SPECIES REPORT
FOR
STEPHENS' KANGAROO RAT
(*Dipodomys stephensi*)

Stephens' kangaroo rat habitat, Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County
Photo credit: Stephens' kangaroo rat (Photo credit: Joanna Gilkeson, USFWS).

U.S. Fish and Wildlife Service
Carlsbad Fish and Wildlife Office, Carlsbad California
Version 1.1

July 30, 2020

[This page intentionally left blank]

Suggested citation:

U.S. Fish and Wildlife Service. 2020. Species Report for the Stephens' kangaroo rat (*Dipodomys stephensi*). Version 1.1, July 30, 2020. U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. xi + 125 pp.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Stephens' kangaroo rat (*Dipodomys stephensi*) was first described (as *Perodipus stephensi*) from a specimen collected near the city of Winchester, Riverside County, California (Merriam 1907, p. 78). It is one of 22 recognized species of the *Dipodomys* genus found from southern Canada to southern Mexico. As a group, kangaroo rats are generally found within well-drained loamy-sandy or gravelly soils in open, sparsely vegetated, hot and dry grassland habitats. The Stephens' kangaroo rat is currently listed as endangered under the Endangered Species Act of 1973, as amended (Act), and as threatened by the State of California.

We prepared a 5-year review for the species in 2011 (Service 2011), in which we evaluated recovery progress based on the recovery criteria for downlisting in the draft recovery plan and also considered the current threats attributable to one or more of the five threat factors. Based on that review, we recommended that the Stephens' kangaroo rat be reclassified from endangered to threatened (Service 2011, p. 4).

In this species report, we evaluated new observational data and additional conservation actions implemented towards recovery of the Stephens' kangaroo rat in order to assess the factors affecting the species and an evaluation of the recovery progress to date. Based on this evaluation, the Stephen's kangaroo rat is patchily distributed in southwestern Riverside and northwestern and central San Diego Counties within suitable habitat, which consists primarily of grassland with a large proportion of relatively open, bare ground. Comprehensive surveys have not been conducted across the species' presumed distribution since 1988. Some locations that are monitored on regular basis have reported steady or increasing populations.

Habitat loss due to urban and agricultural development has resulted in a significant loss of historical habitat, most of which occurred in the early 20th century. In order to better assess the effects of habitat loss and fragmentation to the Stephens' kangaroo rat, we spatially modeled habitat using suitable vegetation, detections/observations, elevation, and slope, and removed areas that were considered urbanized or otherwise unsuitable. Based on this analysis, we estimated approximately 69,104 acres (ac) (27,966 hectares (ha)) of modeled habitat exists in Riverside County and approximately 22,434 ac (9,079 ha) in San Diego County.

We also analyzed potential fragmentation of our modeled habitat and found a high level of habitat fragmentation relative to habitat characteristics associated with the Stephens' kangaroo rat in both western Riverside and San Diego Counties. Though Stephens' kangaroo rat habitat is fragmented across the landscape, the majority of modeled habitat (75.0 percent) remains as large patches (> 1 km^2) that are likely sufficient in size to sustain them (Price and Endo 1989, p. 299). However, much of this habitat is not connected and further isolation of SKR in the future could result in highly fragmented habitat patches that are uninhabitable.

Additional potential habitat destruction or modification-related stressors evaluated in this report include nonnative ungulates, off-highway vehicle activity, and the effects of fire suppression or prevention activities. We determined that these were either not a stressor (nonnative ungulates) or represented a low-level stressor to Stephens' kangaroo rat habitat. However, we found that habitat modification resulting from conversion of vegetation (invasive plants) represents a localized, but low- to moderate-level stressor to the species' habitat in Riverside County.

Other potential stressors evaluated in this assessment include those related to effects to the Stephens' kangaroo rat and its habitat from overutilization for commercial, recreational, scientific, or educational purposes, disease, predation, use of rodenticides, wildfire, and effects of a changing climate. We found no evidence that disease or overutilization for commercial, recreational, scientific, or educational purposes are current or future stressors to the species. Predation by natural or nonnative predators is not a stressor to the Stephens' kangaroo rat beyond impacts to a few individuals, now or into the future. We determined that the risk of mortality or injury resulting from the use of rodenticides represents a low-level risk at the individual level both currently and in the future. Wildfire is both a natural and human-caused event in the currently occupied range of the Stephens' kangaroo rat. In general, studies have found that wildland or controlled fire management actions represents a beneficial effect to the species.

Based on computer model climate projections, potential effects to the habitat occupied by the Stephens' kangaroo rat from changes in precipitation patterns related to climate change appear to be minimal. However, projections of temperature increases for the area may have an effect to the species' habitat, particularly related to an increase in invasive nonnative plants. We estimate that climate change and the cumulative effects of climate change, as well as potential changes in habitat due to increase nonnative vegetation represents a low-level stressor to the Stephens' kangaroo rat and its habitat given the proactive fire prevention and suppression activities conducted within the current range, and that is likely to remain so into the mid-21st century.

Conservation measures including Federal and State mechanisms currently provide some protections to the Stephens' kangaroo rat and its habitat. The Act provides protections to the species through section 7 and the consultation process, as well as through section 10 through incidental take permits on non-Federal lands. In addition, the Sikes Act represents a significant natural resource management law and three San Diego County military installations are actively managed for the conservation of the Stephens' kangaroo rat.

Our modeling efforts identified approximately 69,104 ac (27,966 ha) of potentially suitable, modeled habitat for the Stephens' kangaroo rat in Riverside County and 22,434 ac (9,079 ha) in San Diego County. Of the modeled suitable habitat approximately 16,438 ac (6,652 ha) in Riverside County and 12,457 ac (5,041 ha) in San Diego County is considered conserved. Therefore, a total of 28,895 ac (11,693 ha) of 91,538 ac (37,044 ha) of modeled habitat is conserved (31.6 percent). The majority of modeled habitat (66.3 percent) for the Stephens' kangaroo rat occurs on private land, of which only 3.2 percent is currently conserved. We estimated that approximately 7.0 percent of modeled habitat occurs on Department of Defense property (both Riverside and San Diego Counties).

The California Endangered Species Act (CESA) and the Natural Community Conservation Planning (NCCP) Act provisions provide protections to the Stephens' kangaroo rat through its listing under CESA (threatened) and general inclusion within both State and Federal planning processes. Developed in coordination with California's NCCP Act, the Stephens' Kangaroo Rat Habitat Conservation Plan (SKR HCP) and the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) identify management and conservation objectives that provide additional conservation measures to the Stephens' kangaroo rat and its habitat within populations in Riverside County, including the establishment of a reserve system in western

Riverside County. We estimated that approximately 17.0 percent of all modeled habitat is found within these reserves and the SKR HCP core reserves. A total of 24.0 percent of total modeled habitat is conserved through HCP reserves and INRMPs.

In order to characterize a species' current and future viability and demographic risks, we consider the concepts of resilience, representation, and redundancy (Shaffer and Stein 2000, pp. 301–302; Wolf *et al.* 2015, entire). To do this we assess a species' current biological condition and its projected capability of persisting into the future (Smith *et al.* 2018, entire). Based on the best available data for our analysis, we found the current major stressors to Stephens' kangaroo rat are habitat loss and habitat fragmentation. Currently, populations persist throughout its historical range and maintain subsequent genetic makeup and adaptive capabilities. The species currently has a sufficient number of large, managed populations distributed throughout its historical range (across two counties), providing a margin of safety to withstand catastrophic events. There are also several populations that are presently managed over a large area that could withstand stochastic events. Based on this analysis, Stephens' kangaroo rat is currently maintaining its representation, redundancy, and resiliency. In the future, the impacts from habitat fragmentation may continue to affect Stephens' kangaroo rat populations, and if not addressed could impact their overall fitness by reducing representation (reducing genetic heterozygosity, increased inbreeding), resiliency (impacts from stochastic events), and redundancy (fewer healthy populations, fewer populations overall).

ABBREVIATIONS AND ACRONYMS USED

ACEC = Area of Critical Environmental Concern
Act = Endangered Species Act
BLM = Bureau of Land Management
Cal/EPA = California Environmental Protection Agency
Camp Pendleton = Marine Corps Base Camp Pendleton
CCR = California Code of Regulations
CDC = California Department of Conservation
CDF = California Department of Forestry and Fire Protection
CDFW = California Department of Fish and Wildlife
CEQA = California Environmental Quality Act
CESA = California Endangered Species Act
CDPR = California Department Parks and Recreation
CNDDB = California Natural Diversity Database
CNLM = Center for Natural Lands Management
CWHR = California Wildlife Habitat Relationship
Detachment Fallbrook = Naval Weapons Station Seal Beach Detachment Fallbrook
DOD = Department of Defense
DPR = (California) Department of Pesticide Regulation
EIS = Environmental Impact Statement
ENSO = El Niño-Southern Oscillation
FLMPA = Federal Land Policy and Management Act
FMMP = Farmland Mapping and Monitoring Program
GHG = greenhouse gas
GIS = Geographic Information System

HCP = Habitat Conservation Plan (for Stephens' kangaroo rat)
INRMP = Integrated Natural Resource Management Plan
IPCC = Intergovernmental Panel on Climate Change
March ARB = March Air Reserve Base
MSCP = Multiple Species Conservation Plan (San Diego County)
MSHCP = Multiple Species Habitat Conservation Plan (Western Riverside County)
MSL = mean sea level
mtDNA = mitochondrial deoxyribonucleic acid
NCCP = Natural Community Conservation Planning
NCDC = National Climatic Data Center
n.d. = no date
NEPA = National Environmental Policy Act
NFMA = National Forest Management Act
RCA = Regional Conservation Authority (Western Riverside County)
RCHCA = Riverside County Habitat Conservation Agency
Service = U.S. Fish and Wildlife Service
SKR HCP = Stephens' Kangaroo Rat Habitat Conservation Plan
USDA = U.S. Department of Agriculture
USFS = U.S. Forest Service
USGS = U.S. Geological Survey
Warner Springs = Naval Base Coronado Remote Training Site Warner Springs
WRCC = Western Regional Climate Center

1.0 INTRODUCTION

The Stephen's kangaroo rat (*Dipodomys stephensi* Merriam) is one of 22 species of kangaroo rat found in North America from southern Canada to southern Mexico. The Stephens' kangaroo rat is currently distributed in Riverside and San Diego Counties in southern California. It was listed as a threatened species by the State (CESA) in 1971 (California Code of Regulations, Title 14, Chapter 6, sections 783.0-787.9; California Fish and Game Code, Chapter 1.5, sections 2050-2115.5) and as federally endangered under the Act on September 30, 1988 (53 FR 38465).

Based on the best available information at the time of listing, we determined that the Stephens' kangaroo rat was threatened by the following factors: (1) habitat loss resulting from widespread, rapid urbanization and agricultural development; (2) fragmented and isolated populations; (3) reduction of habitat suitability (from anthropogenic activities including grazing, off-highway vehicle use, disking, plowing, introduction of nonnative vegetation, and rodent control programs); (4) predation by domestic cats; and (5) the lack of existing regulatory protections. In our 2010 12-month finding published in the *Federal Register* (FR) (75 FR 51204; August 19, 2010) and subsequent 2011 5-year review (Service 2011), we found that the threats to Stephens' kangaroo rat remained similar to those identified at listing in 1988, with additional impacts from nonnative plant species and climate change. However, as we noted in our most recent 5-year review, the primary and imminent threat at the time of listing, habitat destruction from urban and agricultural development resulting in isolated habitat patches, had been largely ameliorated through the implementation and design of the core reserve system in western Riverside County (through the Stephens' Kangaroo Rat Habitat Conservation Plan), through ongoing land acquisitions and easements, and with other conservation plans and efforts (Multiple Species Habitat Conservation Plan (MSHCP) and Integrated Natural Resource Management Plans (INRMPs)) (Service 2011, p. 2). On September 18, 2015, we published a 90-day finding in the *Federal Register* (80 FR 56423) in response to a petition requesting that we remove protections of the species under the Act. We found that the petition did not present substantial scientific or commercial information indicating that the petitioned action may be warranted for the Stephens' kangaroo rat.

In our most recently published 5-year review in 2011, we recommended that the Stephens' kangaroo rat be reclassified from endangered to threatened (Service 2011, p. 4). In that review, we changed the recovery priority number of the species from 2C (a full species facing a high degree of threat but with a high potential for recovery, if appropriately managed, and with recovery that may be in conflict with construction or other forms of economic activity) to 11 (a full species facing a moderate degree of threat and low potential of recovery (because of poorly understood limiting factors and poorly understood or pervasive and difficult to alleviate threats), with intensive management needed) (Service 2011, p. 7). This Species Report presents a summary description of the Stephens' kangaroo rat, including its geographical distribution and life history requirements, its biological status, potential stressors that may be affecting the species, and an assessment of management actions to conserve the species and its habitat.

2.0 SPECIES DESCRIPTION

2.1 Taxonomy

The Stephens' kangaroo rat belongs to the Order Rodentia, Family Heteromyidae, Subfamily Dipodomyinae. It was first described as *Perodipus stephensi* based on a specimen collected near Winchester, Riverside County, California (Merriam 1907, p. 78). Based on his evaluation of the *Dipodomys* genus in California, Grinnell (1921, p. 95) recognized its current name of *Dipodomys stephensi*. In his subsequent published study of kangaroo rats in 1922, Grinnell (1922, p. 7) indicated that the previous recognition of the *Perodipus* as a subgenus distinct from *Dipodomys* based on the number of toes on the hind foot was not phylogenetically valid. In addition, *Dipodomys cascus* was previously considered a separate conspecific species, but this entity is now considered to be synonymous with the *D. stephensi* (Hall 1981, p. 574; Huey 1962, p. 479; Lackey 1967a, p. 315). The Integrated Taxonomic Information System (ITIS 2018, TSN 180247) and checklists continue to recognize *Dipodomys stephensi* as a valid and distinct species (Baker *et al*. 2003, p. 13; Bisby *et al*. 2010, p. 3; Bradley *et al*. 2014, p. 20; Spencer *et al*. 2018, p. 62).

The New World rodent family Heteromyidae exhibit a number of noteworthy morphologically and ecologically diverse forms (Hafner *et al*. 2007, p. 1129). An early review of the phylogeny of *Dipodomys* was presented within Setzer's (1949, entire) treatment of the subspeciation of the Ord's kangaroo rat (*Dipodomys ordii*). He described a phyletic trend of dipodomyines (the subfamily of heteromyid rodents) toward saltatorial (leaping/jumping) habit, which required a number of morphological changes, such as lengthening of the tail and hind legs, shortening of the forelimbs, and various spinal-cranial adaptations (Setzer 1949, pp. 484–485). A review of the molecular phylogenetics of heteromyids reported a divergence date of the genus *Dipodomys* around 11.4 million years ago (mid-Miocene epoch) (Hafner *et al*. 2007, p. 1137).

2.2 Physical Appearance

Kangaroo rats possess a number of behavioral, morphological, and physiological adaptations that allow them to inhabit warm, arid environments. They are characterized by fur-lined, external cheek pouches used for transporting seeds; large hind legs for rapid, bi-pedal, saltatorial locomotion; relatively small front legs; tails that are usually longer than combined length of head and body; and large heads (Daly *et al.* 2000, pp. 145–146). Additional morphological descriptions for the genus *Dipodomys* are provided in Hall (1981, p. 563).

The Stephens' kangaroo rat is a small, nocturnal mammal and is considered medium in size for the *Dipodomys* genus (Bleich 1977, p. 1). The Stephens' kangaroo rat is described as having dusky cinnamon buff overfur, pure white underfur, and a white lateral line on the tail, with five toes present on the hind foot, a tail with a long black tuft that is 1.45 times the length of head and body (bicolored and crested), and several distinguishing cranial features (Ingles 1965, pp. 228–229; Bleich 1977, p. 1). Total external length is 10.9 to 11.8 inches (in) (277 to 300 millimeters (mm)) and adult body weight averages 2.37 ounces (oz) (67.26 grams (g))) (Bleich 1977, p. 1). There are no size differences (dimorphism) between sexes (Best 1993, p. 203). However, body weights were recorded for individuals captured as part of a recent translocation study in southwestern Riverside County and reported an average of 2.1 oz (59.3 g) for adult females and 2.3 oz (65.9 g) for adult males (Shier and Swartz 2012, p. 39). Summary descriptions of the species are presented in Bleich (1977, entire, and references cited therein), and Ingles (1965, pp. 228–229). Eisenberg (1963, entire) also presents a detailed summary of life history and behavior of heteromyid rodents, including several *Dipodomys* species. Of note, one characteristic of the Stephens' kangaroo rat and other dipodomyines is the large size of the middle ear (expanded auditory bullae) (Webster and Webster 1980, pp. 247–248). The large volume of the auditory chamber confers an increase in low-frequency hearing sensitivity (Webster and Webster 1980, p. 253), which, based on experimental studies, represents an adaptation for predator avoidance (Webster and Webster 1980, p. 253), as does the leaping ability and rapid movements characteristic of the kangaroo rat group (Webster 1962, p. 254).

3.0 Range and Habitat Use

3.1 Historical Biogeography

The genus *Dipodomys* is unique to western North America (Grinnell 1922, p. 2). The historical biogeography of the Heteromyidae in the context of key influences of paleoclimatic and paleogeographic events on lineage divergence within this group was summarized in Hafner *et al*. (2007, pp. 1139–1140). In sum, beginning in the mid-Miocene, western North America experienced increased aridity, decreased temperatures, spread of grasslands and desert shrub habitat, fragmentation of vegetation previously adapted to Mediterranean climate, and major dispersal pulses of mammals (Woodburne 2004, pp. 336–337). The climatic changes occurred in conjunction with dramatic changes in the western landscape due to tectonic plate shifting, which altered the Pacific and Baja California coastlines (Hafner *et al*. 2007, p. 1140). The significant climatic shift and tectonic events of the middle Miocene had a strong influence on two arid-adapted heteromyid subfamilies, Dipodomyinae and Perognathinae (Hafner *et al*. 2007, p. 1140). Thus, as a group, kangaroo rats became restricted mainly to sandy soils in arid and semi-arid regions (Schmidly *et al*. 1993, p. 337) where fluctuations in both physical conditions and food resources are typically unpredictable (McClenaghan and Taylor 1991, p. 20).

Lackey (1967a, pp. 331–332) posited that climatic influences (i.e., reduced precipitation) and the secondary effects to the establishment of plant communities in southern California may have resulted in a range expansion and establishment of the Stephens' kangaroo rat into northwestern San Diego County from its northern populations in western Riverside County. Results of a comprehensive study of the species' genetic structure throughout its range (both Riverside and San Diego Counties) found that the highest genetic variation (allelic richness) was observed primarily in northern populations (i.e., Lake Perris, San Jacinto Wildlife Area, March Preserve, Sycamore Canyon, Lake Mathews) and the lowest genetic variation was observed in the southernmost populations (i.e., Ramona Grasslands, Rancho Guejito, Camp Pendleton) (Shier and Navarro 2020, n.d., p. 23). Based on their findings, the authors suggest that the Stephens' kangaroo rat may have expanded from an ancestral population in the northern portion of its current range to the south (Shier and Navarro n.d., p. 23).

3.2 Geographical Distribution

The Stephens' kangaroo rat was first described (type locality) based on a specimen collected near Winchester, Riverside County, California (Merriam 1907, p. 78) (see Grinnell 1922, p. 67, for additional details). Another type locality (previously considered as *Dipodomys cascus*) was collected in 1961 in San Diego County, 1 mile (mi) (1.61 kilometer (km)) east of Bonsall (Huey 1962, p. 479). The known distribution of the Stephens' kangaroo rat in 1977, as described by Bleich (1977, p. 1), included the San Jacinto Valley and adjacent areas of western Riverside, southwestern San Bernardino, and northwestern San Diego counties, including the community of Fallbrook.

At the time of (Federal) listing under the Act in 1988, the known geographic range of the Stephens' kangaroo rat included 11 general areas, encompassing the Perris, San Jacinto, and Temecula Valleys in western Riverside County (Temecula Valley was mistakenly reported as located in San Diego County), and the San Luis Rey Valley in San Diego County (53 FR 38465).

As noted in our 2010 12-month finding (75 FR 51206; August 19, 2010), additional populations of the Stephens' kangaroo rat have been discovered, which has modified the geographical distribution of the species. In that 12-month finding, we indicated that the species was known from 15 geographical areas (75 FR 51205; Table 1). Although discovered after listing, we indicated that the four additional populations were likely extant at the time of listing and were detected as a result of more focused surveys and consultations subsequent to listing; that is, although these new populations were new records of occurrence, they were not considered to represent a range expansion of the Stephens' kangaroo rat (75 FR 51206). However, based on his early population studies of the Stephens' kangaroo rat, Thomas (1975, p. 36) indicated that its distribution should not be assumed to be static nor "that all possibilities for range extension have been exhausted." Citing Csuti (1971, p. 50) who reported changes in distributions, including range extensions, for several species of kangaroo rats in southern California from previously published ranges in which suitable habitat was not properly considered. Thus, it is also possible that individuals and/or populations of the Stephens' kangaroo rat have been expanding south and west, given their ability to disperse along (and colonize) disturbed roadways (e.g., dirt roads, firebreaks) and utility power line corridors (O'Farrell and Uptain 1989, p. i, Appendix II; Shomo 2018, pers. comm.), occasionally at distances greater than 66 ft (20 m) (Price *et al*. 1994a, p. 933; Brock and Kelt 2004b, p. 633). Table 1 below has an updated list of geographic locations where the Stephens' kangaroo rat has been detected.

3.2.1 Range Maps

We created a map to depict the Maximum Extent of Occurrence of the Stephens' kangaroo rat, which represents the area defined by circumscribing all known locations of the species, or the perimeter of the outermost geographic limits, based on occurrence records from survey reports, the California Natural Diversity Database (CNDDB), and other literature, including a historical range map based off preferred habitat presented in RECON (1992, p. 13; Figure 2). This depiction is presented in Figure 1.

We also developed a current distribution map for the Stephens' kangaroo rat by reviewing our previous analysis of occupancy in locations presented in our 2010 12-month finding and reviewed observations (e.g., survey results) post-2010 in order to define an area to represent the

Table 1. Summary of geographical locations and detections for the Stephens' kangaroo rat.

Geographical Location	**Prior to Listing (pre-1988)**	**Listing (1988)**	**2010 Status Review**	**Present (2018) (observed trends)**	**Last Year Observed**
Riverside County					
Sycamore Canyon	Presumed Extant	Extant	Extant	Extant	2011
March Preserve	Extant	Extant	Extant	Extant	2011
Lake Mathews/Estelle Mountain	Extant	Extant	Extant	Extant	2017
Motte Rimrock	Presumed Extant	Extant	Extant	Extant	2016
Steele Peak	Presumed Extant	Extant	Extant	Extant	2010
San Jacinto/Lake Perris	Extant	Extant	Extant	Extant	2016
Potrero Valley	Extant	Extant	Extant	Extant (lower numbers observed in 2014 when compared to 2008)	2014
Lake Skinner/Dominigoni Valley	Extant	Extant	Extant	Extant	2015
Silverado Ranch	Presumed Extant	Likely Extant[1]	Extant	Extant	2015
Anza-Cahuilla Valley	Presumed Extant	Likely Extant[1]	Extant	Extant	2011
Norco	Presumed Extant	Likely Extant[2]	"Non-viable"	Extant[3]	2013
Alessandro Heights	Presumed Extant	Likely Extant[2]	"Non-viable"	Likely Extirpated	-
Kabian Park	Presumed Extant	Extant	"Non-viable"	Likely Extirpated	-
Sage/Wilson Valley			Extant	Extant	2017
San Diego County					
Fallbrook	Extant	Extant	Extant	Extant	2013
Naval Weapons Station Seal Beach Detachment Fallbrook	Extant	Extant	Extant	Extant (stable to increasing occupancy, based on established plots)	2018

Geographical Location	Prior to Listing (pre-1988)	Listing (1988)	2010 Status Review	Present (2018) (observed trends)	Last Year Observed
Camp Pendleton	Presumed Extant	Extant	Extant	Extant (steady increase since 2005 in amount of occupied habitat; high densities in occupied habitat)	2016
Lake Henshaw/Warner Springs	Presumed Extant	Extant	Extant	Extant (at Remote Training Site Warner Springs (Warner Springs): increase in number of occupied sites; increase in density)	2017
Rancho Guejito	Presumed Extant	Presumed Extant	Extant	Presumed Extant	2005
Ramona Grasslands	Presumed Extant	Presumed Extant	Extant	Extant	2018
San Luis Rey (Bonsall)	Extant[4]	Extirpated	Extirpated	Extirpated	-

Sources: Merriam 1907; Huey 1962; Thomas 1973; Bleich and Swartz 1974, Service 1997; RECON 1992; RCA Biological Monitoring Program; RCHA survey reports; USGS monitoring reports; submitted section 10(a)(1)(A) permit reports.
[1] Verified in 1990 by Montgomery (Service 1997).
[2] Discovered in 1994 (Service 1997, citing Montgomery pers. comm.)
[3] Few individuals observed in 2013 near the city of Norco (SJM Biological Consultants 2013)
[4] Considered extirpated in 1973 (Thomas 1973); confirmed by O'Farrell and Uptain (1989)

Current Potential Extent of Occurrence for Riverside County and San Diego County. This is presented in Figure 1 below. These areas represent the Maximum Extent of Occurrences area minus those areas where we believe the species has been extirpated, though we acknowledge that recent and/or comprehensive surveys may not have been conducted in all areas; thus, we have depicted these areas with dotted (- - -) lines. We recognize (as noted by both Csuti (1971, p. 50) and Thomas (1975, p. 36)) that, given the disjunct and complex pattern of distribution of plant communities in southern California, defining a current range for small mammals should be done cautiously. In addition, as was described for the Marine Corps Base Camp Pendleton (Camp Pendleton) population (San Diego County), occupancy of the Stephens' kangaroo rat is not static, with high levels of localized extinction and colonization as individuals appear to move frequently among the patches of habitat within their population boundaries in concert with changes in habitat suitability (Brehme *et al*. 2017, p. 2). For comparison, the California Department of Fish and Wildlife (CDFW) current range map for the species (CDFW 2012) is provided in Appendix A. Additional discussion of the population status of the species is provided in section 5.0 (Species Biological Status) below. We also prepared a spatial analysis to estimate modeled habitat for the Stephens' kangaroo rat, as described below (see section 3.3.3 Suitable Habitat).

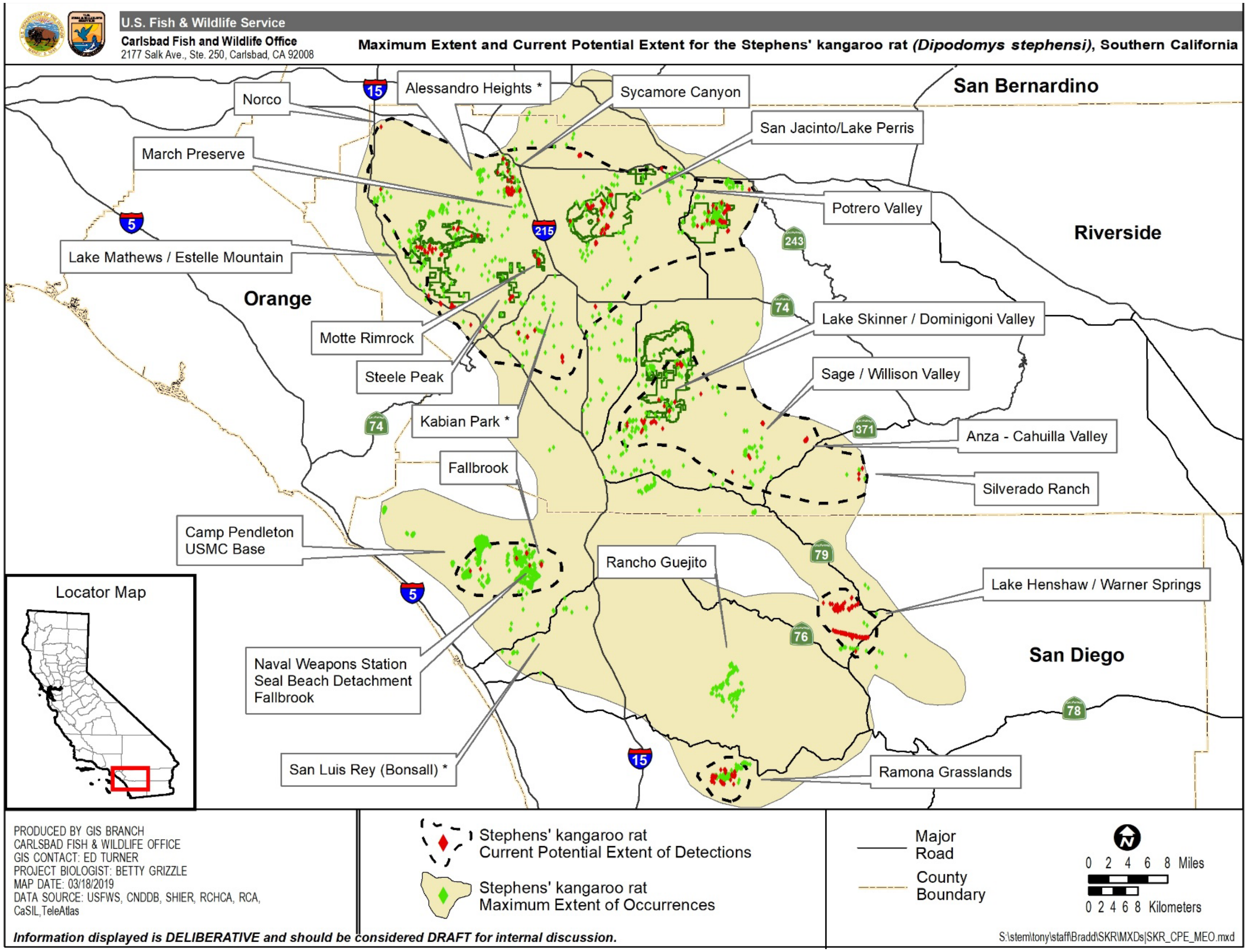

Figure 1. Maximum Extent and Current Potential Extent of Occurrences for the Stephens' kangaroo rat. Sources: AECOM 2009; CFWO GIS data; County of San Diego (SanBIOS); CNDDB; RCA; RCHCA; SANDAG (Regss); Shier and Navarro. *Extirpated.

3.3 Habitat

3.3.1 Physical Setting

Previous reports indicated that the Stephens' kangaroo rat is found in Riverside and San Diego Counties within an elevational range from approximately 180 to 4,101 feet (ft) (55 to 1,250 meters (m)) above MSL, with most populations occurring below 2,001 ft (610 m) (Service 1997, p.10; and references cited therein), with slopes from 7 to 10 percent (Moore-Craig 1984, p. 8) and 0 to 50 percent (O'Farrell and Uptain 1989, pp. 8–11; Appendix II). Recent observations indicate that this species is also found in areas with slopes greater than 15 percent (Shomo 2018, pers. comm.), though other recent studies have also found that the probability of occupancy in slopes greater than 5 percent was near zero (Clark *et al.* 2018, p. 18). Our spatial analysis using occurrence records from 2010 to 2017 in both Riverside and San Diego Counties indicates that the species has been observed at elevations ranging from approximately 397 to 3,563 ft (121 to 1,086 m) (median = 1,519 ft (463 m)) and on slopes ranging from 0 to 40 percent (median = 4 percent), with most (95 percent) records at 15 percent slope or lower (Service 2018).

Populations of the Stephens' kangaroo rat reach their highest densities in grassland communities dominated by forbs and characterized by moderate to high amounts of bare ground, gentle slopes, and well-drained soils (Bontrager 1973, p. 101; O'Farrell and Uptain 1987, pp. 39, 45; O'Farrell and Clark 1987, p. 80; Burke *et al*. 1991, p. 22; Andersen and O'Farrell 2000, p. 12). O'Farrell and Clark (1987, p. 13) also reported that the Stephens' kangaroo rat selected habitats in Riverside County with low rock cover.

Because burrows can be as deep as 18 in (46 centimeters (cm) (Thomas 1975, p. 38), soil cover depth for supporting habitat has been assumed to be at least 20 in (50 cm) (Price and Endo 1989, p. 295). However, at Warner Ranch (San Diego County), O'Farrell and Uptain (1987, p. 41) found that burrow tunnel entrances descended almost vertically to a depth of approximately 8 in (21 cm), and the depth of tunnels were relatively constant at 8.27 to 9.06 in (21 to 23 cm).

Soil type influences the distribution of kangaroo rats and has been previously found to be an accurate predictor of the presence or absence of Stephens' kangaroo rat (Price and Endo 1989, p. 297), though this varies somewhat by region. For example, in the Santa Ana Mountains, the Stephens' kangaroo rat was found to be restricted to gravelly soils (Pequegnat, 1951, p. 53). On Camp Pendleton, this species was observed on several different well-drained soil series (O'Farrell and Uptain 1989, p. 8; Table 3). Stephens' kangaroo rats were observed on soils containing high percentages of granule gravel near Fallbrook (San Diego County) (Bleich 1973, p. 61). Over 30 soil series were reported for individuals trapped at Naval Weapons Station Seal Beach Fallbrook (Det. Fallbrook, formally Fallbrook Annex), most of which were sandy loam soils (Service 1993, p. 12; Table 5). At the San Jacinto Wildlife Area (Riverside County), nearly all trapped Stephens' kangaroo rats were found within sandy loam soils and outside floodplain areas (alkali-clay soils) (Moore-Craig 1984, pp. 1–2). On the Santa Rosa Plateau of the Santa Ana Mountains (Riverside County), Bontrager (1973, p. 98) found this species most abundantly in grassland areas with sandy surfaces (coarse and fine sand soil texture; Bontrager 1973, pp. 21, 70). In a review of the species' natural history, Burke *et al*. (1991, p. 15) stated that patches of fine-grained soil might be required for sandbathing based on a report by Eisenberg (1963, p. 8) that the fur of *Dipodomys* becomes matted and greasy if sand is not available for sandbathing and dusting (pelage dressing). Additional discussion is provided below regarding sandbathing behavior as a form of chemical communication (see section 4.0 Life History and Ecology).

Conversely, a study of the distribution of the Stephens' kangaroo rat in the Lake Mathews area (Riverside County) did not identify any soil characteristic (e.g., soil group or soil type) that explained their distribution in their study area (Jones and Stokes 1983, p. 11). Similarly, at the Rancho Guejito location (San Diego County), Montgomery (2005, p. 10) did not find a clear correlation between the distribution of the Stephens' kangaroo rat and general soil types. Additionally, although the Stephens' kangaroo rat generally does not occur in hard, claypan soils, presumably because of difficulty digging and thus burrow construction (Bontrager 1973, p. 82), clay soils alone do not necessarily preclude the species as Stephens' kangaroo rat burrows have been observed in clay soil on Det. Fallbrook (San Diego County) (Service 1993, p. 17).

As noted above, climatic conditions have been an important factor in the biogeographical history of kangaroo rats. The climate of southern California where the Stephens' kangaroo rat occurs is influenced by its latitude and cold Pacific Ocean water, which creates a combination of maritime (persistent marine layer) and Mediterranean (long, hot summers and moderate winters) climates (Schoenherr 1992, p. 316). There are two distinct precipitation patterns in the southern California region: (1) winter (December-February), when rainfall is generated from sporadic winter storms (from the west) interspersed with clear, sunny days; and (2) summer (generally August–September), when rain is produced from occasional localized thunderstorms that develop from monsoonal flows (northward flux of tropical air) from the south (e.g., Gulf of California) (Schoenherr 1992, pp. 36–40). The wettest water years and winter season rainfalls are often associated with El Niño Southern Oscillation (ENSO) events, that is, when sea-surface temperature in the eastern tropical Pacific increases more than 0.9° Fahrenheit (°F) (0.5° Celsius (°C)). El Niño events often produce more severe winter weather including heavy rains in southern California.

Climate summaries for regions containing representative habitat for the Stephens' kangaroo rat provide support for the typical warm and arid climate conditions where the species is found. A previous study of rainfall patterns in the western Riverside County region reported that temporal patterns of rainfall variation were homogeneous, and concluded that population fluctuations and viability of the Stephens' kangaroo rat would be highly correlated throughout much of the species' range (Burke *et al*. 1991, p. 19). In Table 2, we provide a summary of precipitation and temperature patterns for representative locations within the Current Potential Extent of the Stephens' kangaroo rat. At all stations, most precipitation occurs from December through March, with almost no snowfall recorded. Temperatures in inland areas of southern California can fluctuate widely during the year (i.e., hot summers and cold winters) and microclimatic conditions are prevalent in the entire region due to the varied topography and proximity to the Pacific Ocean.

Drought events, including multi-year drought conditions, are not uncommon in southern California (Meko *et al*. 1980, p. 599; California Department of Natural Resources 2015, entire; Kalansky *et al*. 2018, p. 24), and the State experiences both high year-to-year and within year variability in precipitation, since annual totals depend, in large part, on precipitation events from relatively few storms (Dettinger *et al*. 2011, p. 460). In a previous analysis of potential environmental predictor variables and abundance of the Stephens' kangaroo rat, rainfall was found to be correlated with its abundance (Burke *et al*. 1991, p. 18). Further, March rainfall was found to be the best predictor of desert rodent abundance in the fall, and likely is the case for the Stephens' kangaroo rat (Burke *et al*. 1991, p. 19). Thus, if March rains are lower than average due to, for example, drought events, this may lower recruitment for the population in the fall (Burke *et al*. 1991, p. 19).

Table 2. Historical precipitation and temperature averages for representative areas of Stephens' kangaroo rat occurrence, Riverside and San Diego Counties.

Location and Elevation	Precipitation (avg. annual, total)	Temperature
San Jacinto (Riverside Co.), 1,550 ft (472.4 m) elevation	12.93 in (32.8 cm), period of record 1893–1978	Average annual max = 80°F (26.7°C) Average annual min = 45.2°F (7.3°C)
March Field (Riverside Co.), 1,480 ft (451 m) elevation	8.23 in (20.9 cm), period of record 1948–1964	Insufficient data
Fallbrook (San Diego Co.), 682 ft (208 m) elevation	13.21 in (33.55 cm), historical average	Average annual high = 74.4°F (23.56°C) Average annual low = 50.4°F (10.22°C)
Ramona at Spalding Station (San Diego Co.), 1,480 (451 m) elevation	14.5 in (36.8 cm), period of record 1949–1973	Average annual max = 78.2°F (25.67°C) Average annual min = 44.5°F (6.94°C)

Sources: WRCC 2018a; Intellicast.com 2018.

An evaluation of populations densities by Kelt *et al*. (2005a, p. 270; 2008, p. 253) found that the Stephens' kangaroo rat exhibited a demographic decline in populations during rainy periods (including an ENSO-associated rain event in 1998), but then rebounded with increased population density. Drought conditions may also provide a beneficial effect by reducing vegetative cover, as has been observed for some Stephens' kangaroo rat populations in Riverside County (Shomo 2018, pers. comm.). Similarly, monitoring results for Camp Pendleton following several years of drought conditions in southern California suggest habitat suitability improved for the Stephens' kangaroo rat and resulted in a decrease in competition for seed due to a decline in rodent competitors less adaptive to drought conditions (Brehme *et al*. 2017, p. 2). Other rodent populations have also been found to be correlated with large-scale weather patterns, such as ENSO, due to an increase in precipitation and subsequent increase in vegetation (i.e., food resources) that follows this winter/spring rain event (Mills 2005, p. 47; Lightfoot *et al*. 2012, p. 1024), though these effects can vary due to interactions with other environmental factors such as season, temperature, and elevation (Mills 2005, p. 50; Mills *et al*. 2010, p. 567).

Temperature and precipitation trends over the past 150 years for these general regions are discussed below (see section 6.10 Climate Change).

3.3.2 Ecological Setting

Grinnell (1922, p. 30) placed Stephens' kangaroo rat in the Lower Sonoran life zone, based on Merriam's (1898, entire) life zone classification, which extends west of the 100th meridian from

Texas into Arizona, New Mexico, Utah, Nevada, and into eastern and southern California, encompassing the arid deserts of western North America (Merriam 1898, p. 41). This life zone classification scheme was based primarily on temperature isotherms and has been criticized for its reliance on a single environmental factor (see review by Daubenmire 1938). The 2015 California State Wildlife Action Plan (see discussion in section 7.0 Regulatory Mechanisms and Management/Conservation Measures) places the species in the South Coast Province, within isolated grassland habitats (CDFW 2015, p. 5.5-1).

The Stephens' kangaroo rat is primarily associated with open, annual grassland (O'Farrell and Uptain 1987, p. 44). Typical habitat consists of native and nonnative annual herbs (e.g., gold fields (*Lasthenia* sp.) and filaree (*Erodium cicutarium*), and native and nonnative grasses (e.g., foxtail fescue (*Vulpea megalura)* great brome (*Bromus diandrus*), red brome (*B. madritensis* ssp. *rubens*), and wild oat (*Avena fatua*) (Bleich 1973, p. 61; Bontrager 1973, p. 70; Service 1993, pp. 14–15; Price *et al*. 1995, p. 54: Tetra Tech, Inc. 2013, p. 6). The Stephens' kangaroo rat is also found in sparse coastal sage scrub habitat where perennial species such as encelia (*Encelia farinosa*)*,* coastal sagebrush (*Artemisia californica*)*,* and California buckwheat (*Eriogonum fasciculatum*) occur (Moore-Craig 1984, p. 6, Table 2), with an average cover of about 9 percent (Moore-Craig 1984, p. 7; Table 3), as well as on formerly cultivated land (Moore-Craig 1984, pp. 2, 5).

The Stephen's kangaroo rat appears to prefer intermediate seral stage (secondary succession) plant communities that are maintained by disturbance (e.g., fire, grazing, and agriculture) (O'Farrell 1990, p. 81); however, dense grasses are avoided and areas with high cover of nonnative grasses (e.g., *Bromus diandrus*) and forbs can exclude the Stephens' kangaroo rat from otherwise suitable habitat (O'Farrell 1990, p. 80; Service 1997, p. iii; Shier 2009, p. 4).

3.3.2.1 Effects of Habitat Management Actions

In an early experimental study of the effects of management actions to the Stephens' kangaroo rat, Price *et al*. (1994b, pp. 13–14) found that the removal of shrubs, that is, woody shrub canopy cover, regardless of the understory (with dominant species of *Eriogonum fasciculatum*, *Artemisia californica,* and *Encelia farinosa*), resulted in higher abundance of Stephens' kangaroo rats in downslope (grassland) areas that lacked shrub cover. The authors concluded that, while this type of activity should be evaluated for similar benefits at other sites, shrub removal did enhance the suitability of coastal sage scrub habitat for the Stephens' kangaroo rat. The positive effects extended into adjacent grassland habitat most likely because of an increase use of the newly created suitable habitat (Price *et al*. 1994b, p. 15).

Disturbance factors such as fire and grazing can also serve as moderators of populations fluctuations relative to their effect of reducing the density of annual grasses and thatch while providing conditions favorable for the growth of annual forbs (e.g., *Erodium* sp.) (Spencer and Montgomery 2007, p. 17). Annual forbs provide an important food source while not significantly restricting movements that the presence of annual grasses can cause since annual forbs die back in late spring creating open conditions that are preferred by the Stephens' kangaroo rat during breeding season (Spencer and Montgomery 2007, p. 17).

As part of an ecological study of the Stephens' kangaroo rat at Det. Fallbrook, cattle grazing was found to be compatible with the species' persistence, likely due to the reduction of vegetation resulting from this activity (Service 1993, p. 17). However, that study suggested that domestic sheep grazing may be more compatible given the potential for larger animals to cause damage to burrows during wetter conditions due to their lighter mass/weight (Service 1993, p. 33).

In a study within portions of the Southwestern Riverside County Multi-Species Reserve, Kelt *et al*. (2005b, p. 427) found that Stephens' kangaroo rat populations responded positively to both mowing and grazing treatments. Their results provide support for mowing or grazing by sheep as management tools to improve nonnative habitats (Kelt *et al*. 2005b, p. 428). Similarly, Spencer and Montgomery (2007, p. 17) indicated that the creation of heavily used cattle trails and dirt roads in areas with suitable soil may provide some benefit to the Stephens' kangaroo rat and provide connectivity to other habitat areas.

The Stephens' kangaroo rat monitoring program at Camp Pendleton evaluated the effects of military disturbance to the Stephens' kangaroo rat and its habitat. The 2017 report indicated that populations of the Stephens' kangaroo rat were more likely to occupy disturbed areas and appeared to tolerate moderate to relatively high levels of military disturbance activities as long as habitat conditions continued to support the growth of forb vegetation (Brehme *et al*. 2017, pp. 2, 38). The authors' cautioned, however, that heavy disturbance that results in areas of open ground but with little forb cover does not support occupancy, and ground disturbance activities that create deep ruts are less likely to be tolerated given the potential for burrow destruction and disruption of movements (Brehme *et al*. 2017, p. 2).

Controlled use of fire has also been viewed as a positive (at least in the short-term) management tool for heteromyid species in providing open habitats and promoting connectivity to adjacent habitats (Potter *et al*. 2010, pp. 5–6). Results from the multi-year monitoring study at Camp Pendleton indicate that colonization events for the Stephens' kangaroo rat were more likely to occur in areas with frequent fire (less than 5 years) and with over 40 percent open/bare ground (Brehme *et al*. 2017, p. 2). For that area, scientists continue to recommend management actions that incorporate regular disturbance (e.g., fire, vegetation thinning) at a level that supports the growth of forbs over nonnative grasses and shrubs (Brehme *et al*. 2017, p. 3). Following habitat management actions (e.g., prescribed burning, mowing, chemical treatment) at the Juliett SKR Management Area at Camp Pendleton, 21 Stephens' kangaroo rat individuals were translocated to the area in 2011 and continued to be detected as recently as the fall and winter of 2015–2016 (Brehme *et al*. 2017, pp. 18, 22). However, at this location, active management is needed to prevent invasive annual grasses and an increase in shrub growth, conditions that are likely to decrease colonization events for the Stephens' kangaroo rat (Brehme *et al*. 2017, p. 44).

As part of a multi-year translocation and genetics study of the Stephens' kangaroo rat, Shier and Swartz (2012, p. 14) conducted a larger-scale, field experimental study to evaluate whether the type of site preparation method used (i.e., sheep grazing, controlled burning, and mowing) influenced the settlement and survival of translocated individuals. The study found controlled burn treatments had a relatively long lasting positive effect on translocated animals, while grazing to mowing treatments were preferred in the short term, though, for the latter two treatment methods, the effects did not extend beyond 6 months, post-release (Shier and Swartz 2012, p. 16). Both translocated and new individuals observed on the research plots preferred restoration subplots (Shier and Swartz 2012, p. 4). This study also found that the number of burrows established 6 months after release of animals into study subplots was significantly higher in those areas with restoration (Shier and Swartz 2012, p. 16). Significantly more burrows in the burn treatment subplots were observed as compared to the grazed or mowed subplots, with burn plus restoration subplots having the highest rate of burrow establishment (Shier and Swartz 2012, p. 16). At 12-months after release, they also observed more active burrows on burned subplots compared to grazed and mowed subplots (Shier and Swartz 2012, p. 16). Although the study results represent only a 1-year period, the researchers concluded that treatments using prescribed fire *plus* post-fire application of herbicide and planting of native grass seedlings provided the best habitat for Stephen's kangaroo rats (Shier and Swartz 2012, p. 18). Shomo (2018, pers. comm.) also observed that Stephens' kangaroo rats were quick to colonize areas recently restored (e.g., thatch removal and burning).

Based on observations and monitoring within the Ramona Grasslands region (San Diego County), Spencer and Montgomery (2007, p. 16) summarized the Stephens' kangaroo rat distribution and abundance as follows: population density and distribution generally decrease during periods when vegetation growth is high (i.e., high soil moisture), but populations increase with drier conditions and less vegetation growth, and may reoccupy areas that contain less well-drained soils or less disturbance. The decline in population density and distribution observed during periods of increased vegetation results from the restriction of movement of the Stephens' kangaroo rat and possible decline in food availability (due to out-competing annual forbs that provide preferred seeds) (Spencer and Montgomery 2007, p. 16).

3.3.3 Suitable Habitat

In an early habitat selection study, O'Farrell and Clark (1987, entire) found that, although the Stephens' kangaroo rat was observed in habitats containing up to 30 percent aerial shrub cover, most occurrences (over 75 percent) were found in habitat patches completely devoid of shrubs (O'Farrell 1990, p. 80). Abundance was also found to be positively related to a lack of shrub cover (O'Farrell 1990, p. 80). Other *Dipodomys* species also appear to prefer open areas that offer abundant forbs (Reichman 1975, p. 737; *D. merriami*), where structure can facilitate movement and foraging for food sources, but this behavior can also be dependent on the level of perceived predation risk (Brown *et al*. 1988, p. 411). A recent study of the Gulf Coast kangaroo rat (*D. compactus*), an endemic species of Texas, found that this species appeared to avoid areas with either extensive horizontal or vertical cover, which may conceal predators (Bell 2017, p. 33). However, Thompson (1982, p. 1306) found that, although *Dipodomys merriami* and *D. deserti* spend the majority of their foraging time beneath aerial cover, trapping overestimates the extent of foraging by *Dipodomys* in open microhabitat areas when compared to direct observations. Thus, results from live trapping of kangaroo rats (as compared to direct observations of foraging patterns) may not always provide an accurate depiction of either foraging effort or the time allocated for foraging (Thompson 1982, p. 1306). In addition, captures are generally correlated with lunar phase (e.g., higher with new moon) (Moore-Craig 1984, p. 6), which can also introduce bias in capture results. Although, Prugh and Brashares (2010, p. 1205) consistently found a positive correlation between moonlight and trapping success of the giant kangaroo rat (*Dipodomys ingens*). Moore-Craig (1984; Table 3) found that *total* percent cover of grasses and herbaceous cover for sites inhabited by the Stephens' kangaroo rat in the San Jacinto Wildlife Area was 30 to 40 percent.

In their statistical analysis of environmental variables affecting abundance of the Stephens' kangaroo rat (using previously collected survey data), Burke *et al*. (1991, p. 22) found that the species was significantly more abundant in "grassland only" vegetation as compared to "grassland with shrub" vegetation, regardless of the elevation. The authors cautioned that other independent variables, such as soil type, slope, and presence of competitors, should also be including in this type of analysis to reduce unexplained variability (Burke *et al*. 1991, p. 22). Other kangaroo rat studies have used soil type/depth and percent of vegetation cover to develop modeled habitat (e.g., Bliss 2016, entire).

In a study of populations of the Stephens' kangaroo rat conducted at Det. Fallbrook, statistical models constructed to predict the species' occurrence produced a poor fit using landscape-scale habitat variables. This study reported that finer scale and difficult to measure or quantify factors, such as density dependent variables, stochasticity, historical elements, and social behavior, as well as relationships within the ecological community, were likely needed in developing models for accurately predicting population densities (Service 1993, p. 19). Further, given the temporal variability of individual and community populations, a predictive model may only be useful for the study period in which it was developed (Service 1993, p. 19). The researchers who conducted the Det. Fallbrook study concluded that mapping habitat by visual notation of signs of presence (e.g., scat, tail-drag markings, burrows) followed by verification trapping represented the best method to determine the occupancy of the Stephens' kangaroo rat (Service 1993, p. 20).

Andersen and O'Farrell (2000, entire) conducted a tree-structured data analysis (i.e., Classification and Regression Trees or CART) in an effort to model burrow count data as a function of habitat and vegetation predictor variables from several Stephens' kangaroo rat sites in southern California; habitat data was collected in 1989 and 1990. Though there were some differences in the two regression trees due to fitting of different data sets, the CART algorithm produced regression trees that provided a consistent general prediction: habitats with higher burrow counts of the Stephens' kangaroo rat tend to be characterized by gentle slopes (9 to 14.5 degrees), moderate to high amounts of bare ground, and high forb cover, as well as avoidance of habitats dominated by grasses or shrubs (Andersen and O'Farrell 2000, p. 13).

Multi-year integrated habitat occupancy modeling (summarized in Brehme *et al*. 2011, pp. 17–18) was developed for Stephens' kangaroo rat monitoring data at Camp Pendleton for 2005–2010 (Brehme *et al*. 2011, pp. 29-31); and 2011-2012 to 2015-2016) (Brehme *et al*. 2017, pp. 33–37). Results for the 2011 to 2016 period indicate that the best predictors of occupancy of the species at Camp Pendleton were slopes less than 10 degrees, high proportions of forbs, and moderate proportions of open ground (Brehme *et al*. 2017, p. 33). However, there is currently no standardized population monitoring across the species' range and no new statistical models have been prepared to identify key habitat features from the occurrences. A range-wide Stephens' kangaroo rat habitat suitable model study is under development, using fine-resolution multispectral imagery and other environmental data layers (i.e., predictive variables).

Finally, a multi-year study of the Stephens' kangaroo rat population at Warner Springs evaluated predictors of occupied habitat (summarized in Clark *et al*. 2018, entire). Results from this study found that slope and covariates of forb or shrub cover were important predictors of occupancy of the species (Clark *et al*. 2018, p. 18). Specifically, in this study area, the probability of occupancy in slopes greater than 5 percent was near zero ((Clark *et al.* 2018, p. 18). The probability of the Stephens' kangaroo rat occupying a plot increased with increasing cover of *forbs* and decreased with increasing cover of *shrubs* (Clark *et al*. 2018, p. 18). Similarly, results from Stephens' kangaroo rat surveys in the Anza-Cahuilla and Potrero Valleys in Riverside County found that occupancy of the Stephens' kangaroo rat declined sharply when shrub cover was greater than 10 percent (Biological Monitoring Program 2009, p. 19).

Modeled habitat

Given this background, for this species report, we conducted a spatial analysis to create modeled habitat for the Stephens' kangaroo rat (Service 2018). We mapped (in Geographic Information System (GIS) format) detections of Stephens' kangaroo rat for both Riverside and San Diego Counties from the years 2010 to 2017. We then identified an average home range (~0.4 ac) (1,575 m^2) using information presented in Kelly and Price (1992, pp. 19–20) based on telemetry data (averaging areas for both males and females in the two study areas) and, assuming a circular polygon, we buffered our detection data points by radius of 73.458 ft (22.39 m). Using the CDFW Stephens' kangaroo rat range map (shown in Appendix A) as our boundary, we incorporated a current vegetation data layer (U.S. Department of Agriculture (USDA) 2018a) to identify the California Wildlife Habitat Relationships (CWHR) types. (This range map was also used as a delimiter for incorporating elevation, slope, and soil spatial layers). We reviewed those CWHR codes within the range map (CDFW 2014) and removed those that were determined to be unsuitable for the Stephens' kangaroo rat. Next, we identified elevation for each of these detection locations, which, as noted above (section 3.3.1 Physical Setting) produced an elevational range from 397 to 3,563 ft (121 to 1,086 m), and incorporated percent slope using a range of 0 to 15 percent (see section 3.3.1 Physical Setting). We then identified soil types for our 2010 to 2017 detections in both counties and reviewed the resulting list relative to those identified in the literature. The selected soils were then mapped using a Soil Survey Geographic Database (SSURGO) (USDA 2018b). Finally, we applied the 2016 Farmland Mapping and Monitoring Program (FMMP) data (CDC 2018a) and used National Agriculture Imagery Program 2016 imagery to conduct visual checks for possible suitable habitat, removing areas that were agricultural or developed lands but were not identified as such in the FMMP data layer.

Our analyses estimated a total of 91,538 ac (37,044 ha) of modeled habitat for the Stephens' kangaroo rat, with approximately 69,104 ac (27,966 ha) located in Riverside County and 22,434 ac (9,079 ha) in San Diego County (Figures 2 and 3). We recognize that our modeled habitat is coarse and conservative in scope and scale, and, for Riverside County, is not directly comparable to the potential Stephens' kangaroo rat habitat estimates (pre-modern, 1938, 1984) presented in Price and Endo (1989, pp. 297–298) given that the differences in methodology used to develop these maps and the different years in which these maps were constructed (see discussion below). Nevertheless, we also conducted a spatial analysis to estimate lands within the CWHR-defined range map for the Stephens' kangaroo rat that are currently classified as either urban or agricultural lands, similar to the analysis presented in Price and Endo (1989, entire), who identified these land types relative to what they determined was representative of the potential distribution of the species using their selected soil types as suitable habitat (Price and Endo 1988, Appendix 1). We used the SSURGO database (USDA 2018; data current as of 2014) to map only those selected soil types and combined those results with the 2016 FMMP data to create a comparison to the suitable habitat map identified in 1984 for Riverside County by Price and Endo (1989, p. 297; Figure 3), who found approximately 40.5 percent of their suitable habitat remaining in 1984 (Price and Endo 1989, p. 296). We found that, for Riverside County, approximately 32.6 percent of suitable habitat (based on Price and Endo soil types) was classified as either urban or agricultural lands. These results are presented in Appendix F. We note here that the 2016 FMMP data set we used may consider non-agricultural or non-urban lands differently than was classified by the analysis presented in Price and Endo (1989). Modeled habitat is defined as habitat likely suitable based on criteria described below.

Until additional, standardized population monitoring information becomes available across the entire range of the species and robust statistical models are developed, we consider the results from our spatial analyses to be based on the best available information.

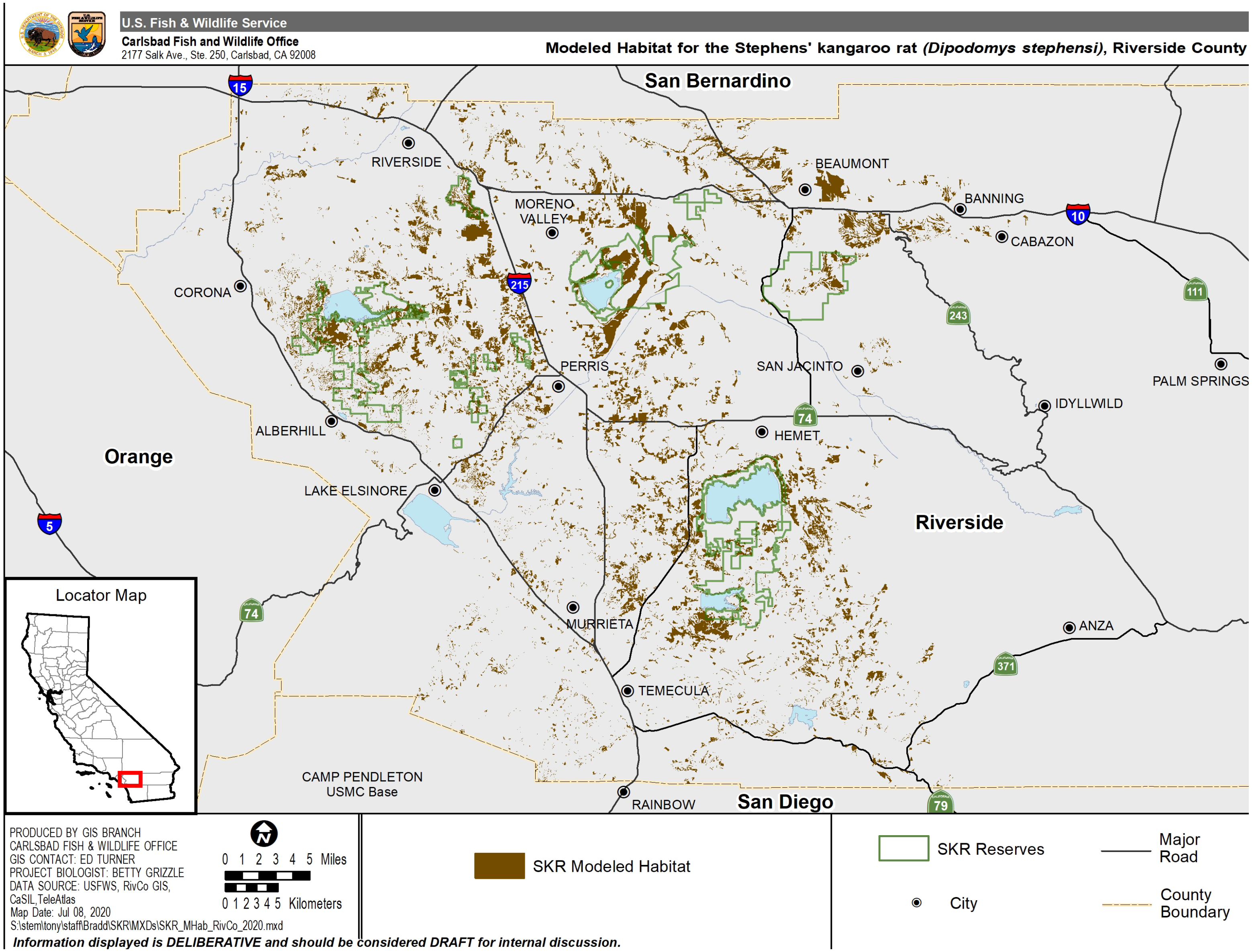

Figure 2. Modeled habitat for the Stephens' kangaroo rat, Riverside County

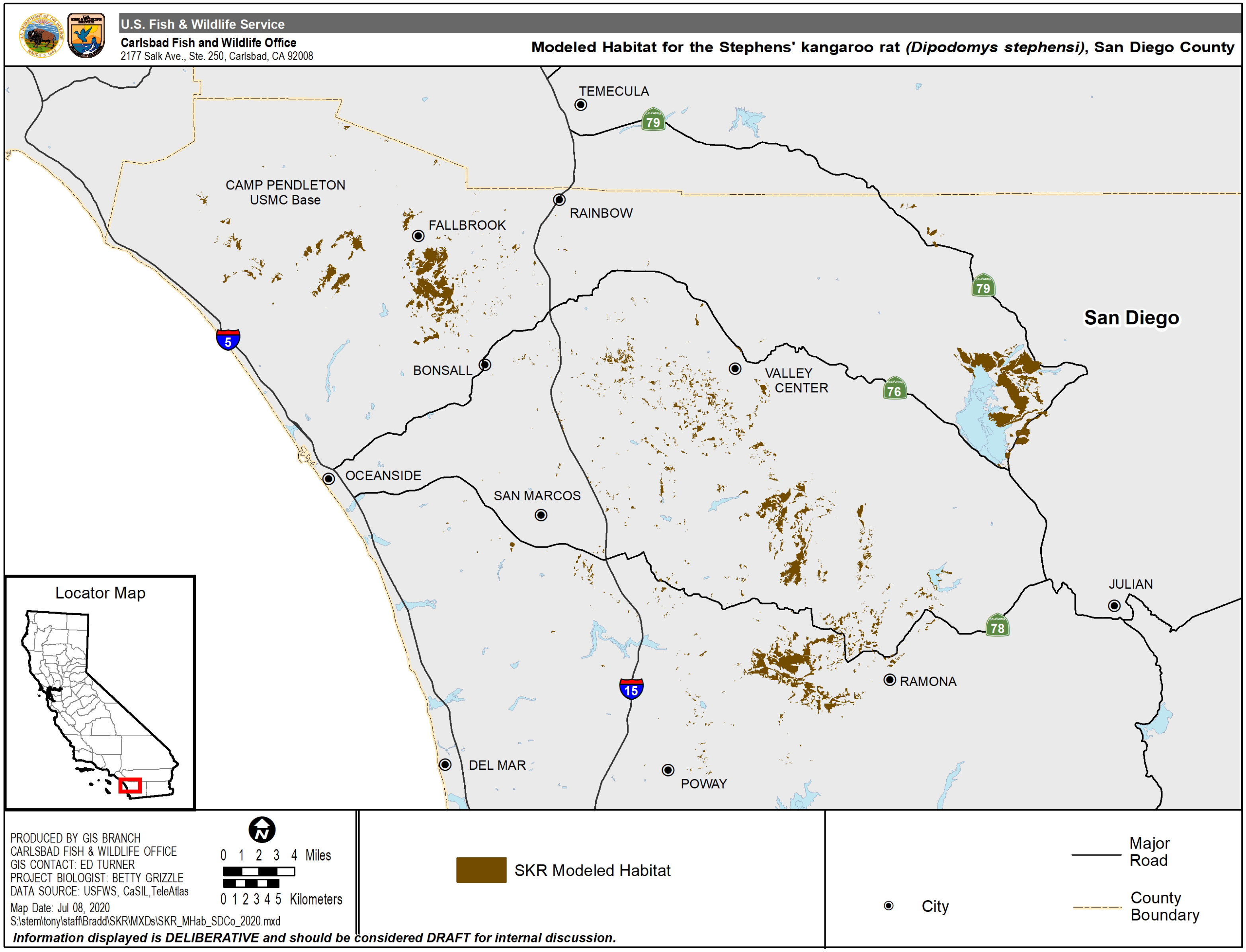

Figure 3. Modeled habitat for the Stephens' kangaroo rat, San Diego County

3.3.4 Summary

Populations of the Stephens' kangaroo rat reach their highest densities in grassland communities dominated by forbs and characterized by moderate to high amounts of bare ground, moderate slopes, and well-drained soils (Bontrager 1973, p. 101; O'Farrell and Uptain 1987, pp. 39, 45; O'Farrell and Clark 1987, p. 80; Burke *et al*. 1991, p. 22; Andersen and O'Farrell 2000, p. 12). The Stephen's kangaroo rat appears to prefer intermediate seral stage (secondary succession) plant communities that are maintained by disturbance (e.g., fire, grazing, and agriculture) (O'Farrell 1990, p. 81); however, dense grasses are avoided and areas with high cover of nonnative grasses (e.g., *Bromus diandrus*) and forbs can exclude the Stephens' kangaroo rat from otherwise suitable habitat (O'Farrell 1990, p. 80; Service 1997, p. iii; Shier 2009, p. 4). Disturbance factors such as fire and grazing can also serve as moderators of population fluctuations relative to their effect of reducing the density of annual grasses and thatch while providing conditions favorable for the growth of annual forbs (e.g., *Erodium* sp.) (Spencer and Montgomery 2007, p. 17). Based on these factors, a habitat suitability model was created to determine current suitable habitat throughout its range. We estimated there is a total of 91,538 ac (37,044 ha) of modeled habitat for the Stephens' kangaroo rat, with approximately 69,104 ac (27,966 ha) located in Riverside County and 22,434 ac (9,079 ha) in San Diego County. Our model is not directly comparable to Endo and Price (1989), but we found that for Riverside County, approximately 32.6 percent of suitable habitat (based on Price and Endo soil types) was classified as either urban or agricultural lands.

4.0 LIFE HISTORY AND ECOLOGY

4.1 General Habits

As noted above, as a group, kangaroo rats are nocturnal and generally found in arid and semi-arid environments, but are active year-round. Kangaroo rats, including the Stephens' kangaroo rat, construct burrow systems, which provides shelter from the environment (e.g., temperature extremes), protection from predators, food storage (caching), and place for nesting (Meadows 1991, p. 1). However, since adult kangaroo rats do not nest together, individuals must leave burrows to mate and to establish/defend a territory (Daly *et al*. 2000, p. 149), which requires performing displays of important social, interactive behaviors (e.g., short chases, marking behavior) (Kenagy 1976, p. 131).

Most of the surface activity of the Stephens' kangaroo rat is believed to be restricted to runways or trails, burrow aprons (cleared areas at burrow entrances), and dusting areas (O'Farrell and Uptain 1987, p. 41), but digging sites (for seeds) have also been observed (O'Farrell and Uptain 1987, p. 41). Well-used trails connect the various burrows, and aprons are cleared around most burrows and all burrow complexes (O'Farrell and Uptain 1987, p. 41). Cleared areas have also been observed at the intersection of major trails and appear to be used for sand bathing (O'Farrell and Uptain 1987, p. 41).

Within the genus *Dipodomys*, there is much variability in the pattern of burrow construction, but, in general, burrows are of two types depending on their age, with new burrows used as subsidiary or "duck-in" tunnels that are short in length and simple, and older tunnel systems that can be much longer and more complex (Eisenberg 1963, p. 18). The size of the tunnels entrance also varies by species in this genus (Eisenberg 1963, p. 19).

In a study of the species in San Diego County (Det. Fallbrook), the burrows of the Stephens' kangaroo rat were often clustered in interconnected burrow complexes (Service 1993, p. 37). At Warner Ranch (San Diego County), O'Farrell and Uptain (1987, p. 41) also found the neighboring burrow entrances were often connected by a series of tunnels and aboveground pathways. However, in that study, most (81 percent) of the burrows or burrow complexes were solitary (greater than 3.3 ft (1 m) from the nearest hole), with some clustering into burrow complexes observed (O'Farrell and Uptain 1987, p. 41). That study also found that Stephens' kangaroo rat burrows and complexes were generally located close together, with about 55 percent of burrows and complexes separated by less than 9.84 ft (3 m) and about 12 percent separated by distances that exceeded 32.8 ft (10 m) (O'Farrell and Uptain 0987, p. 41). Brook and Kelt (2004a, pp. 53–54) reported shared burrow entrances for the Stephens' kangaroo rat, suggesting some evidence of non-solitary use of burrows.

In addition, researchers have speculated that the Stephens' kangaroo rat colonize areas in which Botta's pocket gopher (*Thomomys bottae*) and the California ground squirrel (*Otospermophilus beecheyi*) have previously established a network of burrows in areas disturbed by agriculture, following subsequent soil compaction and establishment of forbs (Thomas 1975, p. 37; O'Farrell and Uptain 1989, p. 7).

In grassland habitat occupied by the Stephens' kangaroo rat at Warner Ranch, high densities of burrow entrances have been observed along the edges of dirt roads, though areas away from roadways were also found to have extensive occupation (O'Farrell and Uptain 1987, p. 40). Some researchers have suggested they use dirt roads as landscape linkages between habitat patches, possibly due to a foraging advantage given the weedy plant species that colonize these areas (Brock and Kelt 2004b, p. 638) and the seral stage plant community that these areas represent (O'Farrell and Uptain 1989, p. 7). However, high levels of disturbance can cause direct mortality (e.g., vehicle traffic) to the Stephens' kangaroo rat and/or destruction of its habitat (Brehme *et al*. 2017, p. 8). In a field study of the Stephens' kangaroo rat in western Riverside County, trapping results indicated a strong bias of animals in or on roads, or in road berms, with 98 percent of all individuals that were trapped found within the dirt roadways (Shier 2009, p. 12). All of the sites in the western Riverside County study were reported to have extensive coverage of nonnative grasses, with one exception where a small area of native bunch grasses was found (Shier 2009, p. 12).

Within the Lake Henshaw population of the Stephens' kangaroo rat, a 2010 survey found that in some parts of the grassland habitat, individuals appeared to maintain an unusual system of narrow pathways among their burrow entrances in grass cover that would normally be considered too dense for regular occupation, and which created "ruts" in the grass that connected the systems of burrows (Chambers Group, Inc. and SJM Biological Consultants, Inc., 2012, p. 9; photos in Appendix B).

As noted above, open and relatively sandy soils are important habitat features for the Stephens' kangaroo rat that are used for sandbathing. Eisenberg (1963, p. 43) concluded that heteromyid rodents may routinely use sandbathing spots that serve to communicate physiological states (e.g., breeding status); thus, this behavior serves as a form of chemical communication (Eisenberg 1963, p. 81; see also Shier 2008, p. 24). Sandbathing in two *Dipodomys* species (*D. spectabilis* and *D. merriami*) is believed to function as a territorial scent-marking behavior (Jones 1993, p. 579), and sandbathing sites likely attract kangaroo rats since chemical signals (e.g., sebaceous gland secretions) are deposited during this activity (Lepri and Randall 1983, p. 263).

Communication of female reproductive status to males through sandbathing was found not to be the case for *Dipodomys merriami* (Lepri and Randall 1983, p. 263); however, results from laboratory studies of *D. heermanni* did suggest that females may communicate reproductive status (estrous) to males via sandbathing (Shier 2008, p. 24, citing D. Shier, unpublished data). Further, initial results from Stephens' kangaroo rat translocation experiments found that scent placement significantly influenced short-term survival, possibly by influencing settlement decisions (Shier 2008, p. 25). Thus, sandbathing is likely an important means of communication in kangaroo rats (Shier 2008, p. 24), including the Stephens' kangaroo rat, and this behavior highlights the importance of sandy soils/open areas as important habitat features for the Stephens' kangaroo rat.

A conceptual model for the life history of the Stephens' kangaroo rat was developed as part of the monitoring protocol program prepared for Camp Pendleton (Brehme *et al*. 2006, Appendix 4) and is reproduced below in Figure 4. This diagram provides a summary of the spatial and temporal elements and demographic factors discussed in this section that influence the population dynamics for the Stephens' kangaroo rat. In sum, the distribution and density of populations of the Stephens' kangaroo rat can vary temporally, within and between years, and spatially, depending on natural changes in habitat conditions and succession of plant communities (Brehme *et al*. 2006, p. 6).

4.2 Reproduction, Growth, Longevity

Early field studies (e.g., O'Farrell *et al.* 1985; O'Farrell and Clark 1987) supported the idea that the Stephens' kangaroo rat displayed a prolonged breeding season as well as the potential for multiple litters. Climatic conditions and effects on resource availability were identified as likely accounting for annual variations (O'Farrell and Clark, 1987, p. 11). A study of reproductive activity from a trapping study of the Stephens' kangaroo rat in Riverside County (McClenaghan and Taylor 1991; McClenaghan and Taylor 1993) found that reproductive adult males were observed year-round while breeding activity in females was more restricted, but, for both sexes, the intensity of breeding activity was higher in winter and spring (McClenaghan and Taylor 1993, p. 639). The observed onset of estrus appeared to be triggered by the start of winter precipitation, which is a typical pattern of kangaroo rats, and is likely related to the availability of resources needed for nutritional and energy needs for reproduction and rearing of young and (McClenaghan and Taylor 1991, p. 19; McClenaghan and Taylor 1993, p. 643). Similarly, Price and Kelly (1994, p. 813) also reported that the timing and length of the reproductive season for this species correlated with winter rainfall patterns.

The onset of male reproductive activity precedes the receptivity of females and extends beyond this period (McClenaghan and Taylor 1991, p. 18; Figure 2). As noted by Price and Kelly (1994, p. 811), this breeding pattern is consistent with a promiscuous mating system and no lasting pair bonds, similar to reports for other kangaroo rats (Jones 1993, p. 584). However, in her study of the banner-tailed kangaroo rat (*Dipodomys spectabilis*), Randall (1991, p. 219) remarked that the promiscuous label may not adequately capture the observed paired encounters that can result from neighbor recognition of long-term associations of male and female neighbors and preferential interactions with neighbors.

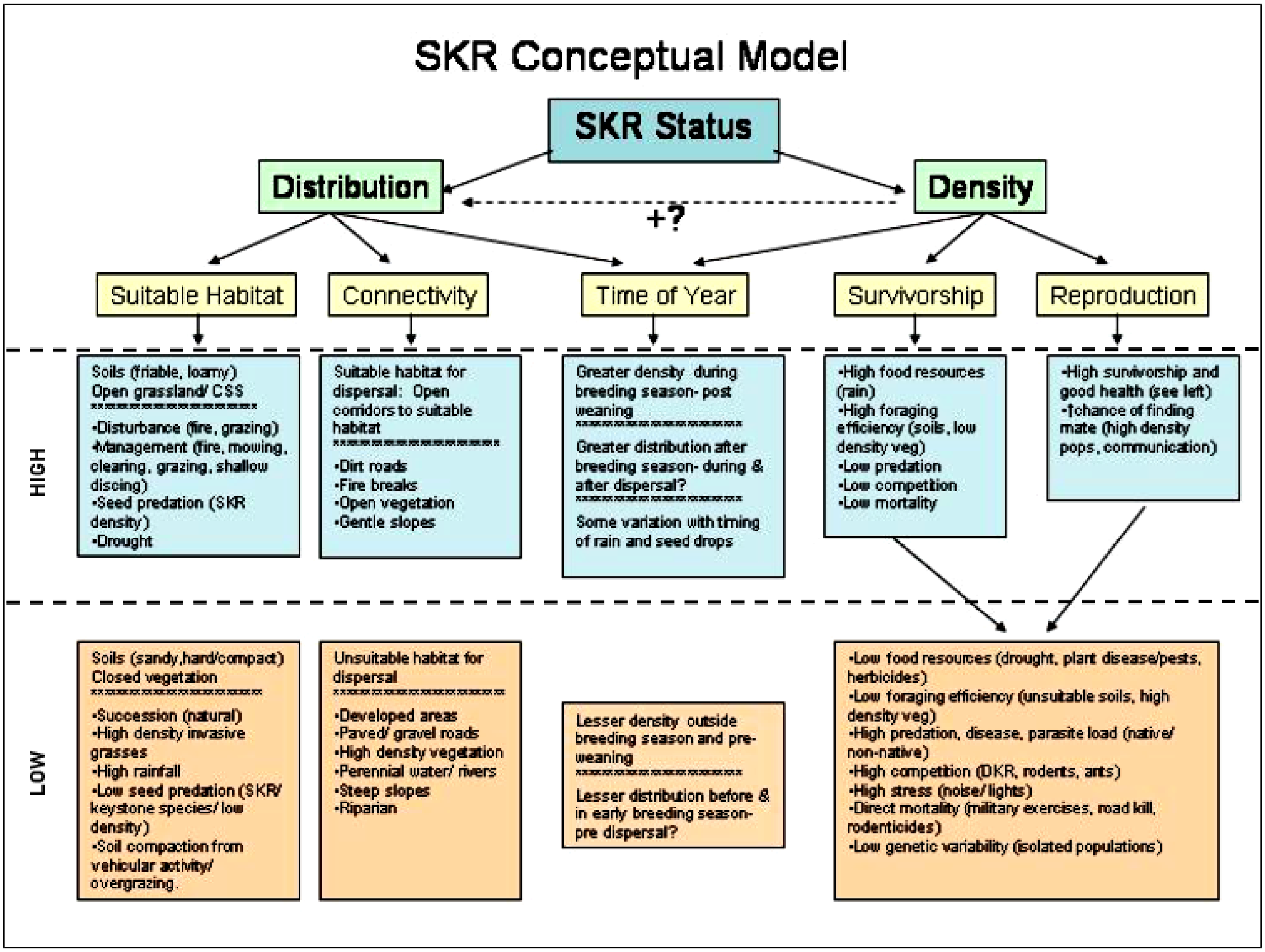

Figure 4. Conceptual life history model for the Stephens' kangaroo rat.
Source: Brehme *et al*. 2006.

In captivity, those females who gave birth to young constructed elaborate nests (Lackey 1967b, p. 627). Edelman (2011, p. 435) noted that the banner-tailed kangaroo rat (*Dipodomys spectabilis*) uses an insulated nest chamber that reduces exposure to cold burrow air temperatures. In wild Stephens' kangaroo rat populations, Thomas (1975, pp. 37–38) excavated several Stephens' kangaroo rat burrows (include those established by other species) and found nest areas located at the end of the main tunnel, with one den lined with *Brassica* sp. (mustard) leaves.

Capture rearing of five female Stephens' kangaroo rats (collected in San Diego County) reported 16 young from 6 litters, or a mean litter size of 2.67, with weaning between 18 and 22 days (Lackey 1967b, pp. 625, 628). In their live-trapping study conducted at two sites in Riverside County, Price and Kelly (1994, p. 815) determined a mean litter size of 2.83 from 6 females (based on litters observed in traps or examination of embryos or uterine scars of deceased animals).

A study of the growth and development of two species of kangaroo rats (*Dipodomys deserti*, *D. merriami*), found that both species reached about half of their adult weight in 30 days, with full average adult weight attained by 150 to 180 days (Butterworth 1961, p. 137). In a study of captive bred animals, growth rates for the Stephens' kangaroo rat was said to be intermediate between those of *D. deserti* and *D. merriami*, and young were found to be about 70 percent of adult weight at 63 days (Lackey 1967b, p. 624). Additional information detailing early physical growth and development of the Stephens' kangaroo rat is presented in Lackey (1967b, pp. 625–627).

Field growth rates for two populations of the Stephens' kangaroo rat in Riverside County (Motte and San Jacinto Wildlife Area) were reported by Price and Kelly (1994, pp. 813–814) and were found to be similar to those of Lackey (1967b). They reported a gain of 0.71 oz (20 g) in the first month, then 0.21 oz (6 g) in the subsequent month, with generally slower monthly growth rates at a mass (weight) of 2.12–2.4 oz (60–69 g) and declining monthly growth rates after reaching 2.47 oz (70 g) (Price and Kelly 1994, p. 814). Significant differences between male and female mass-specific growth rates, with female growth rates decreasing faster than males (Price and Kelly 1994, p. 814). This study reported that, based on the average female growth trend, a newly-weaned female (weighing 0.88 oz (25 g)) would reach 1.94 oz (55 g), or the minimum mass observed in this study for lactating females, in 3 months (Price and Kelly 1994, p. 814).

The maximum life span for *Dipodomys* species has been reported from 2 years (*Dipodomys merriami*) to 6 years (*D. spectabilis*) (Jones 1993, pp. 580–581). Lackey (1967a, p. 324) reported that [wild] kangaroo rats may live 5 or 6 years, but the life span for the Stephens' kangaroo rat is likely variable depending on a number of environmental factors. Predation is an important mortality factor linked to mobility, and may be largely age-independent or higher in mobile juveniles. (Price and Kelly 1994, p. 817; Daly *et al.* 1990, p. 386). Captive *Dipodomys merriami* may live at least 5 years (Ingles 1965, p. 236). Others have reported captive (but wild-caught) kangaroo rats living over 7 years (Egoscue *et al*. 1970, p. 623).

Estimates of mean length of life (longevity) for the Stephens' kangaroo rat based on trapping history of individual animals (Riverside County) were presented in McClenaghan and Taylor (1991, p. 12). These estimates were calculated using the average number of months that individuals tagged during the first 4 months of the study and recaptured at least once remained on the study area (McClenaghan and Taylor 1991, p. 12). The reported mean lengths of life ranged from 4.5 to 6.6 months (McClenaghan and Taylor 1991, p. 12); however, in each of the three study areas, one or more individuals were captured in the first month of the study and found to be still alive at the end of the study (i.e., 18 months for the Motte Reserve and San Jacinto Wildlife Area populations and 15 months for the Lake Mathews population). The mean length of life estimate was considered to be low because the study could not distinguish mortality from emigration; that is, some of the Stephens' kangaroo rats presumed to have died may have emigrated out of the study area (Service 1997, pp. 14–15). McClenaghan and Taylor (1993, p. 643) found that within adult and sub-adult age classes, males and females had similar survival rates, but adults displayed higher survival rates than sub-adults. Survival was linked to season and location. Overall *monthly* adult survival varied between 0.79 (San Jacinto Wildlife Area females) and 0.87 (Motte Reserve females) (McClenaghan and Taylor 1991, p. 11).

4.3 Diet and Foraging Behavior

As a group, most of the heteromyids that occupy arid environments are primarily granivorous (seed eating) and nearly all store food (burrow caches) during periods of abundance (French 1993, p. 510). Heteromyids appear to locate seeds by smell, though touch and taste are also likely involved in recognizing seeds and separating them from other items encountered while foraging (Reichman and Price 1993, p. 543). Heteromyid rodents harvest seeds by directly clipping fruiting stalks and then extracting seeds from the felled seed heads (Reichman and Price 1993, p. 542), or by harvesting seeds directly from fruit that is located within about 6 to 8 in (15 to 20 cm) of the ground (Reichman and Price 1993, p. 543, and references cited therein). Kangaroo rats also clip and collect grass blades to use as bedding or nesting material in their burrows (Robbins 2013, p. 11). The extent of this behavior in the Stephens' kangaroo rat is unknown, but as reported for *Dipodomys ordii*, this activity may be important for maintaining or altering plant communities (Robbins 2013, p. 11). Some *Dipodomys* species are known to feed on other plant parts (French 1993, pp. 533–534). For example, *Dipodomys microps* is a desert species, but many populations are phytophagous year round, foraging by leaf shaving, a learned behavior in which the salty epithelial layer of *Atriplex* leaves are shaved off using lower incisors so that the more nutritious and moister interior can be consumed (French 1993, p. 533). Additional details of movement patterns during seed gathering and extraction for kangaroo rats and other heteromyid rodents are provided in Reichman and Price (1993, pp. 543–544).

Foraging by heteromyids is almost entirely done at night, presumably due to hotter daytime climatic conditions (to reduce energetic costs) and competition and predation factors (e.g., predator-avoidance costs), though poor daylight vision may also play a role in the timing of this behavior (Reichman and Price 1993, p. 547). Foraging patterns of the Stephens' kangaroo rat were observed as part of a study at in San Diego County (Det. Fallbrook) (Service 1993, entire). Individuals were observed emerging to forage for short periods of time soon after sundown and a few hours before sunrise (Service 1993, p. 37), which generally coincides with periods of lower temperatures and water loss, respectively (Reichman and Price 1993, pp. 547–548). Foraging begun in early evening also provides the advantage of locating seeds that become available earlier in the day either by seed production or redistribution by daytime winds (Reichman and Price 1993, p. 548). Seasonal foraging patterns are also likely for kangaroo rats, related to both reproductive activity and moonlight avoidance (Reichman and Price 1993, pp. 548–549). Kenagy

(1976, p. 129) posited that the large fur-lined cheek pouches of heteromyid rodents represents a preadaptation that contributed to the evolution of the shortened temporal requirement for surface activity in *Dipodomys* species by being able to transport sufficient seeds below ground without having to process or eat the seeds on the surface.

A number of studies have evaluated the physiological and morphological adaptations that allow some heteromyids, but especially kangaroo rats, to conserve water in warm, arid environments (see review of water balance in heteromyids, French 1993, pp. 520–534). Most desert heteromyids do not need to drink or eat succulent food, but rather rely entirely on the water produced during oxidative (aerobic) metabolism (French 1993, p. 534). In general, seed-eating heteromyids assimilate over 90 percent of the food that they ingest (French 1993, p. 529, and references cited therein), which minimizes the amount of undigested material and, thus, the amount of associated water excreted in urine (French 1993, p. 529).

The selection of where to forage by heteromyids is influenced by habitat features at the landscape level (e.g., topography features and plant community types), but also at the microhabitat level. That is, at the scale of foraging distance and home range use, the species of seeds, their numbers, and their spatial distribution will vary, as does the texture and density of soils where seeds are embedded (Reichman and Price 1993, p. 553). For example, soils found under shrubs and trees are coarser in texture and of lighter density than soils found in open spaces between perennial plants, which can affect foraging patterns and efficiency in seed harvesting of heteromyids (Reichman and Price 1993, p. 553). As noted above (see section 3.3, Habitat), in general, the Stephens' kangaroo rat is observed in sandy-loamy soils in conjunction with open areas and low plant cover. Predation risk and densities of other rodent species (competitors) also influence the use of microhabitats for foraging (Reichman and Price 1993, pp. 555–557). Shier *et al.* (2020, p. 5) found a decrease in Stephens' kangaroo rat foraging near artificial light at night, with the effects dampened during a full moon.

Food habits of the Stephens' kangaroo rat were evaluated in two study sites in western Riverside County by Lowe (1997, entire) by sampling fecal pellets and cheek pouches for live-trapped animals. This study found that seeds and vegetative components of *Erodium cicutarium* and nonnative grasses (*Schismus barbatus* and *Bromus madritensis* ssp. *rubens*) comprised the majority of items in fecal pellets, though fecal pellet analysis likely underrepresented the presence of seeds (Lowe 1997, p. 359; Table 1). Insects such as ants, lice, and beetles were reported in fecal material at a frequency of about 8 percent, some of which may have been consumed during foraging or grooming (lice) activities (Lowe 1997, pp. 359, 361). Cheek pouch contents contained primarily seeds, predominantly *S. barbatus*, *E. cicutarium*, and *Amsinckia menziesii* (Menzies' fiddleneck), but also included complete spikelets (plant structure that contains the flower) of *S. barbatus* (Lowe 1997, p. 359).

Caching behavior is also characteristic of most kangaroo rats. For the Stephens' kangaroo rat, based on studies of *Dipodomys* species of similar body size (e.g., Price *et al*. 2000, entire), the likely approach to caching food is by scatter hoards (Kelt *et al*. 2005a, p. 271). This occurs when an animal places one or a few food items in many caches that are scattered throughout the species' home range (Smith and Reichman 1984, p. 334). This strategy minimizes the probability of losing seeds to one pilfering individual yet places food at locations where adequate seed densities can support favorable energetic costs for retrieval (Smith and Reichman 1984, p. 334; Reichman and Price 1993, pp. 563–564).

4.4 Movement and Home Range

As reported in our 2010 12-month finding (75 FR 51207), assessments of home range size and/or movement patterns of the Stephens' kangaroo rat have been determined either by live trapping (Thomas 1975, p. 7) or a combination of live trapping and telemetry (Kelly and Price 1992, p. 4; Price *et al*. 1994a, pp. 930–931). As reported in Kelly and Price (1992. pp. 19–20), these accounts indicate differences depending on whether live trapping or telemetry was used and locations of populations, as well as slight differences between males and females. For example, at Motte Rimrock Reserve (Riverside County), mean home ranges (using minimum convex polygon method) based on trapping were estimated at 0.23 ac (943 square meters (m^2)) for females and 0.4 ac (1,620 m^2) for males, while mean home ranges based on telemetry were slightly higher with 0.33 ac (1,353 m^2) for females and 0.48 ac (1,961 m^2) for males (Kelly and Price 1992, p. 19). For the San Jacinto Wildlife Area (Riverside County), mean home ranges based on trapping efforts were estimated at 0.06 ac (248 m^2) for females and 0.21 ac (860 m^2) for males based on trapping efforts, and were also slightly higher based on telemetry with 0.08 ac (321 m^2) for females and 0.66 ac (2,665 m^2) for males, with wide ranges reported for this area for all estimates (Kelly and Price 1992; p. 20) (Note: estimates reported here based on minimum convex polygon method).

In addition to the potential for underestimating home range sizes based on live trapping data, surveys for the Stephens' kangaroo rat need to be timed appropriately to account for natural seasonal changes in vegetation and/or year-to-year changes in precipitation. In an early study, Moore-Craig (1984, p. 12) indicated that late winter was the best season for conducting surveys, except for abnormally dry years when there is a reduction in forage from spring annuals and grasses. Detection probabilities for the Stephens' kangaroo rat at Camp Pendleton were found to be much lower in September and October than in November and December (Brehme and Fisher 2009, p. 37; Figure 8). Although researchers have used burrow entrance counts within population of the Stephens' kangaroo rat to estimate population size and demographic structure of the Stephens' kangaroo rat, this method is influenced by both spatial features (at the microsite scale) and demographic factors (age of individuals and density) and should be used cautiously (Brock and Kelt 2004a, pp. 55–56). Researchers evaluating populations of the Stephens' kangaroo rat at Camp Pendleton also concluded that there is an inconsistent relationship between burrow counts and the species' abundance in that area given the variability in proportion of occupied habitat with the frequently co-occurring Dulzura kangaroo rat (*Dipodomys simulans*) and the inability to distinguish between burrows of the two species (Brehme *et al*. 2017, pp. 9, 16). The ongoing study at Camp Pendleton is implementing a multi-tiered, habitat-based, adaptive monitoring program designed to track yearly trends in the total area occupied by the Stephens' kangaroo rat and uses a two-phased approach to sampling (i.e., search for signs of kangaroo rat activity, followed by live-trapping activities) (Brehme *et al*. 2006, p. 1).

The Stephens' kangaroo rat is a proficient colonizer (O'Farrell 1990, p. 81) based on its observed ability to occupy linear features along disturbed roadways, which function as (short-term) seral stage habitat (O'Farrell and Uptain 1989, p. 7). Dirt roads also likely provide corridors for longer distance movements of the Stephens' kangaroo rat and dispersal pathways between territories

(Service 1993, p. 16; Brock and Kelt 2004b, p. 638). Evidence to support this outcome can be found in results of trapping studies conducted from 2007 to 2017 at the Naval Base Coronado Remote Training Site Warner Springs (Warner Springs) (Clark *et al*. 2018, p. 15), where roadways likely facilitated movement to and occupation of additional sites.

An evaluation of maximum distances moved based on live trapping in study sites located in western Riverside County reported a pooled average of 123 ft (37.5 m), with a maximum value for a juvenile male of about 1,152 ft (351 m), as well as three instances of long distance movements across study plots by males (two adults, one juvenile) of over 1,312 ft (400 m) (Price *et al*. 1994a, pp. 933–934). Movements based on telemetered animals reported a pooled average for maximum distance moved of 202 ft (61.5 m) (Price *et al*. 1994a, p. 935).

Localized colonization and extinction dynamics for the species were documented within the Stephens' Kangaroo Rat Monitoring Area at Camp Pendleton (Brehme *et al*. 2017, pp. 33–37). Over time, populations of Stephens' kangaroo rats were found to be more likely to colonize areas that had more open ground and that had experienced recent fire (which is associated with open ground and forb growth), and more likely to become locally extirpated in areas that had "looser" soils (less soil resistance) and abundant nonnative grasses (Brehme *et al*. 2017, p. 33).

Researchers believe that the species' population structure in southern California follows a metapopulation dynamic in which the availability of suitable habitat patches is both spatially and temporally dynamic and is based on the equilibrium between colonization and extinction of local populations as compared to demographic features of individual local populations (Brehme *et al*. 2006, p. 6). However, there has been no formal assessment of the population structure for the Stephens' kangaroo rat such as the minimum habitat patch size required to support a stable population or an estimate of the minimum number of interconnected patches needed to support a potential metapopulation of this species (*cf*. Heinrichs *et al*. 2015; Ord's kangaroo rat). Regardless, some researchers caution that any observed recovery of the Stephens' kangaroo rat from low numbers under suitable conditions should also be viewed in the context of susceptibility to rapid decline in numbers in short time periods of unsuitable conditions, particularly for areas within southern California that continue to experience urban development pressures (Kelt *et al*. 2008, p. 254).

Overall, the population structure for the Stephens' kangaroo rat within its area of Current Potential Extent is patchy in distribution within suitable habitat. Patches consist of spaced burrow entrances connected by a network of well-defined surface runways. The size of a patch and the distance between occupied patches varies depending on topography and soil characteristics as well as changes in broader features such as biotic variables (e.g., vegetation cover, predation) and behavioral factors (e.g., immigration/emigration) (O'Farrell *et al*. 1986, p. 189; Service 1993, pp. 14, 16). Similarly, in their study of Stephens' kangaroo rat populations at Warner Ranch (San Diego County), O'Farrell and Uptain (1987, p. 39) described the distribution of the species as a mosaic of irregularly shaped patches of occurrence with variable size for spaces between patches. Patch size ranged from 0.25 ac (0.1 ha) to over 49.4 ac (20 ha) and contained evenly distributed burrows and trails (O'Farrell and Uptain 1987, p. 39).

4.5 Genetics

As noted in our 2010 12-month finding (75 FR 51207), at that time, two types of studies had formally evaluated the genetic structure of populations of the Stephens' kangaroo rat: McClenaghan and Truesdale 1991 (and subsequent publication by McClenaghan and Truesdale 2002) and Metcalf *et al*. (2001). One approach focused on allozyme (blood proteins) variation in an effort to evaluate potential effects of habitat fragmentation to genetic variation among and within 10 localities from both counties (McClenaghan and Truesdale 2002, p. 540). The results from this investigation found, relative to genetic differences *among populations*, that (1) there was high genetic similarity and that (2) no significant association with geographic distance between populations was observed (McClenaghan and Truesdale 2002, p. 543). With regard to genetic variability *within populations*, the study found that (1) the 10 Stephens' kangaroo rat populations were generally genetically similar (i.e., in Hardy-Weinberg equilibrium where genotype frequencies and allele frequencies of each population is the same in each generation at birth (Smith and Baldwin 2015, p. 577), absent disturbing factors), and that (2) the 10 populations showed low levels of genetic variability, based on proportion of polymorphic loci (where the common allele is present at frequency ≤ 0.99) (McClenaghan and Truesdale 2002, p. 541, Table 2). The authors indicated that the observed heterozygotic deficiencies supported spatial clustering of genotypes at the micro-geographical scale (McClenaghan and Truesdale 2002, p. 545), possibly the result of short dispersal distances of juveniles (natal philopatry) (McClenaghan and Truesdale 2002, p. 546). They concluded that their findings were consistent with their hypothesis that habitat fragmentation has affected the genetic structure of the Stephens' kangaroo rat by limiting interaction between other populations (McClenaghan and Truesdale 1991, p. 13; McClenaghan and Truesdale 2002, p. 546); thus, the genetic uniformity observed among populations might be explained by the relatively recent spatial isolation of populations due to habitat fragmentation, where insufficient time has passed for differentiation, either from selective or stochastic processes (McClenaghan and Truesdale 1991, p. 13).

In the second approach, mitochondrial DNA (mtDNA) was studied in order to evaluate patterns of genetic variation of populations of the Stephens' kangaroo rat across 16 localities (Metcalf *et al*. 2001, entire). In general, mtDNA studies provide information related to phylogenetic relationships based on the geographical distribution and grouping of haplotypes and can help identify historical movement patterns. This study found evidence of high mtDNA diversity (33 haplotypes) with well-supported clades that grouped the Stephens' kangaroo rat populations in southern California into three geographical subdivisions (Metcalf *et al*. 2001, pp. 1236, 1238; Figure 2). This is in contrast to the lack of genetic variation found in the allozyme studies by McClenaghan and Truesdale (1991, 2002). Metcalf *et al*. (2001, p. 1241) note that studies have found kangaroo rats typically have low levels of allozyme variation, which can make it difficult to detect genetic structure.

The regional differentiation observed in Metcalf *et al*. (2001, entire) for the sampled Stephens' kangaroo rat populations included a northern region, which corresponded to northwestern and northeastern Riverside County, a central region that encompasses locations in central-western Riverside County, and a southern region, which includes all locations in north and central San Diego County, including the Camp Pendleton and Det. Fallbrook sample locations (Metcalf *et al*. 2001, p. 1239, Table 2). The regions were found to be genetically different, and the study found differences in their level of genetic variability and diversity within regions (Metcalf *et al*. 2001,

p. 1238). The study results suggested a seven-fold lower effective population size in the southern group (Metcalf *et al*. 2001, pp. 1236, 1239).

The relatively high level of haplotype variation found in the Stephens' kangaroo rat populations sampled in this study and its spatial structuring prompted the authors to evaluate potential explanatory processes, including: (1) whether limited dispersal between habitat patches, each with a fairly large effective size, explained most of the patterns observed in the north and central regions or, alternatively, (2) whether a recent range expansion in the south resulted in the high frequency of the 'CC' haplotype, given the dominance of the 'CC' haplotype in the south and multiple occurrences of this haplotype in other regions (Metcalf *et al*. 2001, p. 1241).

Based on the well-structured grouping of the clades, the authors suggest that, historically, gene flow has been restricted among the three regions, and that the Stephens' kangaroo rat may have been isolated in the central portion of its current range, though their results indicated that the northern region also had a high level of genetic variation and, thus, a fairly robust genetic history (Metcalf *et al*. 2001, p. 1241). The interpretations of the central and northern regions genetic history are in contrast to the patterns of lower genetic diversity and fewer unique haplotypes observed in the southern region (Metcalf *et al*. 2001, p. 1241). In this context, the authors assessed how movement patterns of the Stephens' kangaroo rat comport with their findings of spatial structuring of haplotypes. They concluded that (with the exclusion of the widespread 'CC' haplotype, which was evaluated separately) the observed associations of closely related haplotypes was consistent with restricted movement (Metcalf *et al*. 2001, p. 1242). In addition, they indicated that, because both the range of the Stephens' kangaroo rat and the linear distance among the sampling locations are small and the species is relatively sedentary, geographical and ecological factors are more likely to predict dispersal routes than physical distance; thus, the northern, central, and southern regions defined in the study are based on topographic boundaries (Metcalf *et al*. 2001, p. 1242). The authors concluded that the widespread, but non-random distribution of the 'CC' haplotype, is consistent with a population bottleneck, and is suggestive of a recent population expansion from a small local group, likely the result of a recent range expansion into the disjunct valleys that occur at the southwest and southeast limits of the species current ranges (Metcalf *et al*. 2001, p. 1242).

In further support of the theory of a recent range expansion of the Stephens' kangaroo rat into the valleys in the southern region, the authors note that the genetic spatial structuring is consistent with geographical data. They cite Lackey's (1967a, entire) biosystematic study of the *Heermanni* group of kangaroo rats in which the current distribution of the Stephens' kangaroo rat might be explained by a range expansion from the north into the south region as a result of a warmer and dryer regional climate in the last 6000 years and/or the result of habitat alteration by humans in these southern valleys (Metcalf *et al*. 2001, p. 1242) (see previous discussion in section 3.1, Historical Biogeography). In addition, they cite the hypothesis by Lackey (1967a, pp. 331–332) that this dryer climate prompted changes in vegetation, creating conditions favorable to colonization of the Stephens' kangaroo rat, and this climatic change occurred at the same time as the arrival of Native Americans in coastal southern California (prior to 8000 years ago) and their use of fire, which can also create favorable habitat conditions to the species (Metcalf *et al*. 2001, pp. 1242–1243).

Finally, the authors note that the pattern of dispersal of the Stephens' kangaroo rat (citing Price *et al*. 1994a, pp. 933–934) is characterized by limited dispersal, but with intermittent, rapid long distance dispersal events, and this pattern generally results in a loss of genetic diversity at the leading edge of a range expansion due to the higher level of genetic contribution of the first few colonizing animals (Metcalf *et al*. 2001, p. 1242). Thus, the haplotype clustering and diversity observed in this mtDNA study was found to be consistent with long-term demographic stability that is characterized by limited dispersal and a high effective population size at the local level (Metcalf *et al*. 2001, p. 1233).

Subsequent to our 2010 12-month finding, a range-wide genetic study of Stephens' kangaroo rat populations was completed (Shier and Narvarro (n.d., entire). In an effort to evaluate genetic structures, dispersal patterns, and interpret population histories for the species, this study analyzed: (1) a segment of mtDNA (D-loop control region), and (2) a set of species-specific, nuclear DNA microsatellite loci (Shier 2010, pp. 29–30; Shier 2011, pp. 46–48; Shier and Navarro n.d., p. 3). This study used tissue (ear snip) samples from Stephens' kangaroo rats collected from 2008 to 2015 at 21 sites (Shier and Navarro n.d., pp. 5, 8). Results from the study identified through mtDNA sequencing analysis produced 42 haplotypes, with a greater haplotype diversity at the San Jacinto Wildlife Area (n=10) and Lake Perris (n=9) sites, and lowest in the Ramona Grassland location (n=1) (Shier and Navarro n.d., p. 11; Table 2). The Anza Valley sampling location was found to have the highest number of unique haplotypes (n=4) (Shier and Navarro n.d., p. 11; Table 2). When evaluated using a statistical parsimony network (where the relationships among the different haploid genotypes observed are evaluated through an algorithm and displayed by the percent contribution of haplotype from each population), the study found no clear geographic structure based on location (Shier and Navarro n.d., p. 10; Figure 3). This interpretation is in contrast with the structuring reported in Metcalf *et al*. (2001, entire), as summarized above. For example, Shier and Navarro (n.d., p. 10) found that one frequently observed haplotype (Contig2) was found in 22 percent of the sequences and was widely distributed across 13 sampling sites, but with no geographical pattern, and they note that, although Metcalf *et al*. (2001) used slightly different regions of the mtDNA control region, that study also found that the 'CC' haplotype was frequently observed across the sampling locations. The study also prepared a phylogenetic analysis of the observed haplotypes with two other *Dipodomys* species (using a Bayesian inference consensus tree process) and found low levels of mtDNA divergence and phylogenetic structure to support their conclusion of no clear association between sites sampled and haplotype diversity (Shier and Navarro n.d., p. 13; Figure 4). However, their phylogenetic tree was rooted differently than Metcalf *et al*. (2001, p. 1240; Figure 3), who rooted on two outgroup sequences of *Dipodomys panamintinus*, a closely related species to the Stephens' kangaroo rat (Williams *et al*. 1993, p. 81). This difference, along with differing computational analyses and differences in sample size, may explain the differing results in structuring found between the two studies (Metcalf 2018, pers. comm.). Shier and Navarro (n.d., pp. 10–11) also found that, based on mutational differences presented in the constructed haplotype relationship, all of the observed Stephens' kangaroo rat haplotypes were relatively closely related. These findings suggested to the authors that, historically, the Stephens' kangaroo rat occupied a continuous range that was recently fragmented (Shier and Navarro n.d., p. 23).

The nuclear DNA microsatellite analysis presented in Shier and Navarro (n.d.) provided information regarding genetic diversity and population structure of the Stephens' kangaroo rat across the sampled sites. The results indicated relatively high estimates of genetic diversity (measured by observed heterozygosity) with the highest allelic richness found in central and northern western Riverside County populations and lowest in populations in San Diego County (Shier and Navarro n.d., p. 15; Table 3). With one exception (Det. Fallbrook location), the study found that indications of inbreeding at the sampled sites were low (Shier and Navarro n.d., p. 15; Table 3). The study used two types of clustering analyses to evaluate population structure and found that some sites that were closer to one another fell into clusters; that is, some demarcation was observed between the range-wide populations (Shier and Navarro n.d., pp. 17, 23; Figure 7).

The study evaluated genetic differentiation (variance) (e.g., F_{ST} and F_{IS} estimates[1]) and landscape effects of gene flow (isolation by distance) to examine differences among subpopulations and at the landscape level. They found that the Camp Pendleton, Rancho Guejito, and Ramona Grassland sites had the highest level of genetic differentiation with each other and to the other populations, but only slight trends were found when comparing northern and southern sites to and between one another (Shier and Navarro p. 20; Table 3). Thus, some genetic differentiation was reported, particularly with populations in the southern portion of their range (Shier and Navarro n.d., p. 23). Inbreeding coefficients for the sampled sites (F_{IS}) were relatively low[2] (less than 0.06), with the exception of the Fallbrook subpopulation (F_{IS} = 0.169) (Shier and Navarro n.d., p. 16). Their isolation by distance analysis found a slight positive association between geographic distance and genetic distance (Shier and Navarro n.d., p. 22; Figure 8). However, this type of analysis may not be appropriate since genetic structure for "patchy" metapopulations can be dependent on patch size (area) and isolation (patch connectivity) (Cosentino *et al*. 2012, p. 1579) as well as by the rate of patch occupancy (colonization); genetic divergence is therefore influenced by established subpopulation numbers and genetic representation (e.g., founder effects from recent colonization events) (Cosentino *et al*. 2012, p. 1579). In addition, given the low coefficient of determination estimate reported (R^2 = 0.186), other landscape or ecological factors (e.g., topographic features that act as barriers including development), as suggested by Metcalf *et al*. (2001), may be important in evaluating this geographic distance and genetic distance relationship. The authors concluded that they found no evidence of evolutionary divergence events for the Stephens' kangaroo rat and infer that the effects of habitat fragmentation and population isolation of the species has resulted in a metapopulation (group of subpopulations) type structure across its current range (Shier and Navarro n.d., p. 23).

4.6 Mortality/Predation

Kangaroo rats are known to be a food source for other species. In general, the main predators of kangaroo rats are primarily other nocturnal animals, especially coyote (*Canis latrans*) and barn owls (*Tyto alba*) (Pequegnat 1951, p. 53). Predators or potential predators observed in habitat occupied by the Stephens' kangaroo rat in southwestern Riverside County and populations in

[1] F_{ST} is the proportion of total genetic variance contained in a subpopulation relative to the total genetic variance of population; F_{IS} (inbreeding coefficient) is the proportion of genetic variance of an individual with respect to the local subpopulation.

[2] A 0.06 value, or a rate of 6%, indicates an increase in homozygosity of 6% per generation. However, interpreting how this rate will affect the future health of subpopulations is problematic since not all genes have equal effect and not all alleles within a gene have equal effect (Oldenbroek and van der Waaij, 2015, p. 116) and this parameter may not account for migration/dispersal events. [see also Gaggiotti and Hanski (2004, pp. 350–353) for discussion and citations related to inbreeding depression]

parts of San Diego County include barn owls, great horned owls (*Bubo virginianus*), coyotes, bobcat (*Lynx rufus*) San Diego gopher snake (*Pituophis catenifer annectens*) and several species of rattlesnake (*Crotalus* sp.) (Service 1993, p. 37; Kelt *et al*. 2005a, p. 271; Shier 2010, p. 14; Shier 2011, p. 60; Shier and Swartz 2012, p. 46). Notably, Moore-Craig (1984, p. 6) found (at the time of her study) that most Stephens' kangaroo rat sites occurred in the vicinity of thriving burrowing owl (*Athena cunicularia*) colonies, a nighttime or daytime active owl species that primarily feeds on insects, but often uses other burrows dug by other animals, including kangaroo rats (Poulin *et al*. 2011). Other reports of mortalities for the Stephens' kangaroo rat include a house cat and road kill (1 each) (Price and Kelly 1994, p. 815).

In reviewing comments provided in live trapping monitoring reports for the Western Riverside County Multiple Species Habitat Conservation Plan (Western Riverside County MSHCP) (2005–2016) (Western Riverside County MSHCP Biological Monitoring Program 2017), we noted that trappers reported several instances of wounds or injuries to captured animals (particularly loss or severe damage to a front limb), which may represent the effects of territorial behavior and/or predators.

4.7 Summary

Kangaroo rats are nocturnal and generally found in arid and semi-arid environments, but are active year-round. Kangaroo rats, including the Stephens' kangaroo rat, construct burrow systems, which provides shelter from the environment (e.g., temperature extremes), protection from predators, food storage (seed caching), and a place for nesting (Meadows 1991, p. 1). Their main predators are primarily other nocturnal animals, especially coyotes (*Canis latrans*) and barn owls (*Tyto alba*) (Pequegnat 1951, p. 53). Other potential predators for Stephens' kangaroo rat include the great horned owl (*Bubo virginianus*), bobcat (*Lynx rufus*), San Diego gopher snake (*Pituophis catenifer annectens*), and several species of rattlesnake (*Crotalus* sp.).

The conceptual model prepared for Camp Pendleton shows the distribution and density of populations of the Stephens' kangaroo rat can vary temporally and spatially (Brehme *et al*. 2006, p. 6). Researchers also believe that these temporal and special dynamics create a species' population structure in southern California that follows a metapopulation, although no formal assessment of the population structure has been completed (Brehme *et al*. 2006, p. 6). Regardless, some researchers caution rapid decline in population numbers during unsuitable conditions, especially near areas with high urban development pressure (Kelt *et al*. 2008, p. 254). The genetic structure across the population is starting to be impacted by loss of connectivity due to fragmentation. Shier and Navarro (n.d. p. 24) found that loss of connectivity due to urbanization may be driving the current genetic structuring we are observing between populations, while historically there was no genetic structure across the population. If these fragmentation trends continue, isolated populations may be at risk of extirpation.

5.0 Species Biological Status

5.1 Introduction

In our 1988 final listing rule, we cited habitat mapping results from Price and Endo (1988; subsequently published in 1989) and "cursory observations" that habitat loss worsened since 1984 to support our assessment of extensive and continuing loss of Stephen's kangaroo rat habitat in southern California (53 FR 38467). A subsequent population assessment of the species was prepared by O'Farrell and Uptain (1989, entire), who, in 1988, surveyed the known range at that time (excluding military installations (Det. Fallbrook, Camp Pendleton) and a few inaccessible private lands). They reported that, of the previously known populations, 58.5 percent were extirpated due to agricultural or urban development (O'Farrell and Uptain 1989, p. 5; Appendix I). They also reported 47 new populations (with 6 of those subsequently extirpated) and 8 potential populations, for a total of 132 populations (O'Farrell and Uptain 1989, p. 5). Most extant populations were reported as occupying small, isolated pockets or within thin, linear areas at the base of hillsides (O'Farrell and Uptain 1989, p. 5). As noted by O'Farrell and Uptain (1989, pp. 5–6), the observed changes in size and location of the patchily distributed Stephens' kangaroo rat populations was also likely the result of natural disturbance and changes in vegetative communities as well as detections in areas that were overlooked in prior field studies. Maps of occupied habitat of the Stephens' kangaroo rat in Riverside/San Bernardino Counties based on O'Farrell and Uptain (1989) and subsequent detections were presented in a literature review prepared by RECON (1992, pp. 15–16; Figures 3 and 4), and illustrated the species' patchy distribution.

Population trends and density estimates for the Stephens' kangaroo rat are not determinable at this time given the limited surveys conducted since the species was first described and incomplete surveys of all potentially occupied areas. Studies have found that the abundance of the Stephens' kangaroo rat and its probability of capture are highly variable, making it difficult to detect demographic trends (Brehme *et al*. 2017, p. 8). In addition, field investigation reports present incomparable results, with some reporting density estimates and others reporting potential occupancy, or both. As noted in the genetics section above, results from a recent, rangewide genetic analyses (Shier and Navarro n.d., p. 23) suggested that the distribution of the Stephens' kangaroo rat across its range exists as a "metapopulation-like" population structure due to habitat fragmentation and isolation of populations. This study also indicated that reestablishing corridors through fragmented habitat (e.g., wildlife culverts) may improve dispersal and gene flow between isolated populations while also emphasizing the need for additional information related to habitat selection and movement patterns in order to identify, at the landscape scale, those corridors important for improving connectivity (Shier and Navarro n.d., p. 24).

Based on our analysis of recent detections and observations, the Stephens' kangaroo rat continues to be found in a patchy distribution in suitable (e.g., grasslands, open areas with forbs) habitat in western-southwestern Riverside County (Figure 5) and San Diego County (Figure 6), with a few areas containing high densities of animals. We present in Table 1 a summary of detections for the Stephens' kangaroo rat and geographical areas from the sources described above and these detections are illustrated above in Figure 1. However, delineating a population by location is somewhat subjective (e.g., O'Farrell and Uptain (1989, p. 5) listed 132 "populations" as either extant, extirpated, potential, or new). In addition, the locations described in Table 1 represent areas where researchers have focused their trapping efforts and may not include potentially occupied areas located on private lands due to lack of access. Below we discuss Stephens' kangaroo rate occurrences in Riverside and San Diego Counties.

5.2 Riverside County

As noted above, the Stephens' kangaroo rat was first described from a specimen collected near Winchester, Riverside County, California (Merriam 1907, p. 78). As described in our 2010 12-month finding (75 FR 51212–51214), following the listing of the species in 1988, two large-scale habitat conservation planning efforts were completed—the Western Riverside County SKR HCP (Riverside County Habitat Conservation Agency (RCHCA) 1996) and the Western Riverside County MSHCP (Dudek and Associates 2003). The implementation of these conservation plans has helped to offset potential losses of habitat from urban and agricultural development. In addition, the Southwestern Riverside County Multi-species Reserve was created as part as an environmental mitigation measure for the Diamond Valley Lake project by the Metropolitan Water District of Southern California and surrounds both Lake Skinner and Diamond Valley Lake between Hemet and Temecula.

In sum, the SKR HCP in western Riverside County originally established seven "core reserves" (RCHCA 1996, pp. 110–113), with an eighth core reserve added later (see map in Appendix B) to assist in development of system of areas where the Stephens' kangaroo rat is expected to persist. The SKR HCP is discussed in more detail in section 7.2.4. The requirements of the SKR HCP include maintaining a minimum of 15,000 ac (6,070 ha) of occupied Stephens' kangaroo rat habitat within these core reserves that are managed and monitored for the species. Lake Mathews/Estelle Mountain, San Jacinto/Lake Perris, Southwest Riverside County Multi-Species Reserve (originally named Lake Skinner/Domenigoni Valley), and Potrero represent the largest of these core reserves. Management and monitoring of the Stephens' kangaroo rat within the core reserves is under the jurisdiction of the RCHCA, a Joint Powers Agency comprised of the cities of Corona, Hemet, Lake Elsinore, Moreno Valley, Murrieta, Perris, Riverside, Temecula, and the County of Riverside. RCHCA was formed in 1990 for the purpose of developing a HCP, acquiring land, and managing habitat for the Stephens' kangaroo rat (RCHCA 2007, p. 1).

SKR HCP covers approximately 533,954 ac (216,084 ha) and is inside the Plan Area boundary of the Western Riverside County MSHCP, which is described in more detail in section 7.2.4. Through cooperative management of conserved lands within the HCP core reserves, the Western Riverside County MSHCP established a conservation target of 19,458 ac (7,875 ha) of occupied Stephens' kangaroo rat habitat when the plan is fully implemented. As described in our 2010 12-month finding (75 FR 51214), based on provisions of the Western Riverside County MSHCP, we expect that additional lands (Additional Reserve Lands) established under the plan will continue to add to the conservation achieved by the SKR HCP Core Reserves by conserving additional areas occupied by the Stephens' kangaroo rat (e.g., Anza reserve). The Western Riverside County MSHCP, through the Biological Monitoring Program of the Western Riverside County Regional Conservation Authority (RCA) provides for monitoring of 146 species and associated habitats to assess the conservation goals established by the MSHCP. This include monitoring and management on the Additional Reserve Lands.

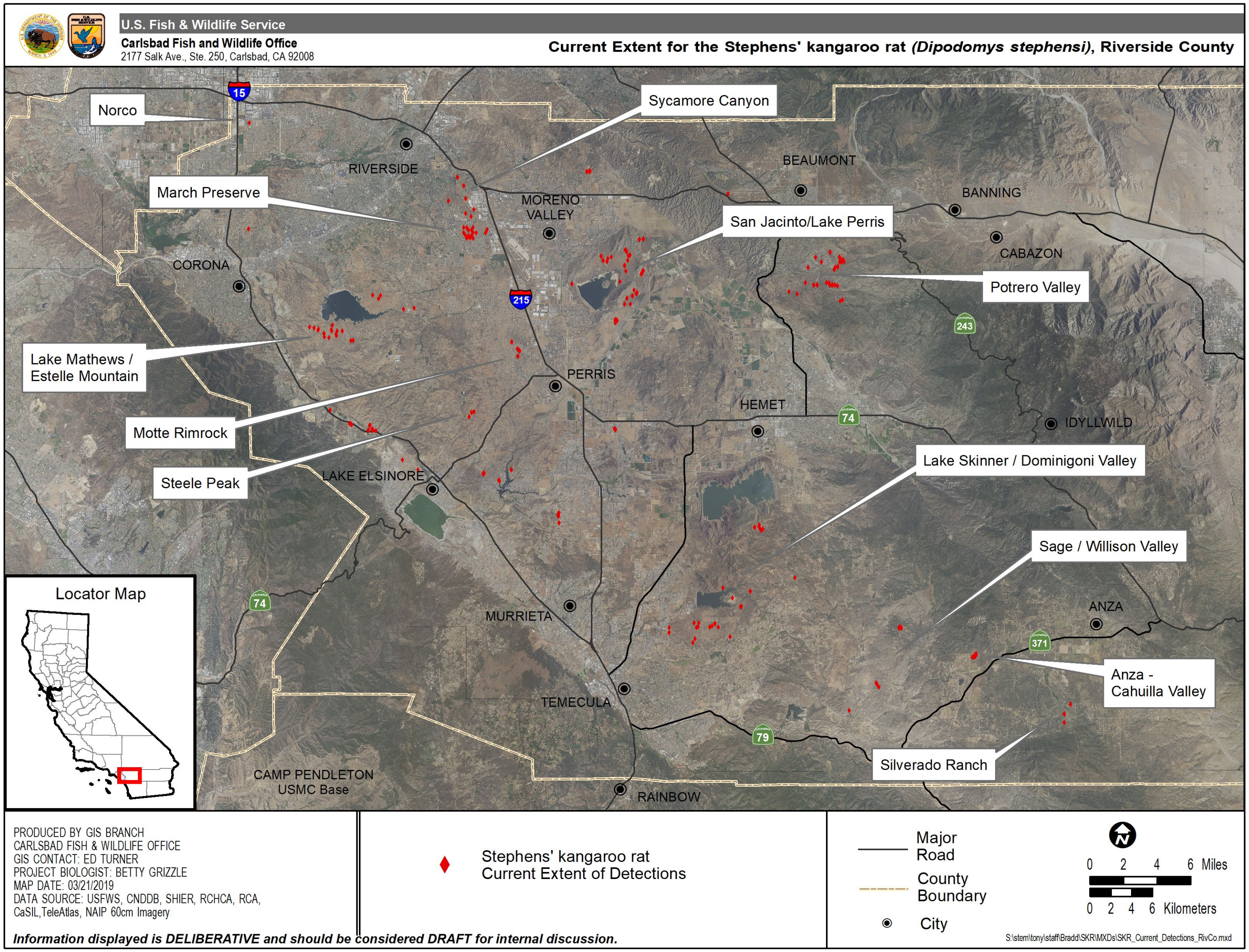

Figure 5. Detections of the Stephens' kangaroo rat, Riverside County, California between 2010-2017. Sources: CFWO GIS database; CNDDB; RCA; RCHCA; Shier and Navarro.

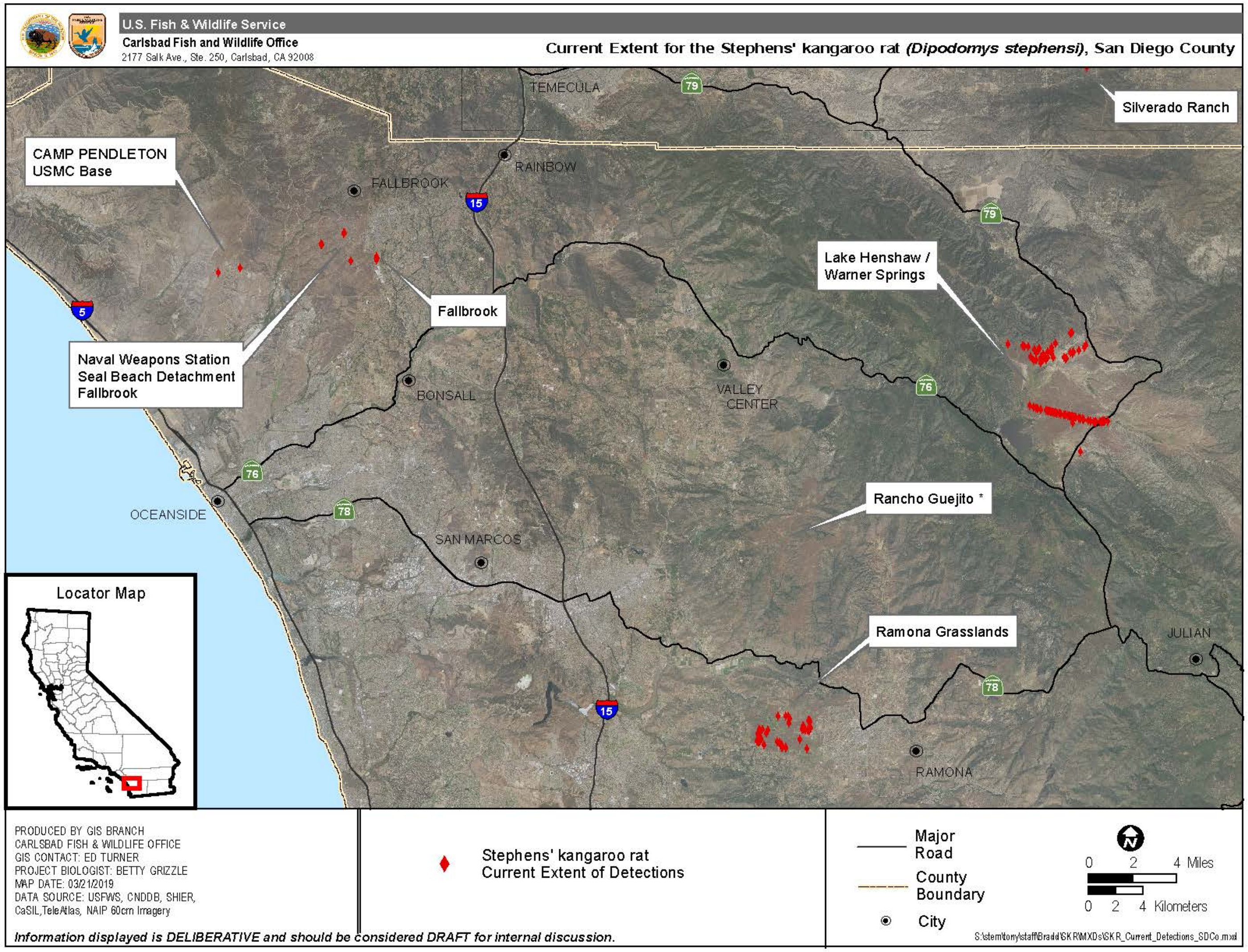

Figure 6. Detections of the Stephens' kangaroo rat, San Diego County, California between 2010-2017. Sources: CFWO GIS database; CNDDB; Shier and Navarro.
* Stephens' kangaroo rat was last reported in Rancho Guejito in 2005, but is presumed to be extant.

In 2006, the RCHCA began collecting data to understand both patterns of population change through time and the biological processes driving those changes in Stephens' kangaroo rat populations at the Estelle Mountain and Steele Peak Reserves. The Biological Monitoring Program participated in the study by collecting data at four other reserves within the Conservation Area following the same seasonal timing and trapping protocols as the RCHCA.

The Biological Monitoring Program conducted surveys for the Stephens' kangaroo rat from 2006 to 2008, with trapping in 2006 conducted in conjunction with the RCHCA to better refine the trapping protocol for estimating population size as well as to determine the relationship between population size and burrow density (Biological Monitoring Program 2015, p. 1). Surveys were conducted by the Biological Monitoring Program's in 2006 (August to December) at grids located in the Estelle Mountain and Steele Peak Reserves along with Lake Perris, Lake Skinner, Potrero, and Silverado Ranch locations (Biological Monitoring Program 2007, entire). Individuals were captured at 9 of 10 grids at Lake Skinner, 7 of 10 grids at Silverado, 10 of 10 grids at Lake Perris, and 10 of 10 grids at Potrero (Biological Monitoring Program 2007, p. 5).

Based on these efforts, the monitoring staff found that a majority of animals were captured on the third night of a 3-night trapping effort; thus, in 2007, program staff increased the number of nights for each grid survey from 3 to 5 nights to increase sample sizes, ultimately concluding that a 4-night trapping effort at each trapping grid was most efficient (Biological Monitoring Program 2015, p. 1). However, surveys for the Stephens' kangaroo rat within the Western Riverside County Conservation Area are conducted based on an annual workplan and not every potentially occupied area is surveyed each year as grids are selected randomly from areas to be sampled. Survey results from 2007 detected Stephens' kangaroo rat (n=2,281) on 87 grids, distributed across four Core Areas–Lake Perris (Davis Unit of the San Jacinto Wildlife Area), Southwestern Riverside County Multi-Species Reserve, Silverado Ranch, and Potrero Unit of the San Jacinto Wildlife Area (Biological Monitoring Program 2008, p. 7; Table 3).

In 2008, the Biological Monitoring Program surveyed both the Anza-Cahuilla Valley and Potrero Valley for the Stephens' kangaroo rat in an effort to better estimate suitable habitat and population density in these two regions (Biological Monitoring Program 2009, pp. 2–3). In the Anza-Cahuilla Valley region, 33 individuals were captured (8 at Silverado and 25 at Wilson Valley grids) with captures at 25 percent of grids (Biological Monitoring Program 2009, p. 13). At the Potrero Valley area, 262 individuals were captured on 75 percent of grids (Biological Monitoring Program 2009, p. 13). The total area of occupied moderate- to high-quality habitat across the two areas surveyed was estimated at 2,045 ac (828 ha) (Biological Monitoring Program 2009, p. 13).

For the 2014 field season, sampled areas included the Potrero Valley and on conserved lands in the Anza-Cahuilla Valley, which included the Wilson Valley Preserve and two small parcels under the jurisdiction of the Bureau of Land Management (BLM) just south of Wilson Valley Preserve (Biological Monitoring Program 2015, p. 2). At the Potrero Valley location, Stephens' kangaroo rat were captured on 13 of 98 grids (13 percent), but no captures were reported for the Wilson Valley Preserve area (Biological Monitoring Program 2015, p. 4). Compared to previous surveys at these locations (Biological Monitoring Program 2009, entire), the percentage of occupied grids at the Potrero location was greatly reduced in 2014 when compared to 2008 (13 percent, down from 75 percent) and the total number of unique animals per grid was also much lower (0.08 percent in 2014, compared to 80 percent in 2008) (Biological Monitoring Program 2015, p. 7). Similarly, for the Anza-Cahuilla Valley trapping effort, three occupied grids were found in 2008, but no animals were captured in 2014 (Biological Monitoring Program 2015, p. 7). The observed reduction in occupancy was likely due to a decline in habitat quality (e.g., increase vegetation cover in Potrero Valley) (Biological Monitoring Program 2015, pp. 7–8).

As noted above, the RCHCA conducts annual surveys at the core reserves established as part of the HCP developed for the Stephens' kangaroo rat (RCHCA 1996). The surveys provide important baseline information regarding the status of the Stephens' kangaroo rat to assist managers in evaluating the effectiveness of management actions and other habitat restoration planning efforts (RCHCA 1996, pp. 160–161). Other surveys conducted and reported below include presence/absence trapping studies. Figure 5 maps Stephens' kangaroo rat trapping locations in Riverside County since 2010.

The following summaries were taken from survey/monitoring reports, post-2010:

- Motte Rimrock Reserve, 2017: For March/April 2014, 37 unique captures at 3 grids (Messin 2018, pp. 6–7). For September 2017, 91 unique captures at 4 grids (Messin 2018, pp. 9–11).
- Potrero Reserve (BLM lands only), 2011: 59 unique individuals on 4 of 4 grids (RCHCA 2012, p. 7).
- Steele Peak Reserve, 2010: 18 unique individuals trapped at 3 of 5 grids (RCHCA 2011, p. 8).
- Lake Mathews Reserve, 2010: 3 unique individuals trapped on 2 of 10 grids (RCHCA 2011, pp. 8–9).
- Sycamore Canyon Wilderness Park, 2010: 22 captures on 6 of 8 grids; occupied habitat estimated at 314.88 acres (127.4 ha) (Richard and Young 2013, pp. 4–5).

Results from other areas surveyed:

- March Stephens' Kangaroo Rat Preserve, 2011: 154 individuals trapped; all surveyed grids occupied with an average of 8 animals per grid (Center for Natural Lands Management (CNLM) 2012, p. 3).
- March ARB in Riverside County has roughly 167 ac (68 ha) of modeled habitat, although Stephens' kangaroo rat is believed to be extirpated from the base (USAF 2012, p. 3-32).
- Norco (project site survey), 2013: 6 unique captures on 1 of 7 trap sites (SJM Biological Consultants 2013, p. 4).
- Johnson Ranch Preserve, 2015: 6 unique captures on 4 of 8 grids (CNLM 2016).
- South of Lake Perris (project site survey), 2015: 12 individuals trapped (uniqueness not specified) on 3 of 4 trapping grids (Vergne 2015, p. 9).

At the Southwestern Riverside County Multi-species Reserve, translocation efforts of the Stephens' kangaroo rat were initiated in 2008 (Shier 2009, entire). In 2010, monitoring at the 2008 and 2009 release sites indicated a continued increase in these populations (Shier and Swartz 2012, p. 5). Researchers also found evidence for genetic mixing of animals at release sites in this study area as well as an unknown genetic source, suggesting that animals migrated to release sites, and parentage analyses found that animals from different source sites were interbreeding (Shier and Swartz 2012, p. 5). Subsequent post-release monitoring results of Stephens' kangaroo rat populations at 2008, 2009, and 2010 release sites found that, 1 year after releasing an additional 152 animals in 2010, 234 animals were captured in the study area, with restoration (burn and graze/mowing treatments) subplots preferred by both translocated and new animals (Shier and Swartz 2012, pp. 15–16). In particular, after releases were conducted in 2008 and 2009 at a single 20-ac (8.1-ha) release site (Schoolhouse Plateau), researchers determined that, based on trapping results and burrow observations, translocations continued to be highly successful 2–3 years later (Shier and Swartz 2012, p. 11).

5.3 San Diego County

Currently, there are six general locations in San Diego County where the Stephens' kangaroo rat is known to occur (see Table 1 above). The status for each of these are summarized below.

5.3.1 Lake Henshaw/Warner Springs

The Stephens' kangaroo rat population found in the Lake Henshaw area is considered to be one of the larger known populations of the species and is the largest known population in San Diego County (Chambers Group, Inc. and SJM Biological Consultants, Inc. 2012, p. 8). As noted below, some occupied lands within this population are managed as part of the Cleveland National Forest.

Naval Base Coronado, Remote Training Site Warner Springs

Warner Springs encompasses 12,544 ac (5,076 ha) and is located on portions of the Cleveland National Forest, Vista Irrigation District lands, and BLM lands in north inland, unincorporated San Diego County, about 8 mi (13 km) from the community of Warner Springs; the site has a complex overlay of land ownership and land use and resource agreements (U.S. Navy 2013, pp. 2-32, 2-36; see figure 1 in Clark *et al*. 2018, p. 5). The Warner Springs site primarily supports Survival, Evasion, Resistance and Escape (SERE) training, and support training activities for Naval Special Warfare personnel (U.S. Navy 2013, p. 2-33). Habitat within Warner Springs consists of chaparral, scrub, oak woodland, riparian and grassland communities with chaparral being the most dominant (Clark *et al*. 2018, p. 4). Grasslands cover approximately 1,593 ac (645 ha) or about 13 percent of Warner Springs, and are largely dominated by cheatgrass and other *Bromus* species, wild oats, and a large mix of native and nonnative forbs, though some areas within these grassland communities support high densities of native bunch grass species (i.e., *Nassella* spp. and *Muhlenbergia* spp.) (U.S. Navy 2013, p. 9-14).

Current management of the Stephens' kangaroo rat includes requirements described in agreements with the Forest Service and BLM, and the Service's 2009 Biological Opinion that addressed the proposed expansion and realignment of the Warner Springs (Service 2009, entire; see discussion below, section 7.0 Regulatory Mechanisms and Management/Conservation Measures). Most of the suitable habitat and detections for the Stephens' kangaroo rat at Warner Springs occur on lands owned by the Vista Irrigation District (Arnold 2018, pers. comm.; Clark *et al*. 2018, p. 17), part of which is leased to the Navy for training as either exclusive use (public access restricted at all times) or non-exclusive use (public access allowed) (U.S. Navy 2013, p.

2-32). The mission of the Vista Irrigation District "is to responsibly manage resources to meet the present and future water needs of the District's service area by providing a reliable supply of high quality water" (Vista Irrigation District 2018, p. 8). The Vista Irrigation District purchased Lake Henshaw (which was the agency's original source of water) along with the 43,000-ac (17,402-ha) Warner Ranch in 1946 (Vista Irrigation District 2018, p. 10). Related to access to USFS lands and the Warner Springs, one recent concern for the species at this location is a public shooting area (located on USFS lands), which was recently closed to the public due to safety concerns and the risk of wildland fire; however, a long-term solution for safe use and access by the U.S. Navy, and thus implementation of management actions that may benefit the Stephens' kangaroo rat, has not yet been resolved (Arnold 2018, pers. comm.).

Focused surveys at Warner Springs for the Stephens' kangaroo rat were first conducted in 2006 as part of a 2-year Biological Resources Survey (U.S. Navy 2013, p. D-40; see Montgomery 2006). Beginning in the fall of 2010 and summer of 2011, the U.S. Geological Survey (USGS) has been conducting a triennial monitoring program for the Stephens' kangaroo rat at Warner Springs, which is designed to track yearly trends in the total area occupied by the species at this site using live-traps over a large number of sample plots (Brehme *et al*. 2012, p. 1; Clark *et al*. 2018, pp. 1, 6). The most recent USGS report (Clark *et al.* 2018, entire) presents the results from the third year of the triennial monitoring program, and summaries of survey results from 2011 and 2014. Of the 40 plots surveyed in 2017, all contained potential kangaroo rat signs (potential burrows, tracks, and/or scat) for the initial survey, with 293 Stephens' kangaroo rats captured in 26 plots and 53 Dulzura kangaroo rats captured in 15 of the plots (Clark *et al*. 2017, p. 15; Figure 4). These results indicate a significant increase in captures of Stephens' kangaroo rat and occupancy in more plots than previous monitoring surveys (Clark *et al*. 2018, p. 15). A similar increase for the Stephens' kangaroo rat was reported for surveys conducted in 2014 as compared to 2010/2011 monitoring surveys (Brehme *et al*. 2015, p. 15). In addition, the 2018 survey report indicated that the amount of habitat occupied by the Stephens' kangaroo rat increased within the total Warner Springs monitoring area in 2017 as compared to 2014 and 2010/2011 (Clark *et al*. 2018, p. 18; Figure 5). Density estimates of the species within occupied plots were also higher in 2017 than those in 2014 and 2010/2011 (Clark *et al*. 2018, p. 18).

Additional but limited sampling for proposed projects in the Lake Henshaw area was conducted in 2009 and 2010 along a utility (tie line) corridor to the east of Lake Henshaw, south of State Highway 79 (SJM Biological Consultants 2009, entire; SJM Biological Consultants 2011, entire). The species was located at two different pole locations along this corridor in 2009 (SJM Biological Consultants 2009, p. 1) and one location in 2010 near one of the 2009 sites (SJM Biological Consultants 2011, p. 3). As part of their range-wide genetics study, Shier and Navarro (n.d. pp. 30–31) also sampled for the Stephens' kangaroo rat in the Lake Henshaw/Warner Springs area in January 2013 and June 2014, and recorded 20 unique individuals.

Cleveland National Forest

The Stephens' kangaroo rat is known to occur on the Cleveland National Forest along the northern edge of the Warner Springs/Lake Henshaw area, near Puerta la Cruz Conservation Camp, with an estimated occupancy of 37 ac (15 ha) (USFS 2005a, p. 184). This occurrence is part of a large population that occurs in Lake Henshaw Valley (USFS 2005a, p. 184). The USFS identified potential habitat for the Stephen's kangaroo rat in grassland habitat within Pamo Valley, on lands owned by the City of San Diego that are adjacent to the Cleveland National Forest (USFS 2005a, p. 184). In addition, two known populations of Stephens' kangaroo rat (Santa Maria and Guejito Valleys) are within 3 to 4 mi (4.8 to 6.4 km) of Pamo Valley (USFS 2005a, p. 184). However, within the Pamo Valley itself, previous surveys indicated that soil types may not be suitable, and surveys conducted in 1983 did not record the species' presence (USFS 2005a, p. 184). The USFS has estimated approximately 200 ac (81 ha) of potentially suitable Stephens' kangaroo rat habitat within the San Diego mountain ranges of the Cleveland National Forest (USFS 2005a, p. 185).

A limited survey conducted within areas of the Cleveland National Forest in the Lake Henshaw area confirmed the presence of the Stephens' kangaroo rat in 2010 (Chambers Group, Inc. and SJM Biological Consultants, Inc. 2012, entire). The grassland habitat in this area is generally maintained (through cattle grazing) in a condition that supports suitable habitat for the species (Chambers Group, Inc. and SJM Biological Consultants, Inc. 2012, p. 8). The results of this survey extended the previously defined occupied area, based on the information provided by the Forest Service, to the west and north (Chambers Group, Inc. and SJM Biological Consultants, Inc. 2012, p. 8).

In 2017, trapping surveys were conducted along a San Diego Gas and Electric power line corridor within the Cleveland National Forest in eastern San Diego County (SJM Biological Consultants, Inc. 2017, entire). Results from these surveys confirmed the presence of Stephens' kangaroo rat as a resident species within the proposed Warner Springs Substation Staging Area as well as at each of 10 sample trap sites along power line poles in the eastern portion of the project area (SJM Biological Consultants 20147, p. 2). The surveys reported five unique Stephens' kangaroo rats captured during two nights of trapping at the substation site, and, from this trapping, the investigators estimated that at least 5, but likely not more than 10 to 12 individuals of this species inhabit the proposed Warner Springs Substation staging area (SJM Biological Consultants 2017, p. 2). At 10 power line poles located at the eastern end of the project area, 6 consecutive nights of trapping reported a total of 63 captures, with an average of 6.3 unique animals captured per pole (SJM Biological Consultants 2017, p. 2). The investigators concluded that, based on this 10-pole trapping effort and the presence of open grassland habitat to the west, the species is very likely to be a resident throughout most of the length the 4.5 mi (km) segment of this surveyed transmission line (TL 682) (SJM Biological Consultants 2017, p. 2).

5.3.2 Marine Corps Base Camp Pendleton Stephens' Kangaroo Rat Monitoring Program

After the listing of the Stephens' kangaroo rat under the Act in 1988, survey efforts were initiated in 1990 for the species at Camp Pendleton and a monitoring program was implemented from 1996 to 2002 using burrow counting and live trapping (Brehme *et al*. 2006, p. 10, and references cited therein). In 2004, the USGS was contracted to develop a science-based monitoring program for the Stephens' kangaroo rat to track trends in occupancy on the base and USGS scientists, in consultation with a scientific peer review panel and Camp Pendleton (Brehme *et al*. 2006, entire), developed a monitoring protocol. Implementation of the monitoring program began in 2005. The monitoring protocol was revised in 2011 after reviewing 5 years of monitoring efforts (Brehme *et al*. 2011a, entire). At that time, annual sample plots were established within a focused "Monitoring Area" and a "Discovery Area" at Camp Pendleton in order to optimize sampling efforts to better detect changes over time (greater study power) and provide for the best coverage within known occupied habitat while also allowing for the discovery of unknown populations (Brehme *et al*. 2011a, pp. 41–42, 51–52). The most recent monitoring report was prepared in 2017 and presented trends in occupancy and population densities over a 10-year sampling period (Brehme *et al*. 2017, entire).

The long-term results for the multi-year Stephens' kangaroo rat monitoring program described above at Camp Pendleton indicate the following: (1) the amount of habitat occupied by the Stephens' kangaroo rat has steadily increased from 148.26 ac (60 ha) in 2005, to 479.38 ac (194 ha) in 2012, and continued to remain relatively high (at 415–516.45 ac) (68–209 ha)) from 2011/2012 through 2015/2016; and (2) population densities of the species within occupied areas, estimated at 25 individuals per hectare, are comparable to 2013 and 2014, which is high relative to historical values of 5 to 30 individuals per hectare (Brehme *et al*. 2017, p. 1; Figure 8). The authors therefore concluded in their 2017 report that the Stephens' kangaroo rat populations that occupy Camp Pendleton are currently healthy. However, they also note that, although the total occupied area has remained relatively constant, the pattern of occupancy is not a static system as animals seem to move frequently among the habitat patches within the boundaries of their population as habitat conditions change (e.g., frequency of fire and extent of open areas/annual grasses) (Brehme *et al*. 2017, p. 2).

On Camp Pendleton, a 34-ac (13.76-ha) Stephens' kangaroo rat (or SKR) Management Area was established in 1992 through several Service Biological Opinions that addressed compensation for the incidental take of the Stephens' kangaroo rat habitat associated with development activities at the installation (Tetra Tech, Inc. 2015, p. 1). The permeable fenced management area is located in the north-central portion of the Juliett Training Area adjacent to the boundary of Camp Pendleton and the Det. Fallbrook, where the Stephens' kangaroo rat also occurs (see discussion below). Several habitat enhancement actions have been implemented at the management area from 2008 to 2015 (e.g., prescribed burns, mechanical and chemical vegetation management, and artificial burrow installations) (Tetra Tech, Inc. 2016, p. 2). Intensive monitoring of population responses has been conducted during this period, with trapping events occurring in January, May, and December 2010 and July 2011. These trapping efforts primarily captured Delzura kangaroo rat (varying in number from four to 146) with only three Stephens' kangaroo rats captured during the January 2010 trapping event (Tetra Tech, Inc. 2016, p. 2). However, as noted above, following habitat management actions at the Juliett SKR Management Area, 21 Stephens' kangaroo rat individuals were translocated to the area in 2011, contained within a fenced enclosure, and continued to be detected as recently as the fall and winter of 2015–2016 (Brehme *et al*. 2017, pp. 18, 22). Additionally, as of September 2014, biologists (SJM Biological Consultants) had tagged 213 individual Stephens' kangaroo rats that originated from the founder (translocated) population at Juliett Training Area, and the enclosure fence was made permeable in September 2014 to facilitate movement of Stephens' kangaroo rat (Brehme *et al*. 2017, p. 43). Subsequently, the presence of Stephens' kangaroo rats was documented in the Fall 2015-Winter 2016 in four plots located outside the fence perimeter (Brehme *et al*. 2017, p. 43).

5.3.3 Fallbrook

Naval Weapons Station Seal Beach Detachment Fallbrook

Det. Fallbrook is an 8,852-ac (3,582-ha) Navy installation located remotely from (detachment of) its parent command at NAVWPNSTA Seal Beach, which lies about 80 miles north on the coast of southern California (U.S. Navy 2016, p. 1-1). Det. Fallbrook is the primary West Coast supply point for amphibious warfare ships and acts together with Naval Weapons Station (NAVWPNSTA) Seal Beach as the major Navy ordnance storage, maintenance, production, and distribution facilities for the western United States (U.S. Navy 2016, p. 2-1). Det. Fallbrook is located adjacent to the unincorporated village of Fallbrook and is bordered on the north, west, and much of the south by Camp Pendleton (U.S. Navy 2016, p. 2-1).

The property now encompassed by Det. Fallbrook has a long history of livestock grazing dating back at least to the early 1800s (U.S. Navy 2016, p. 2-2). With the changes to the region during World War II, in 1942, the land at the Fallbrook site was formally acquired the Federal Government and the ammunition depot (Naval Ammunition Depot Fallbrook) was commissioned in 1942 (U.S. Navy 2016, p. 2-5). Approximately 330 ac (134 ha) or about 4 percent of Det. Fallbrook consists of developed areas, such as facilities, buildings, roads, and landscaping, used for mission support land use (U.S. Navy 2016, p. 2-8). Cattle grazing is currently permitted within four pastures, which encompass the majority of the installation facility (U.S. Navy 2016, p. 2-20; Map 2-3). The goal of the grazing program is to allow cattle to annually graze down the grasses to control fuel loads and create natural fuel breaks to reduce wildfire risks on the installation. The length of the grazing season, number of cattle, and the pasture rotation order and schedule can vary depending on a number of factors (e.g., range conditions, natural resource management objectives, land use requirements) (U.S. Navy 2016, p. 2-20). Within priority management areas for the endangered Stephens' kangaroo rat, optimal range utilization leaves a greater relative forb cover and approximately 20 percent bare ground (U.S. Navy 2016, p. 4-37).

The population of Stephens' kangaroo rat at Detachment Fallbrook has varied since first documented at this installation in the 1970s (U.S. Navy 2016, p. 3-78). The 2016 Integrated Natural Resources Management Plan (INRMP) for Detachment Fallbrook summarized the status of the Stephens' kangaroo rat over the past 16 years based on the occupancy of the species at fixed monitoring plots (US Navy 2016, pp. 3-77–3-78; Appendix L, Figure L-2) as follows: Following declines in plot occupancy between 2004-2008, populations at this facility appeared to remain low, but relatively stable from 2009 to 2011, and have continued to increase through 2015. Prior surveys found that, during the 2002–2004 period, plot occupancy was relatively stable, varying only by about 1 percent over the 3 years of monitoring. The increase in plot occupancy, which started in 2012 and continued through 2015, followed habitat treatments in 2008 to 2010 and the reintroduction of grazing in 2010 (U.S. Navy 2016, p. 3-78).

Within the Fallbrook area, there exists other potential areas of occupied habitat. In 2013, a survey along the western side of the runway at the Fallbrook Airport runway, captured 8 unique animals in 3 of 6 trap areas (Vergne 2013, pp. 11, 13) in an estimated 2.5 acres of occupied habitat.

5.3.4 Ramona Grasslands County Preserve

The Ramona Grassland County Preserve (Preserve) is located in northern San Diego County, within the Santa Maria Valley, about 2 mi (3.22 km) west of the unincorporated community of Ramona, and ranges in elevation from approximately1,350 ft (410 m) above MSL along the valley floor to over 1,700 ft (518 m) above MSL in the rocky hills of the northern portion of the Preserve (ICF 2017, p. 2). The Preserve includes about 3,490 ac (1,412 ha) of native and naturalized habitat, including 1,397 ac (565 ha) of grassland, most of which is considered nonnative grassland (ICF International 2012, p. 2-1). Much of the Preserve was ranched historically, particularly for cattle grazing, and there is an existing network of dirt roads and trails (County of San Diego 2013, p. 2-8). Cattle grazing activity is year-round with no formalized rotation or rest periods (County of San Diego 2013, p. 2-8; ICF 2017, p. 2).

The Preserve was acquired in sections starting in 2003 for inclusion in the Draft North County Plan preserve system and currently encompasses 3,940 ac (1,595 ha) (County of San Diego 2013, p. 1-1). The Draft North County Plan is under development as a Multiple Species HCP under section 10(a)(1)(B) of the Act, the Natural Community Conservation Program, and the California Endangered Species Act (see section 7.0 Regulatory Mechanisms and Management/Conservation Measures). A Resource Management Plan has been prepared for the Preserve, which is owned and operated by the County of San Diego Department of Parks and Recreation (County of San Diego 2013, entire). The goal of the Resource Management Plan, which also includes Area Specific Management Directives, is to balance the preservation of the natural biological and cultural resources in the Preserve with the management strategies of the Draft North County Plan (County of San Diego 2013).

Surveys were conducted for signs of Stephens' kangaroo rat in 2005/2006 and 165.9 ac (67.14 ha) was mapped as being occupied by the Stephens' kangaroo rat to varying degrees 115.3 ac (46.7 ha) were considered to support trace densities, 43.7 ac (17.7 ha) as low density, and 7.0 ac (2.8 ha) as moderate density. An additional 112.7 ac (45.6 ha) was mapped as potential habitat (Spencer and Montgomery 2007, pp. 7–9). Limited inventory surveys were also conducted throughout the Ramona Grassland Preserve in 2010, reporting a total of 3 captures in 2 of 29 "sample areas" (ICF International 2010, pp. 4-25–4-28), in grasslands north of the Ramona airport and south of Santa Maria Creek in the southwestern portion of the Preserve (County of San Diego 2013, p. 3-33).

In 2016, a resource-specific monitoring effort was conducted at the Preserve in support of County of San Diego Department of Parks and Recreation Comprehensive Monitoring Plan (CMP) monitoring efforts for the Stephens' kangaroo rat at the Preserve (ICF 2017, entire). Monitoring areas were selected in four grazing management unit areas, on 28 sample plots (ICF 2017, p. 4). Live trapping of the Stephens' kangaroo rat was conducted in 10 sample plots for confirmatory trapping (ICF 2017, p. 5). Of the 28 sample plots evaluated for potential occupancy, 15 were rated as high, 2 as medium, 4 as low, and 7 were rated as "none" (no potential and presumed unoccupied) (ICF 2017, p. 9). Trapping confirmed the presence of the species in 6 of the 8 sample plots that were rated high for potential occupancy, and its presence in 1 sample plot rated as medium (ICF 2017, p. 9). No animals were captured in the one sample plot rated as low (ICF 2017, p. 9).

Other project-specific (presence/absence) trapping studies for the Stephens' kangaroo rat within the Ramona area include the following:

- 2010 project site survey on 147.3 ac (59.6 ha): 2 unique captures in one portion of surveyed area (1 of 15 trap lines); estimated occupancy on surveyed property was 3.4 acres (Vergne 2010)
- 2011 project site survey on 47.5 ac (19.2 ha): 15 captures (uniqueness not specified) (7 of 15 trap lines); estimated occupancy on surveyed property was less than 2 acres (Vergne 2011)
- 2015 project site survey, habitat assessment and limited trapping in 2014, reporting 5 unique captures within the approximately 3-ac (1.21 ha) sampled area (SJM Biological Consultants 2015)
- 2018 project site survey on 22.24 ac (9 ha): 12 captures (uniqueness not specified) (8 of 34 trap lines); with estimated densities ranging from less than 2 animals per ha to over 10 to 30 animals per ha (Vergne 2018a)
- 2018 project (sewer line) site survey on 984.25 feet-long by 98.43 feet-wide (300 meter-long by 30 meter-wide) area: number of captures not specified; density in occupied areas determined to be high, or greater than 30 animals per ha (Vergne 2018b)

5.3.5 Rancho Guejito Ranch

The Rancho Guejito Ranch is a privately-owned, approximately 22,500-ac (9,105-ha) property, located east of Escondido, California, in San Diego County (see Figure 6 below) (Jones 2012), at an elevation ranging from about 800 ft (244 m) at the southern end to 4,200 ft (1,280 m) at the northern end (Montgomery 2005, p. 1). The Rancho Guejito Ranch, which encompasses a former Mexican land-grant rancho, was grazed by cattle for many decades, which minimized an expansion of scrub vegetation and facilitated the maintenance of the large expanses of grassland (Montgomery 2005, p. 5). Other disturbances or signs of human influence on the property were reported as relatively minor in 2004, and a 2003 wildfire (Paradise Wildfire) was an important event for reducing vegetation ground cover in portions of Rancho Guejito, and likely contributed to the improvement of habitat conditions for the Stephens' kangaroo rat at the time of a 2004 survey for the species on the property (Montgomery 2005, p. 5).

The Service has limited survey information for this area. In 1991, an isolated population of the Stephens' kangaroo rat was confirmed at Rancho Guejito, located east of Escondido, California (Montgomery 1991), though that survey effort only covered a small area within Rancho Guejito Ranch (Montgomery 2005, p. 2). A map of estimated suitable Stephens' kangaroo rat habitat was prepared in 2004 and indicated extensive areas of low to very high quality Stephens' kangaroo rat habitat in three primary sections of the Ranch, with the area of potential habitat generally equal to the area of grassland on the property (Montgomery 2005, pp. 1, 5). A 2004 investigation was conducted, which included recording kangaroo rat sign in open grassland habitat followed by subsequent live-trapping efforts to confirm the presence or absence of the Stephens' kangaroo rat (Montgomery 2005, p. 6). Over 13 trap nights, at 73 localities on the property, 110 captures of the Stephens' kangaroo rat were reported (Montgomery 2005, p. 8). This study identified approximately 3,012 ac (1,219 ha) as occupied Stephens' kangaroo rat habitat, which included 2,171 ac (879 ha) where the species' distribution and abundance was found regularly, at low to high densities (Montgomery 2005, p. 9).

5.4 Summary

In summary, the Stephens' kangaroo rat continues to occur in a patchy distribution within suitable habitat in western-southwestern Riverside and San Diego Counties, with a few locations containing high densities of animals. Two large-scale habitat conservation planning efforts were completed in Riverside County (SKR HCP and MSHCP). The implementation of these conservation plans has helped to offset potential losses of habitat from urban and agricultural development. Three military installations in San Diego County are also actively managed for the conservation of the Stephens' kangaroo rat. Based on detections since 2010, Stephens' kangaroo rat is considered extant in 12 geographic locations in Riverside County and 6 locations in San Diego County (Table 1, Figure 6).

6.0 STRESSORS

At the time of listing, we determined that the Stephens' kangaroo rat was threatened by the following threats: (1) habitat loss resulting from widespread, rapid urbanization and agricultural development; (2) fragmented and isolated populations; (3) reduction of habitat suitability (from anthropogenic activities including grazing, off-highway vehicle use, disking, plowing, introduction of nonnative vegetation, and rodent control programs); (4) predation by domestic cats; and (5) the lack of existing regulatory protections. In our 2010 12-month finding published in the *Federal Register* (FR) (75 FR 51204; August 19, 2010) and subsequent 2011 5-year review (Service 2011), we found that the threats to Stephens' kangaroo rat remained similar to those identified at listing in 1988, with additional impacts from nonnative plant species and climate change. However, as we noted in our most recent 5-year review, the primary and imminent threat at the time of listing, habitat destruction from urban and agricultural development resulting in isolated habitat patches, had been largely ameliorated through the implementation and design of the core reserve system in western Riverside County (through the Stephens' Kangaroo Rat Habitat Conservation Plan), through ongoing land acquisitions and easements, and with other conservation plans and efforts MSHCP and INRMPs) (Service 2011, p. 2) (Appendix D).

This section provides an overview of current and future impacts from stressors to the Stephens' kangaroo rat (Table 3). In this Species Report, we defined the level of stressors as follows: (1) low-level impact indicates a stressor is impacting individual Stephens' kangaroo rat currently or in the future, or a stressor is resulting in a minor amount of habitat impacts or possibly temporary habitat impacts currently or in the future; (2) moderate-level impacts indicates a stressor is impacting the Stephens' kangaroo rat at the population level currently or in the future, or a stressor is resulting in more serious impacts to suitable habitat at the population level currently or in the future; and (3) high-level impact indicates a stressor is significantly impacting the Stephens' kangaroo rat at the species level currently or in the future, or a stressor is causing significant impacts to suitable habitat at the species level currently or in the future.

6.0.1 Stressor Summary Table

Table 3. Summary of stressors to the Stephens' kangaroo rat and its habitat

Stressor	Stressor Impacts	Timing	Scope	Current Management and Conservation Measures	Overall Level of Impact to Species and Habitat
Habitat Fragmentation	Habitat	Listing (1988) 12 month (2010) Current (2019) Future	Rangewide	USFS Land and Resource Management Plan; BLM and USFS Management Plan; CESA; CEQA; Western Riverside County MSHCP; DOD INRMPs	Moderate
Habitat Loss Due To Urban and Agricultural Development	Habitat	Listing (1988) 12 month (2010) Current (2019) Future	Rangewide	USFS Land and Resource Management Plan; BLM and USFS Management Plan; CESA; CEQA; Western Riverside County MSHCP; DOD INRMPs	Moderate to High
Habitat Modification—Conversion of Native Vegetation (wildfires, nonnative grasses, invasive species)	Habitat	Listing (1988) 12 month (2010) Current (2019) Future	Not Rangewide	RCHCA Management Actions (at Core Reserves)	Low
Habitat Destruction or Modification—Other (nonnative ungulates, OHVs, fire suppression)	Habitat	Listing (1988) 12 month (2010) Current (2019) Future	Not Rangewide	RCHCA Management Actions (at Core Reserves)	Low to None
Predation	Individuals	Current (2019) Future	Not Rangewide	N/A	Low to None
Use of Rodenticides	Individuals	Listing (1988) 12 month (2010) Current (2019) Future	Not Rangewide	California DPR Programs and Regulations	Low
Wildfire	Habitat, Individuals	12 month (2010) Current (2019) Future	Rangewide	Prescribed Burns; Fire suppression and fire prevention activities (INRMPs) USFS Land Management Plan	Low
Climate Change Effects	Habitat	12 month (2010) Current (2019) Future	Rangewide	N/A	Low to Moderate

6.1 Habitat Loss Due To Urban and Agricultural Development

In our 1988 listing determination (53 FR 38467), we cited the analyses of Price and Endo (1988) (unpublished manuscript) in support of our assessment that one of the primary threats to the Stephens' kangaroo rat was permanent loss of habitat resulting from urbanization and other land uses. This manuscript was subsequently published as Price and Endo (1989). The study looked at habitat loss in Riverside County (note: San Diego County was not evaluated) and overlaid soil survey aerial photography (cited as U.S. Department of Agriculture 1971, which is the same as Knecht 1971) onto coarse scale (1:100,000) base maps to identify suitable habitat patches and contiguous patches (Price and Endo 1988, 1989). Specifically, the 1971 Riverside County soil map was used to identify the extent of pre-modern development annual grasslands, with the final list of suitable soils based on whether they supported annual grassland habitat (Price and Endo 1989, p. 295). An original habitat map was created based on an assumption of habitat association (at that time) that the species' distribution in western Riverside County was within sparse annual grassland habitat established after Spanish ranching, but prior to modern urban and agricultural development (Price and Endo 1989, p. 295). This estimate of suitable habitat in Riverside County totaled 308,326 ac (124,775 ha) (Price and Endo 1989, p. 296; Figure 1). The authors then used land use base maps (1:125,000 scale) from 1938 and 1984 and subtracted areas of urban and agricultural development from their "original" habitat map to estimate the amount of potential habitat remaining in those two time periods (Price and Endo 1989, p. 295). Based on this analysis, the authors estimated that, by 1938, only 37 percent of suitable habitat (112,604 ac) (45,569 ha)) for the Stephens' kangaroo rat remained in Riverside County, with about the same amount (124,833 ac (50,518 ha) or 40.5 percent) remaining in 1984 (Price and Endo 1989, p. 296). In our final listing rule (53 FR 38465 at 38467), we misidentified the acreage value of suitable habitat that "originally existed" for the Stephens' kangaroo rat presented by Price and Endo (1989, p. 296) as 308,195 ac (124,775 ha).

In our 2010 12-month finding, we presented a different type of analysis to estimate "baseline" occupied habitat (54,909 ac (22,221 ha)) for the Stephens' kangaroo rat, and compared that estimate to developed and conserved lands in Riverside and San Diego Counties (75 FR 51210–51211). Our analysis utilized updated and more comprehensive databases to create a model with better resolution that is more accurate for Stephens' kangaroo rat. For this species report, we developed an estimate of lands within our modeled habitat that are considered conserved; that is, areas not considered to be threatened by urban or agricultural development. We estimated a total of 3,494 ac (1,414 ha) of baseline occupied habitat was lost to development from 1984 to 2006, while 19,237 (7,785 ha) of baseline occupied habitat was conserved over this same period (75 FR 51211; Table 2 (Note: unit conversion to acres was inaccurate for some estimates in Table 2)). We also stated that existing conservation planning efforts had slowed the rate of habitat loss resulting from urban and agricultural developing, and that 19,477 ac (7,882 ha), or about 36 percent, of our estimated baseline habitat for the Stephens' kangaroo rat was conserved at that time through regional HCPs and conservation easements (75 FR 51212). We therefore concluded that urban development pressures remained on a significant portion of baseline occupied habitat within the range of the species (75 FR 51217). In 2010, we concluded the majority of habitat was susceptible to agricultural and urban development.

In California, 1890–1930 was an intensive agricultural period with the expansion of dry land farming as well as rapid growth of intensively irrigated fruit and vegetable crops (Preston *et al*. 2012, p. 282). An unknown amount of native grassland habitat within the maximum extent of occurrence area of the Stephens' kangaroo rat was lost or modified from agricultural activities during this period. The post-World War II population boom resulted in the conversion of many large agricultural areas to urban and suburban developments in southern California (Preston *et al*. 2012, p. 282). We reviewed data from the FMMP of the Division of Land Resource Protection from the California Department of Conservation (CDC) to evaluate land use changes in California from 1984 to 2016 (CDC 2018b). Unfortunately, not all areas within the two Counties have been inventoried – 41 percent for Riverside County, 80 percent for San Diego County – but a review of these data indicate that the net *loss* of agricultural land (all types, including grazing land) from 1984 to 2016 for Riverside County was 173,436 ac (70,187 ha) (25 percent), and, for San Diego County, a net loss of 31,844 ac (12,887 ha) (10 percent), for a total net decline of 205,280 ac (83,074 ha) (CDC 2018b). Correspondingly, the reported net *gain* in urban and built-up land, from 1984 to 2016, for Riverside and San Diego Counties was 170,653 ac (69,061 ha) (104 percent increase) and 111,896 ac (45,283 ha) (44 percent increase), respectively, for a total net increase of 282,549 ac (114,344 ha) (CDC 2018b). These numbers indicate that, although agricultural land use activities declined in southern California from 1984 to 2016, much of the former farmlands have transitioned to urbanized areas rather than reverting to or being restored to native habitats. As noted above, our modeled habitat for Riverside County (Figure 2) is not directly comparable to the 1984 modeled habitat map presented in Price and Endo (1989, p. 297; Figure 3), and this is especially so given the land use changes from 1984 to 2016 reported here for both Riverside and San Diego Counties.

As discussed above, in western Riverside County, conservation areas have been established under the SKR HCP and the Western Riverside MSHCP (see map in Appendix B); see section 7.0 Regulatory Mechanisms and Management/Conservation Measures for a more detailed discussion of this HCP and the Western Riverside County MSHCP relative to conservation actions implemented for the species and its habitat. In our 2010 12-month finding, we indicated that 19,460 ac (7,875 ha) of occupied Stephens' kangaroo rat habitat is to be conserved over the 75-year term of the Western Riverside County MSHCP permit when fully implemented (75 FR 51214). We also stated that we expected that a total of 3,393 ac (1,373 ha) of Additional Reserve Lands would be added to these reserves through ongoing implementation of the Western Riverside County MSHCP (75 FR 51214). As described in our 2011 5-year review, both small and larger ecosystem-based reserves have been established for Stephens' kangaroo rat that help to ameliorate the threat of urban development. The Riverside County Habitat Conservation Agency's HCP for the Stephens' Kangaroo Rat in Western Riverside County has resulted in the conservation of eight reserves. The established eight reserves exceed the four reserves required by criterion 1 of the Draft Recovery Plan for the Stephens' Kangaroo Rat (Service 1997, p. 52). As a result, we concluded that direct habitat loss of Stephens' kangaroo habitat in western Riverside County from large-scale development is no longer the predominant threat to the species, and that most, but not all, proposed projects in western Riverside County would be limited to those permitted under the HCP or the Western Riverside County MSCHP (72 FR 51214).

The North County Multiple Species Conservation Plan (MSCP) planning area includes the Rancho Guejito location, portions of which are currently presumed occupied by the Stephens' kangaroo rat. In the Ramona Grasslands location, which is currently managed by the County of San Diego, private lands acquired from the Cooperative Endangered Species Conservation Fund under section 6 of the Act since 2002 total approximately 3,200 ac (1,295 ha), which includes approximately 1,137 ac (460 ha) of modeled habitat for the Stephens' kangaroo rat (see discussion in section 7.1.1 below). In addition, active INRMPs at Marine Corps Base Camp Pendleton, Det. Fallbrook, and Warner Springs include actions to provide for the long-term conservation of Stephens' kangaroo rat on Federal military lands. The INRMPs are based, to the maximum extent practicable, on ecosystem management principles and provide for the management of Stephens' kangaroo rat and its habitat while sustaining necessary military land uses. Despite the fact that INRMPs may be superseded by the military's obligation to ensure readiness of the Armed Forces and are subject to discretionary funds and planning, the occurrence of the species and its habitat on Federal land, the existing INRMPs, and the continued consultation provisions of the Act provide some of the best assurances for long-term conservation of the species and its habitat.

6.1.1 Conserved Lands—Riverside County

For this species report, we developed an estimate of lands within our modeled habitat for the Stephens' kangaroo rat that are considered conserved; that is, areas not considered to be threatened by urban or agricultural development. For western Riverside County, we combined several data sets to estimate "Current Conserved Lands." This includes those areas identified as conservation easements, conserved lands, public lands, and Public/Quasi-Public lands in the Western Riverside County MSHCP data (as of July 2018). We also estimated modeled habitat for the Stephens' kangaroo rat that are also not yet conserved that are outside of Current Conserved Lands.

Our results indicate that, of the 69,104 ac (27,966 ha) of modeled habitat for the Stephens' kangaroo rat in Riverside County, approximately 1.5 percent occurs on Federal lands, 7 percent occurs on State lands, roughly 17.5 percent occurs on local lands, 1 percent on tribal lands, and 72 percent occurs on private lands. Approximately 1.3 percent of the modeled habitat in Riverside County that occur on private lands are considered to be conserved. A total of 16,438 ac (6,652 ha) of modeled habitat is considered within conserved lands. Additional information is presented in Appendix D.

6.1.2 Conserved Lands—San Diego County

Similar to our analysis presented above for Riverside County, we also evaluated the conservation status of lands in San Diego County within our modeled habitat for the Stephens' kangaroo rat. We identified areas as Current Conserved Lands as conserved lands within San Diego County, as identified in the Conserved Lands database (Sandag/SanGIS, February 2017) as well as all Federal, State, and DOD lands that are not likely to be impacted by urban and agricultural development (Appendix D). Please note that DOD lands are classified as conserved lands in this assessment as they are not likely to be developed and although DOD has a responsibility to recover listed species, we recognize that the primary and overriding obligation of DOD lands is to ensure readiness of the Armed Forces.

Our results indicate that, of the 22,434 ac (9,079 ha) of modeled habitat for the Stephens' kangaroo rat in San Diego County, roughly 55.5 percent (12,457 ac, (5,041 ha)) is conserved. A total of 28 percent of modeled habitat occur on Federal lands, more than 1 percent occur on State lands, 21 percent occur on local lands, 1 percent on tribal lands, and 48 percent occur on private lands. A summary table of land ownership for Riverside and San Diego Counties is presented in Appendix E

6.1.3 Summary

Currently there are 91,538 acres of modeled habitat, with roughly 75 percent occurring in Riverside County. Based on our review of patterns in land use and conservation land status, the best available data indicate that habitat loss due to urban and agricultural development is a moderate- to high-level stressor to the Stephens' kangaroo rat at the population or rangewide level. For Riverside County, we found that, within our estimated modeled habitat for the species, the majority of habitat occurs on private lands. In Riverside County, roughly 16,438 ac are currently conserved, which is 23.8 percent of the modeled habitat in Riverside County. In San Diego County, approximately 12,457 ac are conserved, which is 55.5 percent of modeled habitat in San Diego County. Overall 31.5 percent of modeled habitat is currently conserved throughout the range. In the future impacts from urban and agriculture development are likely to have a population level effect because a substantial portion (64.2 percent) of modeled habitat occurs on private lands that are not conserved.

6.2 Habitat Fragmentation

6.2.1 Introduction

Habitat fragmentation is a process whereby habitat becomes increasingly subdivided into smaller patches, which creates not only spatially disjunct patches, but also a loss in the total habitat area (Noss and Cooperrider 1994, p. 393). Further, in addition to the increased isolation and creation of habitat edges produced with this process, fragmentation of populations also generates responses at the community and ecosystem levels, including decreased residency of individuals within fragments, a reduction in movement among fragments, a reduction in species richness across taxonomic groups, and degradation of basic ecosystem functions, such as mate selection, genetic isolation (Shier and Navarro n.d.), productivity, and pollination (Haddad *et al*. 2015, pp. 4–5).

In a review article of the effects of habitat fragmentation on extinction risk, Burkey and Reed (2006, entire) presented what they found to be the important causal biological mechanisms for the relative persistence of populations (extinction risk) in fragmented versus continuous habitat. Deterministic mechanisms (i.e., expected system responses, without random variation) that confer vulnerability to fragmentation applicable to the Stephens' kangaroo rat include: (1) migration/dispersal (e.g., disruption of routes or restriction of movement); (2) inter-species interactions (e.g., loss of refugia from predators); (3) intraspecific interactions (e.g., allee effect, or reduction in population growth rate from, for example, loss resulting from reduced social interaction); (4) edge effects; (5) patch size smaller than home range or territory; and (6) unprotected loss of important resources to the entire metapopulation within a reserve system (Burkey and Reed 2006, p. 12). As summarized by Haddad *et al*. (2015, p. 7), the ability of natural habitats to sustain both biodiversity and ecosystem function is dependent on the total amount and quality of habitat that remains in fragments, the degree of connectivity, and the effects of other human-cause stressors such as climate change and nonnative invasive species.

In a recent analysis of the potential effects of this stressor to kangaroo rats, the effects of landscape scale and patch level features were evaluated relative to the population persistence of the Ord's kangaroo rat (*Dipodomys ordii*) in Alberta, Canada (Heinrichs *et al*. 2015, entire). Using 15 years of field data, that study found that connectivity at the landscape scale was likely more important for the regional persistence of that species than local patterns of patch clumping and dispersion (Heinrichs *et al*. 2015, p. 61). The authors suggested, however, that if a species' movement was constrained or its dispersal pattern was affected by barriers or other habitat features, then the spatial arrangement of habitats is also likely to be important for population persistence (Heinrichs *et al*. 2015, p. 61). The study's findings reinforce the need for a multi-scale approach in predicting species responses and in assessing the success of conservation actions (Heinrichs *et al*. 2015, p. 56). This type of spatially-explicit population model relative to landscape features has not been developed for the Stephens' kangaroo rat, but, given the species' patchy distribution across a varied topographic landscape in southern California, connectivity and spatial features (i.e., landscape-level quality and habitat arrangement of patches) are also likely important for its persistence. As discussed above (section 4.5 Genetics), results from a range-wide genetic study of Stephens' kangaroo rat populations (Shier and Narvarro n.d.) suggested the range of the Stephens' kangaroo rat in southern California has become fragmented from a historical continuous range (Shier and Navarro n.d., p. 23).

In addition to estimating the potential distribution of the Stephens' kangaroo rat in western Riverside County, Price and Endo (1989, entire) also estimated the amount of habitat fragmentation (using their estimates of suitable habitat) based on patch size, using 1 square kilometer (100 ha) (247 ac) as minimum patch size, which they considered to be the minimum size compatible with "reasonably long-term survival of an isolated population" (Price and Endo 1989, p. 299). Although the study did not quantify the size distribution of habitat patches, separate fragments were counted using their 1938 and 1984 suitable habitat maps, which was then compared to their original habitat map (Price and Endo 1989, p. 299). They estimated that, by 1938, over 80 percent of fragments were smaller than 247 ac (1 km^2) (Price and Endo 1989, p. 299).

6.2.2 Habitat Fragmentation Analysis

To evaluate habitat fragmentation for Stephens' kangaroo rat, we conducted a GIS spatial analysis to evaluate fragmentation of modeled Stephens' kangaroo rat habitat identified within Riverside and San Diego Counties (Service 2018). As shown in Figures 2 and 3, our estimate of modeled habitat consists of numerous individual GIS polygons. We used movement estimates from Price *et al*. (1994a p. 935), who presented a (pooled average from 31 individuals) maximum distance moved for telemetered Stephens' kangaroo rats of 202 ft (61.5 m) (see section 4.4 Movement and Home Range), to develop fragmented or unfragmented areas within our defined modeled habitat (Figure 7). This distance was used in our analysis as a conservative estimate of movement restriction and, thus, a measure of fragmentation of our modeled habitat.

After buffering the geospatially distinct areas using the dispersal distance, we created fragmented and unfragmented areas by first merging (dissolving) together those distinct areas that were touching at least one other buffered distinct area. Thus, the small fragmented areas became separated from its nearest neighbor by more than 202 ft (61.5 m), which is the estimate of movement restriction or dispersal distance identified by Price *et al*. (1994a, p. 935). The modeled habitat represents a total of 3,053 separate polygons, which are illustrated as areas in red on this map (labeled "Modeled Habitat Small Patch", Figure 7). This indicates areas of modeled habitat that are separated by distances greater than 202 ft (61.5 m) or are less than the 247 ac (1 km^2) value presented in Price and Endo (1989, p. 299) as the minimum size for long-term survival of an isolated population of the Stephens' kangaroo rat.

Across both Riverside and San Diego Counties a total of approximately 91,538 ac (37,044 ha) of modeled habitat was identified for Stephens' kangaroo rat (69,104ac (27,966 ha) in Riverside County and 22,434 ac (9,079 ha) in San Diego County). We found that, within our 3000 patches, the majority (95.8 percent) were smaller than 247 ac (100 ha) and 4.2 percent were larger than 247 ac (1 km^2). By area, 23.7 percent of the modeled habitat (22,880 ac (9,259 ha)) occurs in small patches less than 247 ac (1 km^2) and is considered fragmented. In Riverside and San Diego Counties, 23.7 percent and 29.0 percent of the modeled habitat, respectively, is considered fragmented (Table 4).

To estimate the amount of habitat fragmentation for the two counties, we compared the acreage of the habitat patches from "large patches" to "small patches". The results of the spatial analysis are shown in Figure 7; County-specific maps are presented in Appendix C.

Table 4. Results from the fragmentation analysis.

Riverside County	**Modeled SKR habitat ac (ha)**	**Percent of modeled habitat**
Modeled habitat < 1 km^2*	16,369 (6,623)	23.7%
Modeled habitat > 1 km^2	52,735 (21,341)	76.3%
Total modeled habitat in Riverside County	69,104 (27,966)	
San Diego County	**Modeled SKR habitat ac (ha)**	**Percent of modeled habitat**
Modeled habitat < 1 km^2*	6,514 (2,636)	29.0%
Modeled habitat > 1 km^2	15,920 (6,443)	71.0%
Total modeled habitat in San Diego County	22,434 (9,079)	
Total modeled SKR habitat	**Modeled SKR habitat ac (ha)**	**Percent of modeled habitat**
Modeled habitat < 1 km^2*	22,883 (9,259)	25.0%
Modeled habitat > 1 km^2	68,655 (27,784)	75.0%
Total modeled SKR habitat	91,538 (37,044)	

*Areas of modeled habitat that are equal to or greater than 247 ac (1 km^2) represent the minimum size for long-term survival of an isolated population of the Stephens' kangaroo rat. Modeled habitat patches smaller than this and separated by distances greater than 202 ft (61.5 m) represent potentially fragmented patches. Note: Areas may not sum due to rounding.

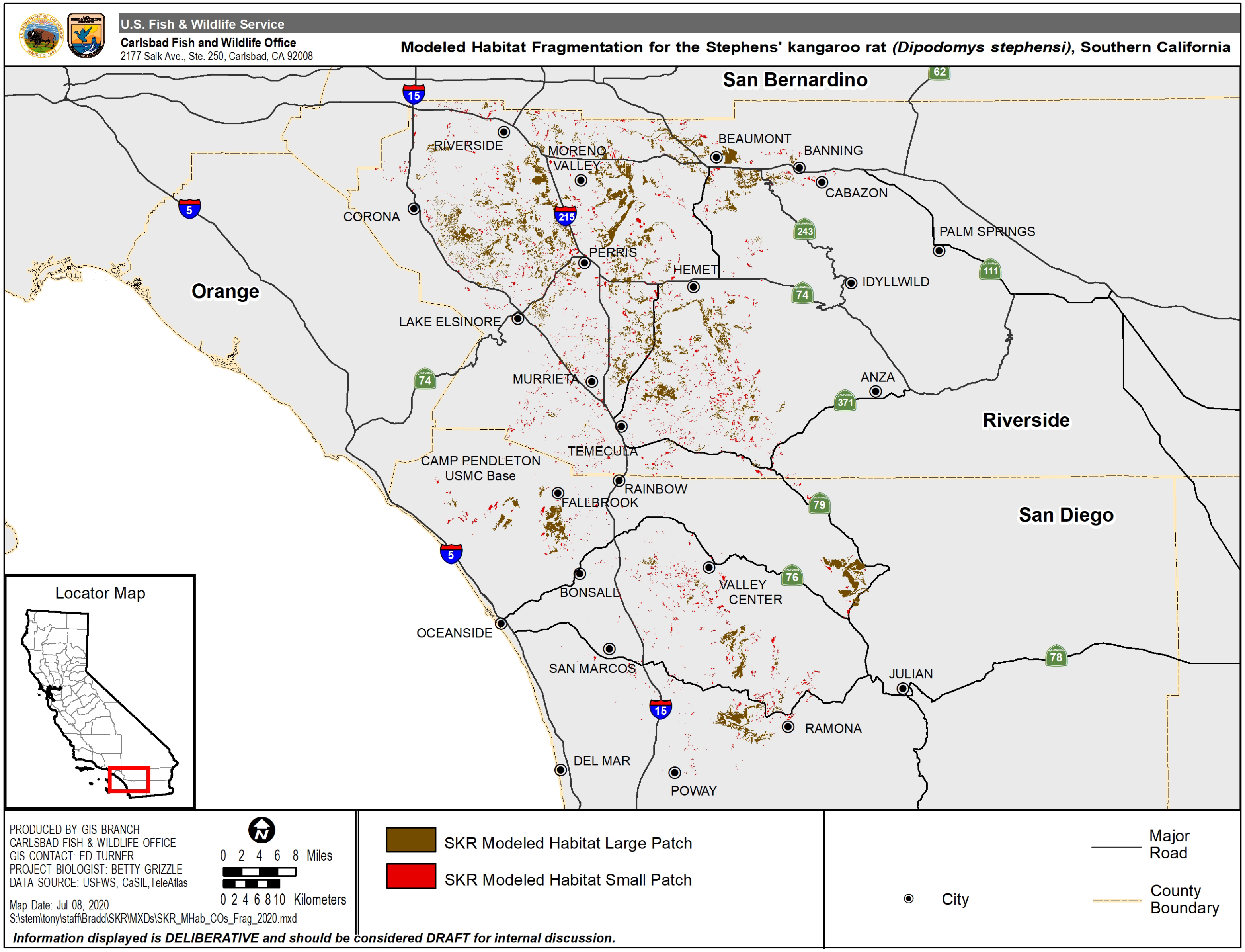

Figure 7. Estimated fragmentation of modeled habitat for the Stephens' kangaroo rat

6.2.3 Current Impact to Stephens' kangaroo rat from Habitat Fragmentation

Although 75 percent of the modeled Stephens' kangaroo rat habitat occur in large patches, these large patches are isolated, limiting connectivity between occupied areas. Shier and Navarro (n.d.) found no genetic structuring historically across populations. However, they found more recent genetic structure (due to increasingly isolated populations due to limited gene flow across its range), creating a metapopulation-like structure across its range, with the least amount of connectivity in the southernmost populations. This recent fragmentation decreases fitness by increasing inbreeding and impacts from stochastic events. In the future, negative impacts on fitness will become more apparent without increasing connectivity between these fragmented habitats. Shier and Navarro (n.d.) found relatively high genetic diversity measured by observed heterozygosity for all populations. The results also found low inbreeding coefficients for all populations, except Fallbrook. These findings suggest that although habitat fragmentation is starting to impact the genetic structure of the species, negative impacts associated with limited gene flow are not currently causing significant impacts to fitness of Stephens' kangaroo rat. Although these negative impacts will become more acute and significant in the future as the full effects of isolation (caused by habitat fragmentation) are observed.

6.2.4 Summary

The habitat has been largely fragmented as a result of urban and agricultural development. This reduces connectivity, which in turn can result in a loss of productivity. Our spatial analysis indicates that there are approximately 69,104 ac (27,966 ha) in Riverside County and 22,434 ac (9,079 ha) in San Diego County of modeled habitat for the Stephens' kangaroo rat. Within that modeled habitat, we found that 95.8 percent of the polygons identified consists of fragments (patches) of less than 247 ac (1 km^2). However, by area, 76.3 percent of the modeled suitable habitat in Riverside County exists in larger continuous patches greater than 247 ac (1 km^2) and 23.7 percent occurs as small patches less than 247 ac (1 km^2). In San Diego County, 71.0 percent of the modeled habitat occurs in larger continuous patches greater than 247 ac (1 km^2) and 29.0 percent of habitat occurs as small patches less than 247 ac (1 km^2). Current data suggest that management actions to restore connectivity and/or (ongoing) translocation efforts may be needed in the future to mitigate habitat fragmentation to ensure gene flow between reserves and other occupied and unoccupied areas (Shier and Navarro n.d., p. 3).

Based on the best available data, habitat fragmentation remains a moderate-level stressor to the Stephens' kangaroo rat and its habitat, and we can reliably predict that these habitat conditions are likely to remain into the future. Since listing, the SKR HCP and MSCHCP have helped to recover Stephens' kangaroo rat through the creation of eight core reserves that have helped to restore and maintain occupied areas to preserve redundancy and representation. Currently 75 percent of the modeled suitable habitat for Stephens' kangaroo rat appears to be greater than 1 km^2, which is a hypothetical threshold for sustainable populations. Future restoration efforts could help reduce impacts from fragmentation. Successful Stephens' kangaroo rat translocations have also been implemented to help limit the effects of habitat fragmentation since listing (Brehme *et al*. 2017, p. 43; Shier and Swartz 2012, p. 11). While these are positive effects in combating habitat fragmentation, since listing more habitat has also been lost to development, further fragmenting remaining habitat.

6.3 Habitat Modification—Conversion of Native Vegetation

6.3.1 Wildfire

Numerous landscapes throughout southern California are subject to wildfire, including those areas occupied by Stephens' kangaroo rat (see section 6.4.3 Fire Suppression and Prevention Activities below). In our 2010 12-month finding (75 FR 51216), we noted that high intensity wildfire may have a detrimental impact to the Stephens' kangaroo rat habitat. However, lower intensity wildland fires or prescribed burns have been found to be beneficial in maintaining or restoring Stephens' kangaroo rat habitat and prescribed burns are regularly conducted within occupied habitat on both DOD lands and in Core Reserves to manage vegetation. High intensity wildfire likely represents a minimal stressor related to modification of the species' habitat because the disturbance helps maintain suitable habitat (open habitat) for Stephens' kangaroo rat. Further analysis of wildfire is discussed in Section 6.9 below.

6.3.2 Nonnative Grasses

Core Reserve managers in western Riverside County recognize that nonnative grasses will likely remain a concern for Stephens' kangaroo rat habitat, if not managed. However, on a landscape scale, reserve managers have been very effective over the last 5 to 7 years in managing nonnative grasses (Shomo 2018f, pers. comm.). As an example, funding for managing this stressor has increased through reserve endowments, and managers have been exploring the timing, concentration, and intensity of various management actions (e.g., mowing, grazing, herbicide applications) to achieve more effective control (Shomo 2018f, pers. comm.). In addition, the RCHCA has enlisted the assistance of University of California, Riverside, to identify a restoration seed mix that is competitive with nonnative grasses, which can be used to restore habitat once the density of nonnative grasses is reduced (Shomo 2018f, pers. comm.). The Vista Irrigation District conducts grazing of Stephens' kangaroo rat habitat immediately northeast of Lake Henshaw; no other management activities for nonnatives are known to occur on Vista Irrigation District land (Winchell 2019, pers. comm.). Stephens' kangaroo rat habitat is also grazed at Warner Springs (Arnold 2019, pers. comm.).

6.3.3 Invasive Species

Oncosiphon piluliferum (Stinknet), an herbaceous winter annual plant originating from South Africa, which occurs in Riverside County, has expanded rapidly in the range of Stephens' kangaroo rat, including along roadways (Shomo 2018e, pers. comm.). Once established in an area and if left unchecked, it spreads rapidly, outcompeting all other plants, including nonnative grasses (Shomo 2018e, pers. comm.). At present, Lake Perris State Park has begun to be overrun with the plant, and it has been found at the Southwest Multispecies Reserve, and the Lake Mathews, Steele Peak, and Motte Rimrock Reserves, but has not been observed yet at Sycamore Canyon and Potrero reserve areas (Shomo 2018e, pers. comm.). Reserve managers are mapping the extent of its occurrence on reserves and are implementing aggressive measures in an attempt to control this plant before it becomes better established (Shomo 2018e; 2018f, pers. comm.). The Mammal Program Lead for the MSHCP Biological Monitoring Program has not seen or had an issue with stinknet in the Stephens' kangaroo rat habitat they monitor, although the threat is frequently discussed (Hoffman 2019, pers. comm.). The main habitat modification stressor observed by Hoffman (2019, pers.

comm.) is brushy habitat encroachment. The buildup of thatch is decreasing percentage of bare ground, negatively impacting habitat suitability for Stephens' kangaroo rat. Areas that have had some sort of disturbance to limit thatch buildup have been correlated with high numbers of animals.

The RCHCA, Metropolitan Water District, the Service, and CDFW recently approved $53,000 for University of California, Riverside, to study the plant and develop an effective herbicide treatment as well as evaluate the ecological community effects (e.g., dietary preferences) of this plant to the Stephens' kangaroo rat. This research will also include identifying seed bank longevity (Shomo 2018f, pers. comm.). Preliminary results are said to be encouraging for targeted applications of herbicide with a pre-emergent and stinknet seed only appears to be viable for about 3 years in soils (Shomo 2018f, pers. comm.).

In San Diego County, San Diego Management & Monitoring Program (SDMMP) reported that stinknet was introduced in San Diego County in 1998 and has become very abundant and pervasive in the San Pasqual Valley, and is well established in other coastal and western island areas of the county (SDMMP 2010). SDMMP is currently mapping stinknet occurrences in San Diego County, which should clarify where stinknet is occurring in modeled habitat for Stephens' kangaroo rat (McCutcheon 2019, pers. comm.).

6.3.4 Summary

Based on the best available information, the effects of wildland or prescribe fire, due to either direct loss of habitat or indirect effects, can provide important benefits in maintaining suitable habitat for the Stephens' kangaroo rat, and is not currently a stressor to individuals. While there is some uncertainty as to the level, intensity, and timing of wildfires across the species landscape in the future, given that management measures to control for wildfire have been implemented within reserve and management areas since the late 1990s, we can reliably predict it to be a very low effect stressor to its habitat for the next 20 years.

Wildfires can promote the spread and introduction of invasive species resulting in the modification or loss of habitat for the Stephens' kangaroo rat. Although the Stephens' kangaroo rat is known to occupy these types of habitat, extensive areas of unmanaged nonnative grasses do not provide long-term suitable habitat for the species. As described above, prescribed fire and other management actions are regularly used on both reserve lands in Riverside County and on military installations in San Diego County to reduce fuel loads and to manage for invasive plants (described in more detail in section 6.4.3). These management measures will help offset the impact of largescale intense wildfires and potential conversion of habitat.

We conclude that habitat modification from nonnative and invasive plant species is occurring throughout the range, but due to active management on Stephens' kangaroo rat habitat, they are considered low-level stressors. Reserve lands and areas within DOD facilities are currently being managed to benefit Stephens' kangaroo rat including managing for wildfire and nonnative and invasive plant species. The impacts from these threats are localized and not acting on Stephens' kangaroo rat at the population- or species-level. Given the ongoing management actions, including funded studies to identify better control measures, this is likely to remain so in the near future.

6.4 Habitat Destruction or Modification—Other

In our 2010 12-month finding, we evaluated several additional stressors that could potentially result in the destruction, modification, or curtailment of habitat or range of the Stephens' kangaroo rat. These stressors included habitat destruction and modification from nonnative ungulates (grazing activities) and unauthorized off-highway vehicle use (OHVs). We have re-evaluated these stressors in the in the following subsections. We also include fire suppression and fire prevention activities in this section.

6.4.1 Nonnative Ungulates

At the time of listing (1988), commercial grazing occurred in areas occupied by Stephens kangaroo rat year-round at high densities using both sheep and cattle, and was not managed for conservation of the species. Commercial grazing has since been reduced, and where such grazing still exists, impacts have been lessened compared to when the species was listed. In our 2010 12-month finding, we determined that grazing practices no longer represented a rangewide threat to the Stephens' kangaroo rat (75 FR 51216). As noted above (see section 3.3.2.1 Effects of Habitat Management Actions), grazing practices continue to be used to assist in habitat restoration and management for some populations of the species, and provide, at minimum, short-term benefits to the species in a landscape dominated by nonnative grasses (see examples in section 6.3.2 Nonnative Grasses). Grazing can provide long-term reduction in reducing thatch buildup that is beneficial to SKR with proper management over the long term.

As an example, reserve managers in western Riverside County have documented a reduction in nonnative grasses, an increase in forb diversity, and elimination of the build-up of thatch due to implementation of managed grazing practices (Shomo 2018b, pers. comm.). In these areas, animals are moved frequently to mimic native herbivore behavior, and the managers have found that, if properly managed, grazing creates a modest disturbance that is easily tailored to the annual precipitation levels and biomass production (Shomo 2018b, pers. comm.). Further, they report that, when compared to prescribed fire as a restoration tool, these grazing practices generate a slower, but steady, increase in population numbers of the Stephens' kangaroo rat (Shomo 2018b, pers. comm.).

Based on the best available information, we affirm our previous determination that grazing practices do not represent a rangewide threat to the Stephens' kangaroo rat. Impacts from grazing are localized and not impacting Stephens' kangaroo rat at the population- or species-level.

6.4.2 Unauthorized Off-Highway Vehicles (OHVs)

OHV activity can result in both direct (mortality or injury) and indirect effects (damage to burrow systems, rutting of habitat) to the Stephens' kangaroo rat and its habitat. For simplicity, we present an analysis of both effects in this section of the Species Report.

In our 2010 12-month finding, we evaluated reports from 2001 to 2006 from the RCHCA in assessing this potential stressor to the Stephens' kangaroo rat. We determined that efforts to limit unauthorized OHV activity within some reserve lands in Western Riverside County was limited in scope and were not successful (75 FR 51217). We therefore determined that OHV activity was a threat to the species.

We contacted the RCHCA (who oversees the management of the Core Reserves within western Riverside County) to obtain recent information regarding the level and effect of OHV activity within the Stephens' kangaroo rat reserves established under the SKR HCP. Overall, it was reported that OHV activity has declined significantly within these reserves (Shomo 2018b, pers. comm.).

More specifically, the following details were provided (Shomo 2018b, pers. comm.):

- In 2006, the Lake Mathews Reserve had no management entity. The portion of the reserve on the south side of Cajalco Road has been subjected to frequent access. However, in 2007, a program manager was hired by the RCHCA, and actions including repairing fencing, installing additional fencing, signing, and patrolling were initiated immediately. In addition, in 2014, the RCHCA was contracted by the Metropolitan Water District (MWD) to manage the remaining portion of the Lake Mathews Reserve, and in this area, repairs to existing fencing, signing, and patrolling were also initiated. The results reduced or eliminated any remaining OHV activity within these areas. Finally, they noted that the Lake Mathews Reserve has also benefited from a few development projects on the periphery of the Reserve, which has blocked existing entrances to this reserve (along the western boundary, which was previously used by unauthorized OHVs).
- At the Steele Peak Reserve, which has also had a number of unauthorized OHV incidents, the RCHCA completely fenced their lands and patrols it regularly. Further, the portion of this reserve managed by the BLM was recently closed to public access due to frequent target shooting and high fire probability. BLM law enforcement patrol the BLM portions of the reserve 4 to 5 times a week, and during the summer fire prevention personnel also patrol 2 to 3 times a week With the increase in patrolling and fencing off unauthorized OHV routes, significant improvements in conditions have been observed (Gannon 2019, pers. comm.).
- At the Southwestern Multi-species Reserve, they report infrequent incursions by unauthorized OHVs and this reserve is routinely patrolled and fencing is being maintained.
- The Sycamore Canyon Wilderness Park does not have problems with unauthorized OHV activity, but despite management activities and regular patrols, the SKR habitat has become overgrown by nonnative grasses and many unauthorized mountain bike trails have been established.
- At Motte/Rimrock Reserve, they report unauthorized OHV activity is minimal.
- For Potrero, some minor unauthorized OHV activity has been observed, but the remoteness and inaccessibility of this reserve has minimized this disturbance.

Through the Reserve Management Coordinating Committee (RMCC), the RCHCA has, since 2007, attempted with much success to coordinate security efforts of the Reserve system, and this has resulted in a noticeable decline in unauthorized OHV activity within Stephens' kangaroo rat reserves (Shomo 2018b, pers. comm.). We contacted the Mammal Program Lead for the WRC MSHCP Biological Monitoring Program and was told OHV is not a major stressor for Stephens' kangaroo rat and their grassland habitat (Hoffman 2019, pers. comm.). One core area (Potrero) is completely fenced, limiting the possibility of OHV activity.

Based on the best available information, we conclude that habitat modification from unauthorized OHV activity is currently limited to minor effects at a few locations and affecting Stephens' kangaroo rat at the population- or species-level. Given management actions implemented since our 2010 12-month finding, we do not anticipate this changing in the near future.

6.4.3 Wildfire Suppression and Prevention Activities

Because these activities may include both potential direct loss of (e.g., mortality) Stephens' kangaroo rat and indirect effects to its habitat, we present an analysis of both effects in this section of the Species Report. Wildfire suppression and prevention activities are implemented as needed, though wildfires are not an uncommon event in much of southern California (see discussion below). An evaluation of potential direct and indirect effects to the Stephens' kangaroo rat from wildfire alone is presented below (section 6.9 Wildfire).

Potential effects of wildfire suppression activities (e.g., off-road vehicle activity, wildfire control lines, aerial suppression, use of backfires) to the Stephens' kangaroo rat were identified by Camp Pendleton and measures are being implemented to reduce these limited impacts to the species and its habitat.

Potential effects of wildfire prevention activities (e.g., fire- and fuel-break maintenance, control line construction) to the Stephens' kangaroo rat identified on Camp Pendleton include direct effects such as direct excavation or crushing of resident animals from heavy equipment, and indirect effects such as excavation of burrow systems or crushing or closure of occupied burrows from firebreak and fuel-break maintenance and control line construction activities (Tetra Tech 1999, pp. 3-53–3-55). Vehicle and foot traffic from fire-fighting training activities may also result in soil compaction and rutting, compaction or crushing of burrow systems, and disturbance from noise and light (Tetra Tech 1999, p. 4-13). Specific avoidance and minimization measures identified for the Stephens' kangaroo rat and its habitat related to these activities include minimization of digging activities, year-round restriction of vehicle and equipment operations near known habitat to existing roads, and maintaining a year-round distance of 164 ft (50 m) for bivouac/command and post/field support activity within known habitat (U.S. Marine Corps 2018, pp. N-52–N-53).

Wildfire fuel management and fire prevention activities are also being implemented at Warner Springs under a Wildland Fire Management Plan, which includes maintaining or establishing fuel breaks and defense zones; however, these are not currently proposed in areas occupied by the Stephens' kangaroo rat (Service 2016, p. 17).

Similarly, activities conducted during prescribed burns (e.g., control or scratch line construction) can also directly or indirectly affect the Stephens' kangaroo rat and its habitat. Natural resource management programs identified in the Joint INRMP for Marine Corps Base and Marine Corps Air Station, Camp Pendleton includes a wildfire management element (U.S. Marine Corps 2018, pp. 4-35–4-38), the goal of which is to maintain natural ecosystem functioning while maximizing military training opportunities (U.S. Marine Corps 2018, p. 4-35). Camp Pendleton regularly conducts prescribed burns (at least every 4 years; U.S. Marine Corps 2018, p. P-7) to reduce vegetation volume, primarily in grassland habitat (Tetra Tech 2015, pp. 2, 41) depending on weather conditions and resource availability, including within the Stephens' kangaroo rat management area. The Service consults with base staff to ensure that conservation measures are implemented for prescribed burn projects, such as the timing of these activities (e.g., outside rainy periods) and the marking and creation of a buffer of burrows prior to ground-disturbing activities, to avoid collapsing or crushing of burrow systems (Service 2017, pp. 3–4).

We requested information on these types of activities within the Stephens' kangaroo rat Core Reserves in Riverside County. Wildfire suppression techniques that may result in direct impacts to the species (e.g., crushing or excavation of occupied burrows) are reported to be relatively rare within these reserves, and any potential impacts would only extend a few inches into the soil and therefore temporary since, for example, an individual animal would soon dig back out from a crushed burrow entrance (Shomo 2018c, pers. comm.). However, bulldozers used during wildfire suppression activities may cause long term scarring of the land surface (indirect effect), and the resulting "roadway" that bulldozers create may allow for easier entry of OHVs and other trespassers (secondary effect) (Shomo 2018c, pers. comm.). Prescribed burns have been conducted on the Core Reserves since the establishment of the reserves in 1996 to control vegetation to improve Stephens' kangaroo rat habitat (Shomo 2018d, pers. comm.). Reserve managers implementing prescribed burns generally use existing roads and hand cut scratch lines to limit the spread of a fire; thus, typically, no equipment enters the prescribed burn area unless absolutely necessary (Shomo 2018c, pers. comm.). Further, hand crews and hose lines are laid along the periphery of the burn plot, and hand held weed whackers are used for all shrubs and sensitive areas within the prescribed burn area (Shomo 2018c, pers. comm.).

Based on the best available information, we consider habitat modification due to fire suppression and prevention activities to be a low-level stressor to the Stephens' kangaroo rat and its habitat. Based on the history of implementation of avoidance and minimization measures within populations of the species (reserves and DOD lands), impacts are likely to remain low in the near future for at least the next 10 to 15 years.

6.4.4 Summary

Based on the best available information, we do not consider habitat modification due to nonnative ungulates to be a stressor to the species or its habitat. Habitat modification or destruction due to OHV activity and nonnative plants is limited in scope and scale and this activity is currently being managed within the Core Reserves established under conditions set out in the 1996 HCP (discussed above and in more detail in section 7.2.4), which is permitted through 2026. Wildfire and prescribed fire management activities (fire prevention and fire suppression) is currently considered to be a low-level stressor that may impact a few individuals and result in indirect impacts, some of which are likely to be temporary. In addition, in some portions of the species' range, avoidance/minimization measures as well as conservation measures related to fire suppression and prevention are being implemented through management actions. These are outlined in DOD INRMPs (San Diego County), which began incorporating measures for the Stephens' kangaroo rat since its listing under the Act. IRMPSs are reviewed/revised every 5 years. Management actions are also being implemented on Core Reserves in Riverside County under the HCP since their establishment in 1996. The low-level effects of these stressors are likely to be remain at this scope and scale for at least the next 10 years.

6.5 Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

In our final rule to list the Stephens' kangaroo rat (53 FR 38467), we did not identify this factor as applicable to the species. In our 2010 12-month finding (75 FR 51218), we determined that no new information indicated that overutilization was a threat to the species. Below, we present an updated review and analysis of this potential stressor.

Scientific Collecting Permits (SCPs) are required by the State of California for the take, collection, capture, mark, or salvage for scientific, educational, and non-commercial propagation purposes any plant or animal life in the state (California Fish & Game Code § 1002(a), 14 CCR 650). CDFW typically provides a higher level of scrutiny for SCP applications of scientific work with species that are designated as Special Animals, which includes the Stephens' kangaroo rat (CDFW 2018), than for SCP applications that target species that do not having any special status designation (Osborn 2015, pers. comm.). Such applications typically require a detailed study proposal and statement of qualifications indicating familiarity with the study species and methods to be used (Osborn 2015, pers. comm.).

These permits (Memorandums of Understanding (MOUs)) are issued under the authority of California Code of Regulations Title 14 Section 783.1(a), and California Fish and Game Code Section 2081(a) of the California Endangered Species Act (CESA), whereby through permits or MOUs, the CDFW may authorize individuals, public agencies, universities, zoological gardens, and scientific or educational institutions, to import, export, take, or possess any endangered species, threatened species, or candidate species for scientific, educational, or management purposes (Osborn 2018, pers. comm.). Individuals who work with the Stephens' kangaroo rat are also typically required to obtain a SCP because of the potential for capturing other species during live-trapping activities (Osborn 2018, pers. comm.).

As of June 2018, there were 29 individuals permitted through CDFW's research permit program to capture and release the Stephens' kangaroo rat, and since the State agency began tracking these types of permits in its SCP database, a total of 97 persons have been authorized to work with this species (Osborn 2018, pers. comm.). All of CDFW's listed-species MOUs require permittees to immediately report serious injuries or mortalities to the primary CDFW contact for the MOU; as of June 2018, no notification of serious injury or mortality for the Stephens' kangaroo rat has been received (Osborn 2018, pers. comm.).

6.5.1 Summary

Based on the best available information, we find that overutilization for commercial, recreational, scientific, or educational purposes is not a current or future stressor to the Stephens' kangaroo rat.

6.6 Disease

At the time of listing, disease was not identified as a threat to the Stephens' kangaroo rat, and in our 2010 12-month finding, we indicated that we had no new information to indicate that disease was a potential threat or would become a stressor to the species in the foreseeable future (75 FR 51218).

A number of ecto- and endo-parasites were identified for heteromyids in a review by Whitaker *et al*. (1993, entire), some of which can serve as disease vectors for rodents (e.g., fleas and ticks). For the Stephens' kangaroo rat, three species of chiggers (parasitic larvae of mites) were identified in this review (Whitaker *et al*. 1993, p. 442), and chiggers are abundant on heteromyids as a group (Whitaker *et al.* 1993, p. 408). Chiggers may cause skin irritation in humans and small mammals, and can transmit disease in humans (e.g., scrub typhus (Walker 2016, p. 913)). For the sometimes sympatrically-occurring species, *Dipodomys agilis* (Agile kangaroo rat), protozoans (8 species), chiggers (7 species), ticks (2 species), and fleas (1 species) have been observed (Whitaker *et al*. 1993, p. 442). However, the authors note that the low (or missing) numbers for some species may be the result of lack of collection (Whitaker *et al*. 1993, p. 466).

In our review of the literature, we found Kelt *et al*. (2005a, p. 271) reported no outward signs or symptoms of illness or heavy parasite loads for populations of trapped Stephens' kangaroo rat in southwestern Riverside County. Observations from populations near Lake Skinner did not report any fleas on trapped individuals (Shier 2010, p. 14). We reviewed incidental comments from Stephens' kangaroo rat monitoring reports for the Western Riverside County MSHCP (2005–2016) and found one account of potential disease and one report of fungus (Western Riverside County MSHCP Biological Monitoring Program 2017).

In addition, viruses can also infect heteromyid rodents (Whitaker *et al*. 1993, p. 393). Based on the best available data, a potential disease that may affect small mammals in southern California is West Nile virus. West Nile virus has been observed in California since 1999, and in Riverside and San Diego Counties since 2003 (from dead birds, sentinel chickens, horse, mosquito pools, and humans) (California West Nile Virus Website 2018). A relatively recent review of exposure of West Nile virus in wild mammals did not report exposure to this virus in kangaroo rats (Root 2012, entire), and, as of June 2018, this virus has not been documented in the Stephens' kangaroo rat.

6.6.1 Summary

In summary, other than incidental reports for a very small number of individuals, the best available data do not indicate that parasitic or other diseases is a current threat and we are not aware of information pointing to it becoming a future threat to the Stephens' kangaroo rat.

6.7 Predation

As noted above, the Stephens' kangaroo rat is natural prey to a number of native species (barn owls, great horned owls, coyotes, bobcat, San Diego gopher snake, and several species of rattlesnake (*Crotalus* sp.)), as well as nonnative species (e.g., domestic and feral cats). In our 1988 final listing rule, we stated that predation from feral and domesticated cats (*Felis catus*) was expected at areas of occurrence located adjacent to urban areas (53 FR 38467) and in our 2010 12-month finding, we also indicated that predation by domestic and feral cats may be impacting the Stephens' kangaroo rat in Riverside County due to the proximity of core reserves to urban areas and potentially higher levels of predation due to fragmentation of habitat (75 FR 51218). Increasingly smaller patch sizes may result in higher predation rates from feral cats because fewer coyotes are predating on the feral cats (Crooks and Soule 1999, p. 564). However, no supporting information was presented regarding the incidence or levels of predation. In our 2010 12-month finding, we also stated that there were no active management measures in place to eliminate or reduce potential predation from feral or domestic cats (75 FR 51218). We therefore determined in that finding that predation by feral and domestic cats was a threat to the species range wide, but primarily in Riverside County (75 FR 51218). Predation from native species has not been discussed in the literature and is not likely to rise above baseline conditions where it would be considered a stressor to the species.

Price and Kelly (1994, p. 815) reported one mortality of a female Stephens' kangaroo rat from a housecat. No other published information documenting this impact to the species was located during the preparation of this species report. We contacted a natural lands manager implementing conservation measures for the Stephens' kangaroo rat in Riverside County who reported that domestic (or feral) cats are not observed in the managed reserves and, further stated that coyotes, which occur in these areas, have been reported to prey upon cats (Burke *et al*. 1991), which would remove their presence (Shomo 2018, pers. comm.). We also reviewed USGS monitoring reports for Camp Pendleton (e.g., Brehme and Fisher 2008, 2009; Brehme *et al*. 2006 through 2017) as well as monitoring reports for this military facility prepared by Tetra Tech, Inc. (SKR Management Area Habitat Enhancement and Monitoring Summary Reports; 2008 through 2014) and did not find any report of mortality from feral or domestic cats.

6.7.1 Summary

Based on the best available information, predation, whether by native or nonnative animals, represents a low-level impact to individuals of the species, but is not likely to be a population or species level impact at the present time or expected to be in the future.

6.8 Use of Rodenticides

In our 12-month finding, we indicated that, while we did not know the magnitude of the threat of rodenticide exposure, we determined that rodenticide use was a rangewide threat to the Stephens' kangaroo rat because second-generation anticoagulants were commonly used as rodenticides targeting rats, mice, ground squirrels and other rodents, and found in many over-the-counter pest control products. Rodenticides were placed around burrows of nuisance species and may have been consumed by Stephens' kangaroo rat and other non-target species. This could have potentially occurred at State recreation areas that had rodent control programs (75 FR 51204, p. 51221). Based on new EPA restrictions and management practices described below, Stephens' kangaroo rat exposure to rodenticide has decreased since our 12-month finding.

We also stated that the use of rodenticides may have affected the Stephens' kangaroo rat at State recreation areas that were implementing rodent control programs and possibly at other locations where known Stephens' kangaroo rat populations have inexplicably disappeared (75 FR 51218). We indicated that direct exposure to rodenticides at bait stations by Stephens' kangaroo rats could be ameliorated in part from the use of elevated bait stations (Whisson 1999, p. 176), and the baiting of traps during daylight hours when kangaroo rats are inactive. However, we concluded that poison bait may fall to the ground or is cached at ground level by targeted species poses a threat to the Stephens' kangaroo rat if ingested during nocturnal foraging or encountered in use of abandoned burrows (75 FR 51218). No supporting information was presented documenting the extent of this threat to the Stephens' kangaroo rat. In addition, we also stated that within the Lake Perris State Recreation Area, California State Parks (California Department of Parks and Recreation) no longer uses rodenticides for rodent control (citing Kietzer 2010; [pers. comm.]).

The rodenticide products that are currently available for consumers are ready-to-use bait stations that contain and/or are packaged with a rodenticide bait in block or paste form, and pelleted baits are no longer permitted to be used in rodenticide products targeted for consumer markets (Environmental Protection Agency (EPA) 2018, p. 1). The bait components of the ready-to-use bait station products currently registered for the consumer market to control mice and/or rats contain one of the following rodenticides; bromethalin, chlorophacinone, and diphacinone, and are first-generation rodenticides (those developed prior to 1970) (EPA 2018 p. 1). These are different than the second-generation rodenticides (those developed in the 1970s to control rodents that are resistant to first-generation rodenticides). We listed three of these second-generation rodenticides in our 2010 12-month finding (brodifacoum, bromadialone, and difethialone), which we said was found in "many over-the-counter pest control products." (75 FR 51221). This is no longer accurate. In addition, these ready-to-use bait station consumer products are labeled for use as either (1) indoors, or (2) indoors and outdoors within 50 feet of buildings (EPA 2018, p. 2). Thus, they are not likely to be broadcast widely outside non-urban areas, such as in natural reserve lands or other protected areas (e.g., military installations) that support the Stephens' kangaroo rat.

We contacted a reserve manager for Riverside County regarding this threat, who indicated that in the past (circa 30 years ago), rodenticides were used in orchards found in this region to prevent damage from rodents (Shomo 2018, pers. comm.). However, much of these areas have been converted to other land uses (Shomo 2018, pers. comm.); thus, the use of rodenticides for commercial/agricultural purposes has likely been reduced.

Finally, we note here that restricted use pesticides are not available for purchase or use by the general public (40 CFR Part 152.160–152.175), which includes brodifacoum. In California, the Pesticide Registration Branch of the California Environmental Protection Agency, Department of Pesticide Regulation (DPR) is responsible for product registration and coordinates the required evaluation process among DPR branches and other state agencies; a pesticide (including a rodenticide) must be registered (licensed) with the state before it can be used, possessed, or offered for sale in California (DPR 2018a). In the DPR's "*Final Decision Regarding Renewal of Registration of Pesticide Products for 2018*," the agency reported, in response to comments received regarding reevaluation of anticoagulant rodenticides, the following (DPR 2018b, p. 2):

> "In July of 2014 DPR concluded its reevaluation of brodifacoum by designating all SGARs [second-generation anticoagulant rodenticides] as California restricted materials in 3 [California Code of Regulations] CCR section 6400(e) and placing additional restrictions in 3 CCR section 6471 on the use of SGARs that are **more stringent** than federal label requirements. DPR is in the process of reviewing data submitted by the California Department of Fish and Wildlife and wildlife organizations to evaluate the impact of the regulations and determine if significant adverse effects to non-target wildlife continue to occur and to what extent. This

review is ongoing. If data indicate that additional regulatory action is necessary to further protect non-target wildlife from anticoagulant rodenticide use, DPR will proceed with that action." [emphasis added]

Additional discussion of the DPR's Pesticide Use Limitations actions related to its Endangered Species Program is presented below in Section 7.0, Regulatory Mechanisms and Management/Conservation Measures.

We also reviewed documents relative to rodenticide use at military installations where the Stephens' kangaroo rat is currently found. At Naval Seal Beach, Detachment Fallbrook, rodenticide baiting and other chemical rodent control methods have apparently not been routinely authorized since the mid-2000s; however, due to reported rodent infestations in some buildings, an integrated pest management approach that may include potential authorization of certain rodenticides in specific locations is currently being reviewed (U.S. Navy 2016, p. 4-116).

6.8.1 Summary

Based on the best available information, we find that the risk of mortality or injury as a result of the used of rodenticides represents a low-level risk at the individual level at the present time and most likely the same in the future.

6.9 Wildfire

Wildfire is a natural, environmental event in much of California (Sugihara and Barbour 2006, pp. 1–2) and is considered to be a keystone ecological process in ecosystems across the entire State (Minnich 2006, pp. 16, 24). In California, the typical 3 to 6-month annual drought condition during the summer months promotes highly favorable conditions for wildfire ignition and spread (Keeley *et al*. 2012, p. 5). Wildfire ignitions by lightning, primarily in July and August, are also part of California's annual fire pattern, particularly along the Peninsular Ranges of southern California and into the eastern crest of the Sierra Nevada and desert areas (Minnich 2006, pp. 22–23; Keeley *et al*. 2012, pp. 130–131). Stephens *et al*. (2007, pp. 212–213) concluded that, historically, a large amount of area within California burned each year, noting that smoky skies were likely experienced in the summer and fall seasons in California based on accounts in the literature. Given the historical presence of periodic wildfire events in parts of southern California, habitat enhancement efforts at, for example, Camp Pendleton, have included prescribed fire, which can be an effective management action for providing open ground and vegetative conditions (i.e., mosaic habitats) that are characteristic of suitable habitat for the Stephens' kangaroo rat (Tetra Tech, Inc. 2015, p. 9). However, more recently, wildfires in California have burned more area, have occurred more frequently, often due to human ignitions (e.g., 97 percent of wildfires attributed to human-causes in Mediterranean ecoregion of California (1992 to 2012) (Balch *et al*. 2017, p. 2,947), and, in some areas, have increased in severity due to warmer temperatures and prolonged drought conditions/decreased precipitation (Wehner *et al*. 2017; Holden *et al*. 2018).

6.9.1 Evaluation of Wildfire—Direct, Short-term Effects

Fire, both wildland fire and prescribed fire, can have direct effects to small mammals including mortality and loss of resources such as nest sites (Price *et al*. 1995, p. 52). In general, these direct effects are short-lived, and can be significant (direct killing) or can be negligible for species that can escape into protected areas or move away from fire (Price *et al*. 1995, p. 51).

Within chaparral and coastal sage scrub plant communities in central and southern California, rodents are considered to be well-adapted to periodic, very high-intensity fire events (Bond 2015, p. 95). Individuals that are highly mobile, such as kangaroo rats, are able to survive intense fires by moving to underground burrows (Lyon *et al*. 2000, p. 28) where temperatures remain cool and ambient air clean (Bond 2015, p. 95).

In an experimental study to evaluate the effect of fire to the Stephens' kangaroo rat using controlled burns at the Lake Perris State Recreation Area (western Riverside County), no short-term effects on survival were observed, likely due to their ability to escape underground (Price *et al*. 1995, p. 55). The study also concluded that there were no short-term effects of fire on the availability of seeds as there was no significant decline in densities of viable seeds after the fires and only a small proportion of charred seeds were observed (Price *et al*. 1995, p. 55).

6.9.2 Evaluation of Wildfire—Indirect, Long-term Effects

Indirect or long-term effects of fire (3 years of censuses, with three separate controlled burns) to the Stephens' kangaroo rat were also evaluated by Price *et al*. (1995, entire). In this study, controlled fire was found to have a positive effect on populations of the species, which persisted for at least 2 years (Price *et al*. 1995, p. 57). The authors concluded that the observed long-term benefit of fire to the Stephens' kangaroo rat was the result of an increase in bare ground, in concert with minimal effects on prostrate forbs (Price *et al*. 1995, p. 56). They note, however, that this benefit is more likely to result from late spring fires, which are effective in promoting a habitat structure that is dominated by bare ground and sparse, low-growing forbs (i.e., suitable habitat) rather than plants that grow upright (Price *et al*. 1995, p. 57).

As described above (see section 3.3.2.1 Effects of Habitat Management Actions) Shier and Swartz (2012, p. 18) reported that, based on short-term responses of vegetation to their experimental treatments, prescribed fire, combined with post-fire herbicide application and planting of native grass seedlings, provides the best habitat for the Stephen's kangaroo rat at sites located on and adjacent to the Southwestern Riverside County Multi-species Reserve. Similarly, at Camp Pendleton, the use of several and repeated treatments (mechanical, chemical, and prescribed fire) for improving habitat of the Stephens' kangaroo rat were reported as providing more effective long-term effects for the suppression of grass regeneration than short-term treatments (Tetra Tech Inc. 2015, p. 42).

Several studies have also evaluated effects of fire to other species of kangaroo rats in southern California. A recent study (Hulton VanTassel and Anderson 2018, entire) evaluated post-fire effects to movement patterns of the Merriam's kangaroo rat (*Dipodomys merriami*) in the Mojave Desert of southern California, a species that has a wide distribution in desert and arid grassland habitat in southwestern North America (Williams *et al*. 1993, p. 57) and which uses a wider range of substrates than other kangaroo rats (Hulton VanTassel and Anderson 2018, p. 690). This study, which was conducted during drought years, found that Merriam's kangaroo rats increased their movements within burned areas considered to be spatially heterogeneous as compared to homogenous burned and unburned areas (Hulton VanTassel and Anderson 2018, p. 690). The authors concluded that this species appears to adapt readily to this type of altered habitat, even though it has not evolved with wildfire events (Hulton VanTassel and Anderson 2018, p. 690).

Similarly, an evaluation of the effects of two large fires (2003 Cedar and Otay fires) in San Diego County within coastal sage scrub, grassland, chaparral, and woodland habitat occupied by the Dulzura kangaroo rat (*Dipodomys simulans*) (but not the Stephens' kangaroo rat) found that this species increased in relative abundance in burned areas (coastal sage scrub and chaparral) (Brehme *et al*. 2011b, p. 92). For this species, which is also a seed-eating, burrowing heteromyid, the authors concluded that fire created more suitable habitat by removing dense vegetation and exposing seeds (Brehme *et al*. 2011b, p. 92).

Finally, in an earlier post-fire study of rodent abundance at the Motte Rimrock Reserve in western Riverside County (Price and Waser 1984, entire), researchers found that the Agile kangaroo rat (*Dipodomys agilis*) was consistently observed to be more abundant in burned sites as compared to unburned sites (Price and Waser 1984, p. 1165), likely due to the changes in vegetation (more open spaces) that support this and other species of kangaroo rats, including the Stephens' kangaroo rat.

6.9.3 Conclusion

Based on the best available information, the effects of wildland or prescribe fire, due to either direct loss of habitat or indirect effects, can provide important benefits in maintaining suitable habitat for the Stephens' kangaroo rat, and is not currently a stressor to individuals. In addition, wildland fire management plans and wildfire suppression/prevention activities are being implemented (see section 6.4.3) within portions of the current potential extent of occurrence area for the species. These actions reduce the potential for wildfire and help protect and enhance natural resources. For example, Warner Springs has prepared a Wildland Fire Management Plan (WFMP) that augments other relevant jurisdictional landowner planning documents (e.g., Cleveland National Forest) and provides specific wildfire management guidance for the military use activities that occur within the boundaries of the Warner Springs (Tierra Data, Inc. *et al*. 2015, p. i).

While there is some uncertainty as to the level, intensity, and timing of wildfires across the species landscape in the future, given that management measures to control for wildfire have been implemented within reserve and management areas since the late 1990s, we can reliably predict it to be a very low effect stressor to its habitat for the next 20 years.

6.10 Climate Change

In this section, we consider observed or likely environmental changes resulting from ongoing and projected changes in climate. As defined by the Intergovernmental Panel on Climate Change (IPCC), the term "climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2013a, p. 1450). The term "climate change" thus refers to a change in the mean or the variability of relevant properties, which persists for an extended period, typically decades or longer, due to natural conditions (e.g., solar cycles) or human-caused changes in the composition of atmosphere or in land use (IPCC 2013a, p. 1450).

Scientific measurements spanning several decades demonstrate that changes in climate are occurring. In particular, warming of the climate system is unequivocal and many of the observed changes in the last 60 years are unprecedented over decades to millennia (IPCC 2013b, p. 4). The current rate of climate change may be as fast as any extended warming period over the past 65 million years and is projected to accelerate in the next 30 to 80 years (National Research Council 2013, p. 5). Thus, rapid climate change is adding to other sources of extinction pressures, such as land use and invasive species, which will likely place extinction rates in this era among just a handful of the severe biodiversity crises observed in Earth's geological record (American Association for the Advancement of Sciences (AAAS) 2014, p. 17).

Comprehensive assessments of other observed and projected changes in climate and associated effects and risks, and the bases for them, are provided for global and regional scales in recent reports issued by the IPCC (2013c, 2014), and similar types of information for the United States and regions within it can be found in the National Climate Assessment (Melillo *et al*. 2014, entire). Results of scientific analyses presented by the IPCC show that most of the observed increase in global average temperature since the mid-20th century cannot be explained by natural variability in climate and is "extremely likely" (defined by the IPCC as 95 to 100 percent likelihood) due to the observed increase in greenhouse gas (GHG) concentrations in the atmosphere as a result of human activities, particularly carbon dioxide emissions from fossil fuel use (IPCC 2013b, p. 17 and related citations).

Scientists use a variety of climate models, which include consideration of natural processes and variability, as well as various scenarios of potential levels and timing of GHG emissions, to evaluate the causes of changes already observed and to project future changes in temperature and other climate conditions. Model results yield very similar projections of average global warming until about 2030, and thereafter the magnitude and rate of warming vary through the end of the Century depending on the assumptions about population levels, emissions of GHGs, and other factors that influence climate change. Thus, absent extremely rapid stabilization of GHGs at a global level, there is strong scientific support for projections that warming will continue through the 21st century, and that the magnitude and rate of change will be influenced substantially by human actions regarding GHG emissions (IPCC 2013b, 2014; entire).

Global climate projections are informative, and, in some cases, the only or the best scientific information available for us to use. However, projected changes in climate and related impacts can vary substantially across and within different regions of the world (e.g., IPCC 2013c, 2014; entire) and within the United States (Melillo *et al*. 2014, entire). Therefore, we use "downscaled" projections when they are available and have been developed through appropriate scientific procedures, because such projections provide higher resolution information that is more relevant to spatial scales used for analyses of a given species (see Glick *et al*. 2011, pp. 58–61, for a discussion of downscaling).

Further, future projections are generally summarized for a given future scenario (e.g., Representative Concentration Pathways (RCP) 8.5 or RCP 4.5) over a range of future climatological times, such as temperature change in 2040–2079 or 2070-2099 relative to 1980–2009 (U.S. Global Change Research Program (USGCRP) 2017, p. 139). This approach has an advantage of developing projections for a specific time horizon, however, the uncertainty in future projections is relatively high; that is, it incorporates both the uncertainty that results from multiple scenarios as well as uncertainty relative to the response of the climate system to human-caused emissions (USGCRP 2017, p. 139). Additionally, as one goes further out in time for these projections, the uncertainties increase (USGCRP 2017, p. 139). Therefore, analyses of projected changes use these transient, scenario-based simulations for a given global mean temperature threshold by extracting a time slice (typically 20 years) that is centered around the point in time at which that change is reached (USGCRP 2017, p. 139; Figure 4.2). A 30-year period is commonly used to better characterize the background state of observed climate around which anomalous conditions and even extremes occur (Arguez *et al*. 2012, p. 1687).

6.10.1 Current Trends–Temperature and Precipitation

According to the recent California Climate Change Assessment for the Los Angeles region, temperature has increased across southern California over the past century (Hall *et al*. 2018, p. 9). Southern California is already experiencing more frequent and intense heat waves (Kalansky *et al*. 2018, p. 23). Sustained record warmth has also been observed recently for the California South Coast Climate Division, with the top five warmest years (annual average temperature) occurring since 2012, where 2014 was the warmest year, followed by 2015, 2017, 2016, and 2012 (Hall *et al*. 2018, p. 9; data accessible at https://www.ncdc.noaa.gov/temp-and-precip/climatological-rankings/).

Regional temperature observations for assessing climate change are often used as an indicator of how climate is changing. The Western Regional Climate Center (WRCC) has defined 11 climate regions for evaluating various climate trends in California (Abatzoglou *et al*. 2009, p. 1535). The relevant WRCC climate region for the distribution of the Stephens' kangaroo rat in southern California is primarily the Southern Interior region, with some populations (Camp Pendleton, Detachment Fallbrook) occurring in the South Coast region.

Two indicators of temperature, the increase in mean temperature and the increase in maximum temperature, are important for evaluating trends in climate change in California. Using California Climate Tracker data (WRCC 2018b), we present in Table 4 a summary of trends in temperature departure for the Southern Interior and South Coast climate regions. All estimated trends from this data set indicate an increase in both mean and maximum temperatures for these two climate regions.

Similarly, for California's South Coast Climate Division, using the 1896–2015 period of record, significant increasing trends in annual average temperature (increase of 0.29°F (0.16°C) per decade), as well as maximum and minimum temperature were reported by He and Gautam (2016, pp. 11, 15). The Climate Change Assessment also reports that, in this same region, every month has experienced significant positive trends in monthly average, maximum, and minimum temperature, with monthly average and minimum temperatures increasing the most in September and monthly maximum temperatures increasing the most in

January (Hall *et al*. 2018, p. 9). It is logical to assume the observed rate of temperature increases are due to the increased use of fossil fuels in the mid-to-late-20th and early 21st centuries and the accumulated effect of GHG emissions.

Table 5. Temperature Departures Summaries, Southern Interior and South Coast Climate Regions (100-year trends). Source: Climate Tracker**.**

	Linear Trend/100 year†	**Linear Trend/100 year**†
Climate Region	**Mean Temperature Departure (Jan-Dec)**	**Maximum Temperature Departure (Jan-Dec)**
Southern Interior		
Since 1895	**+1.79°F** (± 0.46°F) (0.99°C (± 0.25°C))	**+1.52°F** (± 0.56°F) (0.84°C (± 0.31°C))
Since 1949	**+3.27°F** (± 1.10°F) (1.82°C (± 0.61°C))	**+2.60°F** (± 1.30°F) (1.44°C (± 0.72°C))
Since 1975	**+2.57°F** (± 2.34°F) (1.43°C (± 1.30°C))	**+2.71°F** (± 1.10°F) (1.50°C (± 0.61°C))
South Coast		
Since 1895	**+2.77°F** (± 0.48°F) (1.54°C (± 0.27°C))	**+2.05°F** (± 0.52°F) (1.14°C (± 0.29°C))
Since 1949	**+4.41°F** (± 1.16°F) (2.45°C (± 0.64°C))	**+3.43°F** (± 1.27°F) (1.90°C (± 0.71°C))
Since 1975	**+3.12°F** (± 2.53°F) (1.73°C (± 1.40°C))	**+2.30°F** (± 2.67°F) (1.28°C (± 1.48°C))

†Note the large standard deviations for several values indicating less precision in these estimated trends. Source: WRCC 2018b.

Precipitation patterns can also be used as an indicator of how climate is changing. Killam *et al*. (2014, entire) evaluated trends in precipitation for 14 meteorological stations within all of California using annual precipitation data from the National Climatic Data Center (NCDC). They found an increasing trend in annual precipitation since 1925 for the northern and central regions of California, and decreasing or minimal changes in southern California; however, none of the trends for these stations were significant (Killam *et al*. 2014, p. 171). Similarly, He *et al*. (2018, p. 18) found no statistically significant increasing or decreasing trend in historical precipitation across 10 study regions in California. Killam *et al*. (2014, p. 168) concluded that it is unclear as to whether there is a recognizable climate change signal in these precipitation records since annual variability in precipitation overwhelmed their observed trends, particularly precipitation patterns attributed to both the ENSO (as described above in Physical Setting section) and the Pacific Decadal Oscillation (or PDO) (i.e., multidecadal shifts in warm and cool phases in North Pacific sea surface temperatures).

California is known for extremes relative to precipitation patterns (Kalanksy *et al*. 2011, p. 24), including the record-setting 2012–2015 drought and flooding in 2017 (He *et al*. 2018, p. 2). A study by Williams *et al.* (2015, entire) estimated the anthropogenic contribution to California's drought during 2012–2014. They found that the intensifying effect of high potential evapotranspiration on this drought event (measured by summer PDSI) was almost entirely the result of high temperatures (18–27 percent in 2012–2014; 20–26 percent in 2014) (Williams *et al*. 2015, p. 6,825). Another study evaluating the influence of temperature on the drought in water year 2014 in California found that, although the low level of precipitation was the primary driver for the drought conditions, temperature was an important factor in exacerbating the drought, noting that the water year 2014 was the third year of the multiyear drought event and therefore conditions were drier than normal at the beginning of the water year (Shukla *et al*. 2015, p. 4,392).

6.10.2 Future Projections

Although these observed trends provide information as to how climate has changed in the past, climate models can be used to simulate and develop future climate projections. In a recent study, He *et al*. (2018, entire) evaluated potential changes in future precipitation, temperature, and drought across 10 hydrologic regions in California. This study represents a new assessment of the changes from historical baseline and presents trends of projected precipitation and temperature as well as trends in projected drought for California (He *et al*. 2018, p. 2). The study used 10 hydrologic study regions as defined by the California Department of Water Resources (He *et al*. 2018, pp. 2–3; Figure 1); populations of the Stephens' kangaroo rat are located entirely within the South Coast region.

Wilkening *et al.* (2019, p. 3) used an ecological niche model (MaxEnt) to model future and current climatic niche for Stephens' kangaroo rat. Future models predicted substantial loss in future niche suitability and potential distribution with increasing emissions (RCP 2.6- RCP 8.5) by 2050 (Wilkening *et al*. 2019, p. 5). The distribution models project a reduction and geographic shift towards the coast in available habitat across all emissions scenarios. Under the RCP 4.5 and 8.5 models, the amount of modeled climatic niche suitability area decreased by roughly 46 percent and 66 percent respectively. The biggest predictors of the climatic niche identified by the modeling results included precipitation of the driest month, annual mean temperature, and maximum temperature of the warmest month. The paper discusses how California grasslands are classified as mid to high vulnerability to climate change, and points to other research that predicts a 16-48 percent reduction in grassland habitats in southern California by 2100 (Wilkening *et al.* 2019, p. 7). A climate driven shift in vegetation community composition previously ideal for Stephens' kangaroo rat would very likely impact the species in the future because its sole habitat is forb-dominated grasslands.

In their study, He *et al*. (2018, p. 4) evaluated historical and projected precipitation and maximum and minimum temperature data, and developed projections for 2020–2099 based on climate model simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5). Twenty individual projections from 10 Climate Circulation Models (GCMs) under RCP 4.5 (moderate emissions) and RCP 8.5 (high emissions) scenarios. These projections were then downscaled to a high spatial resolution at approximately 3.75 by 3.75 mi (6 by 6 km) (or 1/16th of a degree) in order to ensure that the spatial variability of the climate was considered (He *et al*. 2018, pp. 4–5). The study used two 40-year future periods, mid-century (2020–2059) and late-century (2060–2099), which were compared to a historical (baseline) period of 1951–1990 (He *et al*. 2018, p. 6).

Temperature projections: When compared to their defined baseline conditions, the study found that increases in both maximum and minimum temperatures are expected in both future periods across all regions of California (He *et al*. 2018, p. 10). Comparing differences between baseline and future projections, the study found that, under the RCP 4.5 scenario, mean annual maximum and minimum temperatures for the South Coast region are expected to increase by 3.6°F (2°C) by mid-century and 4.32°F (2.4°C) by late-century (He *et al*. 2018, p. 12; Figure 6). Under the RCP 8.5 scenario, the mean annual minimum temperature in the mid-century is projected to increase by 5.22°F (2.9°C) by mid-century and by 8.1°F (4.5°C) by late-century (He *et al*. 2018; p. 12; Figure 6). Similarly, the mean annual maximum temperature under this emissions scenario is expected to increase by 5.4°F (3.0°C) and by 8.1°F (4.5°C) by late-century (He *et al*. 2018; p. 12; Figure 6).

The recent California's Fourth Climate Change Assessment for the San Diego Region presents a similar estimate of projected changes in temperature (Kalansky *et al*. 2018, entire). That assessment also used the RCP 4.5 and 8.5 emission scenarios and 10 GCMs and variables of interest were selected from the coarse-scale global model simulations for downscaling to finer grid cells of approximately 4 mi (6 km) (Kalansky *et al*. 2018, p. 18). Projections were developed for the end of the 21st century (2100). Results indicate that yearly average temperatures are projected to increase by about 4 to 6 ºF (2.2 to 3.3 ºC) by the end of the century under the RCP 4.5 scenario or 7 to 9 ºF (3.9 to 5 ºC) under RCP 8.5 (Kalansky *et al*. 2018, p. 19; Figure 2). The San Diego coastal zone is projected to experience less change in temperature than the inland areas (Kalansky *et al*. 2018, p. 19; Figure 4). For western Riverside County, similar trends are projected: increase of about 4°F (2.2°C) by mid-century and 5 to 6°F (2.8 to 3.3°C) by the late-century under the RCP 4.5 emissions scenario, and increase of 5 to 7°F (2.8 to 3.9°C) by mid-century and 8 to 9° F (4.4 to 5°C) by late century under the RCP 8.5 emissions scenario (Hall *et al*. 2018, p. 11; Figure 3).

Results from Wilkening *et al*. (2019, p. 6) conducted in Climate Wizard (Medium A1B emission scenario) also predict increases in temperature (2-3°C) by mid-century (2046-2065). Higher temperatures may affect Stephens' kangaroo rat individuals directly by reducing foraging, dispersal, survival, fecundity, or population recruitment, although more research is needed (Wilkening *et al*. 2019, p. 7). Stephens' kangaroo rats are known to alter reproduction strategies during changing environmental conditions, and it is unknown what impacts climate change will have on future fecundity rates. Wilkening *et al*. (2019, p. 7) describes research where higher daily surface temperatures decreases apparent survival of the banner-tailed kangaroo rat (*D. spectabilis*). Warmer nights may also increase predation or competition rates.

Precipitation projections: He *et al*. (2018, pp. 8, 10) found that all regions in California are projected to experience increases in precipitation during the wet season (November to April) under both the RCP 4.5 and 8.5 emissions scenarios when compared to baseline conditions. Most regions are also expected to see an increase in annual precipitation, with the South Coast region experiencing a slight increase (+1.1 percent) under RCP 4.5 scenario by mid-century, but no increase by late-century (He *et al*. 2018, pp. 8–9; Figure 4a, 4c). Under the RCP 8.5 scenario, annual precipitation projections for the South Coast region indicate a slight decline (−0.1

percent) for mid-century and a slight increase (+1.4 percent) in late-century (He *et al*. 2018, p. 10; Table 3).

The Climate Change Assessment for both the San Diego and Los Angeles regions indicate that the already inherent volatility in precipitation will intensify in the future with increasing global warming, but drought events are also projected to become more frequent and intense (Hall *et al*. 2018, p. 13; Kalansky *et al*. 2018, pp. 24, 25).

Results from the analysis conducted in Climate Wizard (Medium A1B emission scenario) by Wilkening *et al*. (2019, p. 6) indicate a decrease in precipitation (100 mm), erosivity, and more arid conditions by 2065. Dryer conditions coupled with more extreme heat will lead to increases in fire frequency. Increases in the natural fire regime frequency and severity can hasten shifts in vegetation community composition (Wilkening *et al*. 2019, p. 7). A study documented large changes in community composition after large fires in San Diego County, in part because of an increases of invasive annual grasses (Zedler *et al.* 1983, pp. 814-818). Increases in drought and aridity in part could cause permanent changes in the vegetation community composition. Predicted changes in soil erosivity could impact vegetation and negatively affect Stephens' kangaroo rat populations because of their specific soil requirements (Wilkening *et al*. 2019, p. 7).

6.10.3 Summary

In summary, climate change due to global warming is influencing regional climate patterns that may result in changes to the habitat for the Stephens' kangaroo rat in the future. For the South Coast and Southern Interior regions of California occupied by the Stephens' kangaroo rat, climate model projections (mid- and late-century) indicate moderate increases in temperature, and a slight increase in precipitation but with more volatility. Stressors can also work in concert with one another to cumulatively create conditions that may impact the Stephens' kangaroo rat or its habitat beyond the scope of each individual stressor. The best available data indicate that cumulative impacts are currently occurring from the combined effects from climate-related changes associated with drought conditions and increasing surface temperatures with an increase in the likelihood of wildfires. An expected increase in temperature in the region before the end of this century will take place in concert with any changes in land use and other environmental factors that may alter Stephens' kangaroo rat habitat.

Impacts from the forecasted climate models described above would impact the SKR in the future. Increase in precipitation volatility and temperature extremes would increase favorable habitat conditions for the SKR by hampering vegetation growth and subsequent thatch buildup while increasing bare ground patches. According to niche suitability modeling by Wilkening *et al.* (2019, p. 5) Stephens' kangaroo rat habitat is predicted to decrease and shift westward. Increases in drought events could also impact fire regimes and could cause more intense wildfires, causing an increase in nonnative grasses and complex impacts that are described above in Section 6.9.

Results from two vulnerability assessments (System for Assessing Vulnerability of Species (SAVS) and Climate Change Vulnerability Index (CCVI)) indicated the Stephens' kangaroo rat is not extremely vulnerable to climate change, and relatively resilient to direct effects of climate change (Wilkening *et al*. 2019, p. 8). Increased fire frequency due to altered climate change regimes may negatively impact Stephens' kangaroo rats that may require natural resource managers to adjust their frequency of disturbance events. Having Stephens' kangaroo rats occupy spatially and topographically complex habitat will help buffer the negative effects of climate change.

Based on the best available regional data on current and potential future trends related to climate change within locations occupied by the Stephens' kangaroo rat indicate that the effects of climate change are a low to moderate stressor at the present time to its habitat. Based on model projections, we can reliably predict this will continue until at least the mid- to late-21st century (~2060 to 2100).

7.0 Regulatory Mechanisms and Management/Conservation Measures

7.1 Federal Mechanisms

7.1.1 Endangered Species Act

Since listing, the Act is the primary Federal law providing protection for the Stephens' kangaroo rat. The Service's responsibilities for administering the Act include sections 6, 7, 9, and 10. Section 7(a)(1) of the Act requires all Federal agencies to utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of endangered and threatened species. Section 7(a)(2) of the Act requires Federal agencies, including the Service, to satisfy two standards in carrying out their program. Federal agencies must ensure that actions they fund, authorize, or carry out are not likely to (1) jeopardize the continued existence of any listed species or (2) result in the destruction or adverse modification of designated critical habitat. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution (50 C.F.R. § 402.02).

The Cooperative Endangered Species Conservation Fund (Conservation Fund), under section 6 of the Act, provides grants to States and Territories to participate in voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to States and Territories for species and habitat conservation actions on non-Federal lands. Four grant programs are available through this Conservation Fund: (1) Conservation Grants, (2) Habitat Conservation Plan Assistance Grants, (3) Habitat Conservation Plan Land Acquisition Grants, and (4) Recovery Land Acquisition Grants.

In San Diego County, these grant programs, along with State, County, and private funding, have resulted in the acquisition of approximately 3,200 ac (1,295 ha) of lands for the Ramona Grasslands area. We evaluated these lands relative to our estimated modeled habitat for the Stephens' kangaroo rat within these acquisitions and determined approximately 1,137 ac (460 ha) were identified as modeled habitat.

The Service has an extensive section 7(a)(2) consultation history with Federal agencies such as the Forest Service (e.g., Service 2013, entire) and DOD installations (e.g., Service 2009; 2016; 2017) for evaluating effects of proposed actions to the Stephens' kangaroo rats. Examples of conservation measures identified in both formal and informal consultations such as avoidance of burrows and timing of proposed actions were described above. For projects without a Federal nexus that may result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B).

Issuance of a section 10(a)(1)(B) permit for a Habitat Conservation Plan is a Federal action subject to compliance under section 7(a)(2). The SKR HCP in western Riverside County is a regional habitat conservation planning effort to guide the recovery of the Stephens' kangaroo rat and, on May 2, 1996, the Service completed an intra-agency biological opinion and issued an Incidental Take Permit for a 30-year term for the SKR HCP under section 10(a)(1)(b) of the Act. The SKR HCP provides for protection of Core Reserves and adaptive management of Stephens' kangaroo rat habitat to ameliorate impacts to the species from habitat fragmentation and degradation associated with development (75 FR 51212). The Core Reserves were assembled from a combination of State and Federal lands, lands already in conservation status, lands acquired by the RCHCA, and other cooperative partnerships (75 FR 51212). The SKR HCP required the conservation of 15,000 ac (6,070 ha) of Stephens' kangaroo rat occupied habitat in seven Core Reserves within the 533,954-ac (216,083-ha) plan area. In our 2010 12-month finding, we presented the 1996 estimated area conserved within the Core Reserves (41,211 ac (16,682 ha) (75 FR 51212). Recent survey results for the Stephens' kangaroo rat within these reserves are summarized in section 5.2.

The Western Riverside County MSHCP is a large-scale, multi-jurisdictional NCCP/HCP permitted under section 10(a)(1)(B) of the Act and is discussed in more detail below.

7.1.2 Sikes Act

The Sikes Act (16 U.S.C. 670a–670f, as amended) directs the Secretary of Defense, in cooperation with the Service and State fish and wildlife agencies, to carry out a program for the conservation and rehabilitation of natural resources on military installations. The Sikes Act Improvement Act of 1997 (Public Law 105–85) broadened the scope of military natural resources programs, integrated natural resources programs with operations and training, embraced the tenets of conservation biology, invited public review, strengthened funding for conservation activities on military lands, and required the development and implementation of an INRMP for relevant installations, which are reviewed every 5 years. Following the Base Realignment and Closure Act of 1988, military training and testing activities have intensified, and subsequent realignment and closure actions have resulted in the accommodation of more troops, many rotations, and training activities on the remaining installations, and which face continued pressure to sustain their ranges and maintain military readiness while remaining stewards of the land (Benton *et al*. 2008, p. 93). The INRMP process aims to balance an installation's various activities and land uses with its military mission requirements (Benton *et al*. 2008, p. 93).

INRMPs incorporate, to the maximum extent practicable, ecosystem management principles, provide for the management of natural resources (including fish, wildlife, and plants), allow multipurpose uses of resources, and provide public access necessary and appropriate for those uses without a net loss in the capability of an installation to support its military mission. Although an INRMP is technically not a regulatory mechanism because its implementation is subject to funding availability, an INRMP is an important guidance document that helps to integrate natural resource protection with military readiness and training. In addition to technical assistance that the Service provides to the military, the Service can enter into interagency agreements with installations to help implement an INRMP. The INRMP implementation projects can include wildlife and habitat assessments and surveys, fish stocking, exotic species control, and hunting and fishing program management.

On DOD lands, including Camp Pendleton, Warner Springs, and Detachment Fallbrook, Stephens' kangaroo rat habitat is generally not subjected to threats associated with large-scale development. However, the primary purpose for military lands, including most Stephens' kangaroo rat habitat areas, is to provide for military support and training. At these installations, INRMPs provide direction for project development and for the management, conservation, and rehabilitation of natural resources, including for the Stephens kangaroo rat and its habitat. March ARB in Riverside County was also previously occupied by Stephens' kangaroo rat but is currently believed to be extirpated from the base (USAF 2012, p. 3-32).

Camp Pendleton

A (revised) joint INRMP for Camp Pendleton and Marine Corps Air Station Camp Pendleton was finalized in March 2018 (U.S. Marine Corps 2018, entire). The Stephens' kangaroo rat is found on Camp Pendleton, but not the Air Station. The joint INRMP provides guidance for implementing a natural resource program that is consistent with the military mission at Camp Pendleton, while providing for the conservation, rehabilitation, and sustainable multipurpose use of natural resources (U.S. Marine Corps 2018, p. ES-1).

A number of Biological Opinions have been prepared by the Service to address effects of proposed projects on Camp Pendleton for Stephens' kangaroo rat and other threatened or endangered species. A mitigation bank was established in the Juliet Training Area in the northeast section of the facility (Juliet bank) to address base-wide impacts to the Stephens' kangaroo rat (U.S. Marine Corps 2018, p. 3-63). In addition to prescribed burns, habitat enhancement and monitoring activities have been conducted at the Juliet bank. For example, human-made burrows were created at the site following a prescribed burn in 2011, and translocation of populations of the Stephens' kangaroo rat have been conducted (U.S. Marine Corps 2018, p. 3-63). These translocation studies are summarized above (see also Brehme *et al.* 2017). The INRMP presents several natural resource management programs relevant to the conservation of the Stephens' kangaroo rat along with a complete list of supporting actions planned for the most current INRMP term (2018–2023) (U.S. Marine Corps 2018, pp. 4-1–4-65 and Appendix P). Management and monitoring measures specific to the Stephen's kangaroo rat and its habitat are also outlined in the INRMP, and include avoidance and minimization of impacts to the species and its habitat related to restrictions and precautions for range and training areas (U.S. Marine Corps 2018, pp. N-52–N-53).

Although a specific Stephens' kangaroo rat management plan has not yet been completed for Camp Pendleton, the facility has conducted a multi-year project for management of the species as part of its overall endangered species conservation program. Specifically, Tetra Tech, Inc. (Tetra Tech) was contracted by the Department of the Navy, Naval Facilities Engineering Command (NAVFAC) Atlantic to perform habitat enhancement activities and monitor vegetation and population response at a Stephens' kangaroo rat (or SKR) Management Area on Camp Pendleton's Juliet Training Area (Tetra Tech 2015, p. 1; Figure 1). The project was initiated in December 2008 and is currently ongoing.

The primary goal of this project is to create habitat conditions that encourages occupation of the Stephens' kangaroo rat at the SKR Management Area (Tetra Tech 2015, p. 3). Specific objectives include the following: (1) measure habitat conditions before and after the application of enhancement treatment options; (2) select enhancement options that are designed to increase habitat suitability for the existing Stephens' kangaroo rat population (if present or introduced) and/or facilitate Stephens' kangaroo rat occupation/expansion from nearby populations; (3) implement selected enhancement options as site conditions dictate; (4) monitor both translocated Stephens' kangaroo rat and population occupation; and (5) develop recommendations based on results and observations (Tetra Tech 2015, p. 3). Results of this project are described in annual habitat enhancement and monitoring reports prepared for NAVFAC Atlantic as well as in other monitoring reports, as described above (e.g., Brehme *et al*. 2011a; Tetra Tech 2015; Tetra Tech 2016).

Naval Base Coronado, Remote Training Site Warner Springs

An INRMP was finalized in 2013 for Naval Base Coronado, which includes the Warner Springs facility, described above (section 5.3). For threatened, endangered, and candidate species and their habitats, which include the Stephens' kangaroo rat, management needs are developed using results from surveys conducted at Warner Springs (see summary presented in section 5.3 above) (U.S. Navy 2013, p. 9-34). Current management of Stephens' kangaroo rat includes compliance with USFS and BLM agreements, and compliance with the 2009 BO on the U.S. Navy's proposed expansion and realignment of the Warner Springs (Service 2009), and its reinitiation in 2015 (Service 2016), which discuss multiple conservation measures for minimizing the effects of proposed actions on the Stephens' kangaroo rat.

For the Stephens' kangaroo rat, the INRMP describes the following management objectives: (1) Maintain current populations and distribution of the species on Warner Springs; (2) promote the recovery of the species, and (3) maintain habitat quality (U.S. Navy 2013, p. 9-44). Specific strategies related to these objectives include (U.S. Navy 2013, p. 9-44):

- Digging, disking, grading, mechanical fill, or deposition of fill must avoid Stephens' kangaroo rat habitat. (Except when approved by the USFWS for revegetation).
- Enhance the feasibility to expand/improve the habitat of Stephens' kangaroo rat.
- Educate military operators to ensure minimization and avoidance measures are followed.
- Outreach and education to local landowners.
- Conduct Stephens' kangaroo rat surveys at least every 3 years, update distribution maps as necessary, and post in appropriate areas at Warner Springs.
- Establish nighttime speed limit of 15 miles per hour in Stephens' kangaroo rat-occupied areas and install signs informing drivers.
- Implement site approval process and NEPA to avoid and minimize impacts to Stephens' kangaroo rat occupied habitat.
- Allow vehicle traffic only on dirt and paved roads.
- Coordination with other elements of the natural resources program.

Natural resources management at Warner Springs is coordinated with the relevant landowners, depending on location, and all proposed work is reviewed and approved by the landowners (U.S. Navy 2013, p. 9-1). For example, all current Naval Base Coronado leases, including agricultural/grazing outleases, are evaluated for their compatibility with natural resources management direction presented in the 2013 INRMP (U.S. Navy 2013, pp. 11-29–11-30). For example, Warner Springs activities on USFS property must comply with the Special Use Permit Operating Plan including compliance with the 2010 Environmental Assessment for the Stephens' kangaroo rat (U.S. Navy 2013, pp. 11-30–11-31). Relatedly, natural resource management related to native grassland communities, including areas occupied by the Stephens' kangaroo rat, is described in the INRMP as follows: enhancement by the removal of invasive exotic plant species and planting of native species, and habitat restoration of particularly disturbed areas (U.S. Navy 2013, p. 9-15).

In addition, Warner Springs activities conducted on BLM right-of-way (ROW) are required to comply with the ROW agreement, and include the following requirements specific to the Stephens' kangaroo rat: (1) Install and maintain information signage in Fink Road on VID land west of SR-79 that passes occupied Stephens' kangaroo rat habitat; (2) siting of areas where military students congregate away from mapped occupied Stephens' kangaroo rat habitat and, for these areas, foot traffic is generally to remain dispersed and light with rotation of areas of activity; (3) ensure compliance with the nighttime (sunset to sunrise) speed limit 15 mi per hour (24 km per hour) in occupied Stephens' kangaroo rat habitat; (4) prohibition of killing or capturing of any kangaroo rat species for the purpose of survival training within occupied Stephens' kangaroo rat habitat; and (5) prohibition of the establishment of navigation points on a burrow that could belong to a Stephens' kangaroo rat (U.S. Navy 2013, p. 11-34).

Naval Weapons Station Seal Beach Detachment Fallbrook

The most recent INRMP was completed for Det. Fallbrook in 2016 (U.S. Navy 2016, entire). At Det. Fallbrook, the U.S. Navy uses an adaptive management approach, including implementing experimental treatments to enhance Stephens' kangaroo rat habitat at certain sites (U.S. Navy 2016, p. 4-9). The INRMP identifies an overarching management objective at Detachment Fallbrook specific to the Stephens' kangaroo rat in which management strategies are implemented in order to maintain a healthy and diverse grassland community to benefit the Stephens' kangaroo rat and other sympatric species (U.S. Navy 2016, p. N-16). Specific project or activities identified to achieve this objective include the following: (1) Survey and monitor Stephens' kangaroo rat population, habitat suitability, and presence/absence distribution; (2) Research, conserve, and protect Stephens' kangaroo rat and enhance their habitat, and (3) Conduct avoidance/minimization measures and monitoring during fuelbreak maintenance, and, to the extent feasible, enhance fuel breaks to benefit habitat for the Stephens' kangaroo rat (U.S. Navy 2016, p. N-16). In addition to these management strategies, the installation also conducts short-term surveys to assess potential effects of project to the Stephens' kangaroo rat and its habitat (U.S. Navy 2016, p. 4-85).

In addition, the Det. Fallbrook INRMP identifies management measures that are designed to specifically support the protection and conservation of federally listed species and their habitats. For the Stephens' kangaroo rat, these are discussed in section 14.13.7 of the INRMP (U.S. Navy 2016, pp. 4-106–4-114). In general, habitat protection and management measures for the Stephens' kangaroo rat population at Det. Fallbrook are guided, in part, by Management Priority Areas, which are based on Stephens' kangaroo rat occupancy, potential habitat suitability, connectivity among occupied patches, and proximity to the population of the species at Camp Pendleton (U.S. Navy 2016, p. 4-106). The Management Priority Areas are presented in the Wildland Fire Management Plan (WFMP) (U.S. Navy 2003; revised in 2015 (Tierra Data, Inc. *et al*. 2015)) and serve as general guidance for conservation and management prioritizations and as a fire management tool for suppression actions (U.S. Navy 2016, p. 4-106).

In addition, the INRMP for Det. Fallbrook presents specific avoidance and minimization measures for the Stephens' kangaroo rat related to wildfire and vegetation management. For wildfire management, these include: (1) Conduct annual pre-disking Stephens' kangaroo rat surveys on select firebreaks, report findings to the Service, and provide biomonitoring during disking operations; (2) Improve firebreak maintenance in select locations so as to simultaneously provide Stephens' kangaroo rat habitat enhancement and fulfill fire management objectives; and (3) Support fire management related surveys for the Stephens' kangaroo rat, monitoring, and research (U.S. Navy 2016, p. 4-33).

Vegetation management measures include maintenance of sufficient habitat (both quantity and quality) in grassland communities to support sustainable populations of the Stephens' kangaroo rat (U.S. Navy 2016, p. 4-52). This includes compliance with the Service's Biological Opinion for the WFMP (Service 2003) to maintain at least 380 ac (154 ha) of grassland habitat occupied by Stephens' kangaroo rat at low densities, as presented in the WFMP (U.S. Navy 2016, p. 4-52). Cattle grazing at Det. Fallbrook helps to support wildfire management by reducing fine fuel, but can also assist in controlling nonnative plants and establish bare ground areas, both of which provide benefits to the Stephens' kangaroo rat (U.S. Navy 2016, p. 4-11).

The INRMP also discusses additional avoidance and minimization efforts associated with firebreak and clear zone maintenance, which include: (1) reduction of footprint (e.g., fewer firebreaks than historically present); (2) continued maintenance to impede vegetation growth and minimize suitability for species (i.e., reducing the potential for direct harm); (3) avoiding potential kangaroo rat burrows and biomonitoring during firebreak disking; and 4) weed control to control the prevalence and spread of noxious invasive plants (U.S. Navy 2016, pp. 4-10–4-11).

In summary, the management and conservation actions and the ongoing monitoring studies implemented under the Sikes Act authority at three DOD installations in San Diego County provide important conservation benefits to the Stephens' kangaroo rat, as summarized above.

7.1.3 National Environmental Policy Act (NEPA)

All Federal agencies are required to adhere to the NEPA of 1970 (42 U.S.C. 4321 et seq.) for projects they fund, authorize, or carry out. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. The Council on Environmental Quality's regulations for implementing NEPA state that agencies shall include a discussion on the environmental impacts of the various project alternatives (including the proposed action), any adverse environmental effects that cannot be avoided, and any irreversible or irretrievable commitments of resources involved (40 CFR part 1502). The public notice provisions of NEPA provide an opportunity for the Service and other interested parties to review proposed actions and provide recommendations to the implementing agency. NEPA does not impose substantive environmental obligations on Federal agencies—it merely prohibits an uninformed agency action. However, if an Environmental Impact Statement is prepared for an agency action, the agency must take a "hard look" at the consequences of this action and must consider all potentially significant environmental impacts. Federal agencies may include mitigation measures in the final Environmental Impact Statement as a result of the NEPA process that may help to conserve the Stephens' kangaroo rat and its habitat.

Although NEPA requires full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats, it does not by itself regulate activities that might affect the Stephens' kangaroo rat; that is, effects to the species and its habitat would receive the same scrutiny as other plant and wildlife resources during the NEPA process and associated analyses of a project's potential impacts to the human environment. For example, we receive notification letters for Draft and Final Environmental Impact Reports prepared pursuant to NEPA, including those prepared by the Forest Service for Land Management Plans within southern California.

7.1.4 Organic Administration Act of 1897 and the Multiple–Use, Sustained–Yield Act of 1960

The U.S. Forest Service (USFS or Forest Service) Organic Act of 1897 (16 U.S.C. § 475–482) established general guidelines for administration of timber on Forest Service lands, which was followed by the Multiple–Use, Sustained–Yield Act (MUSY) of 1960 (16 U.S.C. § 528–531), which broadened the management of USFS lands to include outdoor recreation, range, watershed, and wildlife and fish purposes.

7.1.5 National Forest Management Act

The National Forest Management Act (NFMA) (16 U.S.C. § 1600 *et seq*.) requires the Forest Service to develop a planning rule under the principles of the MUSY of 1960 (16 U.S.C. § 528–531). The NFMA outlines the process for the development and revision of the land management plans and their guidelines and standards (16 U.S.C. § 1604(g)).

A new National Forest System (NFS) land management planning rule (planning rule) was adopted by the USFS in 2012 (77 FR 21162; April 9, 2012). The new planning rule guides the development, amendment, and revision of land management plans for all units of the NFS to maintain and restore NFS land and water ecosystems while providing for ecosystem services and multiple uses. Land management plans (also called Forest Plans) are designed to: (1) Provide for the sustainability of ecosystems and resources; (2) meet the need for forest restoration and conservation, watershed protection, and species diversity and conservation; and (3) assist the Forest Service in providing a sustainable flow of benefits, services, and uses of NFS lands that provide jobs and contribute to the economic and social sustainability of communities (77 FR 21261). A land management plan does not authorize projects or activities, but projects and activities must be consistent with the plan (77 FR 21261). The plan must provide for the diversity of plant and animal communities including species-specific plan components in which a determination is made as to whether the plan provides the "ecological conditions necessary to…contribute to the recovery of federally listed threatened and endangered species…" (77 FR 21265).

The Record of Decision for the final planning rule was based on the analyses presented in the *Final Programmatic Environmental Impact Statement, National Forest System Land Management Planning* (77 FR 21162–21276), which was prepared in accordance with the requirements of the NEPA (discussed below). In addition, the NFMA requires land management plans to be developed in accordance with the procedural requirements of NEPA, with a similar effect as zoning requirements or regulations as these plans control activities on the national forests and are judicially enforceable until properly revised (Coggins *et al.* 2001, p. 720).

7.1.5.1 Cleveland National Forest Land Management Plan

Our spatial analysis found that less than 1 percent of modeled habitat for the Stephens' kangaroo rat within San Diego and Riverside Counties is located on lands managed by the USFS (Cleveland National Forest) (Service 2018). The most recent Land Management Plan for the Cleveland National Forest was prepared in 2005 in conjunction with a final Environmental Impact Statement for four Southern California National Forests (USFS 2005b; USFS 2005c). The Cleveland National Forest Land Management Plan contains specific design criteria including place specific standards for managing the Cleveland National Forest related to minimizing and mitigating impacts to the functionality of landscape linkages and wildlife movement corridors from proposed projects and other activities (USFS 2005b, p. 90). The USFS Species Account for the Stephens' kangaroo rat (USFS 2005d, pp. 1210–1217) lists the following conservation practice that should be considered for activities within the Cleveland National Forest: As opportunities or management activities occur, surveys of suitable habitat will occur on National Forest System lands for undetected populations (USFS 2005d, p. 1214).

No threats were identified to the Stephens' kangaroo rat population found on National Forest Service lands, according to the 2005 biological assessment prepared by the USFS (USFS 2005a, p. 184, citing Winter 2005, pers. comm.). The biological assessment discussed implementation of the revised Forest Plan for the Cleveland National Forest and the use and maintenance of roads and motorized trails, grazing by livestock, dispersed recreation, and fuels management on Stephens' kangaroo rat. They concluded that these activities may affect Stephens' kangaroo rats and their habitat to a limited extent (USFS 2005a, p. 190). For example the USFS determined that occupied (37 ac (15 ha)) and potentially suitable habitat (200 ac (81 h)) occurs in areas where recreation is a suitable use and topography and vegetation would allow for this use (USFS 2005a, p 186). The agency also determined that the magnitude of risk that recreation use is likely to present to the Stephens' kangaroo rat on National Forest Service lands is mitigated by use of Best Management Practices and Forest Plan standards (i.e., S6, S11, S12, S13, S22, S24, S31, S34, S35, S36, S40, S47, and S50) (USFS 2005a, p. 186). Section 7.0 Regulatory Mechanisms and Conservation/Management Measures for discussion relative to Best Management Practices and Forest Plan standards related to additional potential stressors.

In addition, the Forest Service Directive System codifies the agency's policy, practice, and procedures under various Federal laws and regulations under which the USFS operates, including the Act. The Directive System is the primary basis for the internal management and control of all programs as well as the primary source of administrative direction to USFS employees. This system includes the Forest Service Manual and Forest Service Handbooks that outline land and resource management planning and other conservation directives (Forest Service website with additional information).

7.1.6 Federal Land Policy and Management Act (FLPMA) of 1976

FLMPA (43 U.S.C. 1711-1712) represents BLM's "organic act" for public lands management under the principles of multiple use and sustained yield. Its implementing regulations give BLM regulatory authority over activities for protection of the environment, including mining claims. Under FLPMA and BLM policy, public lands must be managed to protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archaeological values (BLM 2005, p. 1). A small portion (316.6 ac (128 ha)) of our estimated modeled habitat is located on lands under the jurisdiction of BLM. This includes portions of five Core Reserves established under the Western Riverside MSHCP.

Land Use and Resource Management Plans

BLM land use planning requirements are established by Sections 201 and 202 of FLMPA and regulations at 43 CFR 1600 (BLM 2005, p. 1). A *Land Use Planning Handbook* (BLM 2005, entire) provides guidance for implementing land use planning requirements established under FLMPA and implementing regulations. Land use plans prepared by BLM include resource management plans (RMPs) and management framework plans (BLM 2005, p. 1). The RMPs establish the basis for actions and approved uses on the public lands, and are prepared for areas of public lands, called planning areas (BLM 2005, pp. 1, 14). These plans are periodically evaluated and revised in response to changed conditions and resource demands (BLM 2005, pp. 33–34).

BLM Manuals

BLM Manual 6840, Special Status Species Management, provides direction and policy with regards to (1) listed species or those proposed to be listed under the Act, such as the Stephens' kangaroo rat, and (2) species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the Act (BLM 2008, p. 3). One key objective of the BLM special status species policy is to conserve and/or recover species listed under the Act, and the ecosystems on which they depend (BLM 2008, p. 3). Under Manual 6840 direction, BLM managers are to ensure that land use and implementation plans fully address appropriate conservation of BLM special status species (BLM 2008, p. 6).

7.1.7 Summary of Federal Mechanisms

In summary, the Act is the primary Federal law providing protection for the Stephens' kangaroo rat, primarily through section 7 and section 10. On DOD lands, the Sikes Act, via the development of installation INRMPs, provides an important natural resource management directive and DOD installations in southern California have incorporated conservation measures and are working with partners to survey or monitor resident Stephens' kangaroo rat populations. Other Federal laws and regulations that confer protections including provisions under the Forest Service Organic Act, which allows for designation of Wilderness Areas or Special Areas for protection based on unique or outstanding physical features, environmental values or social significance, respectively. The NFMA requires USFS to incorporate provisions to support and manage the plant and animal communities for diversity and long-term rangewide viability of native species within the (revised) Cleveland National Forest Land Management Plan.

7.2 State Mechanisms

7.2.1 California Department of Fish and Wildlife Status

The Stephens' kangaroo rat is designated as threatened under the California Endangered Species Act (CESA), which prohibits the take of any species of wildlife designated by the California Fish and Game Commission as endangered, threatened, or candidate species (CDFW 2018a). Additionally, permits are required to take or possess any and all plants and animals in the state, and as noted above, the CDFW may authorize the take of any such species if certain conditions are met through the issuance of permits (e.g., research permits, Incidental Take Permits) (CDFW 2018b).

In order to update the State's Wildlife Action Plan[3] (CDFW 2015, p. C-24; Appendix C), information was gathered for taxa that are indicative of the State's biological diversity. The

[3] The U.S. Congress created the State Wildlife Grant (SWG) funding program in 2000 (Title IX, Public Law 106-553 and Title 1, Public Law 107-63). SWG funds are to be used "…for the planning and implementation of [States and territories] wildlife conservation and restoration program and wildlife conservation strategy, including wildlife conservation, wildlife conservation education, and wildlife-associated recreation projects." Congress stipulated that each State or territory applying for this funding program must develop a wildlife conservation strategy (State Wildlife Action Plan (SWAP)) by October 1, 2005. All 56 States and territories submitted SWAPs by 2005 and made commitments to review and/or revise their SWAP at least every 10 years.

Stephens' kangaroo rat was identified as important to the State's biodiversity and was therefore listed as a Species of Greatest Conservation Need (SGCN) (CDFW 2015, p. C-1).

7.2.2 California Environmental Quality Act (CEQA)

CEQA (California Public Resources Code 21000–21177) is the principal statute mandating environmental assessment of projects in California. The purpose of CEQA is to evaluate whether a proposed project may have an adverse effect on the environment and, if so, to determine whether that effect can be reduced or eliminated by pursuing an alternative course of action, or through mitigation. CEQA applies to certain activities of State and local public agencies; a public agency must comply with CEQA when it undertakes an activity defined under CEQA as a "project." A project is defined as an activity undertaken by a public agency or a private activity that requires some discretionary approval (i.e., the agency has the authority to deny or approve the requested permit) from a government agency, and which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment. Most proposals for physical development in California are subject to the provisions of CEQA, as are many governmental decisions such as adoption of a general or community plan. Development projects that require a discretionary governmental approval require some level of environmental review under CEQA, unless an exemption applies (California Environmental Resources Evaluation System (CERES) 2014).

As with NEPA, CEQA does not provide a direct regulatory role for the CDFW relative to activities that may affect the Stephens' kangaroo rat. However, CEQA requires a complete assessment of the potential for a proposed project to have a significant adverse effect on the environment. Among the conditions outlined in the CEQA Guidelines that may lead to a mandatory findings of significance are where the project "has the potential to … substantially reduce the habitat of a fish or wildlife species; cause a fish or wildlife population to drop below self-sustaining levels; threaten to eliminate a plant or animal community; substantially reduce the number or restrict the range of an endangered, rare or threatened species" (14 CCR § 15065(a)(1)). If significant effects are identified, the lead agency has the option of requiring mitigation through changes in the project or to decide that overriding considerations make mitigation infeasible (Public Resources Code 21000; CEQA Guidelines at California Code of Regulations, Title 14, Division 6, Chapter 3, sections 15000–15387).

7.2.3 California Environmental Protection Agency–Department of Pesticide Regulation

In 1991, California's environmental authority was unified in a single Cabinet-level agency—the California Environmental Protection Agency (Cal/EPA)—and, with that reorganization, the pesticide regulation program was removed from California Department of Food and Agriculture and given departmental status as the Department of Pesticide Regulation (DPR) within the agency (Cal/EPA 2001, pp. 72–73). The DPR is responsible for regulating pesticide use, including rodenticides (as discussed above), in water, air, soil, and biological organisms (Cal/EPA 2001, pp. 72–73).

Within the DPR, exists the Endangered Species Program, which develops pesticide use limitations to help prevent effects of pesticides to endangered species or their habitat (DPR 2018c). The program has created an online database application called 'PRESCRIBE' to assist pesticide applicators in determining the locations of endangered species and their habitats in the vicinity of their application site, and the use limitations that are applicable to the pesticide product(s) they intend to use (DPR 2018c). The application is now available for mobile devices at this link. In addition, the program offers continuing education courses for public education/training and develops educational materials for pesticide applicators (DPR 2018c). One of the recommendations provided in PRESCRIBE is the use of elevated bait stations to protect species of kangaroo rats (and the San Joaquin kit fox) by preventing access to rodenticides targeting ground squirrels; the DPR promotes the use of these stations as part of its continuing education workshops conducted throughout the State (Moreno 2018, pers. comm.).

7.2.4 The Natural Community Conservation Planning (NCCP) Act

The NCCP program is a cooperative effort between the State of California and numerous private and public partners with the goal of protecting habitats and species. The NCCP program identifies and provides for the regional or area-wide protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. The program uses an ecosystem approach to planning for the protection and continuation of biological diversity (https://www.wildlife.ca.gov/Conservation/Planning/NCCP). Regional NCCPs provide protection to federally listed and other covered species by conserving native habitats upon which the species depend. Many NCCPs are developed in conjunction with habitat conservation plans (HCPs) prepared pursuant to the Act.

Western Riverside County Multiple Species HCP

The Western Riverside County MSHCP is a large-scale, multi-jurisdictional HCP that addresses 146 listed and unlisted Covered Species including the Stephens' kangaroo rat within a 1,260,000-ac (509,904-ha) Plan Area in western Riverside County (Service 2004, p. 17). The Western Riverside County MSHCP was designed to establish a multi-species conservation program that minimizes and mitigates the expected loss of habitat and the incidental take of Covered Species. The Western Riverside County MSHCP is also an HCP pursuant to the Act as well as the NCCP under the NCCP Act. In 2004, the Service issued a 75-year, section 10(a)(1)(B) permit for the County of Riverside for the Western Riverside County MSHCP; CDFW also issued NCCP Approval and Take Authorization for the Western Riverside County MSHCP in 2004.

The Stephens' kangaroo rat is a Covered Species within the Western Riverside County MSHCP and is considered to be adequately conserved within the Plan boundary (Dudek and Associates 2003, p. 2-28). To ensure the species' long-term viability in the Western Riverside County MSHCP Plan Area, species-specific monitoring and management actions are required, including tracking population densities and maintaining sparse, open grassland habitats (Dudek and Associates 2003, p. M-197). Summary results from these surveys are described above (see section 5.2).

As outlined in the Western Riverside County MSHCP (Dudek and Associates 2003, pp. 9-105–9-106), the total estimated conservation of occupied and suitable habitat for the Stephens' kangaroo rat in the MSHCP Conservation Area is approximately 22,400 ac (9,065 ha), and the approval and implementation of the SKR HCP (March 1996) was based on the determination that the HCP would conserve the kangaroo rat within the Western Riverside County area covered by the Western Riverside County MSHCP. In addition, expansion of the Conservation Area under the Western Riverside County MSHCP was expected to increase the amount of conserved habitat by at least 3,200 ac (1,295 ha) in the two new Core Areas and by several thousand acres in smaller scattered patches throughout the Western Riverside County MSHCP Conservation Area (Dudek and Associates 2003, pp. 9-105–9-106).

Management actions defined for the Stephens' kangaroo rat within the Western Riverside County MSHCP include (Dudek and Associates 2003, pp. 5-5, 5-28):

> (1) A general management measure to maintain and manage upland habitats, to the extent feasible, in a condition similar to or better than the habitat's condition at the time the lands were conveyed to the Western Riverside County MSHCP Conservation Area; and
>
> (2) a species-specific management activity to maintain at least 30 percent (approximately 4,500 acres) of the occupied habitat, within the minimum 15,000 ac (6,070 ha) of occupied habitat in the MSHCP Conservation Area, at a population density of medium or higher (i.e., at least 5-10 individuals per hectare [citing O'Farrell and Uptain 1989] across all Core Areas.

In addition to baseline inventory field surveys and the long-term monitoring strategy for Covered Species, monitoring of the Stephens' kangaroo rat per the species objectives is also required; these specific species objectives were developed as part of the Conservation Strategy and are intended to provide measurable criteria for evaluating conservation success for Covered Species (Dudek and Associates 2003, pp. 5-73–5-78). For the Stephens' kangaroo rat, monitoring of both its distribution and abundance is to be conducted every 1 in 8 years (i.e., approximate length of the weather cycle) (Dudek and Associates 2003, p. 5-76).

Conservation objectives identified in the Western Riverside County MSHCP for the Stephens' kangaroo rat include the following (Dudek and Associates 2003, pp. 9-105–9-106; M-198):

> (1) Include within the MSHCP Conservation Area a minimum of 15,000 ac (6,070 ha) of occupied Habitat (as defined in the *Habitat Conservation Plan for the Stephens' Kangaroo Rat in Western Riverside County*), as measured across any consecutive 8-year period (i.e., the approximate length of the weather cycle), in a minimum of six Core Areas within the existing boundary of the *Habitat Conservation Plan for the Stephens' Kangaroo Rat in Western Riverside County*. This objective is consistent with the requirements of the Stephens' kangaroo rat HCP. Core Areas, as identified in the HCP, include Lake Mathews-Estelle Mountain, Motte-Rimrock Reserve, Southwest Riverside County Multi-Species Reserve (formally named Lake Skinner-Domenigoni Valley), San Jacinto Wildlife Area-Lake Perris, Sycamore Canyon-March Preserve, Steele Peak, and Potrero Area of Critical Environmental Concern (ACEC);
>
> (2) Include within the Western Riverside County MSHCP Conservation Area at least 3,000 ac (1,214 ha) of occupied habitat, as measured across any consecutive 8-year period, in a minimum of two Core Areas outside the existing boundary of the *Habitat Conservation Plan for the Stephens' Kangaroo Rat in Western Riverside County*. One

of the Core Areas will be the Potrero Valley area (as distinct from the Potrero ACEC Core Areas listed in Objective (1) and the other will be in the Anza and Cahuilla valleys; and

(3) Within the minimum 15,000 ac (6,070 ha) of occupied habitat in the Western Riverside County MSHCP Conservation Area, maintain at least 30 percent of the occupied habitat (approximately 4,500 ac (1,821 ha) at a population density of medium or higher (i.e., at least 5–10 individuals per hectare [citing O'Farrell and Uptain 1989]) across all Core Areas. No single Core Area will account for more than 30 percent of the total medium (or higher) population density area. [Note – this third objective is also identified as a species-specific management action for the Stephens' kangaroo rat (Dudek and Associates 2003, p. 5-28)]

Through the NCCP Program, the Western Riverside County MSHCP provides a comprehensive, habitat-based approach to the protection of covered species, including the Stephens' kangaroo rat, by focusing on lands identified as important for the long-term conservation of its covered species and through the implementation of management actions for conserving those lands. These protections are outlined in the management actions and conservation objectives described above. Therefore, the Western Riverside County MSHCP provides an important conservation mechanism for covered plants and animals, including the Stephens' kangaroo rat within populations located in western Riverside County.

7.2.5 Summary of State Mechanisms

These State regulatory mechanisms provide important protections against current threats to the Stephens' kangaroo rat, primarily through the consultation and take provisions of CESA and the NCCP Act and protections provided through implementation of management actions and conservation measures outlined in the Western Riverside County MSHCP.

7.3 Summary

Federal regulatory mechanisms provide for conservation and management throughout the range of the Stephens' kangaroo rat and provide protections to the species and its habitat. These include the Act, which provides for protection against take under section 7, and implementation of conservation measures identified in both formal and informal consultations. Conservation programs authorized under section 6 of the Act have also been important in securing habitat for the Stephens' kangaroo rat in both Riverside and San Diego Counties. The Sikes Act, and the preparation of INRMPs, has also resulted in implementation of important management measures on three military installations in San Diego County, including ongoing monitoring and translocation efforts.

Additional important Federal mechanisms include protections provided under the USFS Organic Act and other Forest Service management policies, practices, and procedures that guide management within Cleveland National Forest. Land use management practices are also established for lands administered by the BLM under FLMPA. Although NEPA does not itself regulate activities that might affect the Stephens' kangaroo rat, it does require full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats.

State regulatory mechanisms and management and conservation measures also provide protections to the Stephens' kangaroo rat. The species is designated as threatened in California under CESA, which places restrictions on take. This designation also requires the species to be evaluated under the State's CEQA planning processes to assess the potential for a proposed project to have a significant adverse effect on the environment, including an evaluation of any substantial reduction in the number or restriction of the range of an endangered, rare or threatened species. The NCCP Act has been a key State regulatory mechanism, in conjunction with provisions under section 10(a)(1)(B) of the Act, in conserving the habitat of the Stephens' kangaroo rat in Riverside County.

8.0 Overall Summary

The Stephens' kangaroo rat is currently found in a patchy distribution in Riverside and San Diego Counties, California. The distribution and density of populations of the Stephens' kangaroo rat can vary temporally, within and between years, and spatially, depending on natural changes in habitat conditions and succession of plant communities. Comprehensive, rangewide surveys to estimate abundance and distribution for this species have not been conducted since 1988, so we are unable to estimate population trends for the species at this time. There has been no formal assessment of the population structure for the Stephens' kangaroo rat such as the minimum habitat patch size required to support a stable population or an estimate of the minimum number of interconnected patches needed to support a potential metapopulation of this species. Researchers believe that the species' population structure in southern California follows a metapopulation dynamic in which the availability of suitable habitat patches is both spatially and temporally dynamic and is based on the equilibrium between colonization and extinction of local populations.

Populations of the Stephens' kangaroo rat reach their highest densities in grassland communities dominated by forbs and characterized by moderate to high amounts of bare ground, moderate slopes, and well-drained, sandy loam soils. Forb cover is important as a food resource while areas with high levels of shrub cover are avoided. The Stephens' kangaroo rat constructs burrow systems that are used as shelter, protection from predators, food storage (caching), and nesting. Areas of occupied (patchy) habitat consist of burrow entrances connected by a network of well-defined surface runways in which the size of a patch and the distance between occupied patches varies depending on topography and soil characteristics, and broader features such as biotic variables (e.g., vegetation cover, predation) and behavioral factors (e.g., immigration and emigration).

Based on habitat predictors from field studies, we used spatial analyses to model habitat for the Stephens' kangaroo rat. We estimated that there are approximately 69,104 ac (27,966 ha) and 22,434 ac (9,079 ha) of modeled habitat in Riverside and San Diego Counties, respectively.

In this Species Report, we evaluated potential stressors related to the Stephens' kangaroo rat and its habitat from habitat loss due to urban and agricultural development, habitat fragmentation, other habitat destruction and modification stressors, overutilization for commercial, recreational, scientific, or educational purposes, disease, predation, use of rodenticides, wildfire, and the effects of climate change.

Much of the suitable Stephens' kangaroo rat habitat loss due to urban and agricultural development occurred in the early 20th century. Thus, we found a moderate level of habitat fragmentation relative to habitat characteristics attributed to the Stephens' kangaroo rat in both western Riverside and San Diego Counties. These results suggest that restoration of connectivity and/or translocation efforts may be needed to maintain some populations in the future.

Other potential habitat destruction or modification-related stressors evaluated in this report include nonnative ungulates, off-highway vehicle activity, and the effects of fire suppression or prevention activities. We determined that these were either not a stressor (nonnative ungulates) or represented a low-level stressor to the species' habitat. Disease or overutilization for commercial, recreational, scientific, or educational purposes are not presently stressors to the species and are not expected to change in the future. Predation is not a stressor to the species beyond impacts to a few individuals, now or into the future. We determined that the risk of mortality or injury as a result of the use of rodenticides represents a low-level risk at the individual level both currently and in the future. Wildfire is both a natural and human-caused event in the currently occupied range of the Stephens' kangaroo rat. In general, studies have found that wildland or controlled fire management actions represent a beneficial effect to the species. At present, Core Reserves and other areas in Riverside County are currently being managed for conversion of habitat due to the recent establishment of a nonnative invasive plant, which represents a low-level, but not yet rangewide, stressor to Stephens' kangaroo rat habitat.

The best available regional data on current and potential future trends related to climate change within locations occupied by the Stephens' kangaroo rat indicate that the effects of climate change are a low to moderate stressor at the present time to its habitat. Based on model projections, we can reliably predict this will continue until at least the mid- to late-21st century (~2060 to 2100). Potential effects to the habitat occupied by the Stephens' kangaroo rat from climate change from precipitation changes appear to be minimal; however, projections of temperature increases for the area may have an effect to the species' habitat, by increasing the potential for wildfires due to increase fuel loads. However, drought conditions appear to provide favorable conditions to the species by reducing cover and creating open spaces. The cumulative effects of climate change and wildfire, which could result in an increase in the extent of nonnative grasslands, represents a low-level stressor to the Stephens' kangaroo rat and its habitat, and based on climate change projections, is likely to remain at this level to the 2060s.

Conservation measures including Federal and State mechanisms currently provide some protections to the Stephens' kangaroo rat and its habitat. The Act provides protections through section 7 and the consultation process and through section 10 using incidental take permits on non-Federal lands. The Sikes Act also represents a significant natural resource management law and three San Diego County installations are actively managed for the conservation of the Stephens' kangaroo rat. We estimated that approximately 7.0 percent of modeled habitat is found on DOD lands (both Riverside and San Diego Counties).

Additional important Federal mechanisms include protections provided under the USFS Organic Act and other Forest Service management policies, practices, and procedures that guide management within Cleveland National Forest. The Stephens' kangaroo rat is also found on lands administered by BLM (1.1 percent), including within several reserves established for the species. Although NEPA does not itself regulate activities that might affect the Stephens' kangaroo rat, it does require full evaluation and disclosure of information regarding the effects of contemplated Federal actions on sensitive species and their habitats.

The CESA and NCCP Act State provisions provide protections to the Stephens' kangaroo rat through its listing under CESA (threatened) and general inclusion within both State and Federal planning processes. Developed in coordination with California's NCCP Act, the SKR HCP and the Western Riverside County MSHCP identify management and conservation objectives that provide additional conservation measures to the Stephens' kangaroo rat and its habitat within populations in Riverside County, including the establishment of a reserve system in western Riverside County. We estimate that approximately 17.0 percent of all modeled habitat (22.5 percent of our modeled habitat in Riverside County) occurs within these reserves and the SKR HCP core reserves.

9.0 Species Status Assessment

The Act defines an endangered species as any species that is "in danger of extinction throughout all or a significant portion of its range" and a threatened species as any species "that is likely to become endangered throughout all or a significant portion of its range within the foreseeable future." In determining the current status of the Stephens' kangaroo rat, we considered whether the species is presently in danger of extinction throughout all or a significant portion of its range (endangered) or likely to become so in the future (threatened).

The current status of the Stephens' kangaroo rat is a function of the species' viability and demographic risks. Because we often do not have specific demographic or viability information on a species, we consider the concepts of resilience, representation, and redundancy (Shaffer and Stein 2000, pp. 301–302; Wolf *et al.* 2015, entire) as a proxy for this information. To do this we assess a species' current biological condition and its projected capability of persisting into the future (Smith *et al.* 2018, entire). We generally define species' persistence as the ability of a species to sustain populations in the natural ecosystem beyond a biologically meaningful timeframe. To determine the current and future biological condition of a species, we look at whether the physical or biological needs of the species (such as habitat, survival, and reproduction) are currently being satisfied and how stressors may negatively impact those needs now and into the future. Stressors are expressed as risks to its demographic features such as abundance, population and spatial structure, and genetic or ecological diversity. We consider the level of impact a stressor may have on a species along with the consideration of demographic factors (e.g., whether a species has stable, increasing, or decreasing trends in abundance, population growth rates, diversity of populations, and loss or degradation of habitat).

Representation describes the ability of a species to adapt to changing environmental conditions and is a measure of the breadth of genetic or environmental diversity within and among populations. The most recent genetic analysis for Stephens' kangaroo rat concluded that the species historically (before agricultural and urban development) was most likely a single population. However, habitat fragmentation and population isolation of the species has resulted in the Stephens' kangaroo rat as having a metapopulation structure (group of subpopulations).

There is no currently available information to indicate that the current abundance of the Stephens' kangaroo rat across its current range is at a level that is causing inbreeding depression or loss of genetic variation that would affect representation. However, because the habitat is fragmented and the species' behavior results in limited dispersal, some actions to reconnect populations may be needed. The ecological setting where the species occurs is generally uniform (occurring in grassland communities dominated by forbs with various degrees of bare ground on moderate slopes and having well-drained soils). However, there is some variability of the soil types and elevational characteristics of occupied areas. We are uncertain whether the current genetic make-up, population structure, or the current ecological settings in which the species occurs has reduced or limited its ability to adapt to changing environmental conditions (reduced its representation). However, the existing populations of the Stephens' kangaroo rat currently occupy all locations documented in our 2010 12-month finding and some populations have expanded thus potentially showing some degree of its capability to adapt to changing conditions.

Redundancy, the ability of a species to rebound after catastrophic perturbation, can be characterized by the distribution and connectivity of populations. In considering the Stephens' kangaroo rat in Riverside and San Diego Counties, geographically distinct populations are found within a large area of southern California. Populations of Stephens' kangaroo rats have been consistently monitored since listing and remain extant at 12 locations in Riverside County and 6 locations in San Diego County. We estimate that there is approximately 91,538 ac (37,044 ha) of modeled habitat for Stephens' kangaroo rat that occurs within varying ecological settings.

Resiliency, the ability of a population to withstand stochastic events, can be characterized by numbers of individuals and abundance trends. As indicated above, population size, growth rate, and current population trends are unknown for the Stephens' kangaroo rat due to the lack of abundance information. The Current Potential Extent of the species occurs within a large area of southern California (see Figure 1). Density estimates for the species vary across the range, but have not yet been estimated for several locations due to lack of consistent and robust monitoring. Stephens' kangaroo rats have continued to occur throughout large portions of southern California and conservation actions are being implemented, through development of HCPs and INRMPs, to reduce impacts from ongoing threats to the species and the habitat. Over the past 10 years, Stephens' kangaroo rats have been reported from 17 of the 18 geographic locations where we believe them to be extant in Riverside and San Diego Counties. We recognize that there is limited information on populations (resiliency and redundancy) or genetic diversity (representation) for the Stephens' kangaroo rat and no comprehensive studies are available to indicate what a viable (or minimal) population size for the species should be across its range. However, the species continues to occur across the landscape and the best available information does not indicate either increasing or declining numbers of the Stephens' kangaroo rat. At this time, the best available information indicates that populations are moderately resilient, but the species' abundance is likely to be impacted by fragmentation of habitat, which began as early as the 1930s across the species' area of occupancy in Riverside County. The effects of this fragmentation may affect current and future resiliency.

10.0 References Cited

[AAAS] American Association for the Advancement of Sciences. 2014. What We Know: The Reality, Risks and Response to Climate Change. The AAAS Climate Science Panel. 28 pp.

Abatzoglou, J.T., K.T. Redmond, and L.M. Edwards. 2009. Classification of regional climate variability in the State of California. Journal of Applied Meteorology and Climatology 48:1527–1541.

Andersen, M.A. and M.J. O'Farrell. 2000. Regression-tree analyses of habitat use by Stephens' kangaroo rat (*Dipodomys stephensi*). Technical Publications of the New Mexico State Agricultural Experiment Station. Las Cruces, New Mexico. 28 pp.

Apex Contracting and Consulting, Inc. 2017. Work plan for revegetation and erosion control of Remote Training Site Warner Springs, California. Prepared for Naval Base Coronado, California under contract with Naval Facilities Engineering Command, Southwest. October 2017.

Arguez, A., I. Durre, S. Applequist, R.S. Vose, M.F. Squires, X. Yin, R.R. Heim, Jr., and T.W. Owen. 2012. NOAA's 1981-2010 U.S. climate normals: an overview. Bulletin of the American Meteorological Society 93:1687–1697. doi:10.1175/BAMS-D-11-00197.1.

Baker, R.J., L.C. Bradley, R.D. Bradley, J.W. Dragoo, M.D. Engstrom, R.S. Hoffman, C.A. Jones, F. Reid, D.W. Rice, and C. Jones. 2003. Revised checklist of North American mammals north of Mexico, 2003. Occasional Papers, Museum of Texas Tech University 229. 23 pp.

Balch, J.K., B.A. Bradley, J.T. Abatzoglou, R.C. Nagy, E.J. Fusco, and A.L. Manhood. 2017. Human-started wildfires expand the fire niche across the United States. Proceedings of the National Academy of Sciences 114:2946–2951.

Bell, M.M. 2017. Comparison of fine scale vegetative parameters at active and inactive Gulf Coast kangaroo rat burrow sites. M.S. Thesis Texas State University, San Marcos, Texas. 78 pp.

Benton, N., J.D. Ripley, and F. Powledge (eds.). 2008. Conserving Biodiversity on Military Lands: A Guide for Natural Resources Managers. Digital resource available at http://www.dodbiodiversity.org. Arlington, Virginia: NatureServe. Accessed August 8, 2018.

Best, T.L. 1993. Patterns of morphologic and morphometric variation in heteromyid rodents. Pp. 197–235 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Biological Monitoring Program. 2007. Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) Biological Monitoring Program Stephens' Kangaroo Rat (*Dipodomys stephensi*) Survey Report 2006. Prepared for the Western Riverside County Multiple Species Habitat Conservation Plan. Riverside, California. Available online: http://wrc-rca.org/about-rca/monitoring/monitoring-surveys/

______. 2008. Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) Biological Monitoring Program Stephens' Kangaroo Rat (*Dipodomys stephensi*) Survey Report 2007. Prepared for the Western Riverside County Multiple Species Habitat Conservation Plan. Riverside, California. Available online: http://wrc-rca.org/about-rca/monitoring/monitoring-surveys/

______. 2009. Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) Biological Monitoring Program Stephens' Kangaroo Rat (*Dipodomys stephensi*) Survey Report 2008. Prepared for the Western Riverside County Multiple Species Habitat Conservation Plan. Riverside, California. Available online: http://wrc-rca.org/about-rca/monitoring/monitoring-surveys/

______. 2015. Western Riverside County MSHCP Biological Monitoring Program 2014 Stephens' Kangaroo Rat Survey Report. Prepared for the Western Riverside County Multiple Species Habitat Conservation Plan. Riverside, California. Available online: http://wrc-rca.org/about-rca/monitoring/monitoring-surveys/

Bisby, F.A., Y.R. Roskov, T.M. Orrell, D. Nicolson, L.E. Paglinawan, N. Bailly, P.M. Kirk, T. Bourgoin, G. Baillargeon, eds. 2010. Species 2000 & ITIS Catalogue of Life: 2010 Annual Checklist. Digital resource at http://www.Catalogueoflife.org/annual-checklist/2010 Species 2000: Reading, United Kingdom.

Bleich, V.C. 1973. Ecology of rodents at the United States Naval Weapons Station Seal Beach, Fallbrook Annex, San Diego County, California. M.A. Thesis, California State University, Long Beach, California. 102 pp.

______. 1977. *Dipodomys stephensi*. Mammalian Species 73:1–3. Published by The American Society of Mammologists.

Bliss, L.M. 2016. Habitat availability assessment for the Gulf Coast kangaroo rat (*Dipodomys compactus*) in south-central Texas. M.S. Thesis Texas State University, San Marcos, Texas. 60 pp.

[BLM] Bureau of Land Management. 2005. Land Use Planning Handbook. BLM Handbook H-1601-1. Prepared by the U.S. Bureau of Land Management. March 11, 2005.

______. 2008. Manual 6840: Special Status Species Management Manual for the Bureau of Land Management. Dated December 12, 2008.

Bond, M. L. 2015. Mammals and mixed- and high-severity fire. Pp. 89–117 *in* The Ecological Importance of Mixed-Severity Fires [D.A. DellaSalla and C.T. Hanson, eds.]. Elsevier, Inc.; Waltham, Massachusetts.

Bontrager, D.R. 1973. Rodent ecology of the Santa Rosa Plateau, Riverside County, California. M.A. Thesis, California State University, Long Beach, California. 123 pp.

Bradley, R.D., L.K. Ammerman, R.J. Baker, L.C. Bradley, J.A. Cook, R.C. Dowler, C. Jones, D. J. Schmidly, F.B. Stangl, Jr., R.A. Van Den Bussche, and B. Würsig. 2014. Revised checklist of North American mammals north of Mexico, 2014. Occasional Papers, Museum of Texas Tech University 327. 28 pp.

Brehme, C., K. Burnham, D. Kelt, A. Olsen, S. Montgomery, S. Hathaway, and R. Fisher. 2006. Stephens' Kangaroo Rat (*Dipodomys stephensi*) Monitoring Protocol for MCB Camp Pendleton. Prepared for AC/S Environmental Security, Marine Corps Base, Camp Pendleton. 50 pp.

Brehme, C.S. and R.N. Fisher. 2008. Stephens' kangaroo rat monitoring results on MCB Camp Pendleton, 2005. Data summary prepared for AC/S Environmental Security, Marine Corps Base, Camp Pendleton. 52 pp.

______. 2009. Stephens' Kangaroo Rat Monitoring Results on MCB Camp Pendleton, 2006. Prepared for AC/S Environmental Security, Marine Corps Base, Camp Pendleton. 45 pp.

Brehme, C.S., D.R. Clark, and R.N. Fisher. 2011a. Stephens' kangaroo rat (*Dipodomys stephensi*) monitoring on MCB Camp Pendleton, 2005 to 2010 Multi-year Trend Analysis and 5-year Program Review and Optimization. Report prepared for AC/S Environmental Security, Marine Corps Base, Camp Pendleton. 58 pp.

Brehme, C.S., D.R. Clark, C.J. Rochester, and R.N. Fisher. 2011b. Wildfires alter rodent community structure across four vegetation types in southern California, USA. Fire Ecology 7(2):81-98. doi: 10.4996/fireecology.0702081

Brehme, C.S., D.R. Clark, and R.N. Fisher. 2012. Stephens' Kangaroo Rat Monitoring Results on Naval Base Coronado, Remote Training Site, Warner Springs, 2010/2011 Data Summary prepared for Environmental Department, Naval Base Coronado. 24 pp.

______. 2015. Stephens' Kangaroo Rat Monitoring Results on Naval Base Coronado, Remote Training Site, Warner Springs, 2014. Data Summary prepared for Environmental Department, Naval Base Coronado. 26 pp.

______. 2017. Stephens' Kangaroo Rat Monitoring on MCB Camp Pendleton: Results and Trend Analyses for Fall-Winter 2015-16. Report prepared for AC/S Environmental Security, Marine Corps Base, Camp Pendleton. 54 pp.

Brock, R.E. and D.A. Kelt. 2004a. Conservation and social structure of Stephens' kangaroo rat: implications from burrow-use behavior. Journal of Mammalogy 85(1):51–57.

______. 2004b. Influence of roads on the endangered Stephens' kangaroo rat *(Dipodomys stephensi)*: are dirt and gravel roads different? Biological Conservation 118:633–640.

Brown, J.S., B.P. Kotler, R.J. Smith, W.O. Wirtz, Jr. 1988. The effects of owl predation on the foraging behavior of heteromyid rodents. Oecologia 76:408–415.

Burke, R.L., J. Tasse, C. Badgley, S.R. Jones, N. Fishbein, S. Phillips, and M.E. Soule. 1991. Conservation of the Stephens' kangaroo rat (*Dipodomys stephensi*): planning for persistence. Bulletin of the Southern California Academy of Sciences 90(1):10–40.

Burkey, T.V. and D. H. Reed. 2006. The effects of habitat fragmentation on extinction risk: mechanisms and synthesis. Songklanakarin Journal of Science and Technology 28(1):9–37.

Butterworth, B.B. 1961. A comparative study of growth and development of the kangaroo rats *Dipodomys deserti* Stephens and *Dipodomys merriami* Mearns. Growth 25:127–139.

[CDC] California Department of Conservation. 2018a. Farm Mapping and Monitoring Program, GIS data. Digital resource available at: http://www.conservation.ca.gov/dlrp/fmmp

______. 2018b. Farm Mapping and Monitoring Program Land Use Summaries for Riverside County and San Diego County, 1984–2016. Digital resource available at: http://www.conservation.ca.gov/dlrp/fmmp/Pages/county_info.aspx. Accessed September 25, 2018.

[CDFW]. California Department of Fish and Wildlife. 2012. Range map for Stephen's Kangaroo Rat, *Dipodomys stephensi* M108. California Wildlife Habitat Relationships System (Version 9), California Interagency Wildlife Task Group. Digital resource available at https://www.wildlife.ca.gov/data/cwhr

______. 2014. California Wildlife Habitat Relationships. GIS Data – Species Ranges and Habitat Data. Sacramento, California. Digital resource available at: https://www.wildlife.ca.gov/data/cwhr

______. 2015. California State Wildlife Action Plan, 2015 Update: A Conservation Legacy for Californians. [A.G. Gonzales and J. Hoshi, eds.]. Prepared with assistance from Ascent Environmental Inc., Sacramento, California. Digital resource available at: https://www.wildlife.ca.gov/SWAP/Final

______. 2018a. State and Federally Listed Endangered and Threatened Animals of California. Biogeographic Data Branch California Natural Diversity Database. Dated August 6, 2018.

______. 2018b. California Endangered Species Act (CESA) Permits. Digital resource available at: https://www.wildlife.ca.gov/Conservation/CESA. Last accessed September 28, 2018.

[DPR]. California Department of Pesticide Regulation. 2018a. Overview of the Pesticide Regulation Branch. Digital resource available at: http://www.cdpr.ca.gov/docs/registration/aboutreg.htm. Last accessed August 8, 2018.

______. 2018b. Final Decision Regarding Renewal of Registration of Pesticide Products for 2018. California Notice 2018-11. Dated April 18, 2018.

______. 2018c. PRESCRIBE Data Base for Protection of Endangered Species. Online resource available at https://www.cdpr.ca.gov/docs/endspec/esppts/about_prescribe.pdf. Last accessed June 6, 2018.

California Department of Water Resources. 2015. California's Most Significant Droughts: Comparing Historical and Recent Conditions. February 2015. 128 pp.

[Cal/EPA] California Environmental Protection Agency. 2001. The History of the California Environmental Protection Agency. Digital resource available at: https://calepa.ca.gov/about/history01/ Last accessed August 8, 2018.

California West Nile Virus Website. 2018. California Mosquito-borne Virus Surveillance and Response Program Reports. Digital resource available at: http://www.westnile.ca.gov/reports.php?report_category_id=8 Last accessed June 4, 2018.

[CNLM] Center for Natural Lands Management. 2012. Survey report, March Stephens' Kangaroo Rat Preserve, 2011 Stephens' kangaroo rat survey results.

______. 2016. Survey report, Johnson Ranch Preserve (S015J), 2015 Stephens' kangaroo rat survey results. Received January 28, 2016.

Chambers Group, Inc. and SJM Biological Consultants, Inc. 2012. Stephens' Kangaroo Rat (*Dipodomys stephensi*) Focused Survey Report for the San Diego Gas & Electric Cleveland National Forest Master Services Permit Project, San Diego County, California. Prepared for San Diego Gas & Electric. 50 pp.

Clark, D.R., C.S. Brehme, and R.N. Fisher. 2018. Stephens' Kangaroo Rat Monitoring Results on Naval Base Coronado, Remote Training Site, Warner Springs, 2017. Data Summary prepared for Environmental Department, Naval Base Coronado. 28 pp.

Coggins, G.C, C.F. Wilkinson, and J.D. Leshy. 2001. Modern National Forest Management. Pp. 720–737 *in* Federal Public Land and Resources Law, 5th ed. Foundation Press; New York, New York.

Cosentino, B.J., C.A. Phillips, R.L. Schooley, W.H. Lowe, and M.R. Douglas. 2012. Linking extinction-colonization dynamics to genetic structure in a salamander metapopulation. Proceedings of the Royal Society of London, B 279:1575–1582.

County of San Diego. 2018. Ramona Grasslands County Preserve, County of San Diego Department of Parks and Recreation. Digital resource at: http://www.sdparks.org/content/sdparks/en/park-pages/RamonaGrasslands.html Accessed September 21, 2018.

Crooks, K. R., & Soulé, M. E. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature, 400:563-566.

Csuti, B.A. 1971. Distribution of southern California kangaroo rats. Bulletin of Southern California Academy of Sciences 70:50–51.

Daly, M., M. Wilson, P.R. Behrends, and L.F. Jacobs. 1990. Characteristics of kangaroo rats, *Dipodomys merriami*, associated with differential predation risk. Animal Behavior 40:380–389.

Daly, M., P.R. Behrends, and M.I. Wilson. 2000. Activity patterns of kangaroo rats – granivores in a desert habitat. Pp. 145–158 *in* Activity Patterns in Small Mammals. Ecological Studies (Analysis and Synthesis), Vol. 141 [S. Halle and N.C. Stenseth, eds]. Springer-Verlag; Berlin, Heidelberg, Germany.

Daubenmire, R.F. 1938. Merriam's life zones of North America. The Quarterly Review of Biology 13(3):327–332.

Dettinger, M. D., F.M. Ralph, T. Das, P.J. Neiman, and D.R. Cayan. 2011. Atmospheric rivers, floods and the water resources of California. Water 3(4):445–478. https://doi.org/10.3390/w3020445

Dudek and Associates. 2003. Western Riverside County Final Multiple Species Habitat Conservation Plan, Volumes I–V. Prepared for the County of Riverside Transportation and Land Management Agency. Approved June 17, 2003.

______. 2007. Stephens' Kangaroo Rat Habitat Management and Monitoring Plan & Fire Management Plan for RCHCA Lands in the Lake Mathews and Steele Peak Preserves. Prepared for Riverside County Habitat Conservation Agency. Dated June 21, 2007.

Edelman, A.J. 2011. Kangaroo rats remodel burrows in response to seasonal changes in environmental conditions. Ethology 117:430–439.

Egoscue, H.J., J.G. Bittmenn, and J.A. Petrovich. 1970. Some fecundity and longevity records for captive small mammals. Journal of Mammalogy 51(3):622–623.

Eisenberg, J.F. 1963. The behavior of heteromyid rodents. University of California Publications in Zoology 69:1–100; plus 13 Plates. University of California Press, Los Angeles and Berkeley, California.

[EPA]. United States Environmental Protection Agency. 2018. Restrictions on Rodenticide Products. Available at https://www.epa.gov/rodenticides/restrictions-rodenticide-products Last accessed August 8, 2018.

French, A.R. 1993. Physiological ecology of the Heteromyidae: economics of energy and water utilization. Pp. 509–538 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Gaggiotti, O.E. and I. Hanski. 2004. Mechanisms of population extinction. Pp. 337–366 *in* Ecology, Genetics, and Evolution of Metapopulations [I. Hanksi and O.E. Gaggiotti, eds.]. Elsevier Academic Press; Burlington, Massachusetts.

Glick, P., B.A. Stein, and N.A. Edelson (eds.). 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation; Washington, DC. 168 pp.

Grinnell, J. 1921. Revised list of the species in the genus Dipodomys. Journal of Mammalogy 2(2):94–97.

______. 1922. A geographical study of the kangaroo rats of California. University of California Publications in Zoology 24(1):1–124.

Haddad N.M., L.A. Brudvig, J. Clobert, K.F. Davies, A. Gonzalez. R.D. Holt, T.E. Lovejoy, J.O. Sexton, M.P. Austin, C.D. Collins, W.M. Cook, E.I. Damschen, R.M. Ewers, B.L. Foster, C.N. Jenkins, A.J. King, W.F. Laurance, D.J. Levey, C.R. Margules, B.A. Melbourne, A.O. Nicholls, J.L Orrock, D.X. Song, and J.R. Townshend. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances 1(2):e1500052. Published online March 20, 2015.

Hafner, J.C., J.E. Light, D.J. Hafner, M.S. Hafner, E. Reddington, D.S. Rogers, and B.R. Riddle. 2007. Basal clades and molecular systematics of heteromyid rodents. Journal of Mammalogy 88(5):1129–1145.

Hall, E.R. 1981. The mammals of North America, Volume 1. Second Edition. John Wiley & Sons, Inc., New York, New York.

Hall, A., N. Berg, and K. Reich. 2018. *Los Angeles Summary Report*. California's Fourth Climate Change Assessment (University of California, Los Angeles). Publication number: SUM-CCCA4-2018-007.

He, M. and M. Gautam. 2016. Variability and trends in precipitation, temperature and drought indices in the State of California. Hydrology 3(2):14. https://doi.org/10.3390/hydrology3020014

He, M., A. Schwarz, E. Lynn, and M. Anderson. 2018. Projected changes in precipitation, temperature, and drought across California's hydrologic regions in the 21st Century. Climate 6(2):31. Online version published April 23, 2018. doi:10.3390/cli6020031

Heinrichs, J.A., D.J. Bender, D.L. Gummer, and N.H. Schumaker. 2015. Effects of landscape and patch-level attributes on regional population persistence. Journal for Nature Conservation 26:56–64.

Holden, Z.A., A. Swanson, C.H. Luce, W. M. Jolly, M. Maneta, J.W. Oyler, D.A. Warren, R. Parsons, and D. Affleck. 2018. Decreasing fire season precipitation increased recent western US forest wildfire activity. PNAS Direct Submission www.pnas.org/cgi/doi/10.1073/pnas.1802316115

Huey, L.M. 1962. Two new species of broad-faced, five-toed kangaroo rats (Genus Dipodomys). Transactions of the San Diego Society of Natural History 12(29): 477–480.

Hulton VanTassel, H.L. and K.E. Anderson. 2018. Altered space use and movement distances of Merriam's kangaroo rat, *Dipodomys merriami*, in post-fire lands, Journal of Mammalogy 99(3):684–692. https://doi.org/10.1093/jmammal/gyy043

ICF International. 2010. Final Baseline Biodiversity Report, Ramona Grasslands Preserve. Prepared for County of San Diego Department of Parks and Recreation, San Diego, California.

______. 2012. Final Ramona Grasslands Preserve Vegetation Management Plan. Prepared for the County of San Diego Department of Parks and Recreation, San Diego, California.

______. 2016 Stephens' Kangaroo Rat Survey at the Ramona Grasslands Preserve, Ramona, San Diego County, California. Prepared for the County of San Diego Department of Parks and Recreation, San Diego, California.

Ingles, L.G. 1965. Mammals of the Pacific States; California, Washington, Oregon. Stanford University Press, Stanford, California.

[IPCC] International Panel on Climate Change. 2013a. Annex III: Glossary [Planton, S. (ed.)]. *In*: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 20 pp.

______. 2013b. Summary for Policymakers. *In*: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P.M. Midgley, eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 33 pp.

______. 2013c. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley, eds.]. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 1535 pp.

______. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Summary for Policymakers. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 44 pp. URL: http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf

[ITIS] Integrated Taxonomic Information System TSN 180247. Standard report for *Dipodomys stephensi*. Online resource available at https://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=180247#null. Accessed August 7, 2018.

Jones, J.H. 2012. *Owners of Rancho Guejito hit with more violations*. San Diego Union-Tribune (North County). September 29, 2012.

Jones, W.T. 1993. The social systems of heteromyid rodents. Pp. 575–595 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Jones & Stokes Associates, Inc. 1983. Final Stephens kangaroo rat studies at Lake Mathews. Submitted to Metropolitan Water District of Southern California, Los Angeles, California. 16 pp.

Kalansky, J., D. Cayan, K. Barba, L. Walsh, K. Brouwer, and D. Boudreau. 2018. *San Diego Summary Report*. California's Fourth Climate Change Assessment (University of California, San Diego). Publication number: SUM-CCCA4-2018-009.

Keeley, J. D., W. J. Bond, R. A. Bradstock, J. G. Pausas, and P. W. Rundel. 2012. Fire in Mediterranean Ecosystems. Cambridge University Press; New York, NY. 515 pp.

Kelly, P.A. and M.V. Price. 1992. Home range use of Stephens' kangaroo rats: implications for density estimation. Final Report (Part B). Submitted to Riverside County Habitat Conservation Agency.

Kelt, D.A., J.A. Wilson, and E.S. Konno. 2005a. Differential response of two kangaroo rats (*Dipodomys*) to the 1997–1998 El Niño Southern Oscillation event. Journal of Mammalogy 86:265–274.

Kelt, D.A., E.S. Konno, and J.A. Wilson. 2005b. Habitat management for the endangered Stephens' kangaroo rat: the effect of mowing and grazing. Journal of Wildlife Management 69:424–429.

Kelt, D.A., J.A. Wilson, E.S. Konno, J.D. Braswell, and D. Deutschman. 2008. Differential responses of two species of kangaroo rat (*Dipodomys*) to heavy rains: a humbling reappraisal. Journal of Mammalogy 89(1):252–254.

Kenagy, G.J. 1976. The periodicity of daily activity and its seasonal changes in free-ranging and captive kangaroo rats. Oecologia 24(2):105–140.

Killam, D., A. Bui, S. LaDochy, P. Ramirez, J. Willis, and W. Patzert. 2014. California getting wetting to the North, drier to the South: natural variability or climate change? Climate 2:168–180.

Knecht, A.A. 1971. Soil Survey, Western Riverside Area, California. U.S. Soil Conservation Service, Washington, D.C. 157 pp.

Lackey, J.A. 1967a. Biosystematics of *Heermanni* group kangaroo rats in southern California. Transactions of the San Diego Society of Natural History 14(22):313–344.

______. 1967b. Growth and development of *Dipodomys stephensi*. Journal of Mammalogy 48(4):624–632.

Lepri, J.J. and J.A. Randall. 1983. Hormonal regulation of sandbathing in male kangaroo rats (*Dipodomys merriami*). Behavioral and Neural Biology 37(2): 256–264.

Lightfoot, D.C., A.D. Davidson, D.G. Parker, L. Hernández, J.W. Laundré. 2012. Bottom-up regulation of desert grassland and shrubland rodent communities: implications of species-specific reproductive potentials. Journal of Mammalogy 93(4):1017–1028.

Lowe, M. 1997. Diet of Stephens' kangaroo rat, *Dipodomys stephensi*. The Southwestern Naturalist 42(3):358–361.

Lyon, L.J., M.H. Huff, E.S. Telfer, D.S. Schreiner, and J.K. Smith. 2000. Chapter 4: Fire Effects on animal populations. Pp. 35–34 *in* Wildland fire in ecosystems: effects of fire on fauna [J.K. Smith, ed.]. General Technical Report RMRS-GTR-42-Volume 1. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station; Ogden, Utah. 83 p.

McClenaghan, Jr., L.R. and E. Taylor. 1991. Temporal and spatial patterns of demography of *Dipodomys stephensi* from Riverside County, California. Submitted to Regional Environmental Consultants (RECON), San Diego, California. Dated March 22, 1991.

______. 1993. Temporal and spatial demographic patterns in *Dipodomys stephensi* from Riverside County, California. Journal of Mammalogy 74(3):636–645.

McClenaghan, Jr., L.R. and H.D. Truesdale. 1991. Final Report: Genetic variability within and among populations of *Dipodomys stephensi* in Riverside County, California. Submitted to Regional Environmental Consultants (RECON), San Diego California. Dated March 22, 1991.

______. 2002. Genetic structure of endangered Stephens' kangaroo rat populations in southern California. The Southwestern Naturalist 47(4):539–549.

Meadows, A. 1991. Burrows and burrowing animals: an overview. Symposia of the Zoological Society of London 63:1–13.

Meko, D.M., C.W. Stockton, and W.R. Boggess. 1980. A tree-ring construction of drought in southern California. Water Resources Bulletin 16(4):594–600.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 841 pp.

Merriam, C.H. 1898. Life zones and crop zones of the United States. United States Department of Agriculture, Division of Biological Survey. Bulletin 10. Government Printing Office; Washington, D.C.

______. 1907. Descriptions of ten new kangaroo rats. Proceedings of the Biological Society of Washington 20:75–80.

Metcalf, A.E., L. Nunney, and B.C. Hyman. 2001. Geographic patterns of genetic differentiation within the restricted range of the endangered Stephens' kangaroo rat *Dipodomys stephensi*. Evolution 55(6):1233–1244.

Mills, J.N. 2005. Regulation of rodent-borne viruses in the natural host: implications for human disease. Archives of Virology [Suppl.] 19:45–57.

Mills, J.N., K.L. Gage, and A.S. Khan. 2010. Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. Environmental Health Perspectives 118(11):1507–1514.

Minnich, R.A. 2006. California Climate and Fire Weather. Pp. 13–37 *in* Fire in California's Ecosystems [N.G. Sugihara *et al*. (eds.)]. University of California Press; Berkeley, California.

Montgomery, S.J. 1991. Unpublished results of a preliminary trapping survey for Stephens' kangaroo rats on the Guejito Ranch property east of Escondido, San Diego County, California. Prepared for Pacific Southwest Biological Services. National City, California [not reviewed, cited according to Montgomery 2005].

______. 2005. Results of 2004 field surveys for Stephens' kangaroo rats (*Dipodomys stephensi)* at Rancho Guejito, San Diego County, California. Final Report prepared for Helix Environmental Planning (January 12, 2005). SJM Biological Consultants; San Diego, California.

______. 2006. Results of field surveys for the federally endangered Stephens' kangaroo rat (*Dipodomys stephensi*) and incidental mammal observations at the RTS Warner Springs San Diego County, California (October 16, 2006). Prepared for Tierra Data Systems. 20 pp.

Moore-Craig, N.A. 1984. Distribution and habitat preference of Stephens' kangaroo rat on the San Jacinto Wildlife Area. Senior undergraduate thesis, University of California, Riverside, California.

National Research Council. 2013. Abrupt impacts of climate change: anticipating surprises. Committee on Understanding and Monitoring Abrupt Climate Change and Its Impacts; Board on Atmospheric Sciences and Climate; Division on Earth and Life Studies. The National Academies Press; Washington, D.C. 250 pp.

Noss, R.F. and A.Y Cooperrider. 1994. Savings Nature's Legacy: Protecting and Restoring Biodiversity. Island Press; Washington, D.C.

Oldenbroek, K. and L. van der Waaij, 2015. Textbook Animal Breeding and Genetics for BSc students. Centre for Genetic Resources. The Netherlands and Animal Breeding and Genomics Centre, 2015. Digital resource available at Groen Kennisnet: https://wiki.groenkennisnet.nl/display/TAB/ Accessed July 25, 2018.

O'Farrell, M.J. 1990. Stephens' kangaroo rat: natural history, distribution, and current status. Pp. 78–84 *in* Endangered wildlife and habitats in southern California [P.J. Bryant and J. Remington (eds.)]. Memoirs of the Natural History Foundation of Orange County, Newport Beach, California.

O'Farrell, M.J., S.B. Lacy, and W.A. Clark. 1985. Southern California Edison mitigation survey 500 kV Valley Substation to Serrano Line: Stephens' kangaroo rat mitigation. Prepared for Southern California Edison Company; Rosemead, California. [not reviewed; cited according to O'Farrell *et al*. 1987]

O'Farrell, M.J., S.M. Juarez, and C.E. Uptain. 1986. An addition to the known range of the Stephens' kangaroo rat, *Dipodomys stephensi*, in San Diego County, California. California Fish and Game 72:187–189.

O'Farrell, M.J. and W.A. Clark. 1987. Habitat utilization by Stephens' kangaroo rat (*Dipodomys stephensi*). Prepared for WESTEC Services, Inc. Submitted to Southern California Edison Company; Rosemead, California. Dated March 1987. 29 pp.

O'Farrell, M.J. and C.E. Uptain. 1987. Distribution and aspects of the natural history of Stephens' kangaroo rat *(Dipodomys stephensi)* on the Warner Ranch. San Diego Co., California. Wasmann Journal of Biology 45:34–48.

______. 1989. Assessment of population and habitat status of the Stephens' kangaroo rat (*Dipodomys stephensi*). California Department of Fish and Game Nongame Bird and Mammal Section Report Sacramento, California. 19 pp., plus appendices.

Pequegnat, W.E. 1951. The biota of the Santa Ana Mountains. Reprint from the Journal of Entomology and Zoology 42(3 and 4):1-84, plus indexes.

Potter, M.C., H.O. Clark, Jr., P.A. Kelly, and C.S. Uptain. 2010. Fire effects on a population of Heermann's kangaroo rats at the Alkali Sink Ecological Reserve, Fresno County, California. Transactions of the Western Section of the Wildlife Society 46:1–6.

Poulin, R.G., L.D. Todd, E.A. Haug, B.A. Millsap, and M.S. Martell. 2011. Burrowing Owl (*Athene cunicularia*), version 2.0. *In* The Birds of North America [A. F. Poole, ed.]. Cornell Lab of Ornithology, Ithaca, New York. Digital resource available at: https://doi.org/10.2173/bna.61 Accessed June 13, 2018.

Preston, K.L., R.A. Redak, M.F. Allen, and J.T. Rotenberry. 2012. Changing distribution patterns of an endangered butterfly: linking local extinction patterns and variable habitat relationships. Biological Conservation 152:280–290 (with appendices).

Price, M.V. and P.R. Endo. 1988. Manuscript submitted to the U.S. Fish and Wildlife Service, "Estimating the distribution and abundance of a cryptic species, *Dipodomys stephensi* (Rodentia: Heteromyidae), and implications for management" with Appendix 1 and Tables and Figures. Dated January 24, 1988.

______. 1989. Estimating the distribution and abundance of a cryptic species, *Dipodomys stephensi* (Rodentia: Heteromyidae), and implications for management. Conservation Biology 3:293–301.

Price, M.V. and P.A. Kelly. 1994. An age-structured demographic model for the endangered Stephens' kangaroo rat. Conservation Biology 8(3):810–821.

Price, M.V, P.A. Kelly, and R.L. Goldingay. 1994a. Distances moved by Stephens' kangaroo rat (*Dipodomys stephensi*) and implications for conservation. Journal of Mammalogy 75: 929–939.

Price, M.V., R.L. Goldingay, L.S. Szychowski, and N.M. Waser. 1994b. Managing habitat for the endangered Stephens' kangaroo rat (*Dipodomys stephensi*): effects of shrub removal. American Midland Naturalist 131:9–16.

Price, M.V., N.M. Waser, K.E. Taylor, and K.L. Pluff. 1995. Fire as a management tool for Stephens' kangaroo rat and other small mammal species. Pp. 51–61 *in* Brushfires in

California Wildlands: Ecology and Resource Management [J.E. Keely and T. Scott, eds.]. International Association of Wildland Fire; Fairfield, Washington.

Price, M.V., N.M. Waser, and S. McDonald. 2000. Seed caching by heteromyid rodents from two communities: implications for coexistence. Journal of Mammalogy 81(1):97–106.

Prugh, Laura, and Justin Brashares. "Basking in the moonlight? Effect of illumination on capture success of the endangered giant kangaroo rat." Journal of Mammalogy 91.5 (2010): 1205-1212.

Randall, J.A. 1991. Mating strategies of a nocturnal, desert rodent (*Dipodomys spectabilis*). Behavioral Ecology and Sociobiology 28(3):215–220.

[RCHCA] Riverside County Habitat Conservation Agency. 1990. Joint Exercise of Powers Agreement (as amended).

_______. 1996. Habitat Conservation Plan for the Stephens' Kangaroo Rat in Western Riverside County, California: Volume I. Dated March 1996. 396 pp.

_______. 2007. Stephens' Kangaroo Rat Habitat Conservation Plan Annual Report. Prepared for U.S. Fish and Wildlife Service and California Department of Fish and Game. 16 pp.

_______. 2011. Stephens' Kangaroo Rat Monitoring Report for the Lake Mathews and Steele Peak Reserves. Prepared for the Bureau of Land Management. Dated January 2011. 13 pp.

RECON (Regional Environmental Consultants). 1992. Stephens' Kangaroo Rat Literature Review. Prepared for Riverside County Habitat Conservation Agency. Technical report *in* Habitat Conservation Plan for the Stephens' Kangaroo Rat in Western Riverside County, Volume II (February 1995).

Reichman, O.J. 1975. Relation of desert rodent diets to available resources. Journal of Mammalogy 56(4):731–751.

Reichman, O.J. and M.V. Price. 1993. Ecological aspects of heteromyid foraging. Pp. 539–574 in *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Richard, M. and C. Young. 2013. Summary of trapping activities for Stephens' kangaroo rat – Sycamore Canyon Wilderness Park in Riverside, CA. Summary prepared for U.S. Fish and Wildlife Service. Dated July 2, 2013.

Robbins, A. 2013. Range-wide habitat mapping for Ord's kangaroo rats (*Dipodomys ordii*). M.S. Thesis. University of Calgary, Department of Geography; Calgary, Alberta, Canada. 84 pp.

Root, J.J. 2012. West Nile virus associations in wild mammals: a synthesis. Archives of Virology Published online December 2, 2012. DOI 10.1007/s00705-012-1516-3.

SDMMP. 2010. Threats and Stressors Oncosiphon Piluliferum (Stinknet) Management. San Diego Management and Monitoring Program. Digital resource available at: this embedded link. Accessed April 9, 2019.

Schmidly, D.J., K.T. Wilkins, and J.N. Derr. 1993. Biogeography. Pp. 319–356 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Schoenherr, A.A. 1992. A natural history of California. University of California Press; Berkeley, California.

[Service] U.S. Fish and Wildlife Service. 1993. Stephens' kangaroo rat study, Naval Weapons Station, Fallbrook Annex, San Diego County, California. Prepared for U.S. Navy Southwestern Division, Naval Facilities Engineering Command, San Diego, California. Dated July 1993.

______. 1997. Draft recovery plan for the Stephens' kangaroo rat (*Dipodomys stephensi*). U.S. Fish and Wildlife Service, Region 1, Portland, Oregon. April 1997. 71 pp.

______. 2003. Formal Consultation for the Wildland Fire Management Plan at Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County, California; Original Tracking Number FWS-SD-3506.3; Post 2015 Tracking Number FWS-SDG-04B0004-04F0005-003.

______. 2004. Intra-Service Formal Section 7 Consultation/Conference [Opinion] for Issuance of an Endangered Species Act Section 10(a)(1)(B) Permit (TE–088609–0) for the Western Riverside County Multiple Species Habitat Conservation Plan, Riverside County, California. Dated June 22, 2004. 1203 pp.

______. 2009. Biological Opinion on the Formal Section 7 Consultation for the Navy's Remote Training Site Warner Springs, San Diego County, California. FWS-SDG-09B0277-09F0806. Dated October 30, 2009.

______. 2011. Stephens' kangaroo rat 5-Year Review, Short Form Summary. July 22, 2011.

______. 2013. Programmatic Biological Opinion for the Revised Land Management Plans for the Four Southern California National Forests, California. U.S. Fish and Wildlife Service Biological Opinion FWS-05B0017-05F0009-R002. Dated September 30, 2013.

______. 2016. Reinitiation of Section 7 Consultation for the U.S. Navy's Remote Training Site Warner Springs, Naval Base Coronado, San Diego County, California. FWS-SDG - 0980277-09F0806-R001. Dated May 5, 2016.

______. 2017. Informal Consultation for the Range 409 Prescribed Burn Project, Marine Corps Base Camp Pendleton, California. FWS-MCBCP-17B0237-17I0719. Dated April 11, 2017.

______. 2018. Carlsbad Fish and Wildlife Office, Geographic Information System Analysis, Summary of Procedures.

Setzer, H.W. 1949. Subspeciation in the kangaroo rat, Dipodomys ordii. University of Kansas Publications, Museum of Natural History Volume 1, Number 23, pp. 473–573 [Project Gutenberg ebook #42810, May 26, 2013]

Shaffer, M.L. and B.A. Stein. 2000. Safeguarding our precious heritage. Pp. 299-321 in Precious Heritage the Status of Biodiversity in the United States. Oxford University Press.

Shier, D. M. 2008. Behavioral ecology and translocation of the endangered Stephens' kangaroo rat (*Dipodomys stephensi*): Draft Report for the period June 2008 to December 2008. San Diego Zoo Institute for Conservation Research, Escondido, California.

______. 2009. Behavioral ecology and translocation of the endangered Stephens' kangaroo rat (*Dipodomys stephensi*): Annual Report for the period June 2008 to December 2008. San Diego Zoo Institute for Conservation Research, Escondido, California.

______. 2010. Behavioral ecology and translocation of the endangered Stephens' kangaroo rat (*Dipodomys stephensi*): Annual Report for the Period January 2009 thru December 2009. San Diego Zoo Institute for Conservation Research, Escondido, California.

______. 2011. Behavioral Ecology and Translocation of the Endangered Stephens' kangaroo rat (*Dipodomys stephensi*): Annual Report for the period January 1, 2010 thru December 31, 2010. San Diego Zoo Institute for Conservation Research, Escondido, California.

Shier, D.M. and A. Navarro. No Date. Range-wide genetics of the Stephens' kangaroo rat (*Dipodomys stephensi*). Final Report. San Diego Zoo Institute for Conservation Research. 33 pp.

Shier, D.M. and M. Swartz. 2012. Behavioral ecology, stress, genetics, and translocation of the endangered Stephens' kangaroo rat (*Dipodomys stephensi*). Annual Report for the Period January 2011–December 2011. San Diego Zoo Institute for Conservation Research. 64 pp.

Shier, D.M., A. Bird, and T. Wang. 2020. Effects of artificial light at night on the foraging behavior of an endangered nocturnal mammal. Environmental Pollution 263: 1-9.

Shukla, S., M. Safeeq, A. AghaKouchak, K. Guan, and C. Funk. 2015. Temperature impacts on the water year 2014 drought in California. Geophysical Research Letters 42:4384–4393. doi: 10.1002/2015GL063666.

SJM Biological Consultants. 2009. Letter report, "Results of a Trapping Survey for Stephens' Kangaroo Rat Survey at Select Locations along TL685 in Lake Henshaw, San Diego County, California." Prepared for SDG&E. Dated October 28, 2009.

______. 2011. Letter report, "Report of Stephens' kangaroo rat (*Dipodomys stephensi*) (SKR) mitigation actions taken at the SDG&E Wood-to-Steel Pole Replacement, Tie Line 685 (TL685), project site in November 2010. Prepared for Chambers Group. Dated January 20, 2011.

______. 2013. Survey report, former Wyle Laboratory site, city of Norco, Riverside County. Submitted to VCS Environmental. SJMBC 880. Dated May 16, 2013.

______. 2015. Survey report for Staging Area project, Ramona Grasslands Preserve. Submitted to Jennifer Price, County of San Diego Parks and Recreation. Dated January 11, 2015.

______. 2017. Habitat Assessment and Preliminary Trapping Results of Stephens' Kangaroo Rat, SDG&E's Cleveland National Forest Power Line Replacement Projects (Project), Transmission Line (TL) 682. Report to SDG&E Environmental Project Management. Dated July 17, 2017.

Smith, D.R., N.L. Allan, C.P. McGowan, J.A. Szymanski, S.R. Oetker, H.M. Bell. 2018. Development of a Species Status Assessment Process for Decisions under the U.S. Endangered Species Act. Journal of Fish and Wildlife Management 9:302-320.

Smith, C.C. and O.J. Reichman. 1984. The evolution of food caching by birds and mammals. Annual Review of Ecology and Systematics 15: 329–351.

Smith, M.U. and J.T. Baldwin. 2015. Making sense of Hardy-Weinberg equilibrium. The American Biology Teacher 77(8):577–582. URL: http://www.bioone.org/doi/full/10.1525/abt.2015.77.8.3

Spencer, W.D. and S.J. Montgomery. 2007. Biological Survey Report for the Santa Maria Creek Restoration Project: Stephens' Kangaroo Rat. Prepared for County of San Diego, Department of Parks and Recreation. Dated January 2007. 23 pp.

Stavros, E.N., J.T. Abatzoglou, D. McKenzie, and N.K. Larkin. 2014. Regional projections of the likelihood of very large wildland fires under a changing climate in the contiguous Western United States. Climatic Change 126:455–468.

Stephens, S.L., R.E. Martin, and N.E. Clinton. 2007. Prehistoric fire area and emissions from California's forests, woodlands, shrublands, and grasslands. Forest Ecology and Management 251:205–216.

Sugihara, N.G. and M.G. Barbour. 2006. Fire and California Vegetation. Pp. 1–9 *in* Fire in California's Ecosystems [N.G. Sugihara *et al*. (eds.)]. University of California Press; Berkeley, California.

Tetra Tech, Inc. 1999. *Draft* Biological Assessment and Management Plan for Stephens' Kangaroo Rat Marine Corps Base Camp Pendleton, California. Prepared for U.S. Marine Corps. Dated April 29, 1999.

______. 2013. Stephens' Kangaroo Rat Management Area Habitat Enhancement and Monitoring Summary Report – 2012, Marine Corps Base Camp Pendleton, California. Prepared for United States Marine Corps, Naval Facilities Engineering Command Atlantic. Final Report. Dated September 2013.

______. 2015. Stephens' Kangaroo Rat Management Area Habitat Enhancement and Monitoring Summary Report – 2014, Marine Corps Base Camp Pendleton, California. Unpublished report prepared for Assistant Chief of Staff, Environmental Security, Marine Corps Base Camp Pendleton by Tetra Tech, Inc., Arlington, Virginia.

______. 2016. *Draft* Stephens' Kangaroo Rat Management Area Habitat Enhancement and Monitoring Summary Report – 2015, Marine Corps Base Camp Pendleton, California. Unpublished report prepared for Assistant Chief of Staff, Environmental Security, Marine Corps Base Camp Pendleton by Tetra Tech, Inc., Arlington, Virginia.

Thomas, J.R., Jr. 1975. Distribution, population densities, and home range requirements of the Stephens' kangaroo rat (*Dipodomys stephensi*). M.S. Thesis, California State Polytechnic University, Pomona, California. 73 pp.

Thompson, S.D. 1982. Microhabitat utilization and foraging behavior of bipedal and quadrupedal hetermoyid rodents. Ecology 63(5):1303–1312.

Tierra Data, Inc., ManTech International, and Firewise 2000, Inc. 2015. Wildland Fire Management Plan, Naval Base Coronado Remote Training Site Warner Springs, California. Draft Final. Prepared for Naval Facilities Engineering Command Southwest, San Diego, California. Dated May 2015.

Tremor, S., D. Stokes, W. Spencer, J. Diffendorfer, H. Thomas, S. Chivers, and P. Unitt (eds.). 2017. San Diego County mammal atlas. San Diego Society of Natural History Proceeding 46 p.

[USAF] U.S. Air Force. 2012. Final Integrated Natural Resources Management Plan for March Air Reserve Base, California. Dated June 2012.

[USDA] U.S. Department of Agriculture. 2018a. Forest Service Geodata Clearinghouse, National Datasets. Forest Service Existing Vegetation: Region 5 - South Coast (published 2017-11-16, last refreshed January 18, 2018). https://data.fs.usda.gov/geodata/edw/datasets.php

______. 2018b. Web Soil Survey (SSURGO). Soil Survey Staff, Natural Resources Conservation Service. Digital resource available at https://websoilsurvey.nrcs.usda.gov/. Last accessed May 2014.

[USFS] U.S. Forest Service. 2005a. Biological Assessment for the Revised Land Management Plans (Forest Plans) for the four southern California National Forests. Unpublished document submitted to the U.S. Fish and Wildlife Service. Dated March 18, 2005.

______. 2005b. Land Management Plan, Part 2, Cleveland National Forest Strategy. *In* Revised Land Management Plans and Final Environmental Impact Statement--Angeles National Forest, Cleveland National Forest, Los Padres National Forest, San Bernardino National Forest [CD ROM]. R5-MB-086-CD. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. September 2005.

______. 2005c. Final Environmental Impact Statement for Southern California Forest Plan Revisions, Volumes 1 and 2. *In* Revised Land Management Plans and Final Environmental Impact Statement--Angeles National Forest, Cleveland National Forest, Los Padres National Forest, San Bernardino National Forest [CD ROM]. R5-MB-086-CD. U.S. Department of Agriculture, Forest Service, Pacific Southwest Region. September 2005.

______. 2005d. Land Management Plan, Species Accounts. United States Department of Agriculture, Forest Service, Pacific Southwest Region.

[USGCRP] U.S. Global Change Research Program. 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock, eds.]. U.S. Global Change Research Program; Washington, DC, USA. 470 pp. doi:10.7930/J0J964J6.

U.S. Marine Corps. 2018. Final Joint Integrated Natural Resources Management Plan for Marine Corps Base and Marine Corps Air Station Camp Pendleton, California. 2018 Revision. Dated March 2018.

U.S. Navy. 2013. Final Integrated Natural Resources Management Plan Naval Base Coronado, California. Dated July 2013.

______. 2015. *Draft* Environmental Assessment for Wildlands Fire Management Actions at Remote Training Site Warner Springs. Dated October 2015.

______. 2016. Final Integrated Natural Resources Management Plan for Naval Weapons Station Seal Beach Detachment Fallbrook, San Diego County, California. Dated May 31, 2016.

Vergne, P. 2010. Stephens' kangaroo rat presence/absence trapping studies for Rancho Las Pampas in Ramona, San Diego County, California. Prepared by ENVIRA for The Judd RR Investments, LLC. Dated March 11, 2010.

______. 2011. Stephens' kangaroo rat presence/absence trapping studies and burrowing owl surveys, Montecito Air Center, San Diego County, California. Prepared by ENVIRA for Ramona Air Center, LLC. Dated March 6, 2011.

______. 2013. Stephens' kangaroo rat presence/absence trapping studies on the Fallbrook Community Airpark proposed expansion, County of San Diego, California. Prepared for HELIX Environmental Planning, Inc. Dated November 8, 2013

______. 2015. Stephens' kangaroo rat and Los Angeles pocket mouse relocation for Lakewood Substation project, Riverside County, California. Prepared by ENVIRA for Environmental Intelligence, LLC. Dated April 19, 2015.

______. 2018a. Stephens' kangaroo rat presence/absence trapping studies Ramona Municipal Water District proposed sewer line project segment 6, San Diego County, California. September 5, 2018.

______. 2018b. Stephens' kangaroo rat presence/absence trapping studies Ramona Municipal Water District proposed sewer line project segment 4, San Diego County, California. September 27, 2018

Vista Irrigation District. 2018. Vista Irrigation District 2017 Annual Report. Available at: https://www.vidwater.org/annual-reports

Walker, D.H. 2016. Scrub Typhus—Scientific Neglect, Ever-Widening Impact. New England Journal of Medicine 375(10):913–915.

Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) Biological Monitoring Program. 2017. Metadata for Species_Occurrence_Data_2005-2016. Publication date: September 15, 2017.

Webster, D.B. 1962. A function of the enlarged middle-ear cavities of the kangaroo rat, Dipodomys. Physiological Zoology 35(3):248–255.

Webster D.B. and M. Webster. 1980. Morphological adaptations of the ear in the rodent family Heteromyidae. American Zoologist 20:247– 254.

Wehner, M.F., J.R. Arnold, T. Knutson, K.E. Kunkel, and A.N. LeGrande, 2017: Droughts, floods, and wildfires. Pp. 231–256 *in* Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA. doi: 10.7930/J0CJ8BNN.

Whisson, D. 1999. Modified bait stations for California ground squirrel control in endangered kangaroo rat habitat. Wildlife Society Bulletin 27(1):172–177.

Whitaker, Jr., J.O., W.J. Wrenn, and R.E. Lewis. 1993. Parasites. Pp. 386–478 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Wilkening, J., Pearson-Prestera, W., Mungi, N.A., and S. Bhattacharyya. 2019. Endangered species management and climate change: When habitat conservation becomes a moving target. Wildlife Society Bulletin 43(1):11-20.

Williams, D.F., H.H. Genoways, and J.K. Braun. 1993. Taxonomy. Pp. 38–196 *in* Biology of the Heteromyidae [H. H. Genoways and J. H. Brown, eds.]. Special Publication 10, The American Society of Mammalogists.

Williams, A.P., R. Seager, J.T. Abatzoglou, B.I. Cook, J.E. Smerdon, and E.R. Cook. 2015. Contribution of anthropogenic warming to California drought during 2012–2014. Geophysical Research Letters 42:6819–6828.

Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: Why recovery under the Endangered Species Act is more than population viability. BioScience 65(2): 200-207.

Woodburne, M.O. 2004. Global events and the North American mammalian biochronology. Pp. 315–343 (Chapter 8) *in* Late Cretaceous and Cenozoic Mammals of North America [M.O. Wooburne, ed.]. Columbia University Press; New York, New York.

[WRCC] Western Regional Climate Center. 2018a. Period of Record Monthly Climate Summaries for: Ramona Spaulding, San Jacinto, and March Field, California. Digital resource available at: http://www.wrcc.dri.edu/ Accessed May 16, 2018.

______. 2018b. California Climate Tracker Summary Report, Southern Interior and South Coast Regions, Temperature. Digital resource available at: http://www.wrcc.dri.edu Accessed August 9, 2018.

Zedler, P.H., Gautier, C.R., and G.S. McMaster. 1983. Vegetation change in response to extreme events: the effect of a short interval between fires in California chaparral and coastal scrub. Ecology 64(4):809-818.

***Federal Register* Publications**

53 FR 38465. September 30, 1988. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Stephens' Kangaroo Rat. Fish and Wildlife Service, Interior. Final Rule.

75 FR 51204. August 19, 2010. Endangered and Threatened Wildlife and Plants; 12-Month Finding on a Petition to Remove the Stephens' Kangaroo Rat From the Federal List of Endangered and Threatened Wildlife. Fish and Wildlife Service, Interior. Notice of 12-month petition finding.

77 FR 21162. April 9, 2012. National Forest System Land Management Planning; Final rule and record of decision. Forest Service, U.S. Department of Agriculture.

80 FR 56423. September 18, 2015. Endangered and Threatened Wildlife and Plants; 90-Day Findings on 25 Petitions. Fish and Wildlife Service, Interior. Notice of petition findings and initiation of status reviews.

Personal Communications

Arnold, A. 2018. Electronic mail message from Arlene Arnold, Biologist, Naval Base Coronado, regarding land ownership/management at Warner Springs, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. September 5, 2018.

Arnold, A. 2019. Electronic mail message from Arlene Arnold, Biologist, Naval Base Coronado, regarding land management at Warner Springs, to Brendan Himelright, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. April 18, 2019.

Gannon, J. 2019. Electronic mail message from James Gannon, Fire Management Specialist, BLM California Desert District, regarding patrolling for OHV in Steele Peak Reserve, to Brendan Himelright, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. May 1, 2019.

Hoffman, J. 2019. Telephone conversation with Jennifer Hoffman, WRC MSHCP Biological Monitoring Program, regarding Stephens' kangaroo rat habitat conditions and stressors, with Brendan Himelright, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. March 19, 2019.

Kietzer, K. 2010. Electronic mail message from Ken Kietzer, Environmental Scientist, California Department of Parks and Recreation regarding pesticide use at Lake Perris, to Mark Pavelka, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. June 30, 2010.

McCutcheon, S. 2019. Electronic mail message from Sarah McCutcheon, Projects Coordinator, SDMMP, regarding stinknet in San Diego County, to Brendan Himelright, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. April 8, 2019.

Metcalf, A. 2018. Telephone conversation with Anthony Metcalf, CSU San Bernardino, regarding Stephens' kangaroo rat genetic studies, with Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. August 15, 2018.

Moreno, L. 2018. Electronic mail message from Leopoldo Moreno, Senior Environmental Scientist, California Department of Pesticide Regulation, Endangered Species Program, regarding bait stations and PRESCRIBE application, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. June 5, 2018.

Osborn, S. 2015. Electronic mail message from Scott Osborn, Senior Environmental Scientist and Statewide Coordinator, Small Mammal Conservation, California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program, regarding legal status and take provisions of SB flying squirrel, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. September 22, 2015.

______. 2018. Electronic mail message from Scott Osborn, Statewide Coordinator, Small Mammal Conservation, California Department of Fish and Wildlife, Wildlife Branch, Nongame Wildlife Program, regarding scientific collecting permits for Stephens' kangaroo rat, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. June 6, 2018.

Shomo, B. 2018a. Telephone conversation between Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding status of the Stephens' kangaroo rat, and Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. June 4, 2018.

______. 2018b. Electronic mail message from Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding previously identified stressors to the Stephens' kangaroo rat and core reserve management, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. August 20, 2018.

______. 2018c. Electronic mail message from Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding fire prevention and suppression activities on reserve lands, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. August 23, 2018.

______. 2018d. Electronic mail message from Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding history of implementation of fire prevention and suppression activities on reserve lands, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. September 20, 2018.

______. 2018e. Electronic mail message from Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding invasive plant species (stinknet) and effects on reserve lands, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. October 5, 2018.

______. 2018f. Electronic mail message from Brian Shomo, Natural Resources Manager, Riverside County Habitat Conservation Agency, regarding nonnative grasses on reserve lands, to Betty Grizzle, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. December 18, 2018.

Winchell, C. 2019. Electronic mail message from Clark Winchell, Fish and Wildlife Biologist, U.S. Fish and Wildlife Service, regarding invasive species management on Vista Irrigation District Land, to Brendan Himelright, U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office. April 18, 2019.

APPENDICES

APPENDIX A –CDFW RANGE MAP FOR STEPHENS' KANGAROO RAT

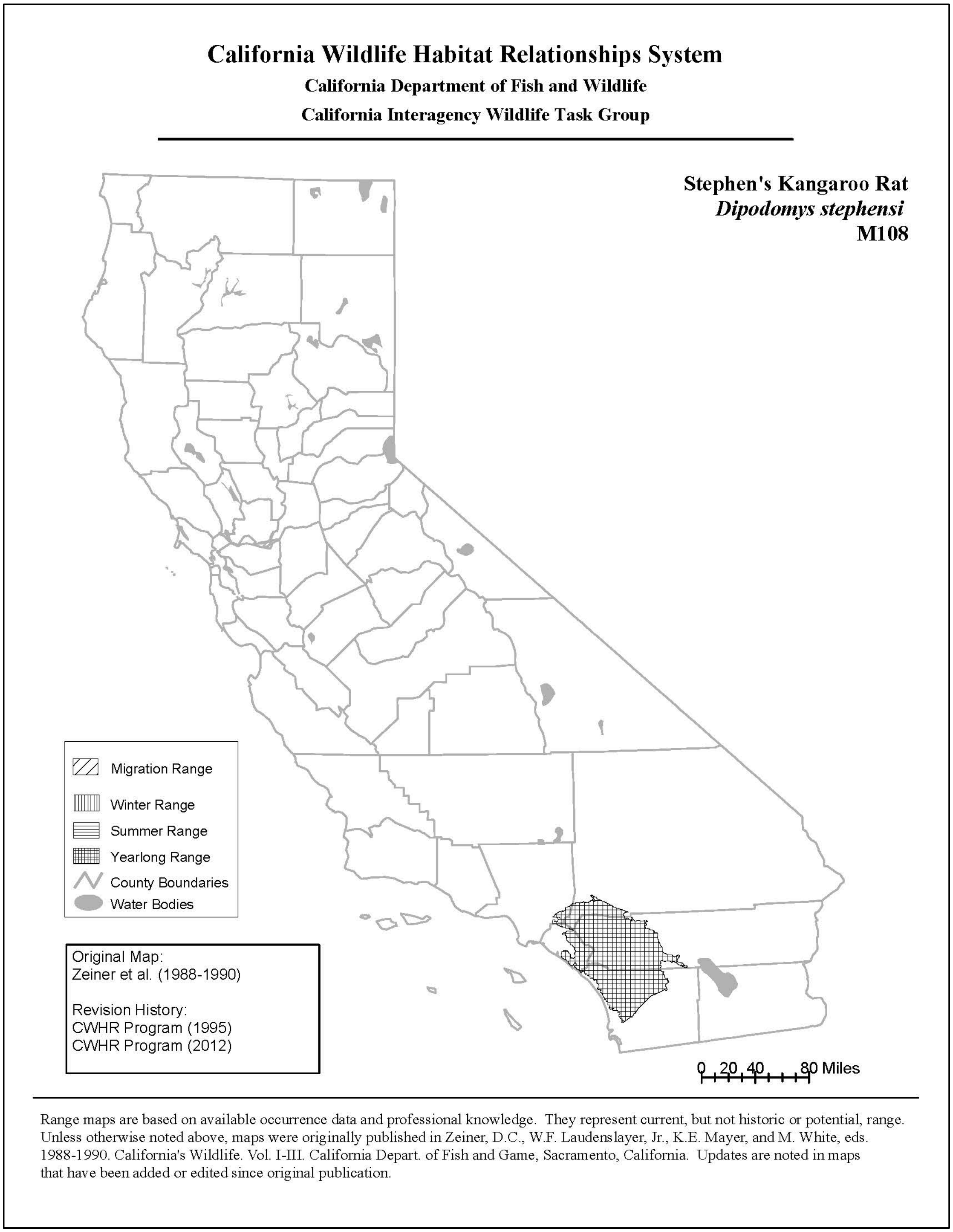

FIGURE A-1. CURRENT RANGE MAP FOR STEPHENS' KANGAROO RAT FROM CDFW. Source: California Department of Fish and Wildlife 2012; Species Explorer https://nrm.dfg.ca.gov/taxaquery/SpeciesDocumentList.aspx?AssociatedItemID=627&STitle=Dipodomys+stephensi&PTitle=Stephens%2526%252339%253b%2bkangaroo%2brat; accessed May 29, 2018.

Appendix B – Western Riverside County Core Reserves

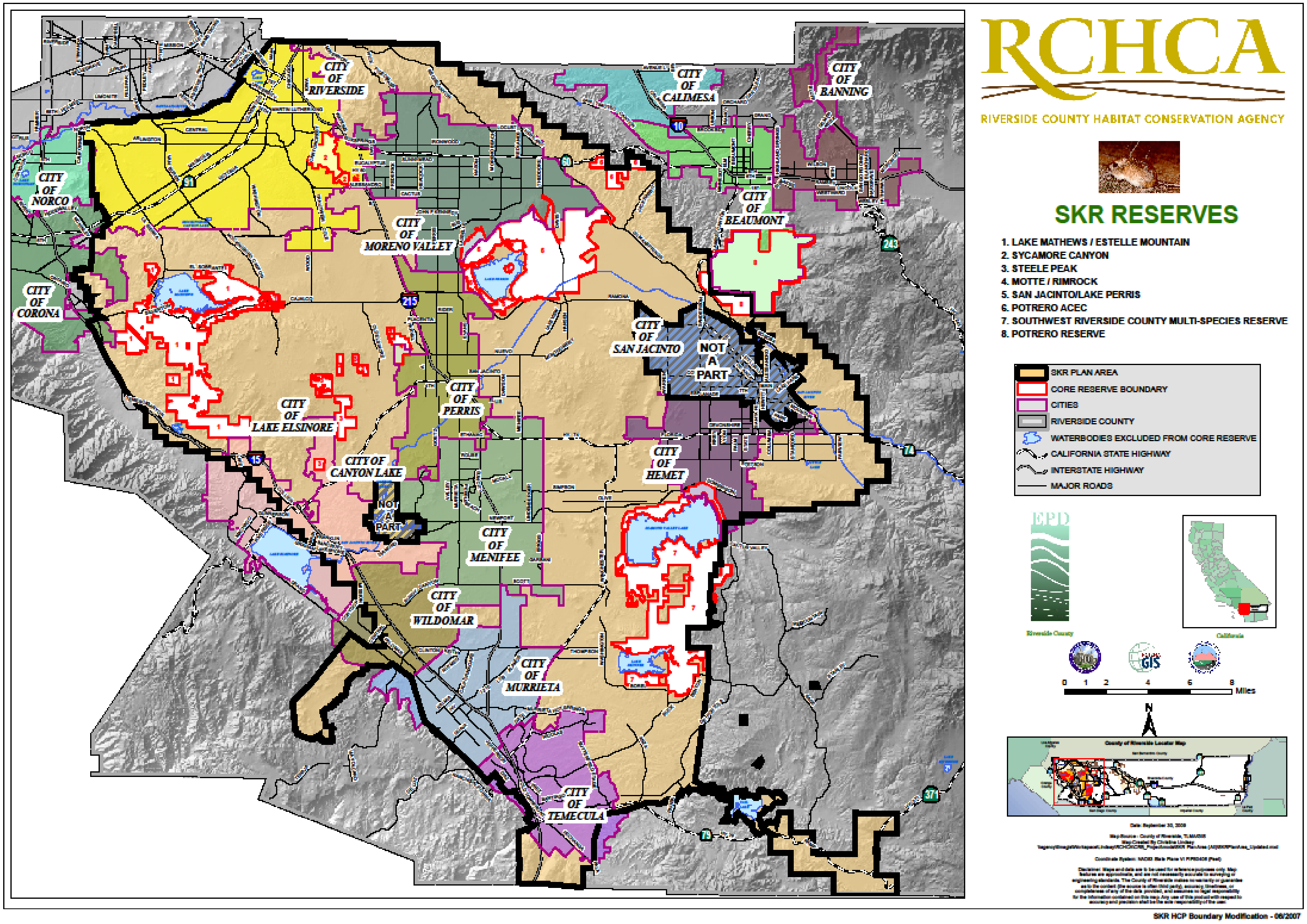

Figure B-1. Western Riverside County Core Reserves for the Stephens' kangaroo rat.
Online resource: [link to above map]() (downloaded September 4, 2018).

APPENDIX C – FRAGMENTATION MAPS

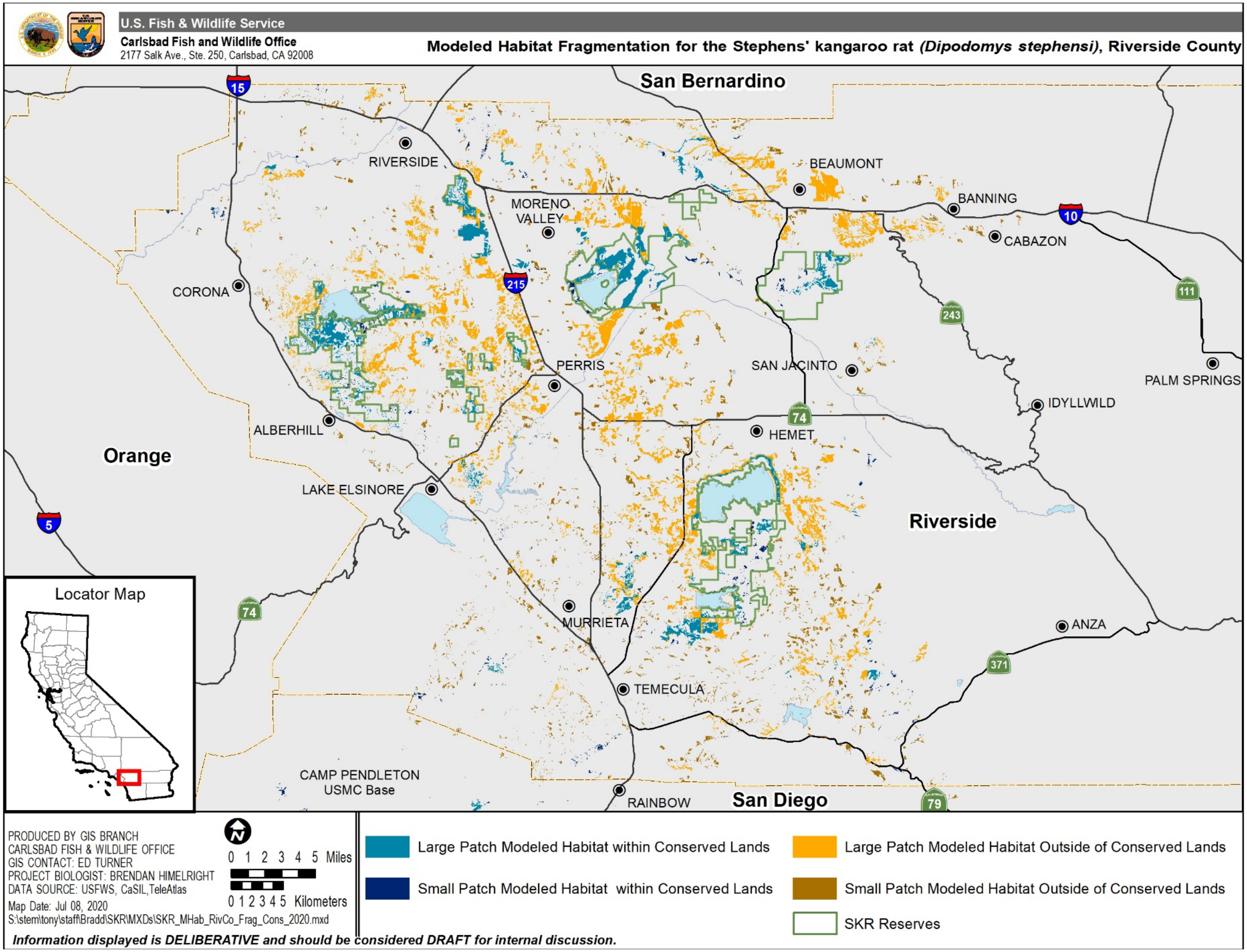

FIGURE C-1. FRAGMENTATION MAP FOR RIVERSIDE COUNTY.
(Modeled Habitat within Conserved Lands in Riverside County includes DoD lands.)

APPENDIX C (continued)

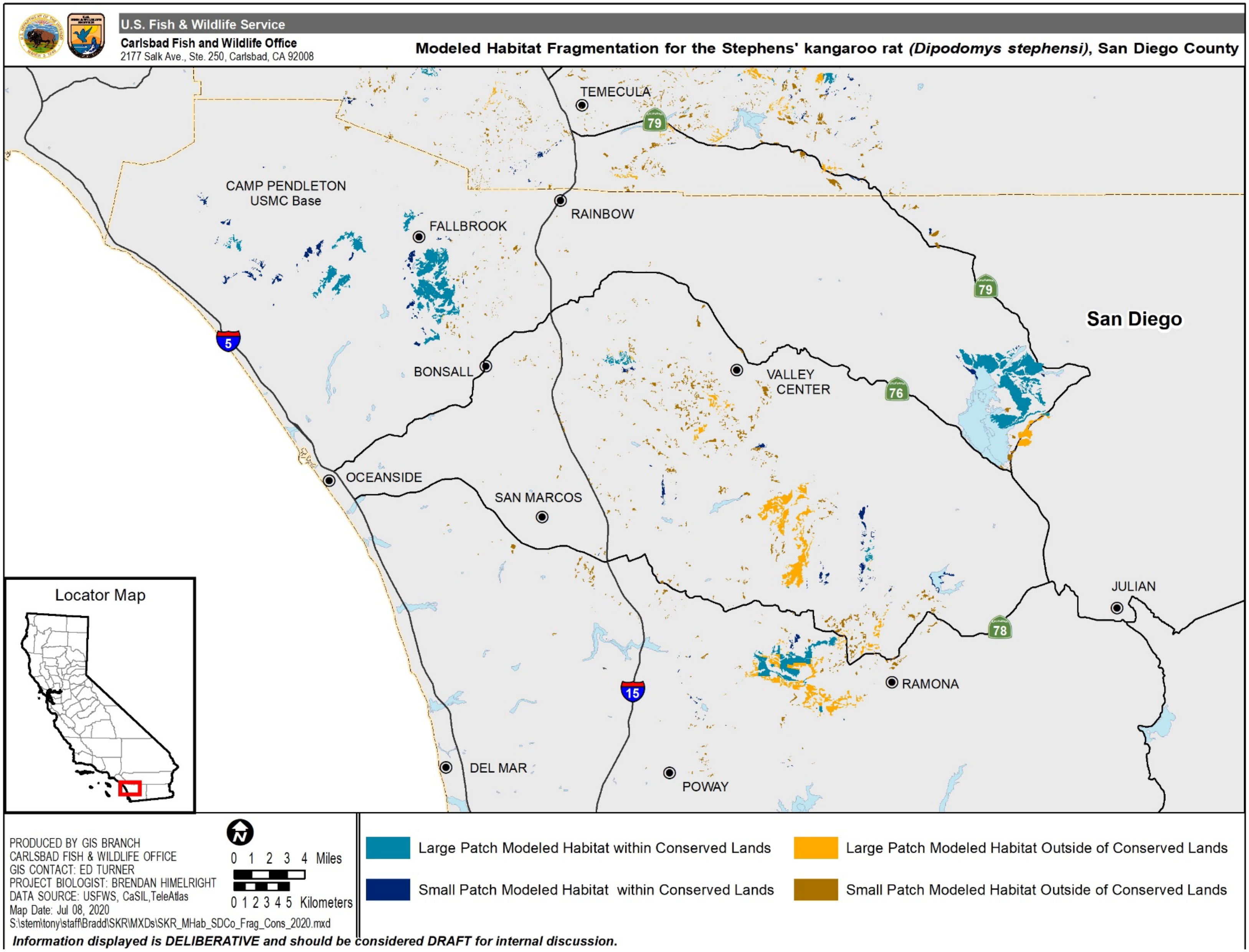

FIGURE C-2. FRAGMENTATION MAP FOR SAN DIEGO COUNTY.

(Modeled Habitat within Conserved Lands in San Diego County includes DOD lands.)

APPENDIX D – CONSERVATION STATUS OF LANDS WITHIN STEPHENS' KANGAROO RAT MODELED HABITAT

TABLE D-1. CONSERVATION STATUS OF LANDS WITHIN STEPHENS' KANGAROO RAT MODELED HABITAT – RIVERSIDE AND SAN DIEGO COUNTIES (see maps below).

Riverside County	**Acres (ac) (Hectares (ha))**	**Percent of Total**
Modeled Habitat within Conserved Lands*	16,438 ac (6,652 ha)	23.8%
Modeled Habitat outside Conserved Lands	52,666 ac (21,313 ha)	76.2%
Preserve Design Lands Not Yet Conserved**	[16,228 ac (6,567 ha)]	(23.5%)
Outside of Conservation Design	[36,438 ac (14,746 ha)]	(52.7%)
Total	69,104 ac (27,966 ha)	100%
San Diego County	**Acres (ac) (Hectares (ha))**	**Percent of Total**
Modeled Habitat within Conserved Lands*	12,457 ac (5,041 ha)	55.5%
Modeled Habitat outside Conserved Lands	9,977 ac (4,038 ha)	44.5%
Total	22,434 ac (9,079 ha)	100%

*Modeled Habitat within Conserved Lands- for both counties and Appendix D maps includes: conservation easements, conserved lands, Public/Quasi-Public, Federal, State, and DOD lands that are not likely to be impacted by urban and agricultural development.

**Preserve Design Lands Not Yet Conserved- lands within the Riverside County that are described for conservation, but are not yet in conservation status. These lands represent a combination of the Western Riverside County MSHCP Reserve Criteria Area and the Service's Conceptual Reserve Design.

Though not in the reserve lands, there are a portion on these lands may include local state and federal lands that we consider conserved outside of the preserve design.

APPENDIX D (continued)

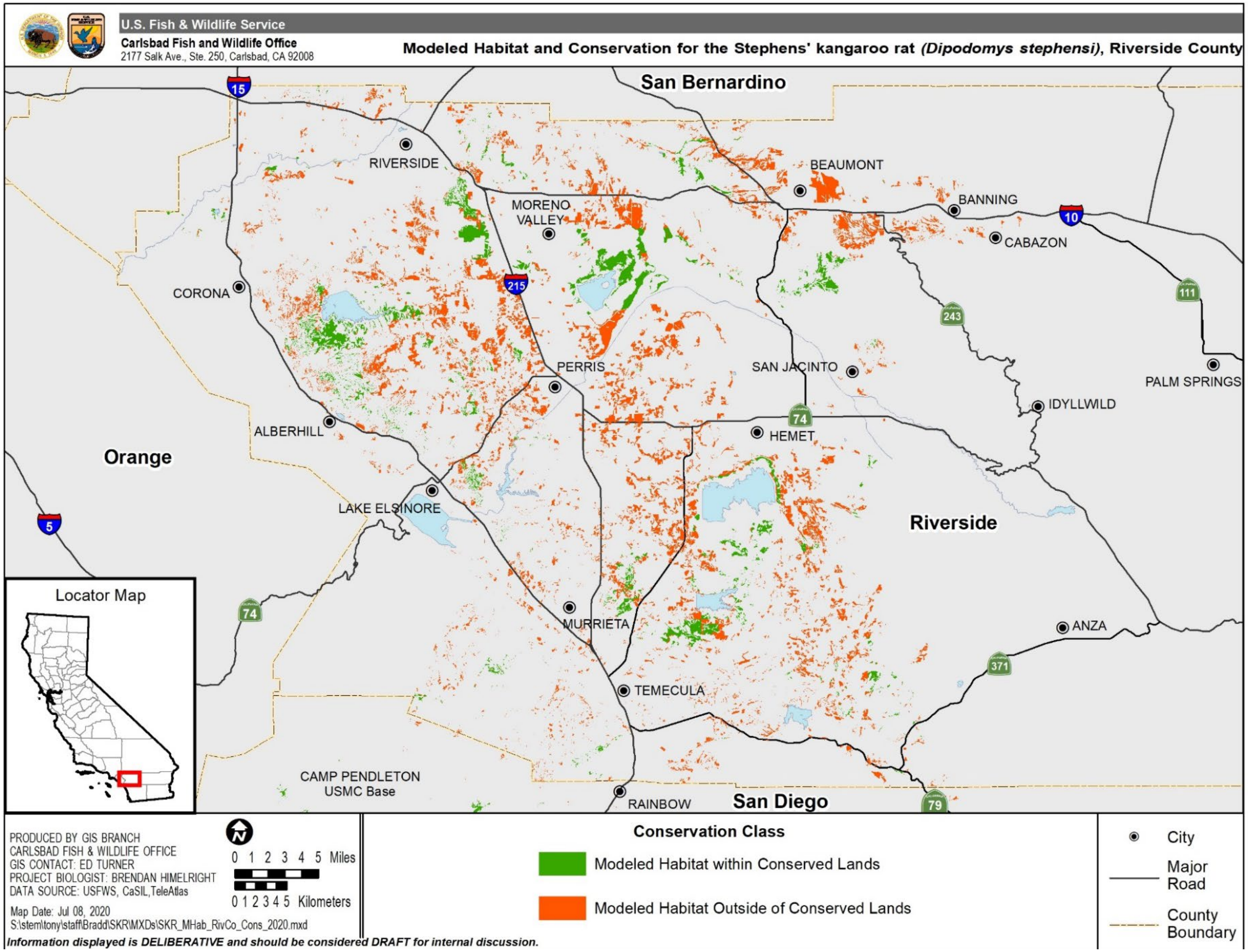

FIGURE D-1. MODELED HABITAT FOR STEPHENS' KANGAROO RAT IN RIVERSIDE COUNTY.

APPENDIX D (continued)

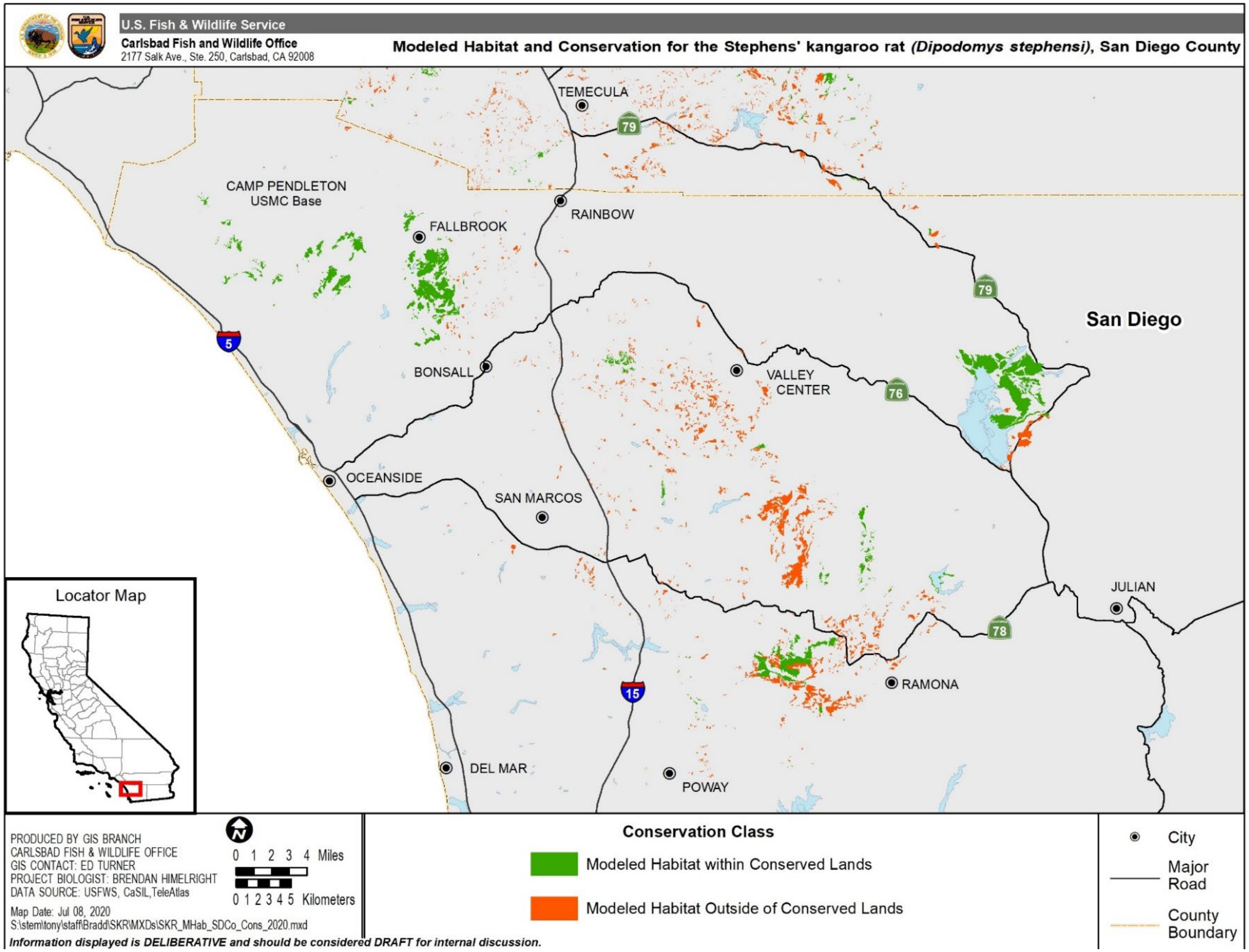

FIGURE D-2. MODELED HABITAT FOR STEPHENS' KANGAROO RAT IN SAN DIEGO COUNTY.

APPENDIX E – LAND OWNERSHIP WITHIN MODELED HABITAT

TABLE E-1. LAND OWNERSHIP WITHIN MODELED HABITAT FOR STEPHENS' KANGAROO RAT – RIVERSIDE AND SAN DIEGO COUNTIES.

County	Land Ownership	Land Ownership Breakdown	Acres	Hectares	County Ownership Breakdown
Riverside County	Federal	1.5%	1,037	420	
	State	7.4%	5,089	2,059	
	Local	17.5%	12,071	4,885	
	Tribal	1.4%	940	380	
	Private	72.3%	49,968	20,211	
	Total		**69,104**	**27,966**	**75.5%**
San Diego County	Federal	28.2%	6,323	2,559	
	State	1.7%	379	153	
	Local	21.1%	4,727	1,913	
	Tribal	1.1%	244	99	
	Private	74.8%	10,761	4,355	
	Total		**22,434**	**9,079**	**24.5%**
Grand Total			**91,538**	**37,044**	

Source: BLM-SMA

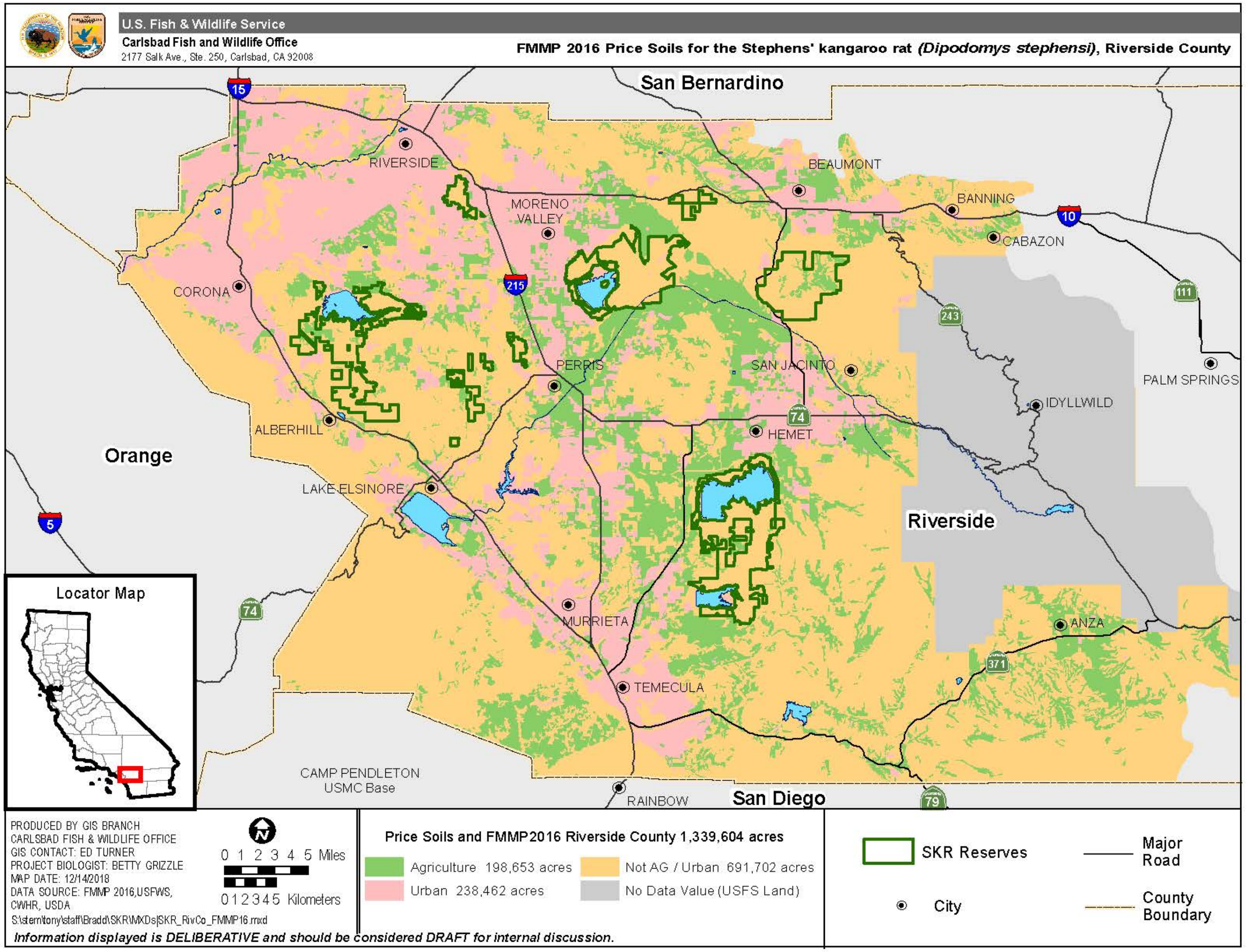

FIGURE F-1. LAND USE MAPPING USING PRICE AND ENDO (1989) SOIL TYPES AND 2016 FARMLAND MAPPING AND MONITORING PROGRAM, RIVERSIDE COUNTY.