that the badger population is sparse, home ranges are large, and individuals likely make large daily and seasonal movements (Brehme et al. 2016). Genetic analysis of badger scat is ongoing to determine feasibility of utilizing scat DNA to identify individual animals and make inferences on movement areas and potential connectivity (Brehme et al. 2016). Future work on badgers will focus less on their usefulness for indicating connectivity for large animals in general and more on specifically tracking this species' movement in the MSPA using telemetry to inform badger management.

8.3.2 Small Animals

The San Diego Zoo has completed an analysis of Stephens' kangaroo rat population genetics across the species geographic range (Shier and Navarro 2016). The results of this study show the highest genetic variation in terms of allelic richness primarily in northern populations (i.e., Lake Perris, San Jacinto Wildlife Area, March Air Reserve Base, Sycamore Canyon, Lake Mathews, etc.) and the lowest in the southernmost populations (i.e., Ramona Grasslands, Rancho Guejito, Marine Corps Base Camp Pendleton) suggesting that the species may have expanded southward from an ancestral population in the north of the current range. The study implies that recent effects of habitat fragmentation and population isolation in Stephens' kangaroo rat have created a meta-population-like structure in the species across its current range.

Genetic studies for the arroyo toad in San Diego County are underway, using genetic material collected during past and present regional surveys to evaluate the degree of genetic variation within and between populations and to possibly identify genetic bottlenecks or barriers; this information will also be used to determine source populations to use in reestablishing arroyo toad in previously occupied areas (R. Fisher, USGS, in prep.).

Genetic studies are currently underway across southern California for the Blainville's horned lizard (J. Richmond, USGS, in prep.). The study will provide data on whether horned lizard populations are genetically interconnected across the NCCP reserve system, or whether gene flow has occurred recently but is no longer possible due to habitat fragmentation.

Recent genetic studies of the southwestern pond turtle performed by USGS throughout southern California using mitochondrial DNA have identified that southwestern pond turtle genetics are distinct between watersheds in southern

California (Fisher et al. 2014). All 4 populations sampled in southern San Diego County in the San Diego River, Sweetwater River, and Tijuana River watersheds appear to have gone through a decline in population size in the past. Based on current knowledge, it was recommended that most of the populations should be managed separately as they represent unique genetic signatures; managing within watersheds should be the priority.

8.3.3 Birds

Regional genetic studies performed for the California gnatcatcher in Ventura, San Bernardino, Los Angeles, Orange, Riverside, and San Diego Counties found that Palos Verdes, Ventura, and Coyote Hills in Orange County comprised statistically distinguishable populations, while all other aggregations from the eastern Los Angeles Basin through southern San Diego County formed a single population (Vandergast et al. 2014).

Genetic studies of the coastal cactus wren have identified that habitat loss and fragmentation and overall poor dispersal ability have led to genetic differentiation between clusters of wrens and loss of genetic diversity over the last 100 years (Barr and Vandergast 2014). In San Diego County, there are currently 4 distinct genetic clusters. The 2 genetic clusters in southern San Diego County—the Otay River Valley and Sweetwater/Lake Jennings genetic clusters—both have small effective population sizes and have little connectivity between them.

8.3.4 Invertebrates

A recent genetic study of Hermes copper butterfly found regular movement among sites within 1 kilometer, although some individuals appear to undertake longer distance movements (Deutschman et al. 2010; Strahm et al. 2012). Topography, habitat fragmentation, and other landscape features may affect dispersal ability and even reduce connectivity between populations in proximity (Deutschman et al. 2010; Strahm et al. 2012). In other cases, topography and vegetation may enhance movement through the landscape. The genetic study showed there is little genetic differentiation in Hermes copper populations, although some differentiation occurs at the edges of their range (e.g., Meadowbrook Ecological Reserve, Boulder Creek Road, and Mission Trails Regional Park) (Strahm et al. 2012). These results likely represent historical connectivity patterns as, more recently, dispersal appears constrained, with only a few of the 14 sites recolonized following population extinction from the 2003 and 2007 wildfires (Strahm et al. 2012; USFWS 2013).

Genetic studies for the San Diego fairy shrimp (Bohonak and Simovich 2013) conducted for City of San Diego lands throughout San Diego County suggest that local pool complexes were historically isolated but are currently homogenized in high use sites. Studies suggest that in order to maximize the likelihood of success, newly created pools should probably be stocked from a very local source (Bohonak and Simovich 2013).

Studies of bees across Conserved Lands in the MSPA (Hung and Holway 2014, see Vol 3 App. for Connectivity Workshop 2014 Project Summary) found that, in fragments of scrub habitat <40 hectares in size (e.g., open space parks embedded in urban matrix), native bee species richness and genus richness were roughly 35% lower than those in large, intact patches of scrub habitat >400 hectares in size (e.g., Mission Trails Regional Park), despite similar richness and density of blooming native plant species in the 2 types of habitats. Possible drivers of loss of bee diversity in fragments are not known but could include loss of host plants or nesting substrate or failure to recolonize following natural processes of local metapopulation extinctions.

8.3.5 Plants

Genetic studies for San Diego thorn-mint completed by the Center for Natural Lands Management (Rogers 2014), indicated that the species has significant genetic structure and that differentiation among populations is consistent with gene flow, decreasing as a function of geographic distance. The overall genetic differentiation observed in San Diego thorn-mint is slightly lower than mean values reported for endemic annuals, but higher than that reported for other members of the Lamiaceae family. Populations that occur within a geographic region (ca. 20 kilometers) were more genetically similar than populations separated by greater distances. This pattern indicates some level of gene flow may continue between populations, despite the limited potential for long-distance gene flow in this insect-pollinated ephemeral winter annual. Alternatively, these populations may have only recently become genetically isolated, and allele frequencies have not yet differentiated. These results also provide evidence for restricting seed dispersal among highly divergent populations. Differentiation among populations appears to be most strongly related to longitude (and elevation) and less so to latitude (i.e., north-south gradient).

Genetic studies for San Diego ambrosia (McGlaughlin and Friar 2006) indicate a high degree of genetic diversity within 3 sampled San Diego ambrosia populations, hinting that sexual reproduction must have occurred at times in the past. There is very little gene flow between nearby occurrences, indicating that large populations are necessary to maintain genetic diversity.

8.3.6 Linkage Studies

In addition to species-level surveys, the 2011 CMSP included an objective to conduct preliminary assessments of 16 priority linkages for their potential functionality in MUs 3, 4, 5, and 6. Based on past monitoring data and available satellite imagery and land use data, the assessment, conducted by USGS, revealed that 8 of the 16 linkages likely support movement for the 5 focal species assessed, while the remaining 8 are constrained and possibly nonfunctional for all but the most disturbance-tolerant wildlife species (C. Rochester, USGS, in prep.).

USGS also conducted detailed track and camera monitoring of many linkages previously studied by CBI (CBI 2002, 2003) to determine if physical connectivity along the various linkages was still present. While a wide variety of taxa were documented to be using several of the undercrossing locations (i.e., snakes, invertebrates, rodents, and deer), other monitored locations were determined not to provide connectivity for terrestrial species for a variety of factors, including lack of wildlife infrastructure and habitat loss due to development and fencing.

USGS performed a study between 2012 and 2013 to evaluate whether adding structure (concrete blocks) to undercrossings enhances their use by small vertebrate species (Tracey et al. 2014). For this study, in 2012, USGS studied wildlife use of 8 underpasses in the MSPA using camera traps. Following an initial 6-month study, USGS added structure, in the form of concrete blocks spaced 5 meters apart, on 1 side of 4 of the 8 underpasses. Two months following structure placement, USGS repeated camera trap surveys of all 8 sites for 6 additional months to evaluate if there was enhanced use of undercrossings by small vertebrates. The results supported the short-term effectiveness of the added structure treatments on small vertebrate use and suggested that these rates changed on the specific side the treatment was applied rather than the entire underpass.

In 2014, the City of Carlsbad, Environmental Science Associates, and the Center for Natural Lands Management evaluated connectivity for medium and large animals for over 20 potential wildlife linkages in the Carlsbad Habitat Management Plan area (City of Carlsbad et al. 2015). Potential linkages and pinch points were first inventoried using available aerial imagery and geospatial data, and then each linkage or pinch point was evaluated in the field to document existing conditions and potential constraints to wildlife movement. Use of identified wildlife linkages was then monitored for 12 months via track and camera trap studies. Bobcat and coyote were documented at nearly all studied linkages, while deer were documented at 2 linkages. Surveys identified the need for maintenance of several pinch points that are overgrown or are otherwise unpassable for wildlife due to pooling of water or fencing.

8.4 MANAGEMENT AND MONITORING APPROACH

The overarching and interrelated goals for protecting and restoring connectivity among core habitat areas within the MSPA and other regional conservation areas are to:

- Ensure the persistence of species across the preserve system and
- Maintain ecosystem functions across the landscape.

The approach for managing connectivity is divided into 2 parts: general and species-specific. General connectivity objectives focus on maintaining landscape permeability across the MSPA, within and between Core Habitat Areas, and benefitting the largest number of species, while species-specific objectives have been developed for those MSP species identified as at highest risk from loss due to fragmentation, and for which specialized connectivity objectives (i.e., maintaining genetic connectivity, restoring habitat) are required to ensure their persistence in the MSPA.

8.4.1 General Approach Objectives

The general approach for managing connectivity focuses on assessing how well existing lands are connected and identifying management actions to enhance connectivity. The primary objectives for General Connectivity Monitoring and Management are to:

- Conduct preliminary linkage evaluations to document the extent to which currently conserved and future conserved linkages connect Core Habitat Areas (structurally and, where data exist, functionally) for a wide variety of species. Where possible, identify the optimal spatial configuration of each linkage based on expert opinion and available habitat suitability modeling. Identify specific actions needed to secure functional connectivity.

- Based on linkage evaluations and results from past connectivity monitoring studies, identify priority linkages for further planning and long-term management and monitoring.
- For each priority linkage, prepare a management plan that includes (a) a spatially explicit linkage design based upon expert opinion and available data (b) identified and prioritized actions (e.g., planning, research, restoration, infrastructure improvement, land acquisition) needed to protect or restore connectivity, and (c) long-term monitoring to evaluate the success of management actions.
- Implement linkage improvement recommendations based on past studies and quantitative and qualitative linkage monitoring results (e.g., culvert maintenance, fencing, land acquisition).
- Evaluate various methods used in previous connectivity monitoring efforts in the MSPA to develop a long-term quantitative and qualitative monitoring strategy for priority linkages.
- Identify, through periodic spatial assessments and available modeling, the ongoing status of Core and Linkage areas to inform the status of regional connectivity objectives and to identify additional monitoring or conservation measures needed to better understand and maintain connectivity.
- Participate, as appropriate, in regional efforts targeted at identifying and prioritizing BMPs and funding in support of connectivity (research, land acquisition and wildlife crossing infrastructure improvements).

Below is more description of the management and monitoring objectives for the threat of loss of connectivity. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Loss of Connectivity summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1454.

Perform Linkage Evaluations

Linkages within the MSPA have been identified in Figure V2B.8-5. As mentioned above, some of these linkages have received preliminary evaluations to assess structural connectivity and some are being evaluated currently (e.g., North County linkage evaluation). For those linkages not yet evaluated or that need further study, evaluations should review the status of the structural connectivity (and functional connectivity, where data are available) for each of the linkages using expert opinion informed by data from various sources, including past monitoring data, spatial assessments using available aerial photography, satellite imagery, land use and vegetation data, and field surveys. These evaluations should identify for each linkage (1) the conserved habitat blocks to be connected by the linkage, (2) species targets that the linkage is intended to protect, and (3) the level of likely permeability for selected target species, as well as barriers to connectivity. This information will be used to identify specific actions to improve connectivity (e.g., further study/modeling, habitat restoration, land acquisition, alternative linkage designs, wildlife crossing infrastructure, and culvert maintenance).

Identify Priority Linkages

Once linkage evaluations have been completed, linkages within the MSPA will be prioritized for further linkage planning, management, and long-term monitoring based on several factors, including (1) the diversity of species and habitats supported; (2) the level of existing and potential conserved habitat to be connected; (3) the severity and immediacy of threat to connectivity posed by existing or proposed development, and (4) the importance of the linkage to sustaining regional connectivity, both within and beyond San Diego County.

Prepare Linkage Management Plans

Identified priority linkages will undergo further study to develop management plans that identify (1) spatially explicit linkage design(s), (2) management that outlines specific locations for prioritized actions to protect or enhance connectivity, and (3) monitoring to guide long-term evaluation of linkage performance. Linkage designs will be informed by linkage evaluations, expert opinion, past/future connectivity monitoring, and available habitat suitability and species movement modeling. Linkage design should incorporate linkage design procedures developed by Beier et al. (2008) and Beir and Brost (2010) as available data and time allow.

Linkage management plans will outline specific locations and types of actions to be implemented to enhance connectivity, including land acquisition, restoration, or infrastructure improvements. Linkage monitoring plans will identify the type of long-term monitoring required to evaluate linkage performance (quantitative, spatial assessments, inspect and manage). Where priority linkages include major roadways that are demonstrated to be a barrier to wildlife movement (SR 67, SR 94, SR 52, SR 78, SR 76, and SR 79), efforts should be made to identify needed wildlife crossing infrastructure improvements to enhance linkage function for target species.

Wildlife infrastructure improvement plans are complete or nearly complete for SR 67 and SR 94 and are intended to guide the placement, design, and long-term effectiveness monitoring of planned wildlife crossing infrastructure. These plans should serve as a model for preparing future wildlife crossing infrastructure improvement plans for priority roads in the MSPA.

Implement Linkage Improvement Recommendations and Monitor their Effectiveness

Recommendations outlined in completed linkage evaluations and Linkage Management Plans to enhance connectivity will be implemented as funding becomes available, and may include land acquisition, habitat restoration, culvert maintenance, directional wildlife fencing, addition of structure to increase use of undercrossings by small animals, or removal of man-made barriers. Connectivity enhancements should be monitored for their effectiveness following implementation using methods developed in the qualitative and quantitative linkage monitoring plans.

Implement Wildlife Connectivity Enhancements for SR 94 and Monitor their Effectiveness

A framework wildlife infrastructure improvement plan has been prepared for 12 miles of SR 94 to guide the placement of wildlife crossing structures aimed at minimizing roadkill and providing movement opportunities for multiple wildlife taxa (CBI 2015). While many of the recommendations, such as the construction of wildlife crossing structures, will be delayed until they can be integrated into future road widening projects, several recommendations should be implemented in the short term, such as directional wildlife fencing, culvert maintenance, additional wildlife monitoring, and habitat restoration. Connectivity enhancements should be monitored for their effectiveness following implementation using methods developed in the qualitative and quantitative linkage monitoring plans.

In addition, land managers should work with the California Department of Transportation to proactively discuss and evaluate locations and designs for wildlife crossing structures presented in the plan to inform road improvement design studies and plans as they are initiated.

Prepare Wildlife Infrastructure Improvement Plans for SR 67

The SR 67 Wildlife Infrastructure Improvement Plan is currently being expanded to include planning for the protection of nearby associated linkages beyond SR 67

(Jennings, in prep.). The plan will incorporate a multi-species movement and resistance-based assessment of functional connectivity and site-specific linkage designs, which will inform specific locations and types of structures to enhance connectivity across SR 67. The plan will also identify crossing locations and designs for nearby roads that are a barrier to wildlife movement, including Wildcat Canyon Road, Scripps Poway Parkway, and Mount Woodson Road. In addition to identifying wildlife crossing infrastructure needs, the plan will identify land protection needs in key linkage areas.

Implement Wildlife Connectivity Enhancements for SR 67 and Monitor Connectivity Enhancements for their Effectiveness

Once the SR 67 Wildlife Infrastructure Improvement Plan is complete, specific actions that can be implemented in advance of planned road improvement/ widening will be identified and prioritized for implementation, such as directional wildlife fencing, culvert maintenance, additional wildlife monitoring, land acquisition, and habitat restoration. Connectivity enhancements should be monitored for their effectiveness following implementation using methods developed in the wildlife infrastructure improvement plans and qualitative and quantitative linkage monitoring plans.

Develop Best Practices

As part of linkage evaluations, follow-up monitoring should be conducted to reassess the effect of added structure on the use of underpasses by small and large vertebrates (Tracey et al. 2014). Based on results of the study, "best practices" (BMPs) for increasing underpass use by small vertebrates should be developed.

Develop and Implement Quantitative Linkage Monitoring Protocols

Development of long-term monitoring protocols to assess functional connectivity should involve the review and refinement of various quantitative monitoring methods used in the MSPA over the last 15 years to identify BMPs and priority linkages for connectivity monitoring. Opportunities for integrating other regional monitoring data into the broader MSP Roadmap connectivity monitoring program should be evaluated and incorporated, as appropriate (e.g., San Diego Tracking Team, feral pig camera monitoring, genetic studies, and other species-specific connectivity monitoring methods). Specifically, the feasibility of integrating camera trap data across various monitoring efforts in the region should be evaluated to assess regional connectivity for various species. If determined that it is feasible to integrate camera data across the region, standardized camera trap monitoring protocols should be developed and implemented to ensure consistent data are collected.

Develop and Implement Qualitative Linkage Monitoring Protocols

In addition to quantitative field-based monitoring, an inspect and manage monitoring program should be developed and implemented for wildlife undercrossings and choke points that are within or abut Conserved Lands. The program should be developed with the input of land managers, and should entail yearly qualitative monitoring of choke points to assess wildlife use, threats, and to identify management actions to abate threats.

Conduct Regional Landscape Connectivity Spatial Analyses

Periodic spatial evaluation and reassessment of the intactness of habitat in cores and linkages across the MSPA should be conducted to inform regional connectivity management. Land conversion resulting from urban or agricultural development and other impacts within a non-conserved or partially conserved linkage can render the linkage ineffective. Documenting the current level of structural connectivity within the MSPA should include an assessment of landscape features, including patches of natural vegetation, agriculture, urban areas, land use, and major roads. Other relevant data layers, such as land facets (Beier and Brost 2010), climate change forecasts, and land use projections can be developed and integrated to provide further insight into regional connectivity management needs. Overlaying conservation status on these features will identify, at the regional scale, the degree to which structural connectivity is currently conserved in Core Habitat Areas and where linkages need to be maintained, both within and between cores, through land acquisition, restoration, or road infrastructure improvements. The periodic assessment of landscape features will allow land managers to assess, over time, how habitat intactness and, thus, connectivity, is changing with the expansion of urban, agricultural, and infrastructure land uses.

Participate in Tri-County Inter-Agency Connectivity Coalition

In 2015, Orange County Transportation Agency convened the first "Tri-County Inter-Agency Coordination Group" meeting to initiate regional discussions and strategies for managing and monitoring species and habitat connectivity in Orange, San Diego, and Riverside Counties. The group, composed of local and regional transportation agencies, Non-Governmental Organizations (NGOs), wildlife agencies, and land managers, is working to prioritize habitat connectivity needs particularly as it relates to roads, and will be working cooperatively to elevate the issues and strategies for enhancing connectivity in the 3-county area.

Convene a Wildlife and Roads Working Group

Protecting and enhancing connectivity across major roads will require the implementation of linkage assessments and monitoring as identified above to inform the planning process, but will also require ongoing outreach and collaboration with transportation agencies to identify future opportunities for incorporating wildlife crossing infrastructure into future road improvement projects. A "Wildlife and Roads" working group is recommended to be established to allow regular communication between wildlife agencies, land managers, and transportation planners to identify opportunities for integrating wildlife crossing infrastructure into planned road improvements.

8.4.2 Species-Specific Approach

Connectivity needs for different species can vary widely. Some species (e.g., mountain lions, bobcat, deer, American badger) are able to move long distances through diverse habitats. For these species, maintaining landscape linkages that have relatively few landscape barriers but do not support breeding individuals may be adequate to provide for movement between areas where populations of those species persist. However, other species that have shorter dispersal distances (e.g., Blaineville's horned lizard, Stephens' kangaroo rat, coastal cactus wren) likely need live-in habitat within the linkages for movement to occur through generations rather than through specific individual dispersal. For these species, maintaining or restoring breeding habitat for small populations in the linkage area may be necessary to achieve a functional linkage between blocks of habitat supporting larger groups of animals.

Recognizing that different species have different habitat needs for connectivity, several expert-based discussions facilitated by the SDMMP were held between November 2009 and July 2010 and again in July 2014 to identify and inform species-specific approaches for connectivity monitoring. A technical working group, organized around taxonomic groups, met to discuss connectivity issues including species, habitats, ecosystem function, monitoring methodologies, and potential approaches to monitoring. The results of connectivity technical meetings are presented in Appendix 11.

Species for which connectivity goals and objectives have been identified as part of their management and monitoring approach are identified in Table V2B.8-3. Three species identified for baseline connectivity monitoring in the 2011 CMSP will not be given priority during the 2017–2021 monitoring period. Regional genetic studies for the California gnatcatcher have sufficiently documented the current level of connectivity to inform management. Monitoring studies conducted during the past 5 years for the American badger have identified that the species is too sparsely distributed to be an effective target for connectivity monitoring. Finally, studies of bobcat connectivity conducted by San Diego State University have sufficiently identified the current level of connectivity for this species; however, the bobcat may be considered as an indicator for assessing functional connectivity under the long-term connectivity monitoring program.

Species-level objectives range from developing species-specific habitat suitability or movement models to inform the location of restoration or wildlife crossing infrastructure improvements, to enhancing connectivity and genetic studies to inform connectivity needs for specific rare plant populations. See each species section for details on objectives identified to reduce the threat of loss of connectivity. Use the MSP Portal for the most updated list of species with Loss of Connectivity objectives.

Table V2B.8-3. MSP plant and animal species with specific connectivity management and monitoring objectives

Scientific Name	Common Name	Management Category	Summary Page Link
Plants			
Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/view_species.php?taxaid=32426
Acmispon prostratus	Nuttall's acmispon	SO	https://portal.sdmmp.com/view_species.php?taxaid=820047
Ambrosia pumila	San Diego ambrosia	SO	https://portal.sdmmp.com/view_species.php?taxaid=36517
Aphanisma blitoides	Aphanisma	SL	https://portal.sdmmp.com/view_species.php?taxaid=20679
Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/view_species.php?taxaid=183764
Brodiaea filifolia	Thread-leaved brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=42806
Brodiaea orcuttii	Orcutt's brodiaea	SO	https://portal.sdmmp.com/view_species.php?taxaid=42815
Chloropyron maritimum ssp. maritimum	Salt marsh bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834234
Chorizanthe orcuttiana	Orcutt's spineflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=21019
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/view_species.php?taxaid=565077
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/view_species.php?taxaid=780273
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834156
Dudleya blochmaniae	Blochman’s dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502165
Erysimum ammophilum	Coast wallflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=22928
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/view_species.php?taxaid=833060
Nolina interrata	Dehesa nolina	SO	https://portal.sdmmp.com/view_species.php?taxaid=42992

	Scientific Name	Common Name	Management Category	Summary Page Link
	Tetracoccus dioicus	Parry's tetracoccus	SS	https://portal.sdmmp.com/view_species.php?taxaid=28420
Invertebrates				
	Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
	Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/view_species.php?taxaid=707282
Amphibians				
	Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
Reptiles				
	Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/view_species.php?taxaid=668677
	Phrynosoma blainvillii	Blainville's horned lizard (Coast horned lizard, San Diego horned lizard)	VF	https://portal.sdmmp.com/view_species.php?taxaid=208819
Birds				
	Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/view_species.php?taxaid=175408
	Athene cunicularia hypugaea	Western burrowing owl	SL	https://portal.sdmmp.com/view_species.php?taxaid=687093
	Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/view_species.php?taxaid=917698
Mammals				
	Lepus californicus bennettii	San Diego black-tailed jackrabbit	VF	https://portal.sdmmp.com/view_species.php?taxaid=900973
	Odocoileus hemionus fuliginata	Southern mule deer	SS	https://portal.sdmmp.com/view_species.php?taxaid=898459
	Puma concolor	Mountain lion	SL	https://portal.sdmmp.com/view_species.php?taxaid=552479
	Taxidea taxus	American badger	SL	https://portal.sdmmp.com/view_species.php?taxaid=180565

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9.0 LOSS OF ECOLOGICAL INTEGRITY

9.1 OVERVIEW

Ecological integrity provides a framework aimed at conserving native biodiversity by using natural or historic variation as a standard for evaluation and for promoting resilience, or the capacity of a system to retain functions and structure following disturbance (Wurtzebach and Schultz 2016). Ecological integrity is defined by Parrish et al. (2003) as follows:

> *…the ability of an ecological system to support and maintain a community of organisms that has species composition, diversity and functional organization comparable to those of natural habitats within a region.*

Ecological processes, including natural disturbance regimes, are important in providing the structure and functions upon which species in the ecosystem or landscape depend (Wurtzebach and Schultz 2016). An ecological system with high integrity is one where different aspects of the system, such as composition, structure, and function, are within the natural range of variation and when impacted by natural or human-caused disturbance can recover to its previous state (Parrish et al. 2003; Wurtzebach and Schultz 2016). Resilience is a measure of the capacity of a system to respond to disturbance and recover to its former state or to remain within the range of variation for that system by maintaining critical ecosystem processes (Seidl et al. 2016). Systems that maintain their native species and natural processes are thought to be more resilient to natural disturbances and anthropogenic threats over time (Parrish et al. 2003). Systems with low ecological integrity are not as resilient and may be shifted into new system domains when disturbed.

Measuring the ecological integrity of a specific system at a specific location requires comparing aspects of the ecosystem with pristine and undisturbed reference sites or by comparing it with measures in the historic range of variation for that system (Wurtzebach and Schultz 2016). These comparisons give an indication of how degraded the system is at a particular site and define its ecological integrity. In many cases, the historic range of variation is unknown and the comparison is among contemporary systems, carefully selected to best reflect what are hypothesized to be natural, high integrity systems.

The concept of ecological integrity is used by land managers to communicate and evaluate how well conservation and management goals are being met (Barbour 2000; Parrish et al. 2003). It is particularly applicable to habitat-based biodiversity conservation strategies (Wurtzebach and Schultz 2016). Ecological integrity metrics can be used to assess whether is it likely that conservation and management goals will be achieved for long-term persistence of viable populations of MSP species in their natural habitats or the maintenance of ecosystem functions. For example, if measures of ecological integrity for a particular vegetation community are found to be rapidly declining across the MSPA, this could be a warning that it may not be possible to meet the conservation goal of long-term persistence for the vegetation community and potentially for the MSP species dependent on it. However, with directed and appropriate management, ecological integrity metrics can also demonstrate the response of the vegetation community to management and, if successful, an improved likelihood of meeting conservation goals. Ecological integrity metrics provide a simple way to conceptualize more complex ecological processes and explain what has been learned from managing different components of the preserve system. They also provide a way to characterize the overall health or condition of an ecosystem and of the individual components.

9.2 LOSS OF ECOLOGICAL INTEGRITY IN THE MSPA

Loss of ecological integrity in the MSPA includes disturbance-induced changes beyond the bounds of historic or natural variation in ecosystem components of composition, structure, and function. Ecosystem composition is the variety of living things within the ecosystem and is defined by attributes such as species richness, evenness, and diversity (Wurtzebach and Schultz 2016). Ecosystem structure includes physical features of the ecosystem like vegetation cover, height, and density or larger landscape-scale features such as patch size and configuration (Wurtzebach and Schultz 2016). There is growing concern that the composition and structure of coastal sage scrub, chaparral, oak woodlands, and riparian forests in some areas of the MSPA are being altered by a suite of interacting threats. An altered fire regime and nitrogen deposition are facilitating the invasion of nonnative grasses into coastal sage scrub and chaparral vegetation communities leading to declines in native shrubs and forbs and simplification of the vegetation community (Vol. 2B, Sec. 1 and 7; Vol. 2C, Sec. 1). Oak woodlands and riparian forests are experiencing large-scale tree die-offs from the combined effects of drought, invasive pests, and novel fungal pathogens (Vol. 2C, Sec. 4 and 7). Loss of ecological integrity in these vegetation communities affects other species inhabiting them, potentially leading to declines in biodiversity as well as certain MSP species.

Important ecological functions or natural processes operating within the historic or natural range of variation are critical for maintaining ecological integrity. Examples of these processes within the MSPA include the hydrologic cycle, nutrient cycling, predator-prey relationships, pollination services, primary productivity, food webs, and natural disturbance regimes such as fire and floods.

9.3 RESULTS OF LOSS OF INTEGRITY STUDIES IN THE MSPA

Within the MSPA, a multi-taxon Index of Biological Integrity (IBI) was developed for coastal sage scrub and there have been a number of studies showing examples of loss in ecological integrity.

Diffendorfer et al. (2007) conducted a study of 5 plant and animal taxomic groups in coastal sage scrub vegetation and found that a multi-taxon IBI could be developed to characterize ecological integrity across a disturbance gradient of invasive nonnative grasses. They found that the IBI performed better than traditional community metrics and that no single taxon was a good indicator of the responses of the other taxa to the disturbance gradient. Responses to disturbance were varied and complex among the different taxonomic groups and there was large variation at multiple scales in abiotic and biotic conditions across the study area. The IBI was able to address this variability and characterize the ecological integrity of sites with 1 measure, which could be decomposed into individual components to understand how the different taxa responded to the disturbance gradient.

Several examples show how the ecological integrity and resilience of ecosystems in some areas of the MSPA are declining. A number of studies in the MSPA and broader southern California region have documented poor post-fire recovery of coastal sage scrub vegetation subjected to an altered fire regime of too frequent fire leading to conversion to a more simplified grassland ecosystem (Vol. 2B, Sec. 1). Conversion to grassland is also affecting post-fire reptile, bird, and mammal communities in the MSPA, often simplifying composition and structure (Vol. 2B, Sec. 1). Fire has directly impacted other species, such as Hermes copper, with lack of recovery attributed partially to lack of nearby populations to recolonize burned habitat. Habitat loss and fragmentation are associated with a lower species richness and higher proportion of generalist species in native bee communities in the MSPA (Hung and Holway 2014). Habitat loss and fragmentation are also associated with reduced connectivity of species such as coastal cactus wren and mountain lions, leading to low genetic diversity and isolated populations vulnerable to extinction (Vol. 2D).

9.4 MANAGEMENT AND MONITORING APPROACH

The primary management focus for the MSP Roadmap is to reduce threats to maintain or enhance high levels of ecological integrity and resilience at prioritized and interconnected species occurrences, vegetation communities, and ecosystems (see Vol. 1, Sec. 2). Managing for high ecological integrity and then monitoring species and system responses at managed and unmanaged sites can lead to a greater understanding of the species or system's capacity to persist under changing environmental conditions and with appropriate management. Ensuring there are multiple interconnected occurrences with high ecological integrity reduces the vulnerability of a species to local extinction or extirpation from the MSPA.

CORE ++ monitoring includes components to evaluate the ecological integrity of the regional preserve system and typically builds upon vegetation monitoring (CORE+) at permanent plots (Vol. 2A). Ecological integrity may be mapped for vegetation communities across the MSPA using remote imagery to characterize integrity classes based on vegetation composition, structure, and plant mortality. These ecological integrity classification maps will be evaluated and validated so they can be used in developing a sampling design for vegetation monitoring and for tracking changes in integrity across the MSPA over time. Vegetation monitoring also includes collecting field-based data on ecological integrity at sampling sites. This will involve selecting and evaluating aspects of the vegetation community to monitor that are representative of the integrity of the system. For coastal sage scrub, this could include using a field-based multi-taxon IBI (Diffendorfer et al. 2007) or using simpler measures of invasive grass cover, shrub cover, and density (see Vol. 2C Sec. 1).

Ecological integrity may also be incorporated into monitoring the status, habitat, and threats of MSP species (SL, SO, SS, and VF species). This will involve identifying variables to measure that reflect habitat integrity for each species. Additional ecological integrity add-on monitoring components can include community level surveys of arthropods, amphibians, reptiles, birds, and small mammals to measure biodiversity of vegetation communities. USGS is developing rapid assessment protocols to monitor various taxonomic groups and is also preparing community-level optimized monitoring protocols that provide greater efficiency. Other types of ecological integrity monitoring include assessing ecosystem processes, such as food webs (e.g., arthropod food resources for MSP bird species); animal movement (e.g., digital camera stations); pollinator services; carbon cycling; soil microbes; and biotic interactions. Some variables might be measured just once (e.g., soil texture, soil type, topography), others on a regular basis (e.g., vegetation), or continuously (e.g., weather station climate variables). Data from these add-on monitoring components can be used to calibrate whether vegetation data are sufficient to characterize ecological integrity for the broader preserve system.

Information obtained through monitoring loss of integrity for species, vegetation communities, and ecosystem processes will be important in identifying and prioritizing management objectives and actions. Results from loss of ecological integrity monitoring will be used to formulate recommendations to be incorporated into management plans for species, vegetation communities, and ecosystem processes.

9.4.1 General Approach Objectives

Below is a summary of the general monitoring objectives for loss of ecological integrity in the 2017–2021 planning cycle. There are no general ecological integrity management objectives in the current planning cycle. For the most up-to-date objectives and actions, refer to the MSP Portal Loss of Ecological Integrity summary page: (https://portal.sdmmp.com/view_threat.php?threatid=TID_20161230_1459).

The overall goal for loss of ecological integrity in the MSPA is to protect, maintain, enhance, and restore natural communities and important ecosystem processes to maintain high levels of ecological integrity in the regional preserve system over the long term (>100 years).

There are 3 general approach objectives for loss of ecological integrity in the 2017–2021 planning cycle. The first objective is to prepare a monitoring plan for riparian and oak woodland bird communities to assess community composition and diversity and the distribution and abundance of individual species across the MSPA that are under threat from tree die-offs due to invasive nonnative pests, fungal pathogens, and drought (see Vol. 2B, Sec. 6; Vol. 2C, Sec. 4 and 7). The second objective is to implement riparian and oak woodland bird community monitoring across the MSPA. The third objective is to prepare a monitoring plan to survey pollinator communities and assess pollinator functions in coastal sage scrub, chaparral, and forblands across the MSPA. Implementation of the pollinator monitoring plan is delayed until the 2022–2026 planning cycle.

9.4.2 Species-Specific and Vegetation Approach Objectives

Descriptions of loss of ecological integrity management approaches, rationale, goals, objectives, and actions for at-risk MSP species and vegetation communities are presented in the corresponding species, threats, and vegetation sections.

Species-specific and vegetation objectives that address ecological integrity are often combined with other threat objectives to reduce threat impacts and improve resilience of populations to enhance continued persistence. These include collecting data on ecological integrity as part of species and vegetation monitoring and developing an ecological integrity map for coastal sage scrub, chaparral, and grassland across the MSPA using remote imagery. Management objectives for MSP species and vegetation communities focus on management to improve habitat quality. Loss of ecological integrity monitoring objectives and actions are presented in the corresponding species sections. Links to species-specific and vegetation objectives that apply to loss of ecological integrity are provided in Table V2B.9-1. Use the MSP Portal for the most updated list of species and vegetation communities with Loss of Ecological Integrity objectives.

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Table V2B.9-1. MSP plant and animal species, and vegetation communities with specific Loss of Ecological Integrity management and monitoring objectives.

	Scientific Name	Common Name	Management Category	Summary Page Link
Plants				
	Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
Invertebrates				
	Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
Vegetation Communities				
	Chaparral			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_3
	Coastal Sage Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_1
	Grassland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_2
	Oak Woodland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
	Riparian Forest & Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7

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10.0 PARASITISM AND DISEASE

There are no objectives for Parasitism and Disease in the 2017-2021 planning cycle. This section will be included in future planning cycles.

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11.0 PESTICIDES

There are no objectives for Pesticides in the 2017-2021 planning cycle. This section will be included in future planning cycles.

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12.0 POWERLINES AND WIND FACILITIES

There are no objectives for Powerlines and Wind Facilities in the 2017-2021 planning cycle. This section will be included in future planning cycles.

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13.0 URBAN DEVELOPMENT

13.1 OVERVIEW

Urban development can have a number of impacts on preserves in the MSPA, including artificial lighting, nitrogen deposition, and various forms of pollution. Human disturbances tend to occur closer to urban areas because of the ease of access and proximity to roads. The urban edge was calculated as any area within 250 meters of an urban land use. In the MSPA, Conserved Lands with a higher land area within the urban edge may be at a higher risk of impact from urban development.

13.1.1 Edge Effects

Urban environments produce a variety of threats to native species. Human disturbance on preserves is typically higher closer to urban areas due to the demand for recreational opportunities, ease of access, and proximity of roads to preserves. These all provide opportunities for authorized and unauthorized use of preserves. Humans can directly damage species through trampling/killing species or their habitat, intentional and unintentional introductions of exotic and invasive species, road kill, increased fire frequency, nonpoint source pollution, and disruption of nighttime movements due to urban and suburban light increasing the ambient light levels in preserves. The percent area of a Conserved Land complex within the urban edge (250 meters) was calculated for all Conserved Land complexes (Table V2B.13-1; Figure V2B.13-1). MUs with Conserved Lands with very high levels of urban-wild interface (> 40%) include MUs 1, 2, 6, and 7. The urban-wild interface area on Conserved Lands in MUs 3, 4, 5, and 8 is much lower, although potential future development in the eastern part of the MSPA would increase the threat/stress from urban sources. This potential increase in urban edge will be tempered by the larger patch sizes of lands conserved in the eastern MUs.

13.1.2 Artificial Lighting

Light from urban areas can disrupt nighttime activities of many animals (Perry and Fisher 2006). It can allow predators to more easily see prey, such as nocturnal reptile species and small mammals, causing significant declines in their populations. Nighttime light pollution is the strongest near urban areas, including roads. Near wetlands, artificial light can disrupt nocturnal activities, such as croaking by frogs and toads, which can interfere with reproduction (International Dark-Sky

Association 2016). Additionally, many insects are drawn to artificial light, which often has fatal consequences. A decline in insect populations can negatively impact all species that rely on insects for food or pollination.

The World Atlas of Artificial Sky Brightness estimates the artificial light intensity based on satellite images and models based on the earth's curvature, topography, and measured locations (Cinzano and Elvidge 2004; Cinzano et al. 2012). The model is based on the Bortle light scale, which ranges from 1 (no light pollution) to 9 (entire sky is greyish or brighter). San Diego County has high levels of light pollution along the coast and city centers with less pollution in the eastern portions and areas blocked by mountains (Figure V2B.13-2). Some species (e.g., amphibians, reptiles, and birds) that occur in high light areas are likely being adversely impacted by night lighting level, especially preserves in MUs 1, 2, 4, 6, and 7.

Table V2B.13-1. Percent of area of Conserved Lands with urban edge.

MU	Acres of Conserved Land in Urban Edge	Total Acres of Conserved Land	Percent of Conserved Land in Urban Edge
1	3,742.4	7,245.6	51.7
2	5,520.7	6,736.2	82.0
3	20,388.5	85,122.9	24.0
4	17,484.5	58,467.2	29.9
5	6,612.5	40,129.2	16.5
6	27,630.5	42,946.3	64.3
7	3,029.5	3,817.8	79.4
8	5,964.3	23,881.6	25.0
9	17,571.1	137,926.2	12.7
10	18,759.7	141,868.2	13.2
11	17,262.3	115,258.8	15.0

13.1.3 Nitrogen Deposition

Nitrogen deposition is defined as reactive nitrogen originating from air pollution caused by fossil fuel combustion and that moves from the atmosphere to the ground as nitrate and ammonium (Simkin et al. 2016). Increasing levels of soil

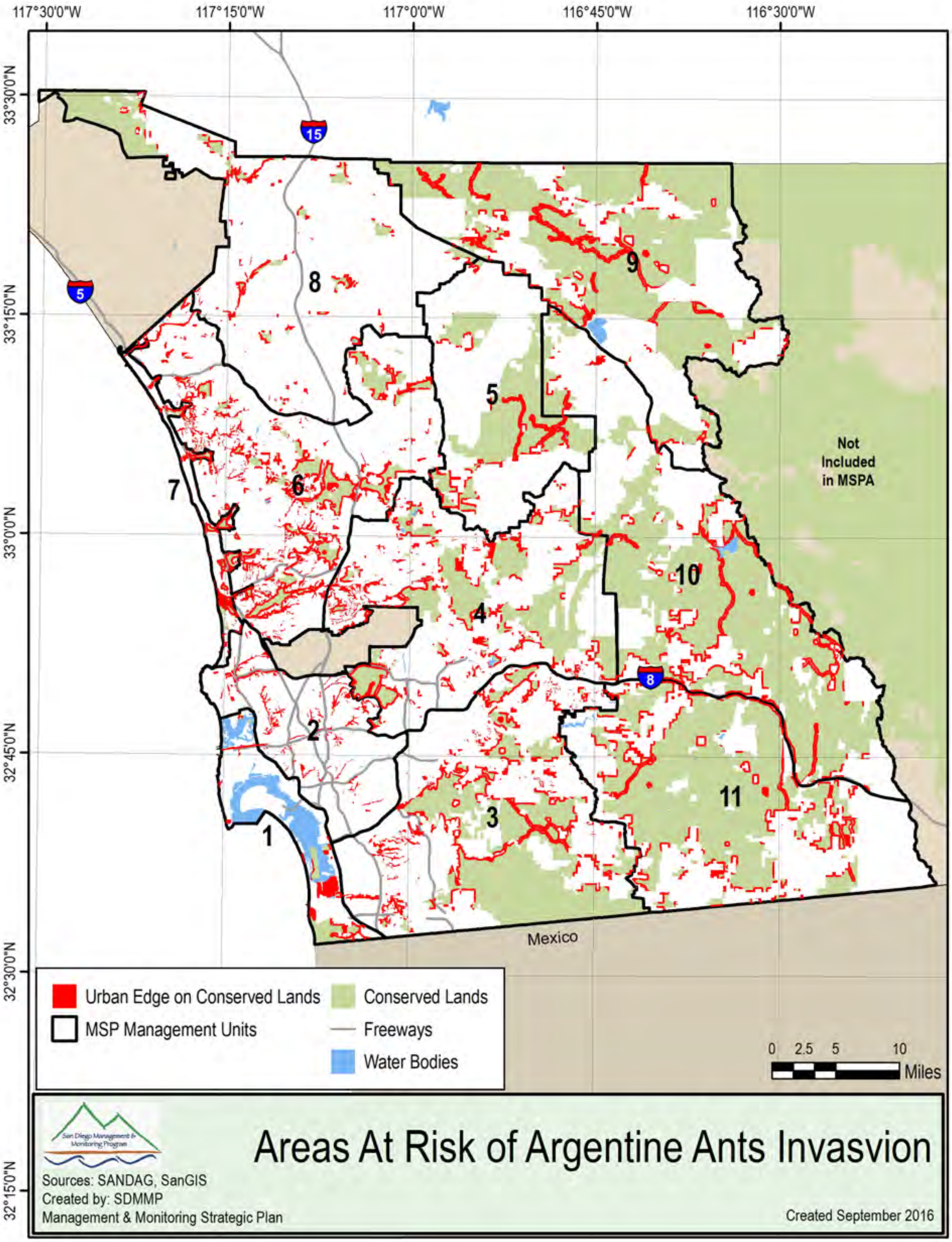

Figure V2B.13-1. Conserved Lands within 250 meters of an urban edge that are at risk of invasion by Argentine ants.

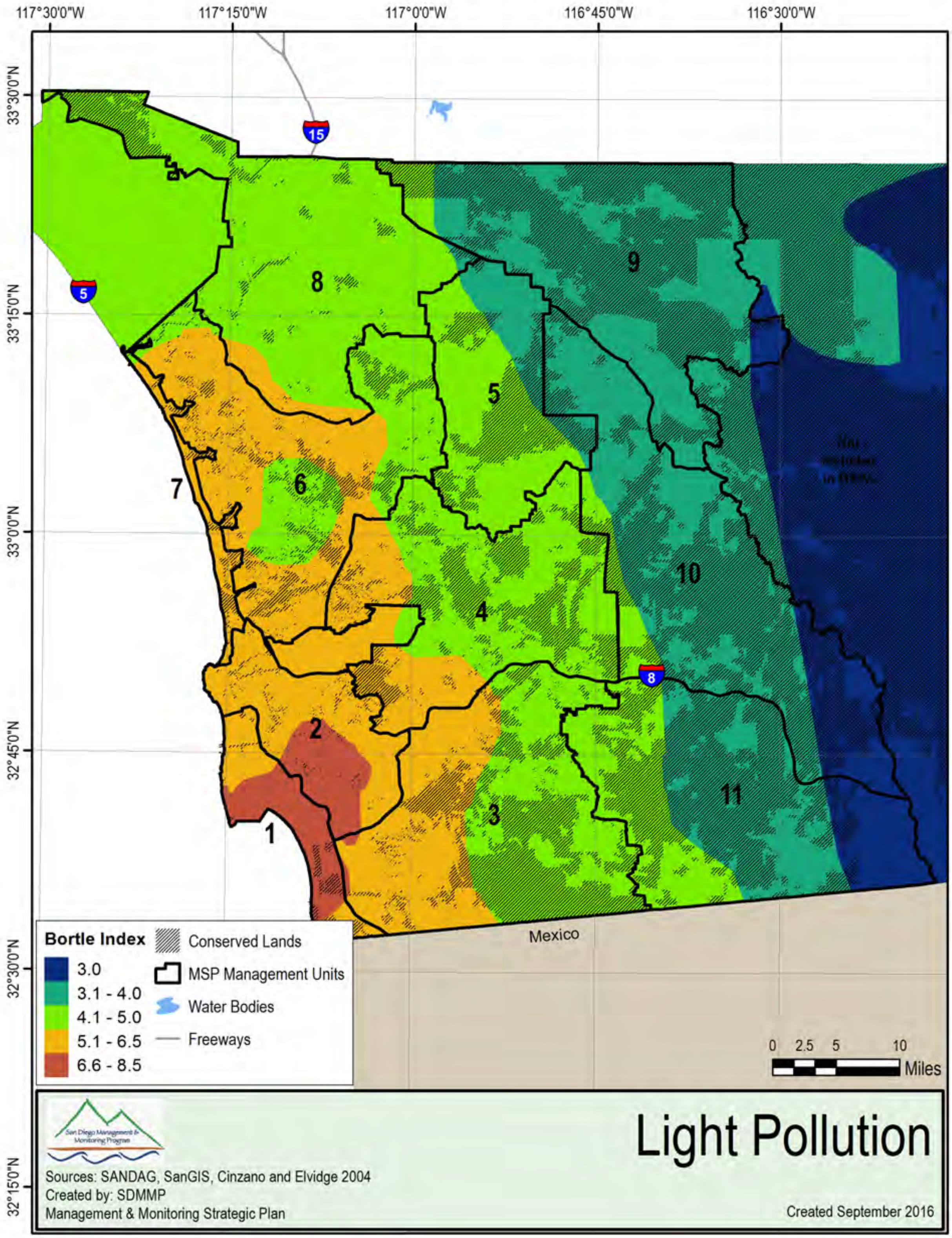

Figure V2B.13-2. Light pollution based on satellite images, topography, and earth curvature (Cinzano and Elvidge 2004).

nitrogen also arise from agricultural runoff (Perry et al. 2010). Global rates of nitrogen deposition have tripled in the last century (Simkin et al. 2016). This nutrient enrichment of the environment has led to worldwide declines in local plant species diversity, particularly the loss of rare plant species (Suding et al. 2005). Fifty percent of global biodiversity hot spots are subjected to nitrogen deposition levels of 15-20 kg N ha/yr, which threatens areas of high plant diversity and endemism (Phoenix et al. 2006). Increased soil nitrogen increases the invasion of nonnative plants into native plant communities (Perry et al. 2010). In the western United States, atmospheric nitrogen deposition is altering plant and microbial communities by changing species composition, and is associated with increased fire frequencies and sensitive species habitat degradation (Fenn et al. 2003).

In southern California, atmospheric nitrogen deposition is leading to the invasion of nonnative grasses into native grasslands, forblands, coastal sage scrub, and chaparral and facilitating vegetation type conversion to nonnative grassland (Weiss 1999; Fenn et al. 2003; Tallluto and Suding 2007; Cox et al. 2014; Kimball et al. 2014). Critical loads of nitrogen are those levels that facilitate invasion of nonnative grasses, with higher levels leading to type conversion to nonnative grassland (Fenn et al. 2010). These critical loads are: 7.8 to 10 kg N ha/yr in coastal sage scrub; 10-14 kg N ha/yr in chaparral; and 6-7.5 kg N ha/yr in grasslands. In California, 54% of coastal sage scrub, 53% of chaparral, and 44% of grassland vegetation communities exceed these critical loads of nitrogen (Fenn et al. 2010). Nitrogen deposition can act in concert with altered fire regimes and drought to accelerate the invasion process (Talluto and Suding 2007; Kimball et al. 2014). The process of coastal sage scrub type conversion is often facilitated by frequent fires, although critical loads of 11 kg N ha/yr or more are associated with landscape-scale type conversion over time in the absence of fire (Cox et al. 2014). Extreme drought may also slow natural succession and increase potential for type conversion of coastal sage scrub to nonnative grassland in nitrogen rich systems (Kimball et al. 2014). Elevated nitrogen deposition levels are impacting sensitive plant and animal species through degradation and type conversion of their habitats to nonnative grasslands (Weiss 1999; Fenn et al. 2003).

Estimates of nitrogen deposition were created by the University of California, Riverside based on remote sensing images and 13 atmospheric sensors in the San Bernardino Mountains (Bytnerowicz et al. 2015). Figure V2B.13-3 illustrates the modeled annual deposition of nitrogen in the MSPA (Tonneson et al. 2007). With the exception of small areas of the coast, the MSPA falls within nitrogen loads that

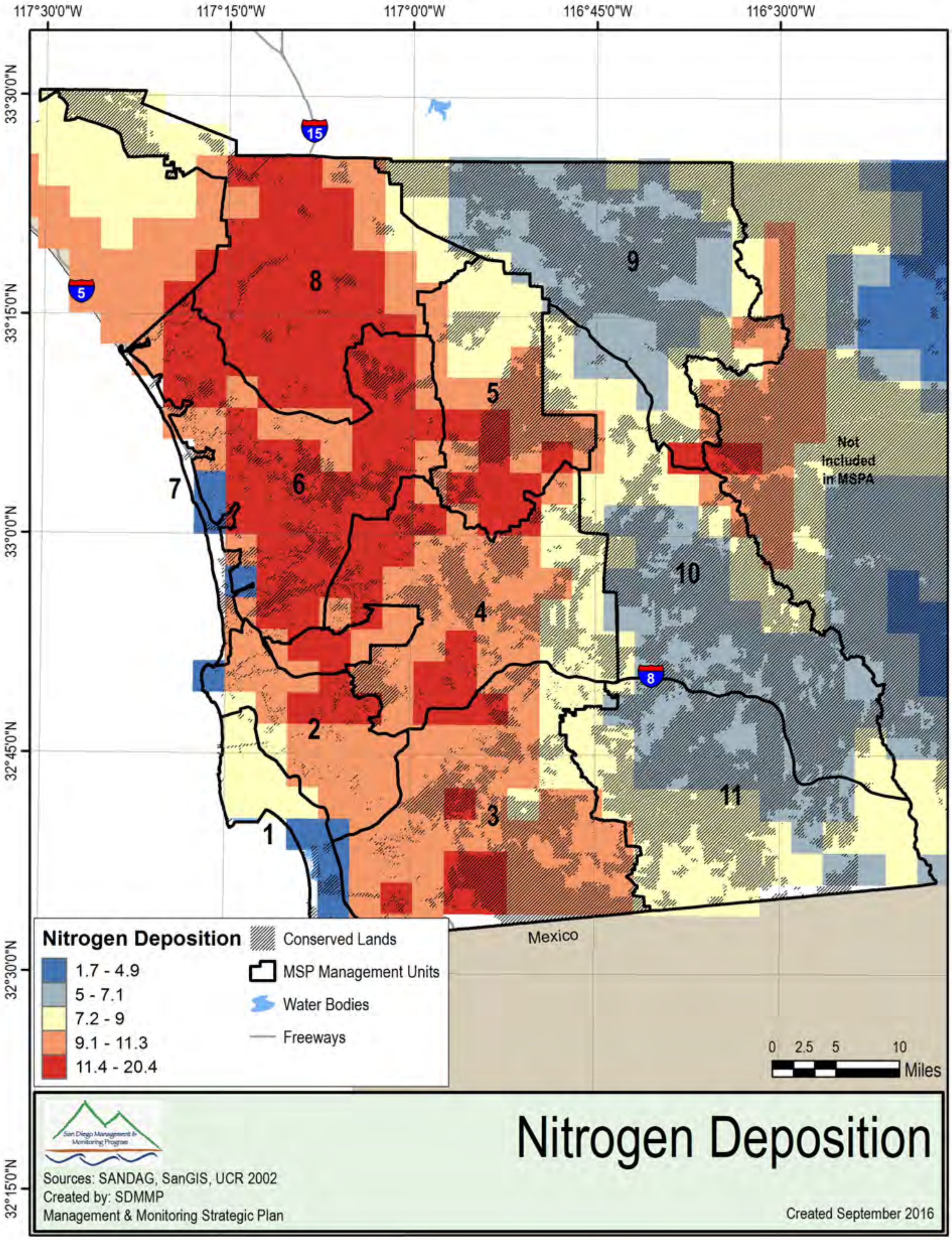

Figure V2B.13-3. Nitrogen deposition in kg ha-1 yr-1 (Fenn et al. 2009).

exceed 5 kg N ha/yr. Coastal valleys and foothills are dominated by nitrogen deposition loads of 9-20 kg N ha/yr, far exceeding levels associated with conversion of coastal sage scrub, grassland and chaparral to nonnative grassland over time.

13.1.4 Pollution

Various forms of pollution exist near urban development, which can include trash and other dry litter, chemical pollution, and noise pollination. In urban areas, trash can easily be transported by stormwater runoff. This could be material illegally dumped at preserves, or material that is blown or washed in from neighboring urban areas. Additional sources of pollution in the preserves can come from recreational users, ORVs, and target shooting.

Preserves in the MSPA that allow recreation, especially heavily trafficked ones, may accumulate large amounts of trash. It is important to provide waste and recycling bins at the trailheads to collect any trash that may otherwise find its way into the preserve. Household trash, such as plastic bags, cups, bottles, and containers, can be hazardous to any wildlife that ingests the plastic or gets caught and strangled. Homeless encampments are another source of pollution in preserves and can have detrimental effects on wildlife through increased refuse and raw sewage disposal (AMEC Earth & Environmental Inc. et al. 2003). The large volume of refuse from the living areas can attract black rats, which contribute to the decline of native rat populations.

ORVs can cause adverse effects to preserves due to air pollution from automotive exhaust and the creation of dust, as well as the illegal dumping of trash (Dillingham and Miner 2009). On preserves where target shooting—whether legal or illegal—exists, spent ammunition and the abandoned targets can introduce harmful pollutants to the wildland areas. When irresponsible shooters use electronics as targets, they can leave behind cadmium, arsenic, selenium, and mercury (Tuell 2016). These heavy metals persist in the soil and can contaminate surface or subsurface water. While legislation has Californians moving away from lead bullets, they are still in use. Numerous studies have documented the adverse effects of lead exposure to waterbirds and scavenger species, like eagles and hawks, as well as reptiles and small mammals near shooting ranges (Live Science Staff 2008). Lead poisoning causes behavioral, physiological, and biochemical effects, and often death. Spent ammunition can also slowly dissolve and enter the groundwater, negatively impacting plants, animals, and even people if it enters a water body or is taken up by plants used for consumption.

13.1.5 Noise

Anthropogenic noise, especially near urban areas, differs from the pitch and amplitude in most natural habitats (Francis et al. 2009). For avian species, noise alone can reduce nesting species richness and alter community composition. However, noise can also disrupt predator-prey relationships, leading to a higher reproductive success for birds in noisy areas. "Chronic and frequent noise interferes with animal's abilities to detect important sounds, whereas intermittent and unpredictable noise is often perceived as a threat" (Francis and Barber 2013). Several impacts of noise exposure on wildlife have yet to be extensively studied, including behavioral and physiological responses. Future research should focus on these areas to help identify practical noise limits that can inform policy and regulation.

13.2 URBAN DEVELOPMENT IN THE MSPA

The percent area of a Conserved Land complex within the urban edge (250 meters) was calculated for all Conserved Land complexes (Table V2B.13-1; Figure V2B.13-1). MUs with Conserved Lands with very high levels of urban-wild interface (>40%) include MUs 1, 2, 6, and 7. The urban-wild interface area on Conserved Lands in MUs 9, 10, 11, and 5 is much lower although potential future development in the eastern part of the MSPA would increase the threat/stress from urban development. This potential increase in urban edge will be tempered by the larger patch sizes of lands conserved in the eastern MUs.

13.3 RESULTS OF URBAN DEVELOPMENT STUDIES IN THE MSPA

There are no known studies of urban development that have been conducted in the MSPA.

13.4 MANAGEMENT AND MONITORING APPROACH

The goal for managing the effects of urban development in the preserves is to better understand and reduce the impacts on Conserved Lands where urban development is reducing the population levels and/or viability of MSP species populations. The approach for managing urban development effects in the preserves is divided into 2 parts: general and species-specific. General objectives focus on supporting land managers in preventing or cleaning up trash across the MSPA. Species-specific objectives have been developed for those MSP species identified as at highest risk from loss due to urban development near the preserves, and for which specialized objectives are required to ensure their persistence in the MSPA.

13.4.1 General Approach Objectives

Managing light and noise pollution and nitrogen deposition at the regional level is outside the scope of the MSP Roadmap and therefore no goals and objectives have been developed. Management of light pollution at the preserve level where it impacts MSP species should be taken into consideration by preserve managers where implementable management actions are possible. The general approach for managing urban development effects in the preserves is focused on preventing and cleaning up trash collection sites, as described below. For the most up-to-date goals, objectives, and actions, go to the MSP Portal Urban Development summary page: http://portal.sdmmp.com/view_threat.php?threatid=TID_20160304_1458.

Management for illegal dumping should focus on preventing future dump sites and cleaning up current trash problems. This could include supporting land managers on enforcement, signage or fencing, public outreach, or cleanup projects.

13.4.2 Species-specific Approach Objectives

Descriptions of urban development management approach and rationale as well as goals, objectives, and actions for at-risk MSP species are presented in the corresponding species sections. Links to species-specific urban development objectives are provided in Table V2B.13-2. Use the MSP Portal for the most updated list of species with Urban Development objectives.

Table V2B.13-2. MSP plant and animal species with specific urban development management and monitoring objectives.

	Scientific Name	Common Name	Management Category	Summary Page Link
Plants				
	Acanthomintha ilicifolia	San Diego thorn-mint	SO	https://portal.sdmmp.com/view_species.php?taxaid=32426
	Acmispon prostratus	Nuttall's acmispon	SO	https://portal.sdmmp.com/view_species.php?taxaid=820047
	Ambrosia pumila	San Diego ambrosia	SO	https://portal.sdmmp.com/view_species.php?taxaid=36517
	Aphanisma blitoides	Aphanisma	SL	https://portal.sdmmp.com/view_species.php?taxaid=20679
	Atriplex coulteri	Coulter's saltbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=20523
	Atriplex parishii	Parish brittlescale	VF	https://portal.sdmmp.com/view_species.php?taxaid=20554
	Baccharis vanessae	Encinitas baccharis	SO	https://portal.sdmmp.com/view_species.php?taxaid=183764
	Bloomeria clevelandii	San Diego goldenstar	SS	https://portal.sdmmp.com/view_species.php?taxaid=509575
	Brodiaea filifolia	Thread-leaved brodiaea	SS	https://portal.sdmmp.com/view_species.php?taxaid=42806
	Brodiaea orcuttii	Orcutt's brodiaea	SO	https://portal.sdmmp.com/view_species.php?taxaid=42815
	Centromadia parryi ssp. australis	Southern tarplant	VF	https://portal.sdmmp.com/view_species.php?taxaid=780715
	Chloropyron maritimum ssp. maritimum	Salt marsh bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834234

Scientific Name	Common Name	Management Category	Summary Page Link
Chorizanthe orcuttiana	Orcutt's spineflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=21019
Clinopodium chandleri	San Miguel savory	SL	https://portal.sdmmp.com/view_species.php?taxaid=565077
Cylindropuntia californica var. californica	Snake cholla	VF	https://portal.sdmmp.com/view_species.php?taxaid=913470
Deinandra conjugens	Otay tarplant	SS	https://portal.sdmmp.com/view_species.php?taxaid=780273
Dicranostegia orcuttiana	Orcutt's bird's-beak	SL	https://portal.sdmmp.com/view_species.php?taxaid=834156
Dudleya blochmaniae	Blochman's dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502165
Dudleya brevifolia	Short-leaved dudleya	SL	https://portal.sdmmp.com/view_species.php?taxaid=502166
Ericameria palmeri ssp. palmeri	Palmer's goldenbush	VF	https://portal.sdmmp.com/view_species.php?taxaid=527914
Eryngium aristulatum var. parishii	San Diego button-celery	VF	https://portal.sdmmp.com/view_species.php?taxaid=528066
Erysimum ammophilum	Coast wallflower	SL	https://portal.sdmmp.com/view_species.php?taxaid=22928
Euphorbia misera	Cliff spurge	VF	https://portal.sdmmp.com/view_species.php?taxaid=28104
Ferocactus viridescens	San Diego barrel cactus	VF	https://portal.sdmmp.com/view_species.php?taxaid=19801
Hazardia orcuttii	Orcutt's hazardia	SL	https://portal.sdmmp.com/view_species.php?taxaid=502882
Monardella viminea	Willowy monardella	SL	https://portal.sdmmp.com/view_species.php?taxaid=833060

	Scientific Name	Common Name	Management Category	Summary Page Link
	Navarretia fossalis	Spreading navarretia	VF	https://portal.sdmmp.com/view_species.php?taxaid=31328
	Orcuttia californica	California orcutt grass	SL	https://portal.sdmmp.com/view_species.php?taxaid=41970
	Pogogyne abramsii	San Diego mesa mint	VF	https://portal.sdmmp.com/view_species.php?taxaid=32639
	Pogogyne nudiuscula	Otay mesa mint	SL	https://portal.sdmmp.com/view_species.php?taxaid=32643
	Quercus engelmannii	Engelmann Oak	VF	https://portal.sdmmp.com/view_species.php?taxaid=19329
	Tetracoccus dioicus	Parry's tetracoccus	SS	https://portal.sdmmp.com/view_species.php?taxaid=28420
Invertebrates				
	Euphydryas editha quino	Quino checkerspot butterfly	SL	https://portal.sdmmp.com/view_species.php?taxaid=779299
	Euphyes vestris harbisoni	Harbison's dunn skipper	SL	https://portal.sdmmp.com/view_species.php?taxaid=707282
	Lycaena hermes	Hermes copper	SL	https://portal.sdmmp.com/view_species.php?taxaid=777791
	Panoquina errans	Wandering skipper	VF	https://portal.sdmmp.com/view_species.php?taxaid=706557
Amphibians				
	Anaxyrus californicus	Arroyo toad	SO	https://portal.sdmmp.com/view_species.php?taxaid=773514
	Spea hammondii	Western spadefoot toad	VF	https://portal.sdmmp.com/view_species.php?taxaid=206990
Reptiles				
	Emys pallida	Southwestern pond turtle	SL	https://portal.sdmmp.com/view_species.php?taxaid=668677

	Scientific Name	Common Name	Management Category	Summary Page Link
	Phrynosoma blainvillii	Blainville's horned lizard (Coast horned lizard, San Diego horned lizard)	VF	https://portal.sdmmp.com/view_species.php?taxaid=208819
Birds				
	Agelaius tricolor	Tricolored blackbird	SL	https://portal.sdmmp.com/view_species.php?taxaid=179060
	Aquila chrysaetos canadensis	Golden eagle	SO	https://portal.sdmmp.com/view_species.php?taxaid=175408
	Athene cunicularia hypugaea	Western burrowing owl	SL	https://portal.sdmmp.com/view_species.php?taxaid=687093
	Campylorhynchus brunneicapillus sandiegensis	Coastal cactus wren	SO	https://portal.sdmmp.com/view_species.php?taxaid=917698
	Charadrius nivosus nivosus	Western snowy plover	SL	https://portal.sdmmp.com/view_species.php?taxaid=824565
	Circus cyaneus	Northern harrier	SO	https://portal.sdmmp.com/view_species.php?taxaid=175430
	Empidonax traillii extimus	Southwestern willow flycatcher	SL	https://portal.sdmmp.com/view_species.php?taxaid=712529
	Passerculus sandwichensis beldingi	Belding's savannah sparrow	VF	https://portal.sdmmp.com/view_species.php?taxaid=179325
	Polioptila californica californica	Coastal California gnatcatcher	VF	https://portal.sdmmp.com/view_species.php?taxaid=925072

	Scientific Name	Common Name	Management Category	Summary Page Link
	Rallus obsoletus levipes	Light-footed Ridgway's rail	SO	https://portal.sdmmp.com/view_species.php?taxaid=176211
	Sternula antillarum browni	California least tern	SO	https://portal.sdmmp.com/view_species.php?taxaid=825084
	Vireo bellii pusillus	Least Bell's vireo	SO	https://portal.sdmmp.com/view_species.php?taxaid=179007
Mammals				
	Antrozous pallidus	Pallid bat	SL	https://portal.sdmmp.com/view_species.php?taxaid=180006
	Lepus californicus bennettii	San Diego black-tailed jackrabbit	VF	https://portal.sdmmp.com/view_species.php?taxaid=900973
	Plecotus townsendii pallescens	Townsend's big-eared bat	SO	https://portal.sdmmp.com/view_species.php?taxaid=203457
	Puma concolor	Mountain lion	SL	https://portal.sdmmp.com/view_species.php?taxaid=552479
Vegetation Communities				
	Oak Woodland			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_10
	Riparian Forest & Scrub			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_7
	Salt Marsh			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_6
	Torrey Pine Forest			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_8
	Vernal Pool/Alkali Playa			https://portal.sdmmp.com/view_species.php?taxaid=SDMMP_vegcom_4

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