State of California
Natural Resources Agency
Department of Natural Resources Agency
Department of Fish and Wildlife

Report to the California Fish and Game Commission

A Status Review of the Petitioned Southern California/Central Coast Evolutionarily Significant Unit (ESU) of Mountain Lion (*Puma concolor couguar*) in California

Charlton H. Bonham, Director

California Department of Fish and Wildlife

December 2025

Table of Contents

List of Figures

List of Tables

Acknowledgments

This report was prepared by Department scientific and technical staff, with substantial contributions from Esther Burkett, Dr. Anne Hilborn, Dr. Ange Baker, Dr. Michael Buchalski, Dr. Deana Clifford, Dr. Jaime Rudd, Dr. Justin Dellinger, Dr. Brett Furnas, Kristi Cripe, Dan Applebee, Neil Clipperton, Pete Figura, Dr. Scott Osborn, Erin Chappell, and Julie Horenstein. Terris Kasteen, Dr. Jeff Villepique, Dave Hacker, Bob Stafford, David Mayer, and Dr. Jason Lombardi provided valuable feedback on a draft version of the report. Dr. Abinand Kodi provided valuable assistance with population modeling. The Department is extremely grateful for the valuable comments provided on this report by the following peer reviewers: Dr. Seth Riley, Dr. Winston Vickers, Dr. Holly Ernest, Dr. Chris Wilmers, and Dr. Paul Beier. The conclusions in this report are those of the Department and do not necessarily reflect those of the reviewers.

Cover photograph by Irvine Ranch Conservancy on Orange County Parks Land; used with permission.

Executive Summary

This status review contains the most current information available on the mountain lion (*Puma concolor couguar*) in the central coast and southern parts of California and serves as the basis for the California Department of Fish and Wildlife's (Department) recommendation to the California Fish and Game Commission (Commission) on whether to list the species in those areas as threatened or endangered under the California Endangered Species Act (CESA).

On June 25, 2019, the Commission received a petition from the Center for Biological Diversity and the Mountain Lion Foundation that proposed the listing of the mountain lion as threatened or endangered in a portion of the state identified as the Southern California/Central Coast Evolutionarily Significant Unit (ESU). The petitioners also requested, in the event the Commission determined that the six populations comprising the identified ESU did not collectively comprise a single ESU or otherwise did not warrant listing, that the Commission consider whether any of the six populations, singularly or in combination, comprise an ESU and meet the criteria for listing. On April 16, 2020, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. The Commission's "may be warranted" decision initiated this status review to inform the Commission's decision on whether listing the petitioned ESU or any portion of the Southern California/Central Coast mountain lion population is warranted. The term "petitioned ESU" is used throughout this report. When "petitioned ESU" appears, it is intended to encompass the petitioners' proposal to list the petitioned area as a single ESU.

Species Description, Biology, and Ecology

Mountain lions are large felids that are primarily solitary, territorial, and occur in low density. In California their primary prey are deer, and they have large home ranges often comprised of multiple vegetation types including riparian, chaparral, oak woodlands, coniferous forests, grasslands, and deserts, and occur from near sea level to high elevations. Mountain lions reach sexual maturity at two to four years, and females care for their young for the first one to two years without help from males.

Population Structure

Mountain lion populations in California are genetically structured (differentiated) by natural barriers such as mountain ranges, water bodies, and deserts, as well as urbanization and the proliferation of highways and interstates. In combination these barriers to movement have facilitated the creation of six distinct genetic populations within the petitioned ESU. Roughly, these are:

1) <u>Central Coast North (CC-N)</u>, including the Santa Cruz Mountains and San Francisco Bay Area counties to the east;
2) <u>Central Coast Central (CC-C)</u>, generally the coastal mountains from southern Monterey Bay to Ventura County;
3) <u>Central Coast South (CC-S)</u>, including the Santa Monica Mountains, Santa Susana Mountains, Sierra Pelona Mountains, and Simi Hills;
4) <u>San Gabriel and San Bernardino Mountains (SGSB)</u>;
5) <u>Santa Ana Mountains (SA)</u>; and

6) Eastern Peninsular Range (EPR), including the mountains of San Diego County, extending east possibly as far as the Colorado River and the Arizona border, and bounded on the south by the border with Mexico.

These genetic populations experience varying levels of isolation and gene flow, and physical signs of inbreeding have been documented in the CC-S, SA, and EPR genetic populations. Available genetic information reveals some level of differentiation between these genetic populations.

Status and Trends

Significant changes in mountain lion distribution have occurred within the petitioned ESU due to habitat loss and fragmentation from land use changes that began in the late 1700s and continue to the present. Agricultural, residential, and industrial development, including the creation of modern transportation and infrastructure networks, has resulted in significant habitat fragmentation and barriers to movement in portions of the petitioned ESU. Mountain lions were historically controlled to protect livestock, and the Department paid a bounty for mountain lions from 1906 to 1963. The size of the California mountain lion population has been estimated periodically. Biologists estimated there were 600 mountain lions in California in the mid-1950s during the bounty period. By 1976, the population was estimated to be 2,400. A 1989 study estimated 4,100–5,700 mountain lions in the state. In 1990, the voters of California enacted Proposition 117, known as the California Wildlife Protection Act of 1990 and codified as Fish and Game Code section 4800, et seq., which prohibited take of mountain lions except in certain limited circumstances. The Department's current and most rigorous statewide population estimate to date is 4,172 (95% CI 3,645–4,750) mountain lions, including dependent young. The current estimate should be considered a refinement of earlier estimates and should not be interpreted to mean the actual population has declined since 1989. There are an estimated 1,449 (95% CI 1,272–1,638) mountain lions within the petitioned area.

Threats

Primary threats to mountain lions in the petitioned ESU include continued habitat loss and isolation of small populations due to expanding human infrastructure. Especially in Southern California, distinct genetic populations inhabit mountain ranges that are surrounded by human development or desert, such that dispersal to and from those ranges is significantly constrained by the presence of freeways and urban areas. From 1974 to 2020, the top sources of mortality throughout the state were removal in response to livestock or property damage and vehicle strikes. These mortality sources exceed "natural" causes of mortality. However, in recent years the number of mountain lions killed for depredating livestock or pets has dropped sharply (as a result of the Department's ongoing efforts to balance Proposition 117's conservation purpose and emphasis on the use of nonlethal methods with the need to provide a reasonable approach to depredation). Rodenticides and infectious disease kill relatively few mountain lions outright but can weaken individuals and make them less resilient to other threats. Recent intense wildfires have killed animals in already small, isolated populations (e.g., the Santa Monica Mountains) and may temporarily reduce habitat suitability. Human infrastructure that challenges or prevents gene flow between the genetic populations is a major concern in much of the petitioned ESU. Malformed sperm and/or kinked tails have been recorded in the SA, EPR, and CC-S genetic populations. Isolation and inbreeding increase the chance of extinction and the SA genetic population has a 16–21% chance of extirpation over the next 50 years if current low levels of gene flow continue.

Although the cumulative population estimate for the petitioned area is over 1,400 animals, the population is not continuous. Instead, it is broken into six genetic populations with varying levels of connection to adjacent populations. Each of the genetic populations has a low or very low effective population size (Ne; the estimated number of individuals in a population that participate in producing the next generation, which is smaller than the estimated population size), with estimates ranging from 3 to 57. None of the six genetic populations has an estimated effective population size of 100 or more, which would help avoid negative impacts from inbreeding in the long term at the population level. Improved connectivity is needed to increase gene flow, mitigate the negative impacts of isolation, and reduce the risk of localized extirpations from a variety of threats.

Recommendation

Although Petitioners seek to have these mountain lion populations listed as one or more ESUs, the Department concludes they are more appropriately analyzed as a distinct population segment (DPS).[1] The Department finds that neither the petitioned ESU nor genetic populations within the petitioned area, singly or in combination, could appropriately be considered an ESU. The genetic populations are not known to be both substantially isolated from other populations *and* important components of the evolutionary legacy of the mountain lion species.

However, the Department also examined whether the mountain lions comprising the six petitioned genetic populations constitute a DPS, based on a federal policy that is applied in listing evaluations under the federal Endangered Species Act and which has previously been used by the Department in CESA evaluations. A DPS is a population or group of populations that is discrete from other populations of the species and significant in relation to the entire species (in this case the statewide population). The Department finds that the mountain lion population composed of the six petitioned genetic populations is discrete, significant, and imperiled; therefore, the Department recommends the Commission find a DPS of mountain lions in an area largely coinciding with the petitioned area[2] should

---

[1] Both DPSs and ESUs are concepts originally developed in the context of the federal Endangered Species Act. The Department and the Commission are not required to apply either the federal ESU policy or the federal DPS policy. CESA permits the Commission to list “species or subspecies” (See Fish & G. Code, §§ 2062, 2067, 2068). To the extent the Commission concludes that an ESU or a DPS of a particular species constitutes a “subspecies” within the meaning of CESA, it may recommend listing of that subspecies as an ESU or DPS (See *Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156 Cal.App.4th 1535).

[2] For the DPS assessment, the Department made modifications to the petitioned ESU boundary. Areas of the southeastern deserts were excluded because no genetic samples from the area have been evaluated, making it impossible to assign lions in this area to a genetic population. Additionally, areas of intensive agriculture in the northeastern portion of the petitioned ESU were excluded. See sections 6 and 9 of this report for more details.

be listed as threatened. The Department further recommends implementation of the management recommendations and recovery measures described in this status review.

1. Introduction

1.1 CESA Petition History

On June 25, 2019, the California Fish and Game Commission (Commission) received a petition from the Center for Biological Diversity and the Mountain Lion Foundation (hereafter "the petitioners") to list the mountain lion (*Puma concolor couguar*) in a portion of the state identified as the Southern California/Central Coast Evolutionarily Significant Unit (ESU) as threatened or endangered under the California Endangered Species Act (CESA). The petitioners also requested, in the event the Commission determined that the six populations comprising the identified ESU did not collectively comprise a single ESU or otherwise did not warrant listing, that the Commission consider whether any of the six populations, singularly or in combination, comprise an ESU and meet the criteria for listing. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on July 5, 2019, and published a formal notice of receipt of the petition on July 26, 2019 (Cal. Reg. Notice Register 2019, No. 30-Z, p. 1086).

On January 31, 2020, the Department provided the Commission with its evaluation of the petition, "Evaluation of a Petition from the Center for Biological Diversity and the Mountain Lion Foundation to List the Southern California/Central Coast Evolutionarily Significant Unit (ESU) of Mountain Lions as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information in the petition (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted. At its public meeting held via teleconference on April 16, 2020, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Southern California/Central Coast ESU of mountain lions became a CESA candidate species on May 1, 2020 (Cal. Reg. Notice Register 2020, No. 18-Z, p.692).

The Commission's action designating the mountain lion within the boundary of the petitioned Southern California/Central Coast ESU as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision as to whether listing the petitioned ESU or any portion of the Southern California/Central Coast mountain lion population as threatened or endangered is warranted. At its scheduled public meeting on April 14, 2021, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

1.2 Status Review Overview

This status review serves as the basis for the Department's recommendation to the Commission on whether the petitioned action to list the mountain lion in the petitioned ESU as threatened or endangered under CESA is warranted. It is based upon the best scientific information available to the Department. It is not intended to be an exhaustive review of all published scientific literature on the mountain lion; rather, it is intended to summarize key points relevant to the status of the species and address regulatory report requirements. All the required elements in Fish and Game Code sections 2072.3 and 2074.6, as well as in California Code of Regulations Title 14 section 670.1, are included and addressed in this status review.

Specifically, this status review addresses each of the required petition components and the listing factors that the Commission must consider in making its determination. A petition to list a species under CESA must include "information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant" (Fish & G. Code, § 2072.3; see also Cal. Code Regs., tit. 14, § 670.1, subd. (d)(1)). A status review must include a preliminary identification of the habitat that may be essential to the continued existence of the species and recommend management activities and other recommendations for recovery of the species (Fish & G. Code, § 2074.6). Additionally, a species shall be listed as threatened or endangered "if the Commission determines its continued existence is in serious danger or is threatened by any one or any combination of the following factors: present or threatened modification or destruction of its habitat, overexploitation, predation, competition, disease, or other natural occurrences or human-related activities" (Cal. Code Regs., tit. 14, § 670.1, subd. (i)(1)(A)).

In addition to addressing each of the petition components and listing factors, the Department must make a recommendation to the Commission as to whether the petitioned action to list the mountain lion as threatened or endangered is warranted. An endangered species is defined under CESA as one "which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species under CESA is one that "although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Id., § 2067).

Receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

1.3 Notifications, Information Reviewed, and Peer Review

Following the Commission's action to designate the mountain lion as a candidate species for threatened or endangered status, the Department notified affected and interested parties and solicited data and comments on the petitioned action pursuant to Fish and Game Code section 2074.4 (see also Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)).

Tribal notifications were distributed by letter and email to tribes identified by the Native American Heritage Commission as having a cultural or traditional affiliation within the geographic area of the mountain lion. The Department received 10 comments in response to the tribal notifications. See Appendix B for additional details.

Public notifications were distributed to affected and interested parties and sent to email distribution lists maintained by the Department and the Commission. A press release was also distributed through the Department's website. The Department received 21 comments in response to public notifications. See Appendix B for additional details.

The draft status review was independently peer reviewed by five experts external to the Department (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). The Department evaluated the input received and amended the status review as appropriate. See Appendix C for additional details and the Department's written response to peer review.

1.4 Administrative Status

For much of the 20th Century, mountain lions were a bountied predator in California (Young and Goldman 1946; Dellinger and Torres 2020). In 1964, bounties ceased and the mountain lion was classified as a nuisance or vermin species that could be taken without a hunting license and with no limits (Dellinger et al. 2021b). In 1969, mountain lions were classified as a game species that could be hunted by licensed hunters. From 1972–1986, mountain lions were classified as a non-game mammal with a moratorium on hunting. Their status as a game species was reinstated in 1986. However, no mountain lions were harvested between this status change and a ballot initiative (Proposition 117) approved in 1990 which classified mountain lions as a "specially protected mammal species" (Fish & G. Code, § 4800). That classification continues to this day, and state law prohibits the take, possession, transport, import, or sale of a mountain lion or mountain lion products with limited exceptions. Take is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86). Take of mountain lions is allowed only under specified conditions, including for the protection of public health and safety, the protection of listed or fully protected bighorn sheep species (*Ovis canadensis* spp.), and in response to livestock or property damage.

1.5 Summary of Petitioned Action

The Petitioners propose listing mountain lion populations south of San Francisco Bay in the coastal, Transverse, and Peninsular Mountain Ranges, the Sonoran Desert, part of the Central Valley, and part of the Mojave Desert as a single Southern California/Central Coast ESU. Alternatively, the Petitioners propose the Commission determine whether one or more of the six genetic populations in the following areas identified by Gustafson et al. (2019) comprise an ESU and meet the criteria for listing as threatened or endangered:

1) Central Coast North (CC-N), which includes the Santa Cruz Mountains and San Francisco Bay Area counties to the east;
2) Central Coast Central (CC-C), generally from southern Monterey Bay to Ventura County in the coastal mountains;
3) Central Coast South (CC-S), which includes the Santa Monica Mountains, Santa Susana Mountains, Sierra Pelona Mountains, and Simi Hills;
4) San Gabriel and San Bernardino Mountains (SGSB);
5) Santa Ana Mountains (SA); and

6) Eastern Peninsular Range (EPR), which includes the mountains of eastern San Diego County, extending east possibly as far as the Colorado River and the border with Arizona, and is bounded on the south by the border with Mexico.

These populations are six of the 10 genetically discernible populations in California as delineated in Gustafson et al. (2019) (Fig. 1).

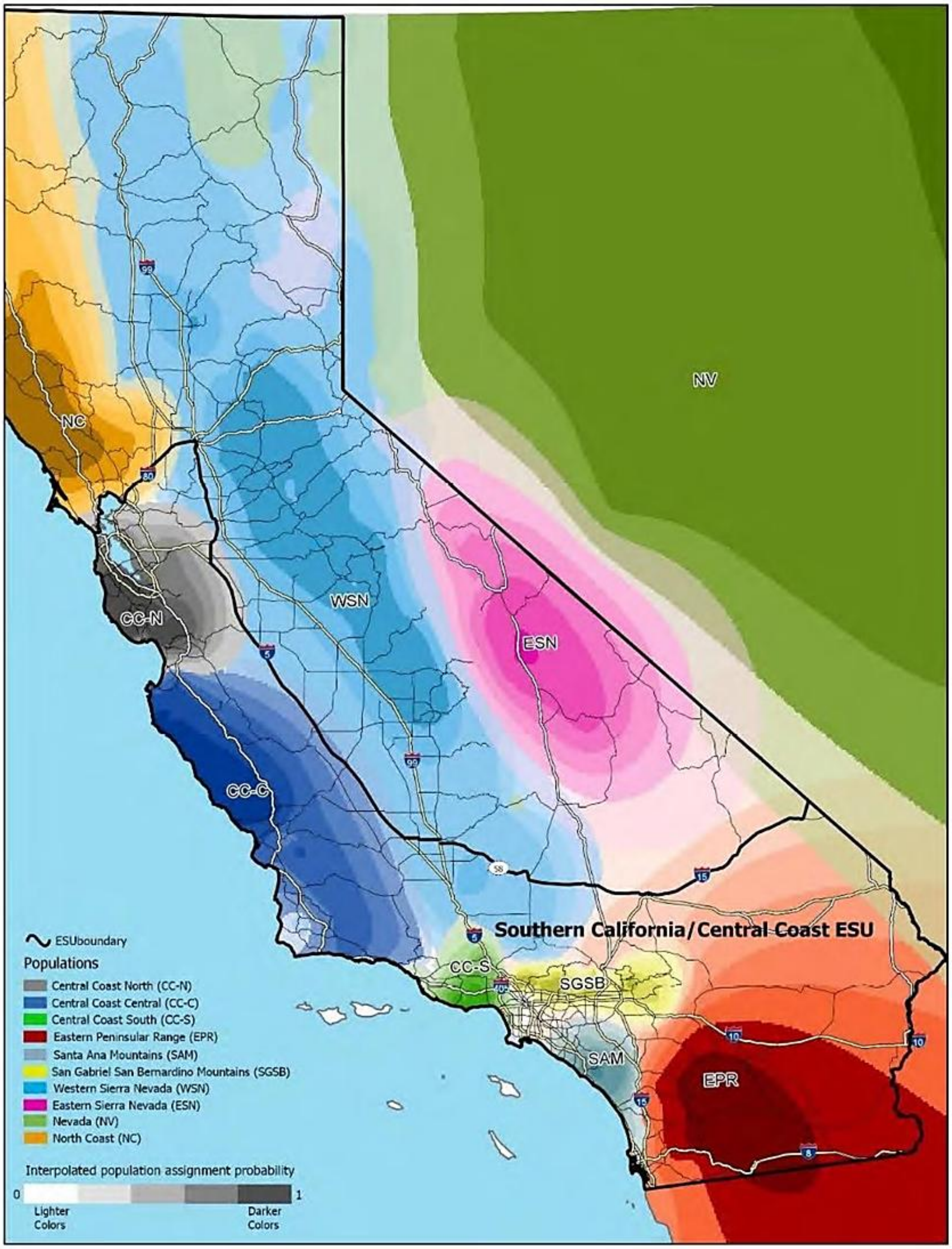


Figure 1. Fine-scale genetically discernible mountain lion populations and major roadways in California based on data collected from 1992 to 2016 (genetic information from Gustafson et al. 2019). Black line outlines the petitioned Southern California/Central Coast ESU boundary. This figure is from the Petition, Figure ES 1.

The Evolutionary Significant Unit concept was developed primarily for use in salmonids by the National Marine Fisheries Service (NMFS) and has been used to list populations of anadromous salmon under the federal Endangered Species Act such as the Columbia River chum salmon ESU (64 Fed. Reg 14508–14517 (March 25, 1999)). The use of ESUs by the Department to evaluate the status of species pursuant to CESA is supported by recent listing determinations by the Commission (e.g., Southern Sierra Nevada Fisher ESU; Coho salmon Central California coast ESU) and by the determination of California's Third District Court of Appeal that the term "species or subspecies" as used in CESA (Fish & G. Code, §§ 2062 and 2067) can include ESUs (*Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156 Cal.App.4th 1535).

To be considered an ESU under federal policy, a population must meet two criteria: 1) it must be substantially reproductively isolated from other conspecific (i.e., same species) population units; and 2) it must represent an important component of the evolutionary legacy of the species that contributes to the genetic diversity of the species as a whole (Waples 1991). The genetic isolation "does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units" (Waples 1991). Although neither the Department nor the Commission is bound by the federal ESU policy or the federal DPS policy, the Department has found these approaches useful for assessing the existence of a subspecies under CESA, has used these criteria in its prior evaluations of ESUs for species such as the Pacific fisher and Coho salmon, and uses them in this status review.

For brevity, the term "petitioned ESU" is used throughout this report. When "petitioned ESU" appears, it is intended to encompass the petitioners' proposal to list the petitioned area as a single ESU.

2. Biology And Ecology

2.1 Species Description and Life History

Mountain lions belong to the mammalian order Carnivora and are members of the cat family Felidae, subfamily Feline, and a part of the puma lineage. They have numerous other common names including puma, cougar, panther, painter, and catamount (Young and Goldman 1946; Hunter 2015). Mountain lions were once widespread in the Americas, but Euro-American settlers extirpated them from most of the U.S. and Canada east of the continental divide by the beginning of the 20th century, with only a small population (< 200 individuals) remaining in Florida and a population of unknown size in western and southern Texas. Populations in Mexico and other countries in Central and South America do not appear to have suffered similar extirpations (Hall and Kelson 1959; Pierce and Bleich 2003). However, since the late 20th century, breeding populations of mountain lions have returned to some areas east of the continental divide, including North and South Dakota and Nebraska (Hunter 2015; Cougar Fund 2023).

There are currently two recognized subspecies of mountain lion throughout the Americas (Culver et al. 2000; Kitchener et al. 2017). Mountain lions in North and Central America are classified as *P. c. couguar,* while most mountain lions in South America are classified as *P. c. concolor.* The Department formerly recognized another subspecies, the Yuma puma (*P. c. browni*) (Williams 1986; Kucera 1998; CDFW 2022a). However, research by McIvor et al. (1995) and Culver et al. (2000) detected little morphological or genetic support for retention of the *P. c. browni* subspecies. Consequently, the Department no longer considers mountain lions from the Colorado River valley and adjacent Sonoran Desert uplands to be a distinct taxonomic unit.

Adult mountain lions are large and slender with muscular limbs and a long, black-tipped tail that is about one third of the animal's total length. Males are typically larger than females. Males generally weigh 55–65 kg (121–143 lbs.) with a length of 2.2–2.3 m (7.2–7.5 ft.) from nose to tail tip, and females generally weigh 35–45 kg (77–99 lbs.) with a length of 2.0–2.1 m (6.6–6.9 ft.) (Currier 1983).

Deer (*Odocoileus* spp.) are the most common prey of mountain lions in the United States, Canada and parts of Mexico, composing about 70% of their diet (Ruth and Murphy 2009). The relationship between mountain lions and deer is so strong that lion distribution throughout the Americas has been described as largely a function of deer distribution (Young and Goldman 1946; Pierce et al. 2000). However, mountain lions are opportunistic predators and are known to eat at least 232 different species of mammals, birds, and reptiles across their extensive geographic range. Larger prey are favored in temperate forest, desert, and grassland biomes, whereas smaller prey are more often consumed in tropical forest biomes (Karandikar et al. 2022). Prey species in North America include, elk (*Cervus canadensis*), feral horses (*Equus ferus caballas*), feral burros (*Equus asinus*), wild pigs (*Sus scrofa*), pronghorn (*Antilocapra americana*), bighorn sheep, coyotes (*Canis latrans*), bobcats (*Lynx rufus*), porcupines (*Erethizon dorsatum*), fishers (*Pekania pennanti*), rodents, wild turkeys (*Meleagris gallopavo*), and livestock (Young and Goldman 1946; Currier 1983; Iriarte et al. 1990; Sweitzer et al. 1997; Wengert et al. 2014; Allen et al. 2015; Vickers and Garcelon 2022).

Mountain lions reach sexual maturity at two to four years, and females care for their young for the first one to two years (Quigley and Hornocker 2009). Mature females typically breed every other year (Robinette et al. 1961). Males will mate with multiple females and do not contribute to rearing young (Logan and Sweanor 2010). Mates locate each other with auditory and olfactory signals including scrapes—shallow troughs with a small mound of debris at the distal end, made using their hind feet. These forms of communication are also vital for maintaining family cohesion and avoiding competition or direct threats from other mountain lions. Identity, social status, and reproductive condition may all be possible functions of scent markers (Logan and Sweanor 2010). Mountain lion scent marks seem to serve as "bulletin boards" which males and females visit to determine the temporal presence, reproductive status, and possibly even the individual identity of other mountain lions (Currier 1983; Logan and Sweanor 2001; Harmsen et al. 2010; Allen et al. 2014).

Gestation lasts 82–96 days (Young and Goldman 1946; Currier 1983; Hunter 2015). Litter size ranges from one to six, though two to four kittens are typical (Pierce and Bleich 2003; Beier et al. 2010; Riley et al. 2014). Reproductive females tend to avoid human disturbances. Wilmers et al. (2013) found that mountain lions exhibiting reproductive behaviors (denning and chemical and vocal communication) avoided human disturbances by distances four times greater than non-reproductive mountain lions. As young reach 12–18 months of age, mothers may come into estrus and become aggressive towards them, encouraging their dispersal (Pierce and Bleich 2003). Adult males are also known to kill kittens, yearlings, subadults, and occasionally other adults (Logan and Sweanor 2010; Riley et al. 2014; Benson et al. 2020). Survivorship of dispersing mountain lions is low relative to adults with established home ranges (Benson et al. 2016; Benson et al. 2020), and dispersing young are more likely than resident mountain lions to be involved in depredation incidents or other conflicts with humans as they try to find prey without the advantage of an established home range (Torres et al. 1996).

Mountain lions are known to move long distances while dispersing. One subadult male was documenting moving 2,450 km (1,522 mi.) from South Dakota to Connecticut (Hawley et al. 2016). Vickers et al. (2015) documented numerous Southern California study animals dispersing > 80 km (50 mi.), and one young male moved approximately 150 km (93 mi.) from California south into Baja California, Mexico and back. Most long-distance dispersers are thought to be young males in search of available mates (Hawley et al. 2016).

A study of juvenile lion dispersal was conducted by Beier et al. (1995) in the Santa Ana Mountains of Southern California from 1988 to 1992. Juvenile mountain lions dispersed via habitat corridors in a landscape fragmented by urbanization. Each collared male dispersed over several weeks to months, and as many as four temporary home ranges were occupied sequentially. The mean dispersal distance from a sample of eight males was 63 km (39.1 mi.). The one monitored female disperser wandered throughout the northern half of the Santa Ana Mountains, changing directions ≥ 5 times upon encountering the urban-wildland interface and covered ≥ 342 km (212.5 mi.) without establishing a temporary home range. Four months after beginning her dispersal, she returned to the edge of her natal range and bedded near her mother for one day before dying near that location days later of unknown causes. All travel in corridors and habitat peninsulas occurred at night.

Adult mountain lions are primarily solitary, territorial, and occur in low density. They require large areas of habitat with adequate prey abundance (Quigley and Hornocker 2009). Their home ranges are often comprised of multiple vegetation community types including riparian, chaparral, oak woodlands, coniferous forests, grasslands, and deserts (Grinnell 1914; Grinnell et al. 1937; Williams 1986; Dickson et al. 2005; McClanahan et al. 2017; Dellinger et al. 2019) and occur from near sea level to high mountain elevations (Grinnell et al. 1937; Young and Goldman 1946; Hunter 2015).

Average home range size in California varies substantially depending on sex, season, and area of the state. The average male home range size is larger than the average female home range size. Home ranges change size depending on season and tend to be larger in the Sierra Nevada compared to the Coastal Ranges. In the Santa Ana Mountains and the Eastern Peninsular Range, Zeller et al. (2017) found that home range size varied from 41–497 km^2 (16–192 $mi.^2$; mean = 231 km^2; female mean = 188 km^2; male mean = 316 km^2). In the Santa Monica Mountains and surrounding areas, Riley et al. (2021) found the average home range size was 134 km^2 (52 $mi.^2$) for females and 372 km^2 (144 $mi.^2$) for males. In contrast, in the Sierra Nevada Mountains the average home range size for females in summer was 541 km^2 (209 $mi.^2$) and 349 km^2 (135 $mi.^2$) in winter (Grigione et al. 2002). For males it was 723 km^2 (279 $mi.^2$) in summer and 469 km^2 (181 $mi.^2$) in winter. While male home ranges can overlap spatially, male mountain lions are territorial, making temporal overlap between males rare (Logan and Sweanor 2001). However, males attempt to overlap their home ranges with multiple female home ranges to enhance breeding opportunities (Logan and Sweanor 2010). Females are less territorial, with their home ranges often including significant overlap, and the degree of home range overlap is typically greater where prey densities are higher (Stoner et al. 2018). Subadult males are generally met with aggression from resident adult males and can disperse long distances (see above). Only about half of subadult females disperse from their natal area (Logan and Sweanor 2010). Due to these behavioral mechanisms, local abundance of male mountain lions is generally limited by available habitat (Maletzke et al. 2014), while female abundance is generally limited by prey availability (Stoner et al. 2018). Given the importance of females to population growth, and because one male can breed with multiple females, mountain lion populations can be primarily limited by prey availability (Pierce et al. 2000; Logan and Sweanor 2001; Logan 2019).

Mountain lions have few natural predators in California. Mountain lions are subordinate to black bears (*Ursus americanus*) and gray wolves (*Canis lupus* sp.) across parts of their geographic range including California (Elbroch and Kusler 2018). Black bears occasionally kill mountain lion kittens (Elbroch and Kusler 2018), but mainly affect mountain lions through the plundering of kills and cache sites in California (Elbroch et al. 2015a). Where gray wolves and mountain lions coexist in North America, wolves are known to affect adult and kitten survival, resource selection, prey selection, bedding locations, and local abundance (Bartnick et al. 2013; Elbroch et al. 2015b; Kusler et al. 2017; Elbroch and Kusler 2018; Elbroch et al. 2020). In 2021, a GPS-collared wolf dispersed into the petitioned area before being struck and killed by a vehicle on Interstate 5. In the summer of 2023, the Yowlumni wolf pack was identified in southern Tulare County, with an activity center approximately 80 km (50 mi.) north of the petitioned ESU boundary; however, there are currently no resident wolf packs or individuals known within the petitioned ESU area.

2.2 Range and Distribution

A species' range is the general geographic area within which it normally occurs, while its distribution is the locations it occupies within its range at a given time. For purposes of CESA and this Status Review, the term range refers to the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal. App. 4th 1535, 1551), though emphasis is on the geographic area of the petitioned ESU. The current range of the mountain lion includes much of California. Though verified mountain lion sightings and encounters have occurred in all counties in the last decade, they are most commonly reported from the more mountainous areas of the state (Dellinger et al. 2021b). Mountain lions are most likely to establish home ranges in areas with sufficient forest and/or shrub cover which promotes presence of their primary prey, mule deer (*Odocoileus hemionus*) and provides cover for stalking (Dellinger et al. 2020a). In California, these areas include the coastal mountain ranges from Southern California north to the Oregon border, the Transverse Ranges, the Sierra Nevada, the southern Cascade Range, the Klamath Mountains, and the Modoc Plateau (Fig. 2).

The areas with the least suitable habitat (i.e., lowest densities of mountain lions), include intensively farmed areas of the Central Valley and lowlands of the inland desert regions of the state. However, resident breeding populations have recently been documented near the Sutter Buttes in the Sacramento Valley and in the Mojave Desert (McClanahan et al. 2017; Dellinger et al. 2019). The distribution of mountain lions in California has changed little from what Grinnell et al. (1937) described in the early 1900s, although they are now absent or uncommon in the large, high density urban areas of the San Francisco Bay Area and the Los Angeles–San Diego coastal plain and inland valleys. They are also absent or uncommon in intensively farmed agricultural areas such as the Salinas Valley and the Central Valley, where historical reports noted mountain lions were not uncommon in riparian areas (Fig. 3) (Newberry 1857). Historically, those riparian corridors likely played an important role in connecting mountain lion populations in the Sierra Nevada with populations in coastal mountain ranges.

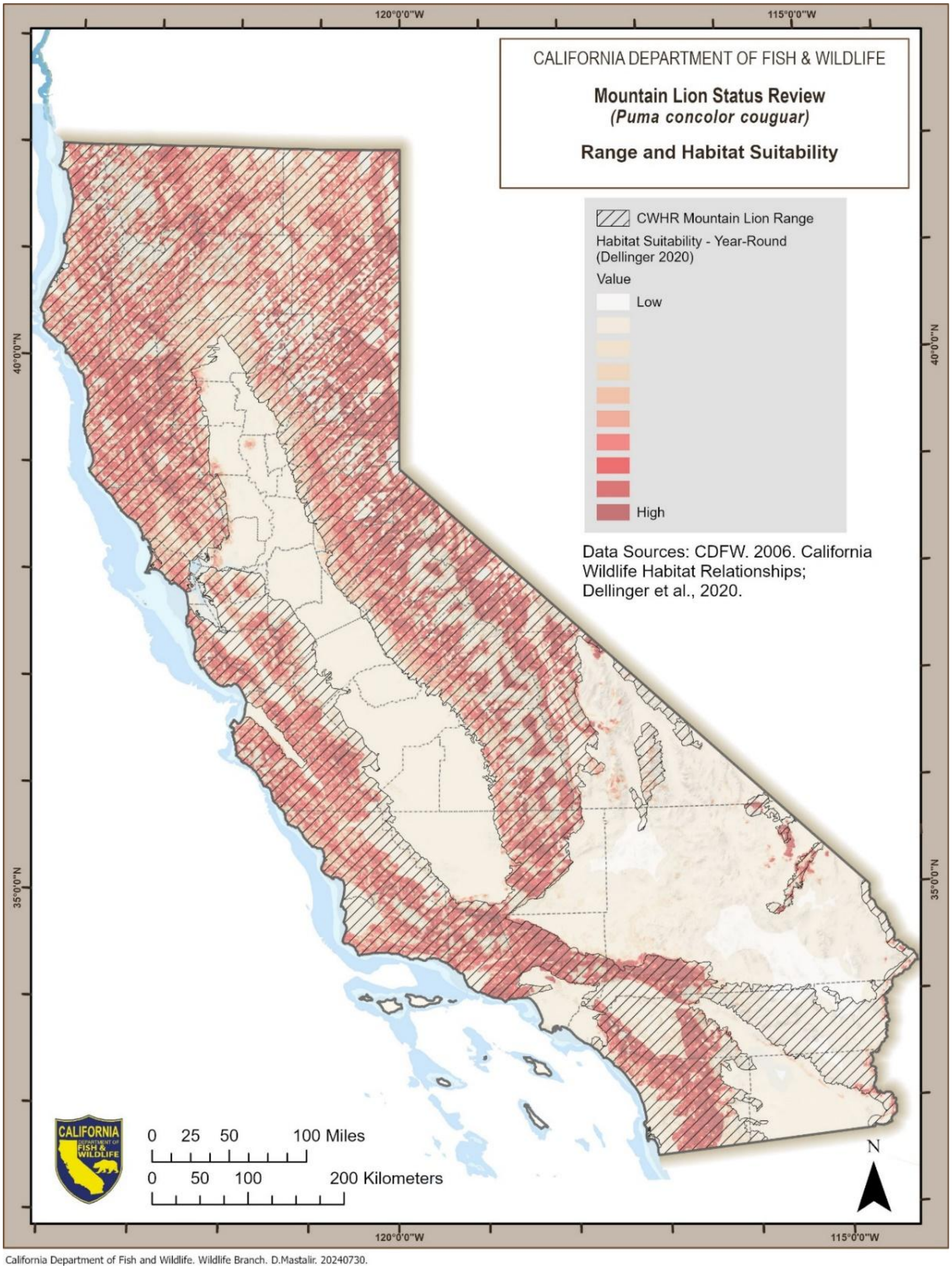


Figure 2. Range and habitat suitability for mountain lions in California. Darker red indicates a higher probability of mountain lion occupancy (Dellinger et al. 2020a). Mountain lions may occasionally occur at low densities outside of this range (most often non-breeding or dispersing individuals).

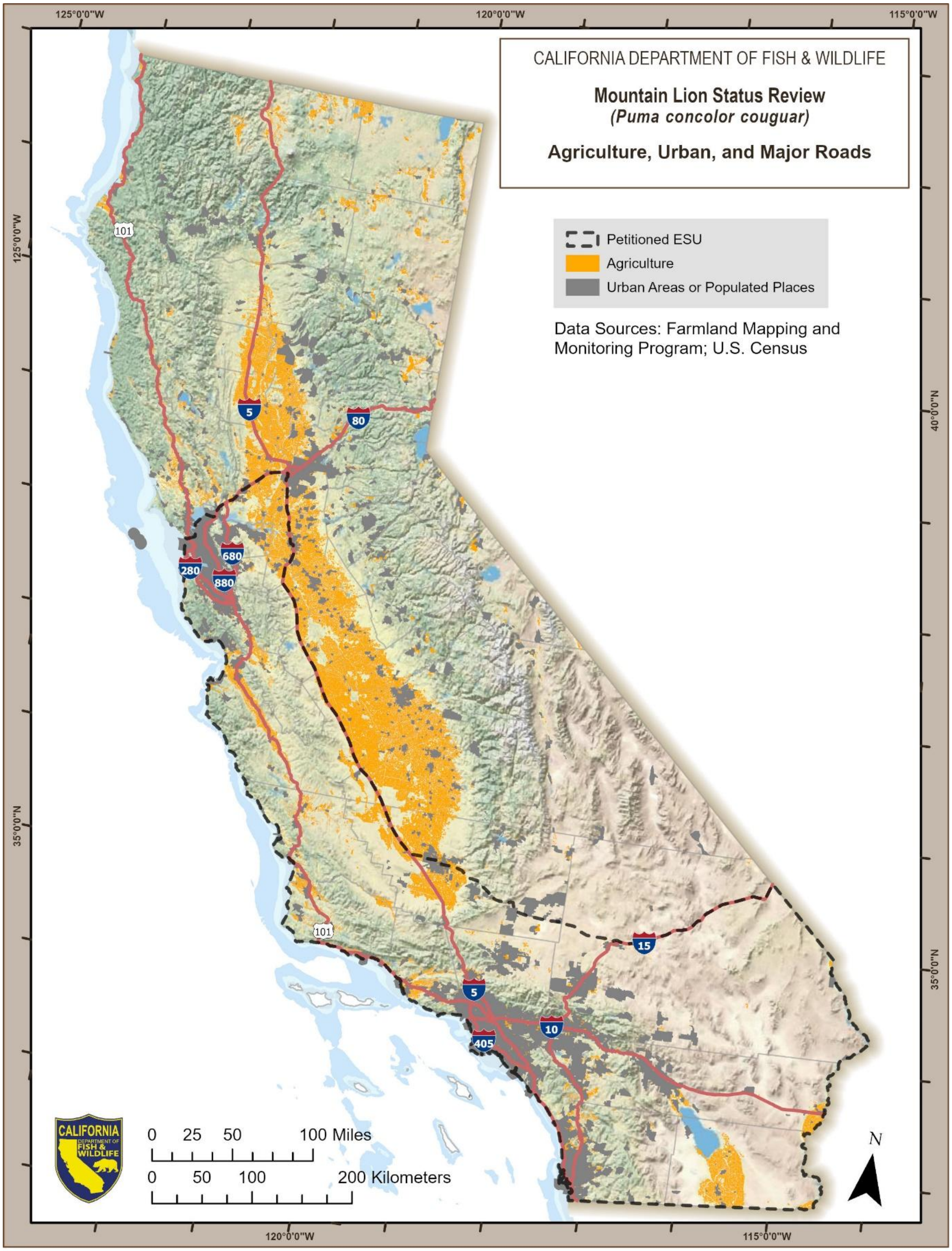


Figure 3. Agricultural and populated areas and major roadways in California.

2.3 Habitat That May Be Essential to the Continued Existence of the Species

Dellinger et al. (2021b) described general patterns of habitat use and selection[3] in California:

> "Mountain lions are among the most widely distributed carnivore species (Logan and Sweanor 2001). This wide distribution is a product of their ability to persist in almost any habitat provided adequate prey is available. When establishing a home range, mountain lions select habitat with adequate prey and stalking cover to aid in meeting energetic demands. After establishing a home range, many things, including human activity, can influence habitat use patterns (Wilmers et al. 2013).
>
> In California, mountain lion habitat use patterns were found to be seasonal in the more temperate areas of the state (Dellinger et al. 2018) while, in the more Mediterranean areas, mountain lion habitat use patterns are more stable between seasons (Wilmers et al. 2013)."

Mountain lions in North America have associations with vegetative and topographic cover, steep slopes, and higher elevations, while avoiding areas of open agricultural land, sagebrush (*Artemesia tridentata*) dominated communities, open meadows, and pastures (Fig. 2) (Murphy 1983; Logan and Irwin 1985; Laing 1988; Lindzey et al. 1994; Pierce and Bleich 2003).

Zeller et al. (2017) found that in Southern California, mountain lions preferred to establish home ranges that contained chaparral, scrub, and grasslands, but within those home ranges, primarily spent their time in relatively rugged terrain, riparian areas, and woodland. Dickson and Beier (2002) noted that riparian areas were selected by mountain lions in all seasons in Southern California and suggested the preference is related to the presence of stalking cover and prey. Riley et al. (2021) found that mountain lions in the Santa Monica Mountains and surrounding areas selected "chaparral, riparian woodland, and coastal sage scrub. The two features of the landscape that they consistently avoided were grasslands and altered open areas, which were also the most open portions of the landscape. These results are consistent with previous work showing that mountain lions select areas with dense stalking cover and avoid open areas to facilitate hunting success." However, Burdett et al. (2010) speculated that dense, mature late seral chaparral may be avoided because mule deer prey cannot easily move through such stands and thus may select against them.

2.4 Population Structure

There are currently two recognized subspecies of mountain lion throughout the Americas (Culver et al. 2000; Kitchener et al. 2017). Mountain lions in North and Central America are classified as *P. c. couguar,* while most mountain lions in South America are classified as *P. c. concolor* (the subspecific identity of some mountain lions west of the Andes in South America remains uncertain). This taxonomy is partly based on the finding that the entire North American population is genetically homogenous across several mitochondrial loci (Culver et al. 2000, Caragiulo et al. 2014). Genetic diversity is greater in Central and South American mountain lions, and it is hypothesized that the North American population derived from a relatively recent (i.e., late Pleistocene, circa 10,000 years ago) recolonization by a small

[3] Habitat selection is the choice by an organism of habitats relative to their availability on the landscape.

number of founders whose ancestors originated in eastern South America 200,000–300,000 years ago (Culver et al. 2000, Caragiulo et al. 2014).

Several studies have demonstrated that the complex geography and land use patterns in California have influenced patterns of gene flow and genetic exchange among mountain lions in different areas of the state (Ernest et al. 2003; Ernest et al. 2014; Riley et al. 2014; Gustafson et al. 2019; Gustafson et al. 2022). Two studies are especially relevant to understanding the genetic structure of mountain lions within the petitioned ESU. The first is Gustafson et al. (2019), which the petitioners referenced extensively. Gustafson et al. (2019) collected samples from 992 mountain lions in California and Nevada (obtained from 1992–2016) and examined genetic diversity across 42 microsatellite markers[4]. The authors identified nine geographic clusters of samples containing similar genetic characteristics in California and one cluster in Nevada (Fig. 1). In addition to the six clusters within the petitioned ESU, the other clusters in California include North Coast (NC), Western Sierra Nevada (WSN) and Eastern Sierra Nevada (ESN) (Fig. 1). In this report, the Department follows Gustafson et al. 2019 in referring to these clusters as genetic populations. Though mountain lions associated with these genetic populations show significant genetic differentiation, the populations are not fully isolated from one another (Fig. 4). The bidirectional migration rates calculated by Gustafson et al. (2019) demonstrate important historical connectivity between the Western Sierra Nevada (WSN) genetic population and the Central Coast populations (CC-S, CC-C, CC-N) and populations to the north and east (North Coast (NC) and Eastern Sierra Nevada (ESN)). Additionally, the SGSB genetic population functions to some extent as a linkage between genetic populations to the south (EPR and SA) and the north (WSN and the Central Coast genetic populations), although gene flow through this linkage appears to be very limited.

[4] Microsatellites are short repetitive segments of DNA base pairs (nucleotides) scattered throughout the genome, often in noncoding regions between or within genes.

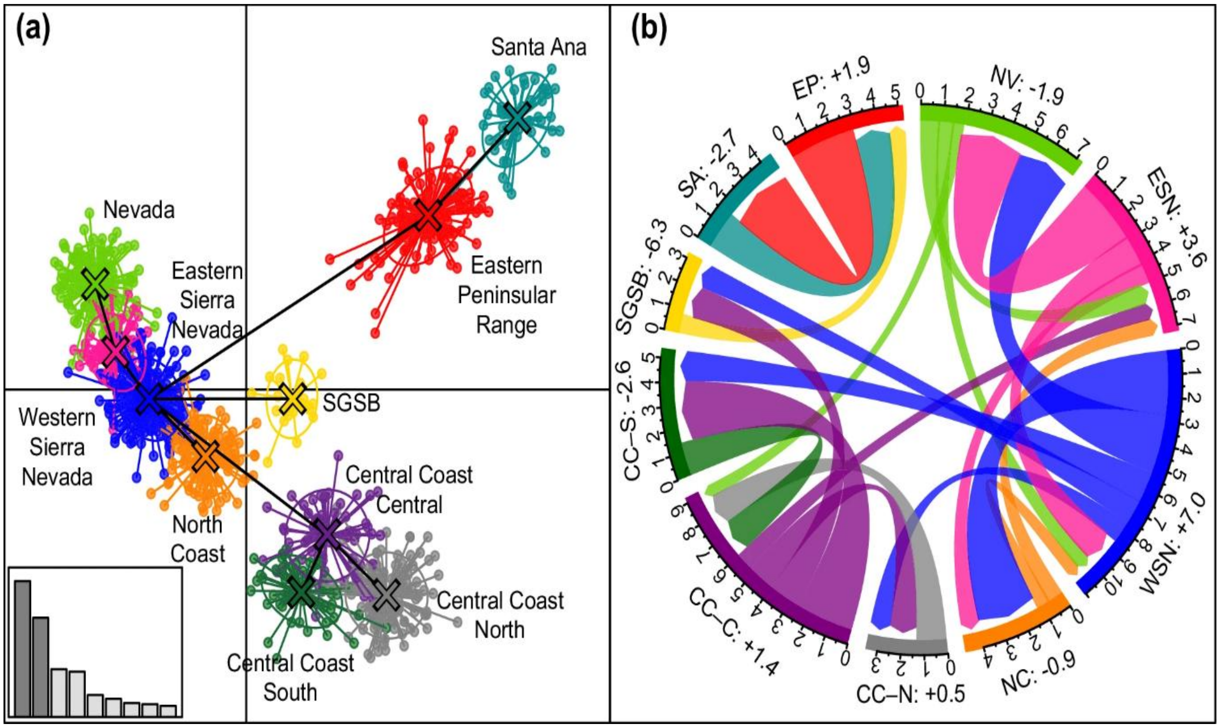


Figure 4. Functional connectedness of mountain lion genetic populations, based on (**a**) discriminant analysis of principal components and (**b**) bi-directional migration rate estimates (multiplied by 100 for visualization). Each dot represents an individual (**a**). Each color (**a, b**) represents a population. Black lines (**a**) indicate the most closely related population based on genetic dissimilarities. The inset barplot (**a**) shows which axes are being displayed (i.e., discriminate functions 1 and 2) and the relative proportion of variation explained by each of the nine discriminant functions. Two-thirds of the individuals in each population are contained within the corresponding ellipsoid. For a biologically meaningful interpretation, only estimates of interpopulation migration rates with 95% confidence intervals that do not cross 0 are presented (**b**). Net genetic source-sink migration rates are presented next to population names with positive values indicating net genetic source and negative values indicating net genetic sink (e.g., WSN exported 9% of migrants and received 2% so its net rate is +7%). Reproduced from Gustafson et al. (2019).

The second study particularly relevant to understanding genetic structure in the petitioned ESU is Gustafson et al. (2022), which analyzed 16,285 genome-wide single-nucleotide polymorphisms[5] (SNPs) from 401 mountain lions sampled broadly across the state from 2011–2017. Using SNPs, Gustafson et al.'s (2022) best supported model identified four broad-scale genetic groups concordant with California's geography: North Coast (NC); Sierra Nevada (SN); Central Coast (CC), which includes Gustafson et al.'s (2019) CC-N, CC-C, and CC-S genetic populations; and Southern Coast (SC), which includes Gustafson et al.'s (2019) SA, SGSB, and EPR genetic populations (Fig. 5).

---

[5] A SNP is a random substitution of the nucleotides at a single position on a DNA sequence.

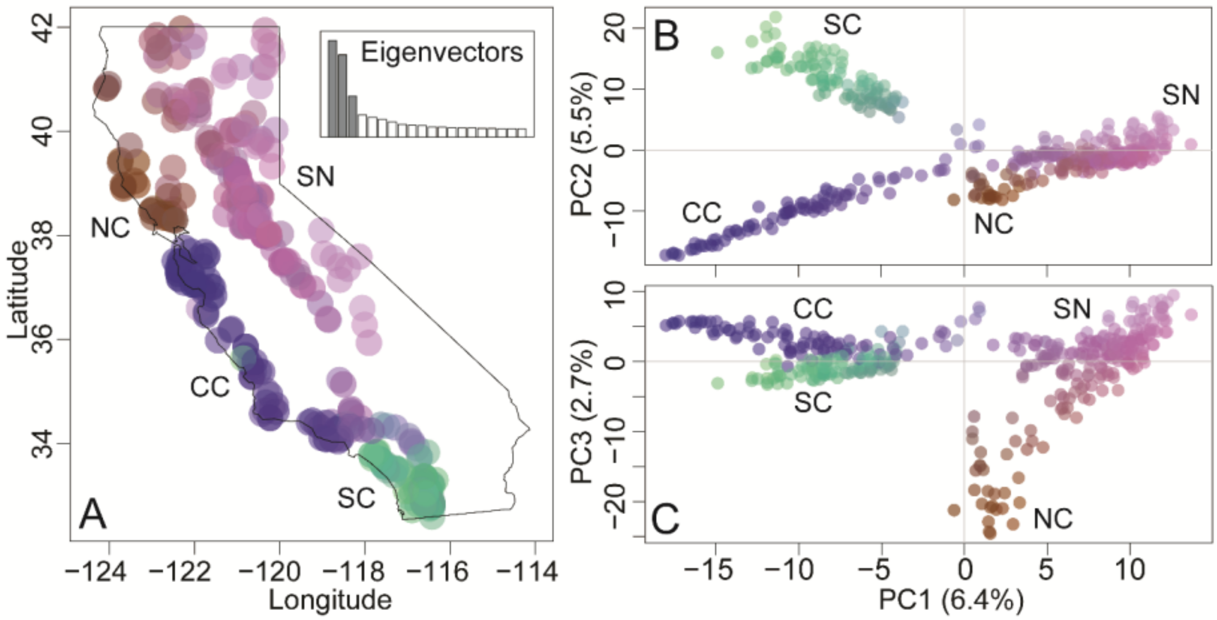
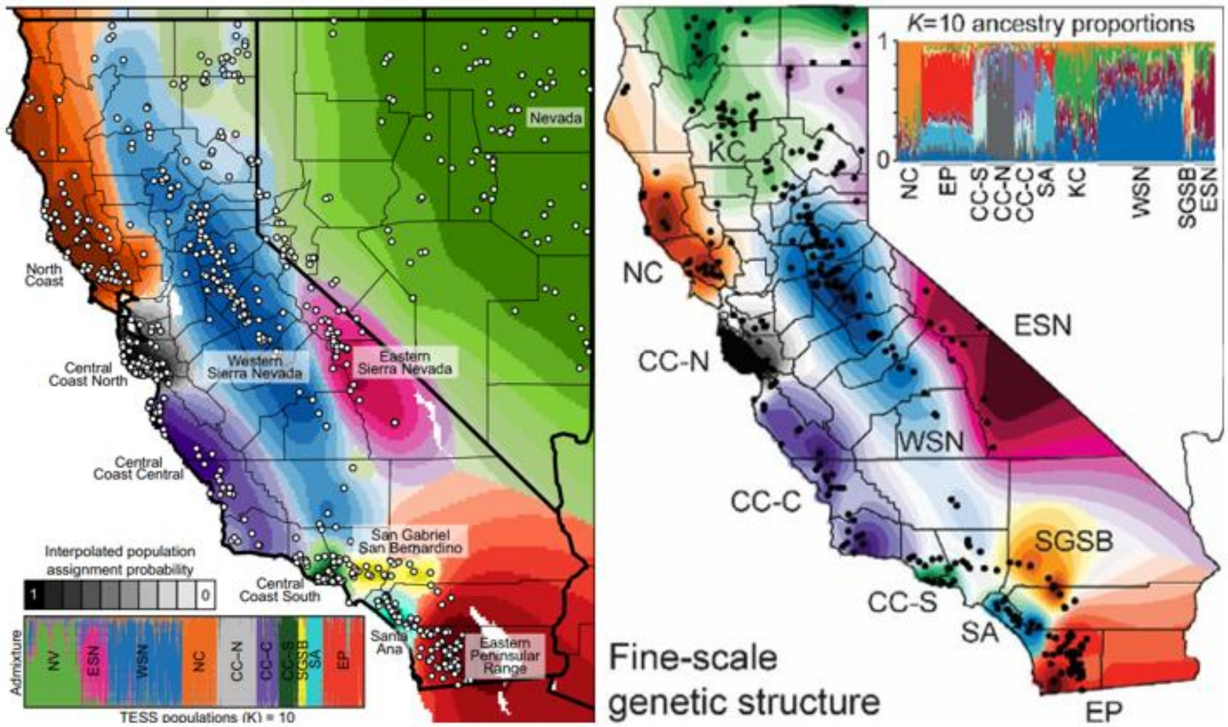


Figure 5. Principal component analysis (PCA) of 401 mountain lions at 16,285 SNPs reveals four broad-scale genetically discernible groups (NC = North Coast, CC = Central Coast, SC = Southern Coast, SN = Sierra Nevada). (A) The color plot of the PCA represents colors corresponding to a combination of the first 3 eigenvectors. The inset plot shows the proportion of the variance explained by shaded PC eigenvectors 1–3 compared to other eigenvectors. The color values are plotted at sample locations to demonstrate geographic structure. Color plots of (B) PC1 and PC2 and (C) PC1 and PC3 resolved the 4 broad-scale genetically discernible groups. Reproduced from Gustafson et al. (2022).

On a finer scale, both cluster analyses and genetic differentiation tests by Gustafson et al. (2022) also supported the presence of nested substructure within the four well-supported, broad-scale groups. The authors found evidence of 10 fine-scale genetically discernible populations roughly corresponding to the genetic populations identified by Gustafson et al. (2019) (Fig. 6). Consistent with the 2019 study, the authors found evidence these fine-scale populations are not fully genetically isolated and have experienced gene flow.

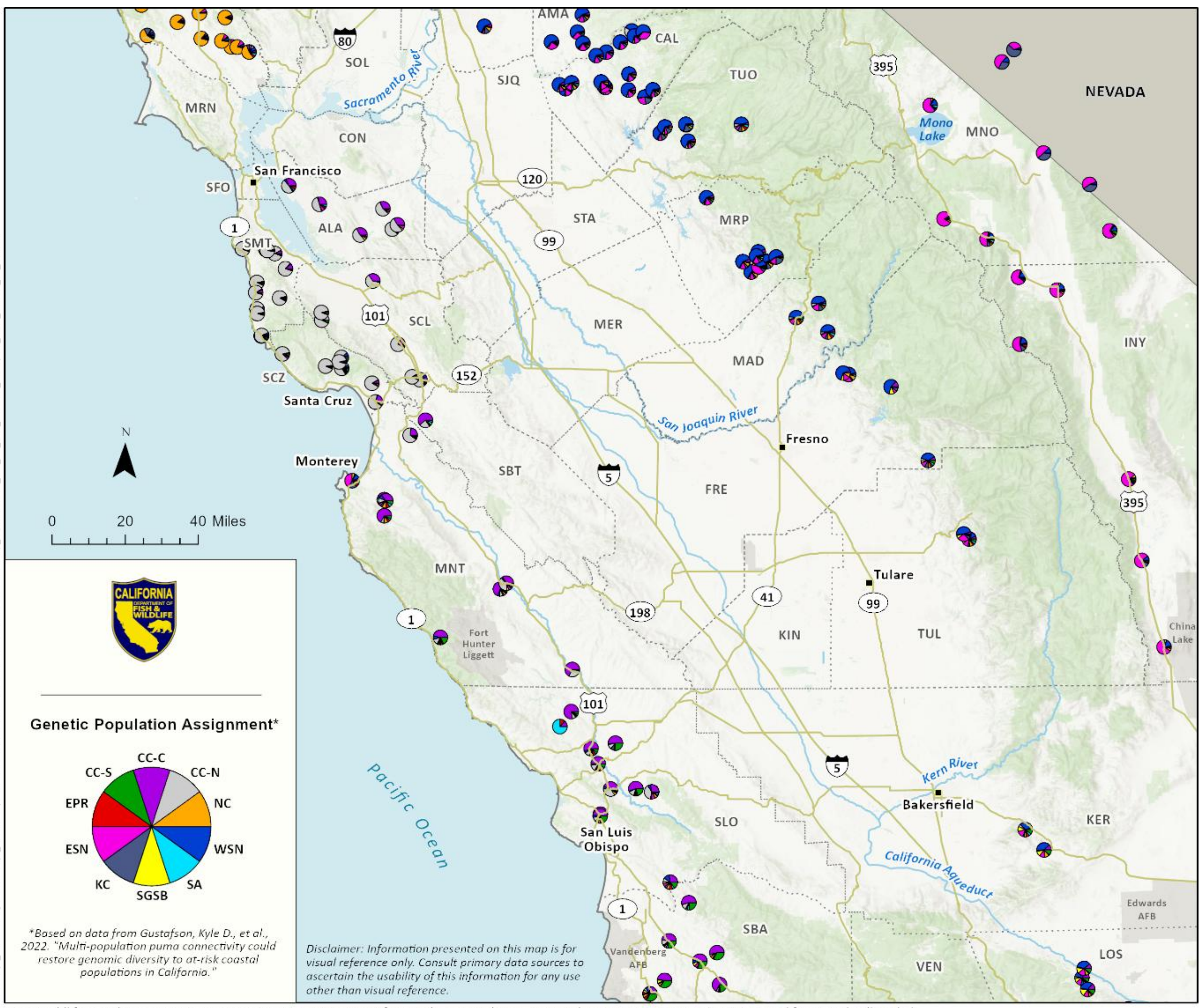


Gustafson et al. (2019) genetic populations K=10 | Gustafson et al. (2022) genetic populations K=10

Figure 6. The geographic distribution of 10 discernible genetic populations from Gustafson et al. 2019 (left) and Gustafson et al. 2022 (right). Dots indicate locations of genetic samples. Note that in Gustafson et al. (2019), 9 of the 10 clusters are in California while in Gustafson et al. (2022), all 10 clusters are in California.

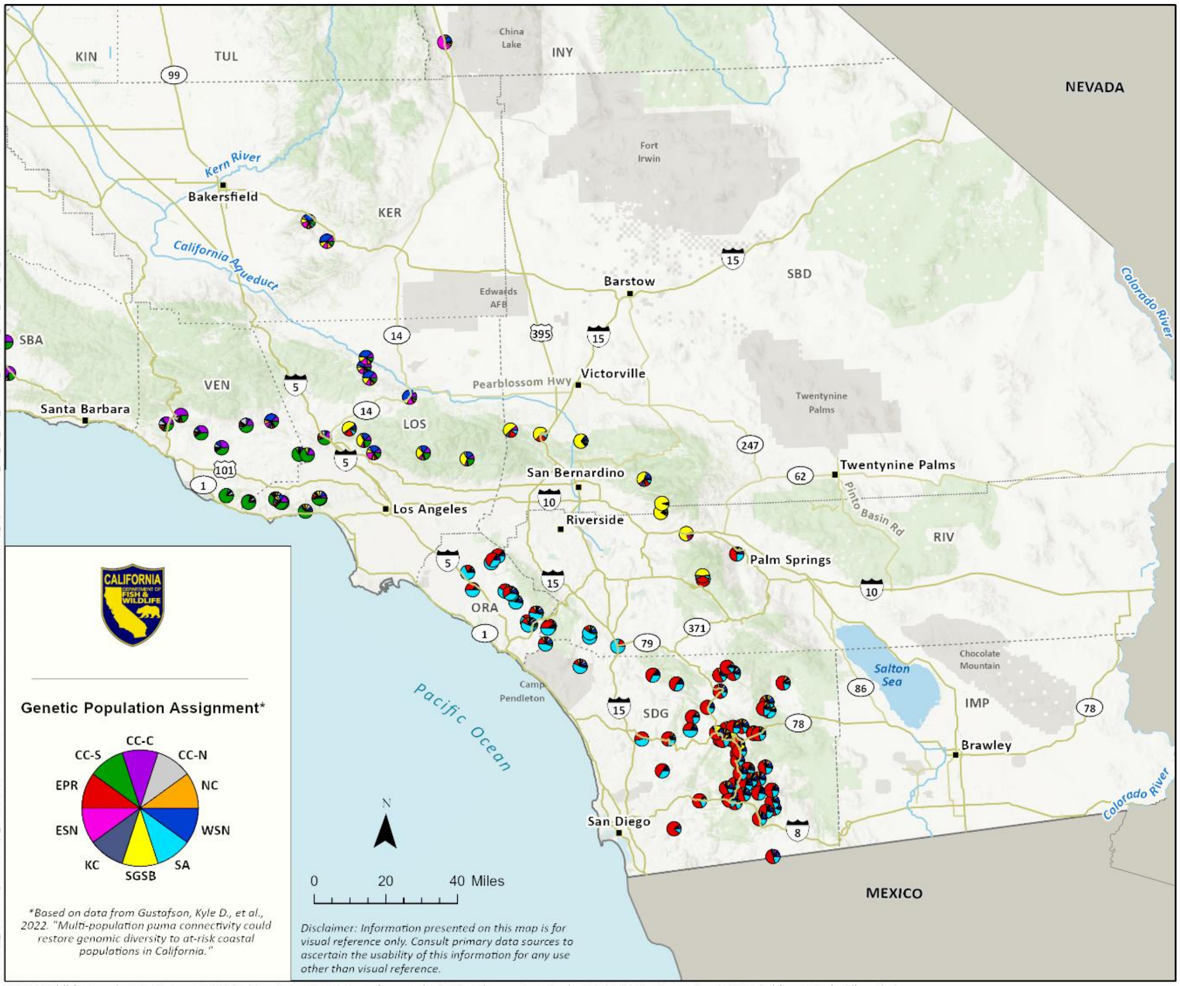
Figures 7 through 10 use pie charts to represent the ancestry of the individual lions sampled in Central and Southern California in the Gustafson et al. 2019 and 2022 studies. Each pie chart represents the location where a genetic sample was obtained from an individual mountain lion and the genetic affinities of that individual The different colors show the percentage of the ancestry of sampled lions that was assigned to different genetic populations. A pie chart that is fully or almost fully one color is strong evidence that both parents were from the same genetic population. If the pie chart of a sampled mountain lion is in the same genetic population as its parents (e.g., a fully gray sample in the Santa Cruz Mountains in Fig. 7), it means the sampled lion is unlikely to have moved from the genetic population of its parents. If a mostly solid pie chart is located outside of the population of its parents, that is strong evidence that it is a first-generation migrant that moved to a new population during its lifetime. It is important to recognize that lions that appear to have dispersed from their parent population may or may not have contributed genes to another genetic population depending on whether they produced surviving offspring in the new location or died before they were able to breed. A pie chart with multiple colors suggests gene flow (movement with breeding) occurred in the past. A pie chart that is a 50/50 split is good evidence of a hybrid offspring among parents from two different genetic populations (i.e., likely the offspring of a migrant). As the pie pieces get smaller, hybridization between genetic populations occurred further and further back among more distant ancestors. Very small pie segments may represent statistical 'noise' in the ancestry calculation.

Gustafson et al.'s 2022 SNP analysis shows evidence of historical genetic exchange among the fine-scale genetic populations, with the WSN genetic population acting as a source of gene flow to the Central Coast genetic populations, to SGSB, and to populations to the north and east. The SGSB genetic population may have historically acted as a linkage between the EPR and SA genetic populations and the WSN and the Central Coast populations (Figs. 7, 8). Many of the samples in the CC-S, SGSB, and the southern part of the WSN genetic population show ancestry from multiple genetic populations, which is to be expected from an area acting as a crossroads. Similarly, the mixed ancestry of individuals in the CC-S and CC-C indicate some level of historical connectivity with one another and with the WSN and SGSB (Fig. 8).



CDFW Wildlife Branch, GIS-LS, Apr 26, 2023 - Map Data: CDFW, Gustafson et al., 2022, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 7. Assignment of individual mountain lion samples from Central California to genetic populations identified by Gustafson et al. (2022) using Single Nucleotide Polymorphisms.



CDFW Wildlife Branch, GIS-LS, Apr 26, 2023 - Map Data: CDFW, Gustafson et al., 2022, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 8. Assignment of individual mountain lion samples from Southern California to genetic populations identified by Gustafson et al. (2022) using Single Nucleotide Polymorphisms.

The microsatellite data from Gustafson et al. 2019 show fewer animals of shared ancestry, and samples are more likely to be assigned to one genetic population (i.e., there are more pies of a solid color in Figs. 9, 10). Microsatellites are fast-evolving genetic markers, and they may represent more contemporary patterns of gene flow relative to the SNP markers. These data suggest relatively little gene flow between populations, potentially due to the expansion of human development and highways making movement more difficult (Gustafson et al. 2019). The population structure revealed by Gustafson et al. (2019; 2022) is consistent with both natural landscape features (e.g., Central Valley, San Francisco Bay, Sierra Nevada Crest) and development (e.g., roads and highways, housing developments) impeding gene flow at various temporal and spatial scales.

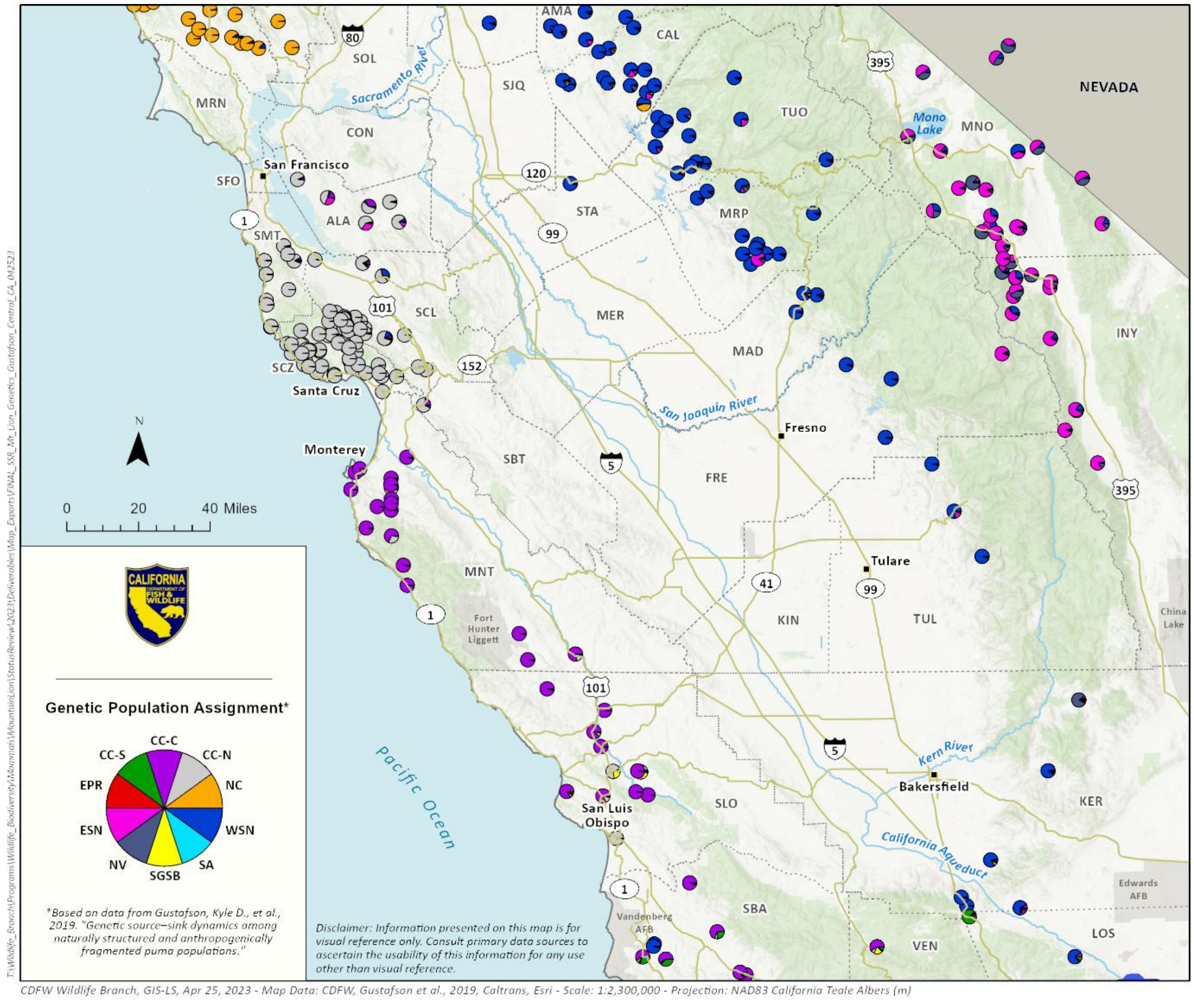
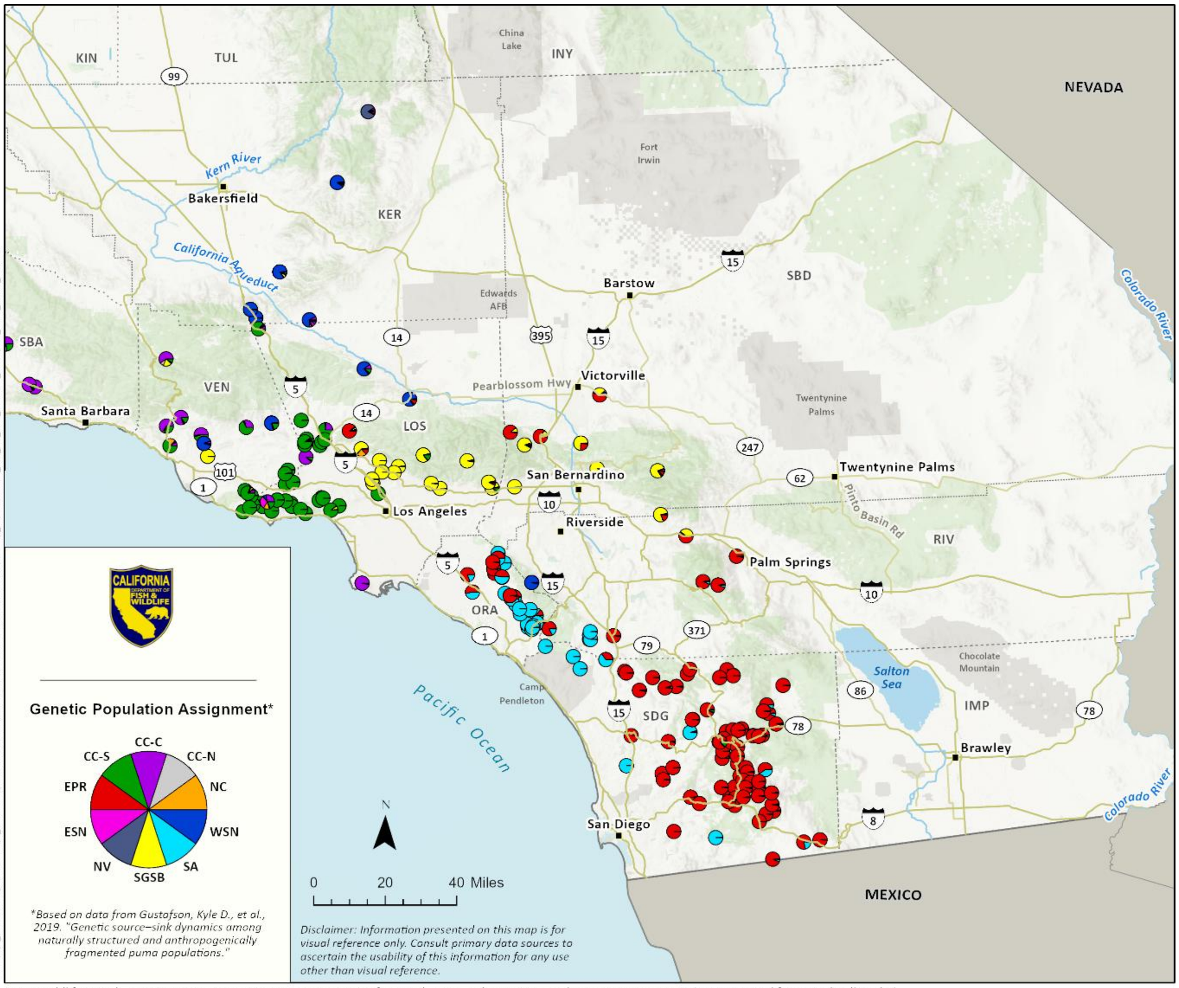


Figure 9. Assignment of individual mountain lion samples from Central California to genetic populations identified by Gustafson et al. (2019) using microsatellite DNA markers.

According to the microsatellite data, the area occupied by the CC-S population, especially north of the Santa Monica Mountains, has been important for sustaining statewide gene flow because of the intersection of mountain lions from the Sierra Nevada and Central Coast broad-scale genetic groups (Fig. 10). The data also reveal some gene flow between CC-C and CC-N, and CC-C and CC-S. The samples show movement between SA and EPR, and EPR and SGSB. However, these three South Coast populations are fairly isolated from other genetic populations in California. Few animals with ancestry from the WSN or the Central Coast group were found south or east of Los Angeles (Fig. 10). The 2022 genetic analysis indicated likely movement of animals from the WSN through the Tehachapi Mountains and into the CC-S and perhaps SGSB populations (Fig. 10). The Tehachapi Mountains seem to provide the only corridor for regular movement between the petitioned areas and more robust mountain lion populations in the Sierra Nevada.



CDFW Wildlife Branch, GIS-LS, Apr 26, 2023 - Map Data: CDFW, Gustafson et al., 2019, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 10. Assignment of individual mountain lion samples from Southern California to genetic populations identified by Gustafson et al. (2019) using microsatellite DNA markers.

Another commonly used measure of genetic differentiation between populations (i.e., genetic population structure) is the fixation index (F_{ST}). F_{ST} was originally developed to estimate differentiation among all subpopulations within a metapopulation (i.e., global F_{ST}; Wright 1931) but is now more commonly used in pairwise fashion to compare two subpopulations (i.e., pairwise F_{ST}). High pairwise F_{ST} values between populations is the result of population isolation reducing the number of migrants and interbreeding. Low F_{ST} values suggest less isolation between populations and more interbreeding. F_{ST} values range from 0 to 1. A value of 0 implies the two populations are completely interbreeding. A value of 1 implies that the two populations do not share any genetic diversity. Values of 0 and 1 are largely theoretical and are not expected to be found in nature. More practically, values of $F_{ST} > 0.15$ are generally considered to represent substantial genetic differentiation between populations, while values < 0.05 are considered minimal differentiation (Frankham et al. 2002).

Gustafson et al. 2022 found that the four broad-scale genetic groups were moderately differentiated, with the South Coast group being the most differentiated from the others and the Sierra Nevada group the least (Table 1). Most of the fine-scale genetic populations within the area of the petitioned ESU had substantial genetic differentiation from each other (Table 2), indicative of limited gene flow between those populations.

Table 1. Mean pairwise genetic distance values for the broad-scale *K* = 4 genetic clusters. Weir and Cockerham F_{ST} is presented below the diagonal, and Nei's F_{ST} is presented above the diagonal (WC\Nei). Higher values indicate greater genetic differentiation and suggest less connection between populations. All pairwise F_{ST} estimates were significant ($p < 0.001$) based on a bootstrapping analysis. Modified from Table 2 in Gustafson et al. 2022.

K = 4	SN	SC	CC	NC
SN	-	0.133	0.124	0.100
SC	0.129	-	0.173	0.198
CC	0.120	0.173	-	0.156
NC	0.094	0.196	0.156	-

Table 2. Mean pairwise genetic distance values for the fine-scale *K* = 10 genetic clusters. Weir and Cockerham F_{ST} is presented below the diagonal, and Nei's F_{ST} is presented above the diagonal (WC\Nei). Higher values indicate greater genetic differentiation and suggest less connection between populations. All pairwise F_{ST} estimates were significant ($p < 0.001$) based on a bootstrapping analysis. Modified from Table 2 in Gustafson et al. 2022.

K =	CC-N	CC-C	CC-S	SGSB	SA	EPR	WSN	ESN	KC	NC
CC-N	-	0.098	0.148	0.210	0.319	0.231	0.188	0.233	0.183	0.229
CC-C	0.100	-	0.060	0.140	0.254	0.164	0.121	0.168	0.117	0.164
CC-S	0.152	0.059	-	0.163	0.287	0.196	0.147	0.189	0.146	0.202
SGSB	0.221	0.141	0.164	-	0.212	0.130	0.106	0.116	0.109	0.205
SA	0.320	0.251	0.289	0.217	-	0.100	0.222	0.226	0.215	0.301
EPR	0.227	0.163	0.192	0.132	0.095	-	0.163	0.163	0.141	0.214
WSN	0.176	0.116	0.136	0.106	0.203	0.146	-	0.045	0.022	0.26
ESN	0.237	0.168	0.183	0.113	0.221	0.166	0.045	-	0.041	0.183
KC	0.178	0.114	FST0.137	0.105	0.202	0.141	0.022	0.041	-	0.093
NC	0.230	0.164	0.203	0.210	0.300	0.211	0.118	0.183	0.093	-

3. Status and Trends in California

3.1 Historical Distribution and Abundance

Habitat loss and fragmentation resulting from land use changes in the petitioned ESU began in the 1700s and continues to the present. Those changes have significantly affected mountain lion distribution in some areas. Many areas within the petitioned ESU have been modified by urban and agricultural development, primarily in the San Francisco Bay Area, Southern California, and the Central Valley, making them mostly unsuitable for mountain lions (Fig. 3). Near the coast in Southern California, extensive urbanization from Ventura County to the border with Mexico has supplanted large areas of mountain lion habitat in the coastal valleys and plains and has isolated patches of remaining habitat in the Santa Monica, San Gabriel, San Bernardino, and Santa Ana Mountains (Fig. 3; Vickers et al. 2015; Benson et al. 2016; Benson et al. 2019). The Eastern Peninsular Range is also affected by human development and road networks but to a lesser degree than the aforementioned mountain ranges. Likewise, remaining habitat in the Santa Cruz Mountains and the southern San Francisco Bay Area is increasingly constricted by development and busy highways (Wilmers 2014; Wang et al. 2017). In contrast, the Santa Lucia and other rugged mountains of the central coast have fewer highways and relatively little development and the distribution of lions has likely changed little there from the pre-European era.

3.2 Population Size

Historical estimates of the size of the mountain lion population within the petitioned ESU do not exist. While some historical estimates of the statewide mountain lion population exist, the methods used to derive the estimates, and the statistical rigor of the estimates varied substantially. As such, these estimates are not directly comparable and cannot be used to examine trends in the statewide population over time.

The Department paid a bounty for mountain lions from 1906–1963 (Dellinger and Torres 2020). McLean (1954) presented bounty numbers from 1907-1950 and estimated there were 600 mountain lions in California. Over a decade after the end of the bounty period, Sitton (1977) estimated that there were approximately 2,400 mountain lions in California. A 1989 study estimated 4,100–5,700 mountain lions in the state based on the amount of suitable habitat and adult density estimates from prior studies (Mansfield and Weaver 1989).

The Department recently developed a statistically rigorous estimate of the statewide mountain lion population size using DNA from the scats of 335 individual mountain lions collected in 2017–2022 from 13 study sites distributed widely across the state. The detection histories of individually identifiable mountain lions from these samples were used to estimate the statewide population size using a Bayesian Spatial Capture Recapture (SCR) model. SCR includes a spatial scale parameter (e.g., how the probability of detection of a mountain lion varies over its home range) that is critical for accurately scaling estimated abundances to density and population size (Royle et al. 2013). Using this method, the Department estimates there are approximately 4,172 (95% CI 3,645–4,750) mountain lions in the state. This population estimate includes all age classes of mountain lions, including dependent young. The estimate represents an average annual number of mountain lions over a recent 5-year period (i.e., 2017–2022). An important caveat is that extrapolation from the modeling was limited to only those portions of state that were mapped as mountain lion habitat by Dellinger et al. (2020b). Accordingly, the estimate may be undercounting a small number of mountain lions outside of the mapped range (e.g., Central Valley and some desert areas). These results are preliminary and may change based on peer review when a manuscript is submitted to a scientific journal for publication.

As part of this analysis, the Department used available California GPS telemetry data from 152 mountain lions to inform the spatial scale parameter in the SCR model. The result of this exercise was that spatial inferences from the telemetry were consistent with those from the scat (e.g., <5% difference) which provides validation that the statewide population estimate is accurate.

The Department also generated regional scale current estimates of abundance that roughly correspond to the genetic populations in Gustafson et al. 2019 (Table 3). The boundaries for the regional genetic population estimates come from Figure 1 in Dellinger et al. (2020b). The Department used SCR to create density estimates that vary over space depending on relative use of specific habitats within an area of interest. However, the covariates the Department used were more effective for extrapolating a statewide population total than drawing accurate inferences about density in specific areas. For this reason, these local estimates may be less accurate than the statewide estimate. The total population estimate within the petitioned ESU is 1,449 mountain lions (95% CI 1,272–1,638). However, each of the genetic populations comprising the petitioned ESU is moderately to considerably isolated from adjacent populations. The petitioned area does not support a single well-connected population and instead effectively consists of several mostly isolated smaller populations. Estimates for the CC-S, SGSB, and SA genetic populations are each lower than 100 individuals. The best currently available data indicate most of the populations within the petitioned ESU have small effective population sizes and low genetic variation (see Section 4.9), which could put them at increased risk of local extirpation (Beier 1993,1995; Dickson et al. 2005; Ernest et al. 2014; Riley et al. 2014; Vickers et al. 2015; Benson et al. 2016; Benson et al. 2019; Gustafson et al. 2019; Gustafson et al. 2022).

Table 3. Estimates of total population sizes and 95% confidence intervals for the genetically distinct mountain lion populations identified in Gustafson et al. 2019. The boundaries used to calculate the population sizes come from Dellinger et al. 2020b. Note: these estimates were derived from modelling at a different geographic scale than the statewide and petitioned area estimates, and consequently, the summed estimates differ from the statewide estimate.

Population	Estimated Population Size (95% CI)
Central Coast North (CC-N)	219 (193–247)
Central Coast Central (CC-C)	480 (422–540)
Central Coast South (CC-S)	64 (56–72)
San Gabriel/San Bernardino (SGSB)	94 (82–107)
Santa Ana Mountains (SA)	67 (59–75)
Eastern Peninsular Range (EPR)	459 (383–546)
North Coast (NC)	821 (707–943)
Modoc Plateau (MP)	377 (307–456)
Western Sierra Nevada (WSN)	1,199 (1,050–1,360)
Eastern Sierra Nevada (ESN)	398 (320–489)

3.2.1 Survival and Sources of Mortality

Benson et al. (2023) analyzed data from 590 radio collared mountain lions in 24 California study areas from 1974 to 2020 (76% of the study animals were collared after the year 2000). They estimated an annual survival rate of 0.67 for males (95% CI 0.63–0.72, n = 297 males and n = 151 deaths) and 0.80 for females (95% CI 0.77–0.83, n = 293 females and n = 112 deaths). Of the 263 known mortalities, 199 were attributable to a specific cause. Management killing had the highest annual mortality rate at 6%. Management killing includes lethal removal of mountain lions following livestock depredations (75% of the mortalities in this category), lethal removal following bighorn sheep depredations (23% of the category), and lethal removal of lions that posed a public safety threat (2%). After management killing, the greatest sources of mortality were vehicle strikes (4%), non-strife natural mortality including starvation and disease (3%), intraspecific strife (3%), poaching (3%), and other human causes including mortalities directly attributable to rodenticide poisoning and wildfire, which combined resulted in a 1% annual mortality rate (Benson et al. 2023).

The Department's approach to issuing depredation permits has evolved toward increased emphasis on nonlethal methods of take, and the relative importance of this mortality factor may have declined (for more detail see section 4.3.2). Benson et al. (2023) found that as human-caused mortality increased in an area, so did natural mortality, though the trend was not significant. This suggests human caused mortality may have been additive during the study period and did not just affect animals that would have otherwise died of natural causes. They also found that human population density influenced mountain lion mortality rates, with human density being a better predictor of mortality risk than the density of sheep and goat farms on the landscape. Both human-caused and natural mortality were highest in areas of the state with intermediate human density, and lower in both high human density areas and remote, low human density areas (Benson et al. 2023).

4. Factors Affecting Ability to Survive and Reproduce

4.1 Past and Threatened Modification and Destruction of Habitat

4.1.1 Urbanization

Anthropogenic habitat loss and fragmentation have been occurring in California since the arrival of Spanish settlers in the 18th century and increased dramatically with expansion of mining and agriculture in the mid-19th century. Early 20th century naturalists catalogued the flora and fauna throughout the state and noted the loss of formerly abundant prey species of the mountain lion, including elk, mule deer, pronghorn, and beaver (*Castor canadensis*) (Stephens 1906; Grinnell 1914; Merriam 1919; Leopold 1966). Successive waves of agricultural and other development, including railroads, canals, roads, and highways resulted in the conversion of natural vegetation and led to further loss and fragmentation of mountain lion habitat. Development impacts have been extensive in the greater San Francisco Bay area, Sacramento and San Joaquin valleys (water diversions, agricultural development, and urban development), and the Los Angeles Basin and adjacent mountain ranges and valleys south to San Diego (urban, agricultural, and industrial uses).

The California State Wildlife Action Plan summarizes existing stressors on wildlife populations and ecosystems in the state and describes recent and ongoing habitat loss, fragmentation, and degradation in California (CDFW 2015). Significant habitat loss continues in many important California ecosystems. For example, over 195,000 ha (480,000 acres) of California rangeland habitats were converted to other uses between 1984 and 2008 (approximately 3% of available rangelands) - primarily due to residential and commercial development and agricultural intensification. Additionally, habitat degradation—resulting from pollution, invasive species, livestock grazing, intensive recreation, soil erosion, drought, flooding, or wildfire—is a widespread stressor to wildlife populations in California (CDFW 2015).

Habitat fragmentation occurs when portions of habitat are lost or degraded such that natural areas are divided into small and isolated remnants (CDFW 2015). This fragmentation can have numerous negative impacts on wildlife including declining biodiversity and impairment of ecosystem functions, isolation of species into small subpopulations susceptible to extinction, and inhibition of movement between populations that leads to reduced genetic variation and inbreeding (Ibid.). Species with large home ranges, like mountain lions, require large contiguous areas of habitat or connectivity between multiple diffuse patches of habitat. Habitat loss and fragmentation can eliminate or isolate key habitat elements from home ranges, such as water and prey associated with riparian zones, and can reduce access to breeding and foraging habitat (Ibid.). These effects impact mountain lion populations as well as populations of their prey. When resources are dispersed across a broader area or fragmentation limits access to resources, mountain lions may be required to expend more time and energy to meet their needs, exposing them to more risk.

In Southern California, human populations are especially dense, and land conversion has been extensive. The significant amount of urban, suburban, and rural development in this area—resulting from population pressures of the region's 24 million residents (Wikipedia 2024)—has led to substantial habitat loss and fragmentation (CDFW 2015). Currently, nearly 40% of the land area in southern coastal California is in urban and suburban use (CDFFP 2010). Sprawling development with residential housing located far from existing urban centers has required new or enlarged roads and infrastructure. These development patterns not only reduce the amount of habitat available but also degrade the quality of adjacent habitat making the remaining natural habitats more vulnerable to the incursion of invasive species, air and water pollution, and altered fire regimes (Ibid.). In addition, the developed areas, roads, and utility corridors fragment the landscape leaving few or no movement corridors between natural areas (Ibid.).

Historical habitat loss and fragmentation have caused reductions in the geographic distribution of mountain lions in the petitioned ESU. Moreover, in the absence of adequate habitat conservation efforts, including connectivity measures, such reductions are expected to continue. A study of mountain lion habitat in CC-S and EPR showed that nearly half of mountain lion habitat in the study area is on private land, and the authors estimated approximately one-third of the lands that were available habitat in 1970 would be developed by 2030 (Burdett et al. 2010). Additionally, some habitat that is currently adjacent to development may become fragmented, with potential loss of connectivity and increased risk to mountain lions from vehicle strikes and depredation take (Burdett et al. 2010). For example, Development within key connectivity areas such as the Tehachapi Mountains near Interstate 5, if not carefully planned, could further constrain lion movement within a relatively narrow corridor of highly suitable habitat connecting the western Sierra Nevada with the central coast and Southern California (Penrod and Smith 2022).

Additionally, limited habitat connectivity has resulted in highly restricted gene flow in many areas of central and Southern California. For example, connectivity between the EPR and the SA genetic populations is limited due to the barrier effect of Interstate 15 in the Temecula region. Similar connectivity challenges occur due to Interstate 5 and Highway 58 between the CC and SN genetic groups. Recently published information on reproductive and morphological abnormalities in mountain lions in the Santa Monica Mountains, SA, and EPR indicate that habitat loss and fragmentation, and associated dispersal challenges, have led to inbreeding (Huffmeyer et al. 2022). See section 4.9 for more information on the inadequate habitat connectivity and highly impeded gene flow for these populations.

Residential and industrial development is projected to continue within the petitioned ESU, even in the areas that are already highly urbanized (EPA 2017). Projections of increased housing density through the year 2050 demonstrate that continued development will exacerbate existing barriers to mountain lion movement, effectively rendering existing pathways less permeable, and in some areas may lead to complete isolation of portions of genetic populations (Ibid.). Areas that are projected to become substantially more isolated by the year 2050 due to residential development include the Santa Cruz Mountains of the CC-N, the San Gabriel and San Bernardino Mountains, the Santa Monica and Santa Susana Mountains, and the Sierra Pelona and Tehachapi Mountains near the nexus of the WSN, CC-S, and SGSB genetic populations (Ibid.).

The cumulative effects of approximately 250 years of habitat loss and fragmentation due to development and road construction, loss of riparian habitat, and the associated reduction and shifting of prey species appear to have contributed to the separation of mountain lions into smaller genetic populations in the central and southern regions of California. See section 4.9 for information on the risks to small and isolated populations.

4.1.2 Agriculture and Forestry

The conversion of native habitat to intensively farmed crops and pasture has resulted in large swaths of land that no longer provide foraging and breeding habitat for mountain lions (Fig. 3). This conversion began as early as the 1700s in coastal California and accelerated rapidly in the 19th and 20th centuries as water storage and delivery systems were developed enabling the irrigation of crops. Approximately 43% of California's land area is used for agricultural production (CDFA 2009). In recent years over 9 million acres has been in irrigated agricultural production (DWR 2024). Although the same pattern of conversion of native plant communities to agricultural uses occurred wherever suitable soils and adequate water existed, this change has been most dramatic in the Central Valley, by far the largest contiguous region of intensively farmed land in the state. The Central Valley appears to form a largely semi-impermeable barrier to mountain lion movement between coastal mountain ranges and the Sierra Nevada and Cascade Mountains. Historically, the Central Valley contained extensive riparian forests along the Sacramento and San Joaquin Rivers, their tributaries, and in the Delta which likely provided corridors of suitable cover for mountain lions living in and traveling through the valley. Within the petitioned area, these historical habitats likely facilitated genetic connection between the WSN and NC genetic populations and the Central Coast group. However, it is estimated that 92-97% of such riparian forests have been lost through channelization, altered hydrology, and conversion to agricultural and urban uses, and much of the remaining riparian forest has been modified (CDFW 2014). The loss of Central Valley riparian forests and scrub, in combination with the development of significant highways and other infrastructure, is likely a major driver of contemporary mountain lion population structure.

Commercial timber harvesting in the petitioned area primarily occurs in the redwood-dominated (*Sequoia sempervirens*) forests of the CC-N. Although the impacts are less intense and less permanent than commercial agriculture, commercial timber harvesting can modify mountain lion habitat in that region. A study of nine mountain lion home ranges in the redwood forest of northwest California found mountain lions used forest areas with a greater proportion of fragmentation and edge more frequently than areas of more contiguous forest; however, mountain lions generally avoided areas of active timber harvest operations (Meinke 2004). Mountain lion home ranges included different stages of forest succession from freshly harvested stands to late seral forests, perhaps indicating commercial timber management, as regulated by the California Department of Forestry and Fire Protection (CAL FIRE), does not fragment mountain lion habitat or isolate populations. Conversely, Smallwood (1994) found mountain lion use of forest stands of the central coast, north coast, and Sierra Nevada sharply declined within six years following clear cut harvest. The timing and extent of mountain lion use of clearcut harvest units likely depends on how rapidly shrub and small tree cover develops in the harvested area, which is influenced by the tree and shrub species composition of the harvested stand, the nature and extent of post-harvest site preparation treatments, and the management of young stands.

4.2 Vehicle Strikes, Roads, and Rail Lines

As mentioned in the section on survival and sources of mortality (3.2.1), vehicle strikes were the second most common cause of known mortalities of mountain lions in California from 1976–2020 (Benson et al. 2023). Figure 11 displays documented mountain lion mortality events caused by vehicle strikes in 2000–2023. The Road Ecology Center at the University of California, Davis (UC Davis) has records of 535 mountain lions killed on state highways in 2015–2022 (Shilling et al. 2023). However, because all vehicle strikes were unlikely to have been reported, the true number is likely higher.

In Southern California, Los Angeles, Orange, and San Diego Counties are major areas of road mortalities (Shilling et al. 2023). From 1981 to 2013, reported vehicle strikes accounted for 50 of 94 (53%) known mountain lion deaths in the Santa Ana Mountains (which includes parts of the greater Los Angeles metropolitan area) and 46 of 154 known deaths (30%) in the Eastern Peninsular Range (which includes the greater San Diego metropolitan area) (Vickers et al. 2015). Vehicle strikes were the main mortality factor for mountain lions in the SA genetic population, and a secondary mortality factor in the EPR genetic populations (Ibid.). The enhancement and/or creation of safe wildlife road crossings may be critical for maintaining lion persistence in these genetic populations.

In the Bay Area (CC-N), vehicle strikes are also a significant source of mortality. California State Routes SR-12, SR-17, SR-1, and especially Interstate-280 have high numbers of mountain lion mortalities (Shilling et al. 2023). Shilling et al. (2023) identify the stretch of I-280 northwest of San Jose as the deadliest highway in California for mountain lions with 20 deaths documented along a 32 km (20 mi.) stretch from 2015 to 2022.

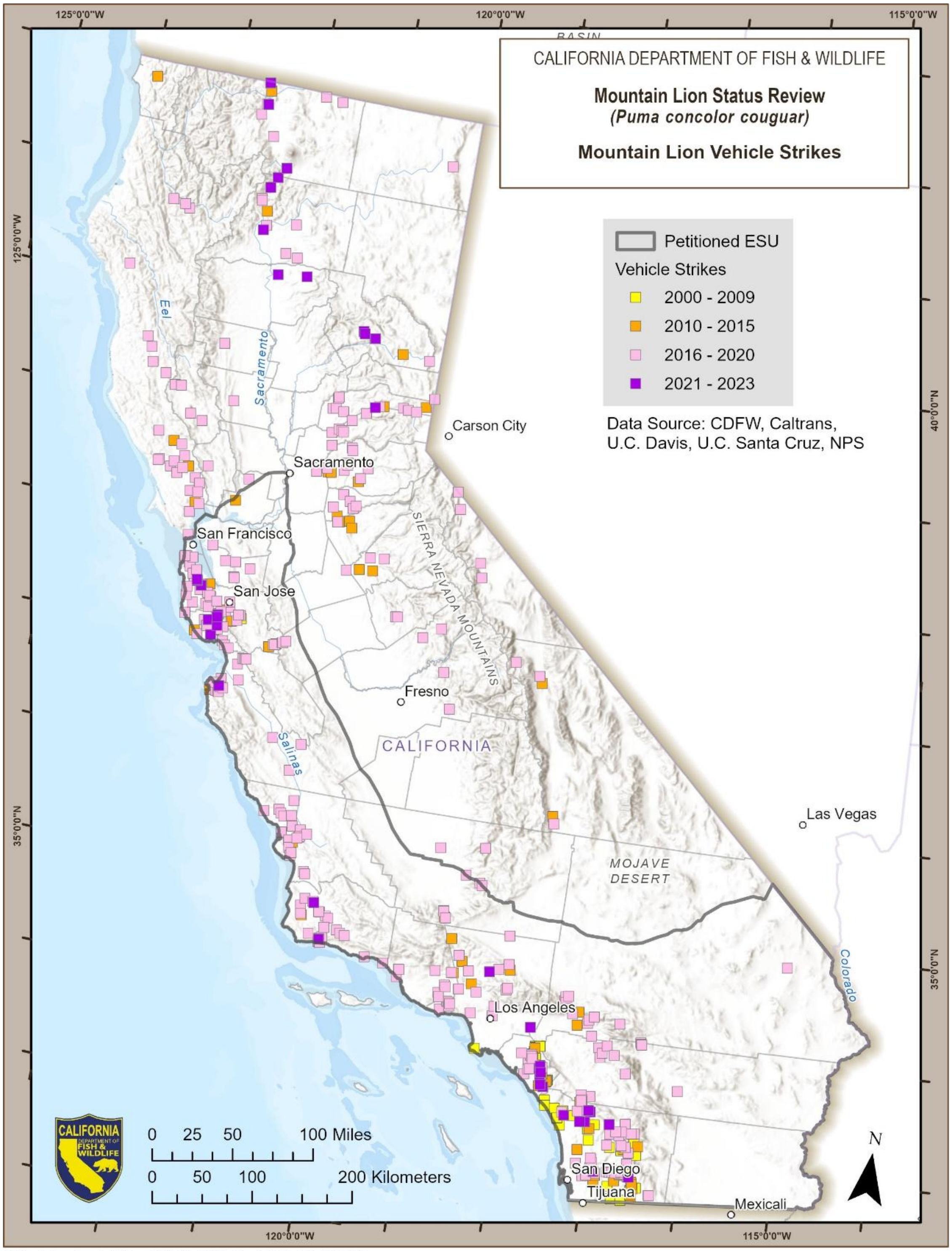


Figure 11. Mountain lion vehicle strike mortality incidents from 2000 to 2023. Roadkill reports are from Department records, Dr. Fraser Shilling and Dr. Winston Vickers at the University of California Davis, Dr. Chris Wilmers at the University of California Santa Cruz, and Dr. Seth Riley at National Park Service.

The threat of vehicle strikes is not limited to roads and highways. Trains also kill wildlife (Gangadharan et al. 2017), and railways often parallel highways and roads (e.g., an existing railway runs roughly parallel to Interstate-15 in the Cajon Pass area between the San Gabriel and San Bernardino Mountains). A high-speed rail line will run along I-15 from Rancho Cucamonga to Las Vegas with multiple crossings for wildlife planned (CDFW 2023). Another planned route for high-speed rail in the petitioned area is from San Jose through Pacheco Pass east to Merced (California High-Speed Rail Authority 2024).

Vehicle strikes may also cause indirect mortality of dependent young mountain lions. When a female with dependent young is struck by a vehicle, the kittens likely starve to death or become easy prey for predators, including other mountain lions. If the kittens are larger and more mobile, they may approach areas where they are more likely to encounter humans as they search for food. This occurred in November 2017, when a mother mountain lion was killed by a vehicle strike in the SA and two of her kittens were found roaming nearby urban areas—one in a backyard and the other along a road (Veklerov 2018). Both kittens, too young to survive on their own, were removed from the wild and placed in the Oakland Zoo.

In addition to direct mortality from vehicle strikes, roads also pose a threat to mountain lions by restricting movements. Radio and satellite-tracking data have revealed that mountain lions will sometimes approach a busy freeway, hesitate to cross, linger in the area, or pace back and forth parallel to the freeway before turning back (Sweanor et al. 2000; Stoner et al. 2008). For example, GPS data from collared mountain lions in the Santa Ana Mountains have revealed that on multiple occasions lions approached one of the three regional freeways that surround the mountains (I-5, I-15, SR-91), only to range back and forth along them before turning back (W. Vickers unpublished data). Only three GPS-collared mountain lions have crossed I-15, the critical barrier between the SA and the EPR genetic populations, during the 19 years that UC Davis researchers have studied mountain lions in the Santa Anas. All three crossed west to east (from SA into the EPR), and all three were dispersal age animals (two males and one female). However, crossing a major barrier like a road does not guarantee the individual will stay or breed in the new area. Of the three who crossed I-15, one was killed on a depredation permit in the EPR within 3 weeks, while the other two returned to the SA after a short period and did not cross the freeway again before their collars dropped off as scheduled (W. Vickers unpublished data). Two uncollared mountain lions have been recorded crossing I-15 on cameras monitoring crossing structures at Temecula Creek and culverts south of that location. Those individuals also crossed I-15 west to east, but no mountain lions have been recorded crossing east to west despite numerous photos of mountain lions being captured along the east side of the freeway (W. Vickers unpublished data). Though one GPS-collared mountain lion has crossed SR-91 from the main body of the Santa Ana Mountains into the Chino Hills and back several times, the Chino Hills are completely surrounded by development and do not provide a pathway to the San Gabriel Mountains to the north.

Planning for safe wildlife crossings in Southern California has been underway for nearly two decades. In 2008, the South Coast Missing Linkages Project identified areas in the coastal areas of Southern California where linkages are needed (South Coast Wildlands 2008). The County of Ventura has incorporated these linkages into its General Plan land use zones to help ensure these important wildlife movement corridors remain passable (Ventura County 2019). In 2020, CDFW assessed priority barriers to wildlife movement throughout the state, and in 2022, 12 were considered to be top priorities, including several in the petitioned ESU area (Fig. 12, CDFW 2022c).

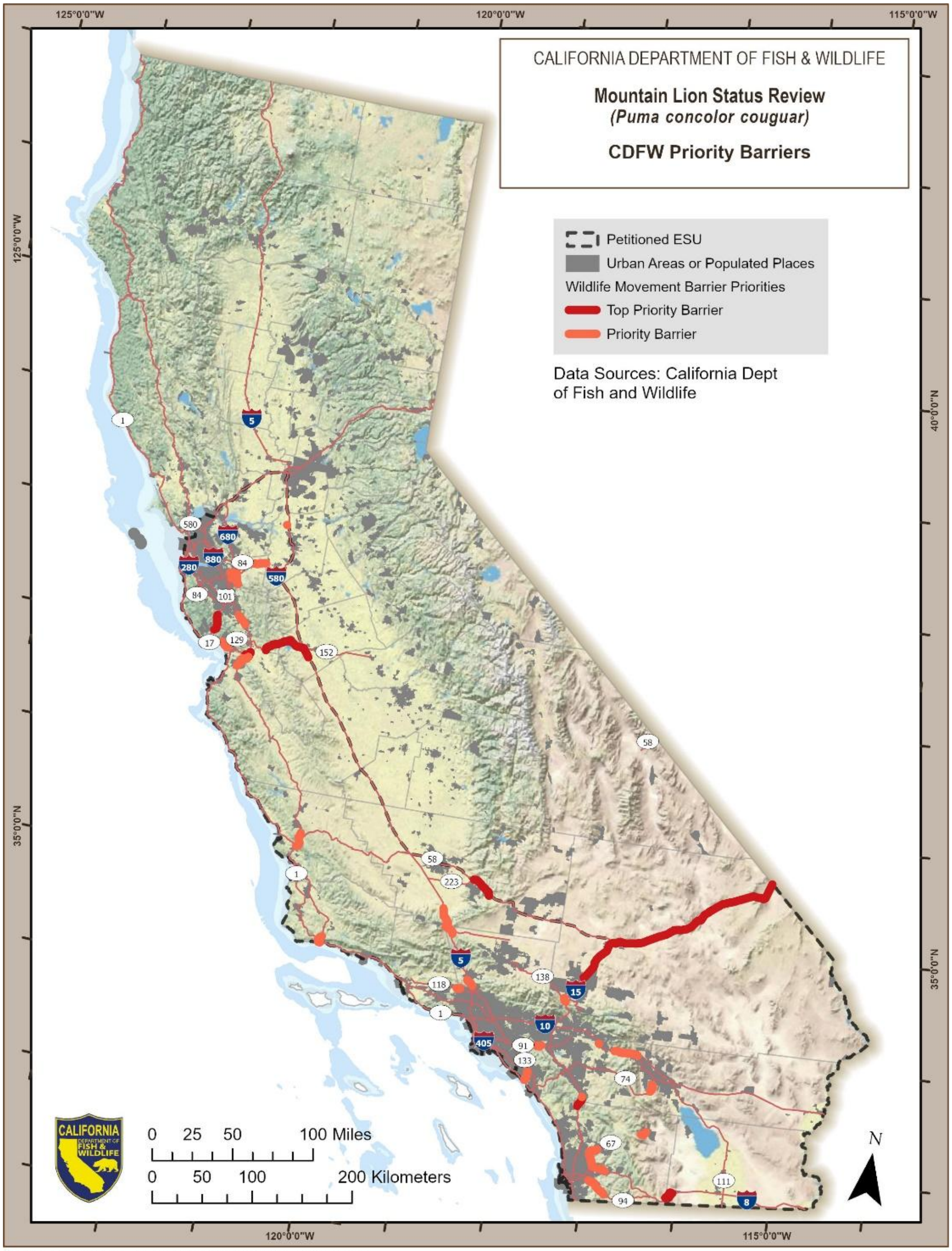


Figure 12. Priority movement barriers within the petitioned area as identified by the Department (CDFW 2022c).

In general, funding to implement wildlife crossing projects, including land acquisition to preserve natural habitat on both sides to make the crossing more suitable for wildlife, has been limited to date. The lack of wildlife crossings with appropriate fencing, and lack of fencing near existing crossing structures, particularly in highly urbanized areas or across major transportation corridors, contributes to continuing vehicle strikes and to the barrier effects on movement and gene flow. However, several crossings have recently been planned and/or approved. Construction of the Wallis Annenberg Wildlife Crossing over Highway 101 in the Liberty Canyon area of CC-S (Fig. 13) began in 2022. The crossing, including the approaches and the crossing over adjacent Agoura Road, is expected to be completed in late 2026. The overpass will help facilitate mountain lion movement between the Santa Monica Mountains and the Simi Hills and could ultimately contribute to genetic exchange throughout the CC-S genetic population, between CC-S and CC-C, and ideally between CC-S and WSN. It may also minimize some local vehicle-related mortality on Highway 101. A wildlife undercrossing with associated fencing and habitat conservation was constructed under Highway 17 in the Santa Cruz Mountains in February of 2023. Another wildlife crossing over Highway 101 in San Benito County is in the planning and fundraising phase. Together, these crossings should help facilitate the movement of mountain lions between the Santa Cruz Mountains in CC-N and the Gabilan Mountains in CC-C. In addition, initial design and environmental studies are being completed for a new crossing structure across I-15 south of Temecula, and improvements to the Temecula Creek passageway are planned. Other connectivity studies are being initiated along I-10 in the Banning Pass area that is critical to mountain lion movement between the EPR and SGSB genetic populations (W. Vickers pers. comm.). Lastly, the Department and the California Department of Transportation (Caltrans) have announced there will be three new wildlife overcrossings along I-15 and the high-speed rail line in San Bernardino County and existing undercrossings and culverts along the corridor will be improved and maintained, all of which should facilitate the movement of mountain lions and other species (CDFW 2023).

Figure 13. Rendering of Wallis Annenberg Liberty Canyon Wildlife Crossing. Source: Santa Monica Mountains Conservancy.

4.3 Overexploitation

4.3.1 Historical Bounties and Hunting

The management of mountain lions in California has varied widely in the last century. From the early 20th century until 1964, mountain lions were a bountied predator in California (Young and Goldman 1946; Dellinger and Torres 2020). During the bounty period, approximately 12,580 mountain lions were killed across California (Dellinger et al. 2021b). Nearly one-third of the bounties paid in the first few decades were in Humboldt, Trinity, Mendocino, and Lake Counties (Dellinger and Torres 2020). Additionally, the Department employed 1–5 hunters whose only job was to remove mountain lions throughout the state (McLean 1954; Dellinger and Torres 2020). One of those hunters, Jay Bruce, killed 669 mountain lions during his long career (Bruce 1953).

When bounties ended in 1964, mountain lions were classified as a nuisance or vermin species—while there was no longer paid incentive for removal, they could be killed year-round without a hunting license and with no limits (Dellinger et al. 2021b). From 1969–1972, mountain lions were considered a game species and could be hunted with a proper hunting license. Two hunting seasons took place (1970–1971) during which 118 animals were harvested from 4,953 permits issued (Dellinger et al. 2021b). Following the second hunting season, a legislative moratorium ceased further mountain lion hunting (Fitzhugh and Gorenzel 1986). From 1972–1986 mountain lions were classified as a non-game mammal and the hunting moratorium remained in place. Their status as a game species was reinstated from 1986, and the Department began to establish hunting zones and harvest quotas and issue tags. However, no mountain lions were harvested due to this change before a 1990 ballot initiative (Proposition 117) approved by California voters classified mountain lions as a “specially protected mammal species” with significant new protections for the species starting in 1991 (Fish & G. Code, § 4800). That classification continues today (see section 1.4). As a specially protected species, the only allowable take of mountain lions occurs via depredation permits when mountain lions have killed or are encountered attacking or threatening livestock, to protect public safety, and the targeted removal of individuals negatively impacting federally listed bighorn sheep populations (Fish & G. Code, §§ 4801–4809).

4.3.2 Poaching

Poaching and other unpermitted take is rarely reported but has been observed in the CC-S, SA, and EPR (Beier and Barrett 1993; Riley et al. 2014; Vickers et al. 2015) as well as in the CC-N (Yap et al. 2019). Benson et al. (2023) reported 26 out of 199 mortalities from known causes in the years 1974–2020 were due to poaching, translating to a 2%–3% annual rate of mortality. This annual mortality rate is lower than the rate for depredation take (6%), vehicle collisions (4%), natural mortality (3%), and being killed by another mountain lion (3%). However, the fact that mortalities from poaching are unreported and difficult to detect means the actual poaching-related mortality rate may be higher than reported in the literature.

4.4 Depredation and Public Safety Management

The interactions between humans and mountain lions in California have profound impacts on the conservation and management of the species. Human-wildlife conflict occurs “when humans and wild animals interact in an unwanted or unsafe way” (CDFW 2024a). As the State’s Trustee Agency for fish and wildlife resources (Fish & G. Code, § 1802), the Department's responsibilities include serving as the primary state agency charged with helping to resolve human-wildlife conflict and public safety wildlife incidents.

4.4.1 Depredation Permits

When mountain lions have attacked or killed domestic animals, depredation permits issued by the Department allow them to be taken, nonlethally and, in some very limited circumstances, lethally (Fish & G. Code, § 4801.5 and 4802, et seq.). Nonlethal methods of take include, but are not limited to, practices such as hazing with hounds and use of less-than-lethal projectiles. Mountain lions encountered in the act of pursuing, inflicting injury to, or killing livestock or domestic animals may be taken—nonlethally or lethally—by landowners and their agents without prior authorization (Id., § 4807). Additionally, the Department or local public safety agencies may take mountain lions perceived to be an imminent threat to public health and safety (Id., §§ 4801, 4801.5).

In 2013, the Department implemented a situation-specific approach to responding to human-mountain lion conflict, which addressed mountain lions in areas of human habitation, mountain lions depredating pets/livestock, and mountain lion public safety situations (CDFW 2013). The most noteworthy change in management action reflected in this approach was specifying that no more than one mountain lion could be taken under a single depredation permit. In 2017, the Department amended its approach, consistent with Fish and Game Code section 4801.5, to prioritize non-lethal measures for dealing with mountain lion depredation in the Santa Monica and Santa Ana Mountains where research indicated that local mountain lion populations constrained by anthropogenic barriers lacked genetic variation (CDFW 2017). Following the Commission's decision to make mountain lion a candidate species in 2020, the Department expanded the area where non-lethal measures would be prioritized to the entire petitioned ESU (CDFW 2020a), and later to the entire state (CDFW 2020b), consistent with Fish and Game Code section 4801.5.

From January 2010 through 2020, the Department recorded 3,637 reported mountain lion incidents statewide. These included depredations, public safety concerns, as well as sightings and nuisance reports[6]. There were 2,202 depredation incidents, wherein mountain lions were reported to have attacked pets and/or livestock.

Across California from 1972 to 2019, the number of reported depredation events trended upward for large hoofstock (cows and horses), small hoofstock (mostly sheep and goats), and pets (Dellinger et al. 2021a). Sheep and goats accounted for 59.4% of confirmed depredations, while large hoofstock accounted for 13.1%, and pets accounted for 10.4%.

From 1972 to 2020, at least 3,694 mountain lions were removed in depredation incidents (Dellinger et al. 2021b), and such removal was the leading cause of attributable mortality of collared mountain lions

---

[6] When reporting a nuisance animal, the reporting party can select "There is⁄are wild animals on or around my property that I would consider pests and I would like more information" or "There is⁄are wild animals on or around my property that is⁄are disturbing my garbage, causing noise or creating some other type of disturbance."

in 1974–2000 (Benson et al. 2023). Between 2001 and 2020, an average of approximately 92 mountain lions were lethally removed pursuant to depredation permits per year statewide (Dellinger et al. 2021b). With recent efforts to prioritize non-lethal measures in response to livestock damage, the number of mountain lions lethally removed pursuant to depredation permits statewide dropped to 3 in 2021, 10 in 2022, and 15 in 2023 (Fig. 14, CDFW 2022b; 2024b; 2025).

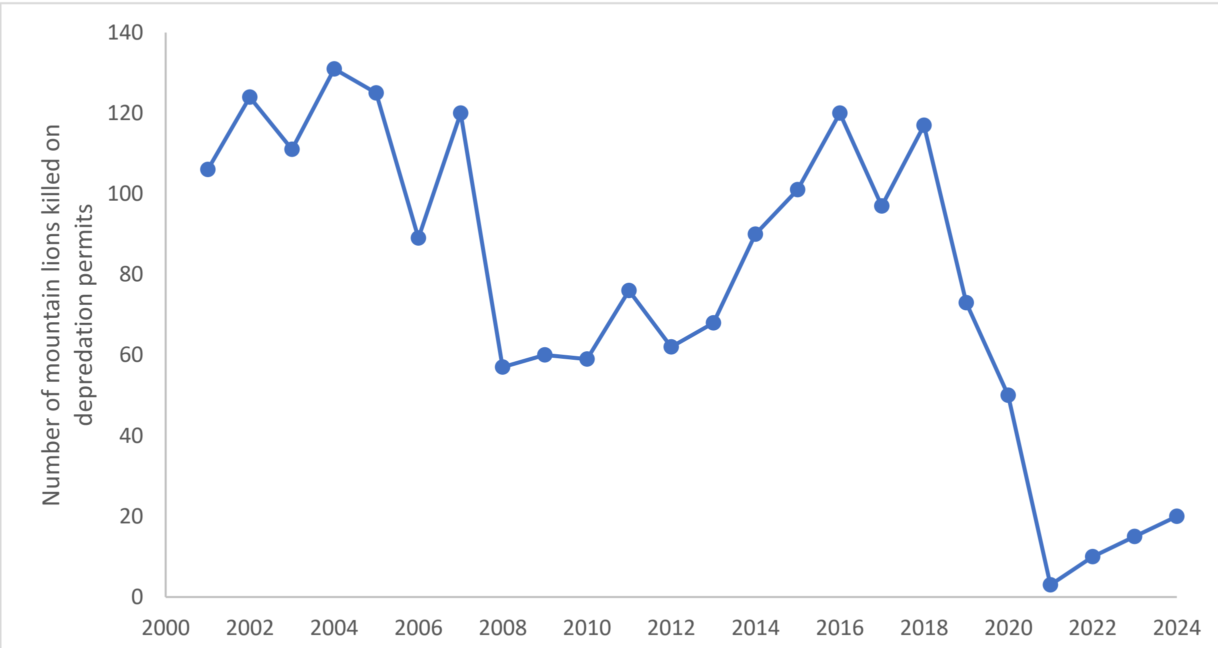


Figure 14. The number of mountain lions reported killed pursuant to depredation permits in California in 2001–2024. Data from (Dellinger et al. 2021b; CDFW 2022b, 2024b, 2025). The Department's approach to mountain lion depredation and public safety response was modified in 2013, amended in 2017, and amended again in 2020.

Interestingly, researchers have noted that at the county level, mountain lion depredation rates increased by 9% for every lion removed through a depredation permit the prior year (Dellinger et al. 2021a). This general pattern of increased depredations in an area the year after mountain lion removal was also seen in Washington State, though removals were done via sport hunting and therefore less targeted to individual mountain lions that may have been involved in depredations (Peebles et al. 2013). Dellinger et al. (2021a) suggested this pattern could be a result of subadults moving to territories vacated when resident adults were removed. Research shows subadults can be more likely to use areas closer to people (Kertson et al. 2013), but evidence that subadults mountain lions have less well-developed hunting skills and are more likely to target easily killed domestic animals is not conclusive (Linnell et al. 1999; Peebles et al. 2013).

Mountain lion removal through depredation permits diminishes the total abundance of mountain lions in an area, and the lions removed are predominantly males (Sweanor et al. 2000). For example, from 1981 to 2013 in the Santa Ana Mountains and the Eastern Peninsular Range, 3.4 times as many males were taken for depredation than females (Vickers et al. 2015). Because males are more likely to disperse than females, depredation removal may thus further inhibit adequate gene flow between mountain lion populations in Southern California by removing the animals most likely to move between genetic populations (Vickers et al. 2017).

To further reduce the number of mountain lions killed for depredation, best practices to minimize livestock predation should be consistently employed. Unfortunately, mountain lions may not adequately interpret human cues and risk levels to substantially modify their behavior and thus reduce the number of conflicts with humans. In the Santa Cruz Mountains, during the day, mountain lions avoided areas of housing where they were most likely to come into conflict with humans (Nisi et al. 2022). However, at night mountain lions were more likely to use areas of intermediate housing density than during the day. Areas of intermediate housing density are where they were also most likely to be killed in response to depredation events. This suggests that improving livestock husbandry to minimize the risk of depredation is vital to further reduce the lethal take of mountain lions.

4.4.2 Bighorn Sheep Management

Mountain lions are occasionally removed when predating upon state and federally endangered Sierra Nevada bighorn sheep (*O. canadensis sierrae*) or state and federally threatened Peninsular bighorn sheep (*O. canadensis nelsoni*). The Department is authorized to take such actions by Fish and Game Code section 4801, and such actions are identified in each species' federal recovery plan (USFWS 2000, 2007). Between 1999 and 2019, 26 mountain lions were lethally removed in the Eastern Sierra Nevada Mountains as part of bighorn sheep recovery (CDFW 2021). These lethal removals occurred outside the petitioned ESU boundary and where mountain lion populations are relatively large and well connected.

4.4.3 Public Safety

The Department prioritizes public safety and lethally removes or attempts to remove mountain lions that represent an immediate threat to human safety. Specifically, a threat to public safety is when a mountain lion "exhibits one or more aggressive behaviors directed toward a person that is not reasonably believed to be due to the presence of responders." (Fish & G. Code, § 4801.5, subd. (b).) From 1986 to April 2024 there were 25 reported mountain lion attacks on humans in California, 4 of them fatal (CDFW 2024c). The Department has records of 10 mountain lions being euthanized following attacks on humans in California between 2000 and 2024 (reliable records prior to 2000 are unavailable).

Collectively, all forms of permitted take are unlikely to negatively influence mountain lion populations and trends at the statewide level or within the relatively large and well-connected NC and SN genetic populations. However, the additive mortality resulting from lethal removals associated with depredations and human conflicts in areas where mountain lion groups are already small and isolated such as California's central and south coasts may result in local population declines (Benson et al. 2023). Importantly, Benson et al. (2023) noted the risk of mortality from management killing declined dramatically from 2001 to 2020, and raised the possibility that the decline may be related to the 2017 changes in CDFW's management policies. The number of management killings decreased sharply after 2020 (Fig. 14), and therefore its relative importance as a source of mortality has decreased.

4.5 Competition

Mountain lions compete with other large carnivores in most areas of their range. Mountain lions and black bears regularly overlap in space in almost all mountain lion-occupied areas in California except for the Santa Cruz Mountains and the Santa Monica Mountains. In a study in the Mendocino National Forest in Northern California, black bears displaced mountain lions from about 50% their kills (Elbroch et al. 2015a), depriving them of calories, and potentially forcing them to expend additional energy hunting to procure more prey (Allen et al. 2021). Instead of avoiding areas with bears, mountain lions increased their predation rates to compensate for the kills stolen by bears (Elbroch et al. 2015a). It is unknown whether displacement by black bears occurs frequently enough to affect mountain lion survival and reproductive rates (Elbroch and Kusler 2018).

In western North America, gray wolves can affect adult and kitten survival by directly killing individual mountain lions, and can affect habitat and prey selection, bedding locations, and population size (Bartnick et al. 2013; Elbroch et al. 2015b; Kusler et al. 2017; Elbroch and Kusler 2018; Elbroch et al. 2020). Mountain lions can also kill individual wolves. In Washington State, at least four collared wolves were killed by mountain lions from 2013–2022 (WDFW 2022). However, given the small size and limited distribution of California's current gray wolf population, competition between wolves and mountain lions has not been a significant threat to the persistence of mountain lions in the petitioned ESU. Wolves are currently absent from the petitioned ESU and therefore wolf competition is not considered a current threat; however, wolves are rapidly expanding their range in the state with one pack known to occupy a portion of the southern Sierra Nevada. If wolf distribution continues to expand, competition between wolves and mountain lions in the petitioned area may become a threat in the future. Finally, smaller predators and scavengers such as coyotes are known to opportunistically feed from mountain lions kills (Brunet et al. 2022), although the degree this loss of food resources impacts lions is difficult to quantify.

Intraspecific conflict and aggression (i.e. aggressive interactions between two or more mountain lions) appears to be a significant mortality factor in areas where mountain lions occupy small patches of suitable habitat surrounded by urban and agricultural development and other dispersal barriers (Riley et al. 2014; Vickers et al. 2015; Benson et al. 2020). Intraspecific aggression was identified as the leading cause of mortality for the nearly isolated mountain lions in the Santa Monica Mountains (a portion of the CC-S; Riley et al. 2014), although more recently, vehicles and toxicants have caused similar levels of mortality (Benson et al. 2020). From 2002 to 2018, about 41% of deaths of telemetered mountain lions tracked in the Santa Monica Mountains were determined to have resulted from intraspecific aggression. There were multiple documented cases of adult males killing their siblings, offspring sired by other males (i.e., infanticide), and previous mates (Riley et al. 2014; Benson et al. 2020). Additionally, in the SA, intraspecific predation was documented on two occasions in recent years (W. Vickers, unpublished data). Therefore, this form of competition should be considered a potential threat to mountain lion populations in small, isolated genetic populations such as the CC-S, SA, and the SGSB. While the effect of inter- and intraspecific competitions on mountain lions within the entire petitioned ESU is unknown, in the smaller genetic populations it likely exacerbates the threats associated with small, isolated populations.

4.6 Toxicants

Mountain lions throughout California are exposed to toxic chemicals in their environment. Depending on the extent of exposure, toxicants may cause clinical signs of disease or debilitation, or may lead to toxicosis and death or debilitation. Some ingested toxicants can be transferred in utero to fetuses, and debilitated lions may be more susceptible to other forms of mortality such as starvation and traumatic injuries.

Anticoagulant rodenticide (AR) baits are commonly used to control rodent pests in urban, suburban, and agricultural areas (Litovitz et al. 1998; Maroni et al. 2000). As summarized in Serieys et al. (2015), ARs interrupt the production of vitamin K-dependent blood clotting proteins, leading to the depletion of these proteins over a period of days and inducing mortality by internal hemorrhage. Comprised of two classes of compounds, ARs are the primary chemical method used worldwide for the control of rats and mice. First-generation ARs, including warfarin, diphacinone, and chlorophacinone, are more readily metabolized, have a shorter half-life in liver tissue (two weeks to several months), and must be consumed in multiple feedings to reach a lethal dose. Second-generation ARs include brodifacoum, bromadiolone, difenacoum, and difethialone, and were developed to target rodents with genetic resistance to warfarin. Due to increased toxicity and persistence in animal tissues, with half-lives ranging from 6–12 months, second-generation ARs may persist in liver tissue for more than a year in some species. Both classes of compounds have a delayed onset of action, and death from AR consumption can occur up to 10 days after ingestion. Individual rodents may continue to accumulate the compounds over a period of days, increasing their likelihood of capture by predators as they become weakened by the toxicant. For these reasons, ARs have the potential of creating primary and secondary poisoning risks to non-target wildlife. Predatory animals are at significant risk of secondary poisoning if they consume prey that had previously ingested ARs. AR exposure in wildlife has been positively associated with proximity to urban areas, raising concerns about long-term conservation impacts of AR exposure on non-target wildlife populations on the fringe of urban areas (Hosea 2000; Riley et al. 2007; McMillin et al. 2008; Gabriel et al. 2012; Serieys et al. 2015; Serieys et al. 2018).

Mountain lions can be exposed to ARs in many settings including near human settlements where legal ARs are used to control vertebrate pests (Moss et al. 2016; Smith et al. 2016). However, even in remote locations on public lands, mountain lions can come into contact with prohibited rodenticides as they are often used to protect illicit cannabis plantations (Gabriel et al. 2012). The Department’s Wildlife Health Lab detected AR exposure in 94.2% (343/364) of tested mountain lion livers submitted between 2016 and 2022 (Fig.15; Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022; CDFW unpublished data). Second-generation ARs were more commonly detected than first-generation ARs, despite a 2014 California regulatory change restricting second-generation AR use to certified pesticide applicators (Rudd et al. 2018; Rudd and Rogers 2021). Eighty-five percent of the mountain lion livers (306/364) tested had two or more different ARs present at the time of death, with 52.2% (190/364) of individuals testing positive for three or four different ARs, which indicates multiple exposure events are common (Fig. 16; Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022; CDFW unpublished data). The 94.2% (343/364) total exposure prevalence recorded between 2016 and 2022 is higher ($X^2 = 14.8$, $p < 0.001$) than the 82.4% (103/125) exposure prevalence found in mountain lion livers analyzed from across the state between 2003 and 2015 (Poppenga et al. unpublished data). In samples from 2003–2015, 67.2% (84/125) of livers indicated exposure to multiple AR compounds, which was lower than the exposure prevalence rate in livers tested between 2016 and 2022 ($X^2 = 15.4$, $p < 0.001$).

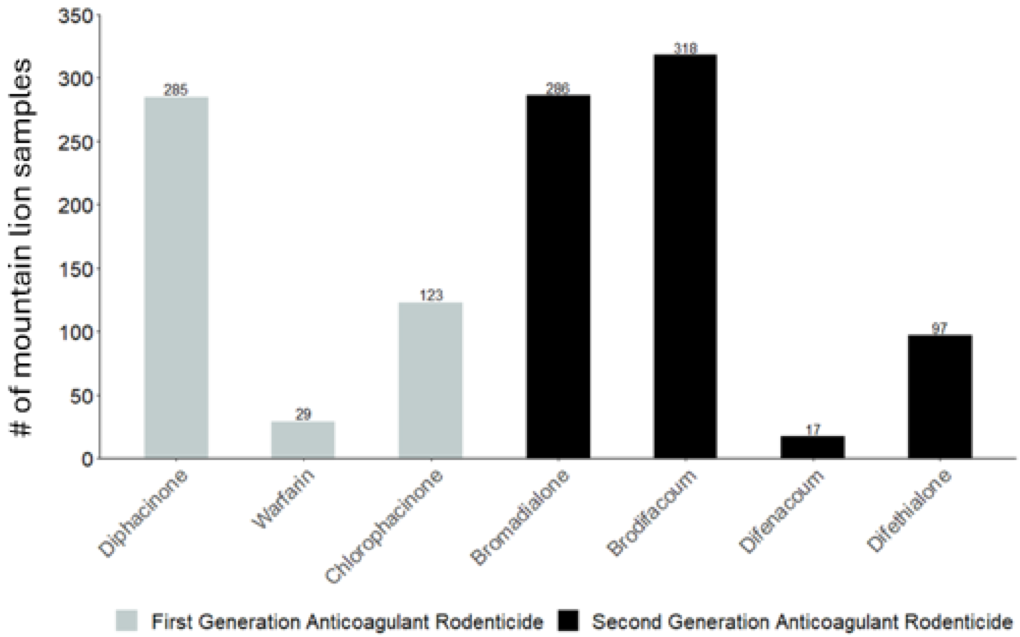


Figure 15. Anticoagulant rodenticide residues detected in 364 livers of mountain lions submitted to the Wildlife Health Laboratory for postmortem examination 2016–2022 (Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022, CDFW unpublished data). Numbers on top of the bars are the number of livers that the specific residue was found in.

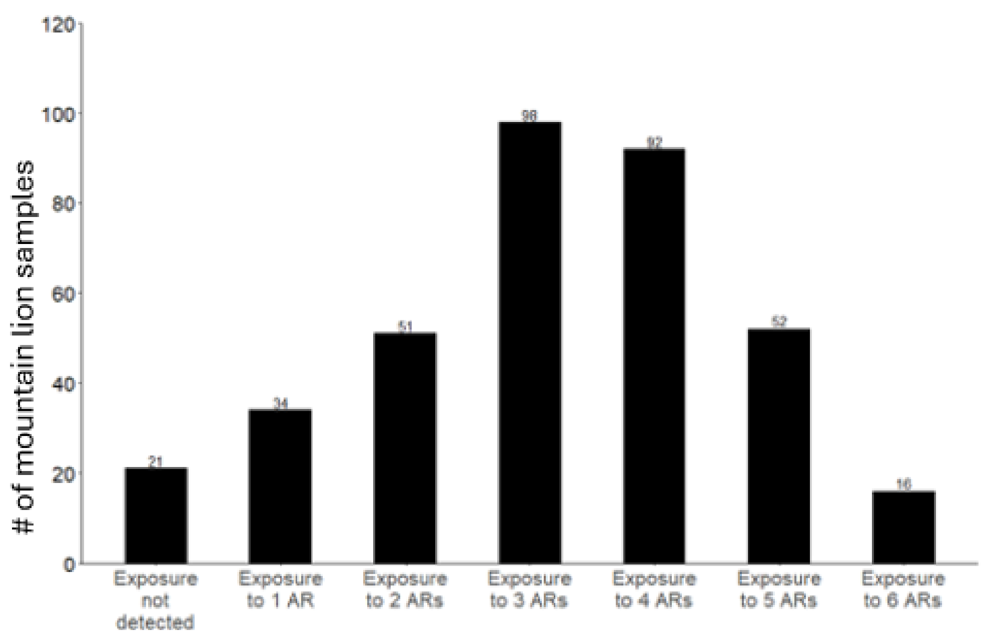


Figure 16. Number of different anticoagulant rodenticide analytes detected in 364 individual mountain lion livers analyzed from 2016–2022 (Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022; CDFW unpublished data).

Fetal AR exposure occurs in mountain lions, as exposure was detected in four of eight (50%) instances where both pregnant female mountain lions and fetal or placental tissues were tested (Table 4; CDFW unpublished data; National Park Service (NPS) unpublished data). Many toxic substances, including ARs, can adversely affect fetal development and survival at doses that may not produce toxic effects in the mother (Gupta 2012). Fetuses are also typically more susceptible to AR toxicity because the placenta is the only source of vitamin K for the fetus (Gupta 2012). AR-related coagulopathy and toxicity was not observed in any of the examined fetuses with AR exposure (Rudd et al. 2020, CDFW and NPS unpublished data).

Table 4. Anticoagulant rodenticide test results for liver samples from 8 pregnant mountain lions and their fetuses, pooled fetal tissue, or placenta (CDFW and NPS unpublished data). BRD: brodifacoum, BRM: bromadiolone, CHL: chlorophacinone, DIF: difethialone, DIPH: diphacinone. An asterisk (*) indicates that the samples were pooled together for qualitative and quantitative analyses (i.e., samples too small to be evaluated individually).

ID	Cause of Mortality	County	ARs detected in pregnant adult (ppb)	# of fetuses	ARs detected in fetal tissue (ppb)
Z16-1126	Depredation	Tuolumne	BRD (230), BRM (trace)	4*	Not detected
Z17-0199	Hit by car	Santa Barbara	BRD (71), BRM (130), CHL (trace), DIF (trace), DIPH (830)	2	**1.** BRD (trace), DIPH (150) **2.** BRD (trace), DIPH (160)
Z17-0281	Depredation	Trinity	BRD, BRM, DIF, DIPH (all trace)	4*	Not detected
Z17-0328	Depredation	Yuba	BRD (trace), BRM (120), DIPH (trace)	3*	Not detected
Z19-0793	Depredation	Amador	BRD, BRM, DIPH (all trace)	3*	Not detected
P054	Hit by car	Los Angeles	BRD (83), BRM (930), CHL (trace), DIF (190), DIPH (230)	4	**1.** BRD (trace), BRM (trace), CHL (trace), DIPH (120) **2.** BRD (trace), BRM (trace), CHL (trace), DIPH (140) **3.** BRD (trace), BRM (trace), CHL (trace), DIPH (130) **4.** BRM (trace), CHL (trace), DIPH (120)
Z23-0437	Depredation	El Dorado	BRD, BRM, CHL, DIPH (all trace)	4*	DIPH (trace)
Z23-1178	Depredation	Yuba	BRD (trace), BRM (400), CHL (trace), DIPH (400)	3	**1.** DIPH (100) **2.** DIPH (86) **3.** DIPH (68)

In the Santa Monica Mountains National Recreation Area (CC-S), the deaths of seven mountain lions since 2004 have been associated with AR exposure and toxicosis (Riley et al. 2007; NPS 2021). Between 2002 and 2019, out of 26 known deaths of adults and subadults in that population, 5 were from AR toxicosis (Benson et al. 2020). Two mountain lions that died from AR toxicosis in 2004 in CC-S also had infestations of notoedric mange (Riley et al. 2007; Uzal et al. 2007). Notoedric mange, typically caused in felids by the parasitic mite *Notoedres cati,* may cause fatal disease in bobcats and mountain lions (Foley et al. 2016). Exposure to higher doses of ARs or to more than one AR was associated with greater likelihood of dying due to severe mange (Serieys et al. 2015).

In addition to ARs, risk of pesticide exposure may also come from neurotoxic rodenticides, such as bromethalin, which have become more widely used as restrictions on ARs have increased (McMillin et al. 2016). Bromethalin is a single-feed neurotoxic rodenticide which once ingested is absorbed and processed in the liver to form its highly toxic metabolite, desmethylbromethalin (DMB). Both bromethalin and DMB accumulate in fat and brain tissues. Lethal intoxication leads to a death via respiratory failure, while sublethal intoxication can cause neurological dysfunctions that may resolve, or result in death (McMillin et al. 2016).

Bromethalin was thought to have low risk of secondary exposure, yet in recent years has been documented in nontarget wildlife in California (McMillin et al. 2016; Rudd et al. 2021; Rudd et al. 2022). Because exposure was documented in probable mountain lion prey species, CDFW and the California Animal Health and Food Safety Laboratory tested fat or brain tissue from 49 mountain lions for the metabolite DMB over two years. In 2021 and 2022, four of 32 (12.5%) and six of 17 (35.3%) mountain lions tested positive for DMB exposure, respectively (Rudd et al. 2021, 2022). Continued surveillance for bromethalin exposure is warranted and more research is needed on exposure pathways and the sublethal effects on mountain lions due to bromethalin products entering the food web.

The Petition cited Rudd et al. (2019) to state that mountain lions in California are exposed to dangerously high levels of illegal pesticides, such as carbofuran. However, this citation is incorrect; the Department has not documented any cases of carbofuran toxicity in mountain lions to date. Further research is needed to investigate the lethal and sub-lethal effects of anticoagulants and other toxicants on wildlife in terrestrial environments (Riley et al. 2007; Gabriel et al. 2015; Rudd et al. 2018).

4.7 Infectious Diseases

Mountain lions are afflicted by various viral, bacterial, and parasitic pathogens. It is not known if these pathogens and their respective diseases alone could imperil the species in California. However, small, isolated mountain lion populations are at greater risk of experiencing population-level impacts from disease, which could reduce their ability to persist into the future, especially when combined with other threats (Foley et al. 2013). Recent detections of emerging diseases in California mountain lions coupled with potential future changes in the distribution of pathogens and disease vectors due to habitat modification and climate change supports the value of continued mountain lion mortality monitoring and disease surveillance (White et al. 2018; Thurman et al. 2024). The following are pathogens documented to have caused the death of at least one mountain lion in California since 2019.

Highly Pathogenic Avian Influenza (HPAI). Since October 2021, outbreaks of H5N1 HPAI belonging to Eurasian lineage, clade 2.3.4.4 have been detected in wild birds and domestic poultry throughout Europe and North America. The majority of H5 HPAI virus detections in both wild and domestic birds have overlapped with annual fall migration and large aggregations of overwintering waterbirds (Verhagen et al. 2021). In California, six GPS-collared mountain lions were documented to have died from the virus: two from Mono County in December 2022 and January 2023, one from Butte County in January 2023, and three from Modoc County in March 2023 (Rudd et al. 2024). Occasionally, wild birds, including waterfowl, can make up a component of the natural diet for mountain lions, and at least three of the mountain lions that died had a history of hunting wild Canada geese (J. Rudd, CDFW, pers. comm.). While infection with H5N1 HPAI is considered uncommon in mammals, there is evidence suggesting that certain mutations in the H5N1 virus may lead to mammal-to-mammal transmission (Plaza et al. 2024). While H5N1 infection has not been detected to date in coastal populations of mountain lions, the potential for it to occur in and to impact the smaller genetic populations within the petitioned area is of concern. Given the six documented H5N1 HPAI-related mortalities in California mountain lions over a four-month period, infections in mammals in general, multiple possible transmission routes, and the potential for zoonotic transmission, H5N1 or other HPAI viruses should be closely monitored in mountain lions.

Feline leukemia virus (FeLV). FeLV is a common immunosuppressive viral pathogen in domestic cats known to cause morbidity and mortality. While infection is seemingly rare in non-domestic felids, FeLV is considered a disease of potential epidemic concern for small populations. Researchers have found antibody test-based infection prevalence in mountain lions to be low, ranging from 0–5.4% (Paul-Murphy et al. 1994; Foley et al. 2013). More recently, the Department, in collaboration with Colorado State University, documented a FeLV infection prevalence of 2.4% in lymph nodes collected from 130 necropsied CA mountain lions tested using Polymerase Chain Reaction from 2016–2018 (J. Rudd, CDFW, pers. comm.). To date, the Department has documented two mountain lion mortalities due to suspected FeLV-related infections (e.g., opportunistic bacterial and fungal infections and anemia)—one in 1993 (Jessup et al. 1993), and another in 2020 (J. Rudd and Q. Martins, unpublished data).

Feline Panleukopenia Virus (FPV). FPV belongs to a family of parvoviruses that are closely related to canine parvovirus and mink enteritis virus (Truyen and Parrish 2013). FPV primarily infects felids and has a high mortality rate, although individuals that do survive infection generally have life-long immunity (Sykes 2014). Antibodies to FPV were detected in 36% of wild mountain lions from California sampled from 1991–2008 (Foley et al. 2013). Infection with FPV resulted in the illness and death of two six-week-old mountain lion siblings from Ventura County in 2021 and was the cause of illness in an emaciated 11-month-old mountain lion with impaired balance and coordination from Nevada County that was euthanized in July 2022 (J. Rudd, CDFW, pers. comm.). Pathological findings for all three mountain lions demonstrated viral-associated encephalitis.

Mange. Notoedric and sarcoptic mange are skin diseases caused by highly contagious parasitic mites. Severe and sometimes fatal mange epidemics from these mites have been described worldwide, and wild felids in California have been infested with the mite *Notoedres cati* (Riley et al. 2007; Serieys et al. 2013; Foley et al. 2016). In wildlife, mange causes considerable suffering, predisposing the individual to secondary bacterial infections through open wounds, changes in behavior, emaciation, and death

(Maehr et al. 1995; Bornstein et al. 2001; Serieys et al. 2013; Niedringhaus et al. 2019). Mange poses a considerable threat to wildlife species that are more social or have high spatial overlap, which can promote transmission (Rudd et al. 2020a). In the Santa Monica Mountains, there have been six known cases of notoedric mange in mountain lions, including one adult female who died of the disease in March of 2022 (S. Riley pers comm. March 2024). Given mountain lions' largely solitary nature, and that *Notoedres* mites are not thought to survive off of the host animal (Paterson 2008), the potential for disease spread population-wide is presumably low. However, notoedric mange had a negative impact on the bobcat population in CC-S in 2002-2004 (Riley et al. 2007), and in 2019-2021 there has been regular bobcat mortality from mange in the same area (S. Riley pers. comm March 2024).

4.8 Wildland Fire and Fire Management

Fire is a natural disturbance in many California ecosystems. However, intense, high-severity burns can significantly modify ecosystems by changing plant and animal community compositions temporarily or long term (Williams et al. 2023). Wildfires in California can cause direct mortality to mountain lions and can result in temporary adverse modification of their habitats. However, after wildfires, deer populations typically respond favorably to the resulting plant regrowth (Lewis et al. 2022).

In California's wildland-urban interface and in many habitats prone to fire, changes in temperature, humidity, and wind patterns attributable to climate change, in combination with other human activities, have led to more frequent wildfires that burn larger areas (Syphard et al. 2007; Syphard et al. 2009; Keeley and Syphard 2017,2021). In California's central coast and south coast regions, Keeley and Syphard (2017) found the area burned per decade increased dramatically from the 1930s to the 2010s. Keeley and Syphard's more recent work (2021) examined wildfire records over a longer period (1860s–2020) and revealed more complex patterns in the central and south coast regions. They found fire frequency peaked during two periods: the 1920s and the 2000s and has been declining since the 2000s. The average fire size in the central coast region was similarly found to have significantly increased from the 1950s through 2020, but no significant trend in average fire size was found in the south coast region.

Keeley and Syphard (2021) distinguished fuel-dominated and wind-dominated fires and considered the latter type more dominant in the grasslands, shrublands, and woodlands of California's central and southern coast. They pointed out that wind-dominated fires rely on both an extreme wind event and an (usually human-caused) ignition source. The authors considered the major driver of wind-dominated fire impacts to be more frequent ignitions associated with human population growth and the expansion of residential developments into the wildland-urban interface (Keeley and Syphard 2021). Climate models predict increasing temperatures and decreasing humidity in the future, and strong, dry easterly winds (i.e., Santa Ana winds) may become more frequent and extend into the late fall and early winter when fuel loads are highest and fuel moistures lowest—suggesting extreme fire events will become more frequent in the future (Miller and Schlegel 2006; Jennings et al. 2016).

Since 2000, a substantial proportion of the mountains in southwestern California where undeveloped mountain lion habitat remains have burned in wildfires (Fig. 17). Fire-return intervals (the average number of years between successive fires in the same location) in Southern California shrublands historically ranged from 30–100 years but return intervals are now 33% shorter (Jennings et al. 2016). This shortened interval between fires can interrupt plant community successional cycles, reduce plant diversity, favor the establishment of non-native species, and shift shrublands to grass-dominated landscapes (Keeley 2005; Jennings et al. 2016). Jennings et al. (2016) warn that if trends continue, vegetative communities preferred by mountain lions such as riparian areas, oak woodland and conifer forests could be converted by repeated, short interval fires into homogenous non-native annual grasslands, which are typically avoided by mountain lions. Should this occur in key locations, migration between genetic populations could be further limited.

The central coast of California has similarly experienced a succession of large, severe wildfires in the last two decades. Major fires in the year 2020 alone included the 160,508 ha (396,624 acres) SCU Complex Fire in the interior of CC-N, the 35,009 ha (86,509 acres) CZU Lightning Complex Fire in the Santa Cruz Mountains (also in CC-N), the 50,555 ha (124,924 acres) Dolan Fire in Big Sur, and the 19,461 ha (48,088 acres) River Fire on the eastern slopes of the Santa Lucia Mountains in Monterey County (CAL FIRE 2020). In the central coast region, the annual distribution of fire sizes has trended toward larger fires in the last 75 years, although trends in the frequency of large fires (≥ 10,000 ha) in over the same period are less apparent (Keeley and Syphard 2021). Trends in annual area burned in the central coast region differ by responsibility area, with U.S. Forest Service (USFS)-managed areas located primarily in the interior coastal mountains experiencing an approximately ten-fold increase between 1940 and 2000, from 5,000 ha/million ha in the 1940s to nearly 50,000 ha/million ha in the 2000s (50 mi.^{2}/10,000 mi.^{2} to 500 mi.^{2}/10,000 mi.^{2}). By contrast, within the California Department of Forestry and Fire Protection (CAL FIRE) responsibility area (largely private lands and state lands located on the coastal plains, valleys, and lower slopes of interior mountains), the annual area burned decreased from approximately 15,000 ha/million ha in 1920 to less than 2,000 ha/million ha in 2010 (150 mi.^{2}/10,000 mi.^{2} to 20 mi.^{2}/10,000 mi.^{2}) (Keeley and Syphard 2017). Making predictions about future trends in this region is complicated by the interplay between precipitation levels and fuel accumulation. Within the central coast zone, projections indicate precipitation levels may increase in the north in coming decades potentially resulting in moister conditions and therefore lessened fire frequency, but higher severity fires when they do occur due to higher fuel loads; while in the south, precipitation is projected to decrease, potentially limiting fuel accumulation thereby limiting fire severity, although fires may become more frequent due to prolonged dry periods (Langridge 2018).

In the redwood forests of the Santa Cruz Mountains, mountain lions likely continue to use burned areas following most wildfires as redwoods are adapted to wildfire with trees frequently surviving low and moderate intensity wildfires and decay-resistant dead trees remaining standing for decades. In 2020, an unusually severe fire burned old growth redwoods in Big Basin Redwoods State Park north of Santa Cruz. Six months later, many trees were able to resprout, suggesting redwoods could have some resiliency to changing fire regimes (Peltier et al. 2023). Additionally, redwood sprouts and seedlings can be prolific following fires, numbering in the tens of thousands per hectare, and canopies can develop rapidly (Lazzeri-Aerts and Russell 2014). Consequently, dense cover favored by mountain lions for hunting and travel can develop within a few years following severe wildfire in these forests.

While mountain lions are likely able to escape most wildfires, quickly moving wind-driven wildfires described by Keeley and Syphard (2021) are capable of overtaking fleeing mountain lions or trapping lions between multiple fire fronts (Fig. 18). Vickers et al. (2015) documented the death of a collared mountain lion in the SA and one in the EPR due to burns from human-caused wildfires and, following the 2018 Woolsey Fire in the Santa Monica Mountains and Simi Hills, one collared lion was found in poor condition with burned feet and eventually died. Another collared lion disappeared and was presumed to have died in the same fire (Blakey et al. 2022). A young lion found with burned paw pads following the 2018 Tomas Fire in the CC-C was treated and placed into captivity. An adult lion found unable to walk due to burned paw pads during the 2020 Bobcat Fire in the San Gabriel Mountains was cared for and released. In Northern California, a three-month-old male kitten suffering burn injuries to the feet and face from the 2020 Zogg Fire in Shasta County was treated and placed into captivity. The same year, the August Complex Fire in Colusa, Glenn, Mendocino, Tehama, Trinity, and Humboldt Counties was likely responsible for the death of one adult female lion and the orphaning of her two kittens which were rescued and placed in captivity (D. Clifford, CDFW, pers. comm.).

Additionally, wildfires can temporarily displace mountain lions, increasing the distances they move and amount of area they use (Blakey et al. 2022). In developed areas, this increased movement may lead them to cross over roads more often, exposing them to vehicle strikes, and potentially bringing them in contact with other mountain lions, increasing the chance of intraspecific aggression (Jennings et al. 2016; Blakey et al. 2022).

Post-fire habitat use by mountain lions may vary over time, with lions initially avoiding heavily burned areas but then utilizing them more as vegetation regenerates (McLean 1954). A study in the Santa Monica Mountains and Simi Hills after the 2018 Woolsey fire showed that, in general, mountain lions avoided burned areas up to 15 months post fire (Blakey et al. 2022). However, assessing use up to 9 years post-fire, Jennings et al. (2016) found mountain lions used regenerating shrub-dominated habitats in the Santa Ana Mountains and the Eastern Peninsular Range to a greater extent than would be expected based on availability (Jennings et al. 2016). The same study assessed suspected cache and kill sites from 44 collared mountain lions and found there were more such sites than expected in recently burned areas (≤ 6 years old), likely reflecting intensive use of recent burned areas by mule deer taking advantage of nutritious young foliage.

Several strategies are employed in different California wildland habits to help minimize the potential for catastrophic wildfires, including prescribed burns and mechanical fuel reduction. Like wildfires themselves, these actions have the potential to benefit or harm mountain lions and their prey. Prescribed fires and mechanical fuel removal can result in the short-term loss of vegetation and cover favored by mountain lions, while over slightly longer terms encouraging vigorous regrowth of palatable foliage favored by key mountain lion prey species.

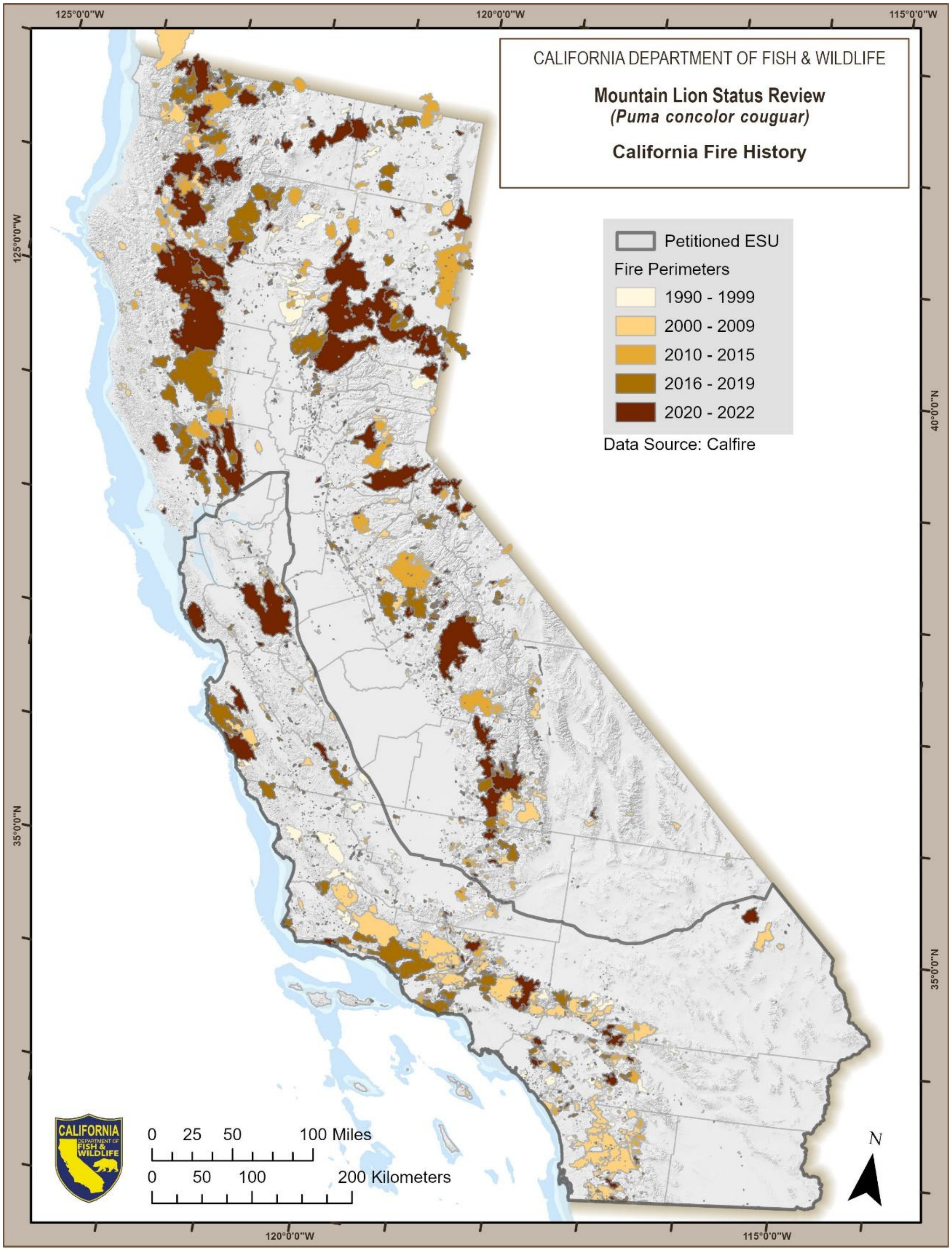


Figure 17. Wildfire perimeters in California by fire year, 1990–2022.

Figure 18. Left: Burned paw of female mountain lion F121 (L) with phalanges showing, found deceased following the Bond Fire in Orange County, California. (Photo Credit: Nick Molsberry, CDFW). Right: F121 prior to the fire (Photo Credit: UC Davis Wildlife Health Center).

4.9 Climate Change

Human-mediated climate change (Bedsworth et al. 2018) threatens biodiversity through both direct effects and interrelated indirect threats (Garcia et al. 2014; González-Orozco et al. 2016). A species' vulnerability to the direct effects of climate change is a function of its level of exposure and its sensitivity to such effects mediated by its ability to adapt physiologically or behaviorally (Dawson et al. 2011). Indirect effects of climate change are those ecosystem changes that affect organisms—including increased frequency and severity of drought, wildfires, flooding, and landslides—which in turn can lead to shifts in vegetation patterns, changes in habitat quality, and modified predator-prey relationships (Williams et al. 2008; Keeley and Syphard 2016).

There has been a consistent trend in recent decades of warming temperatures in California. Average state temperatures have increased by about 1.67°C (3°F) since the beginning of the 20th century (Frankson et al. 2022). The warmest three years on record since 1895 have all occurred in the last decade (OEHHA 2024a), and 2021 was the warmest summer on record in the state (Frankson et al. 2022). Climate model projections for annual temperature in California in the 21st century range from 1.5–4.8°C (2.7–8.8°F) greater than the 1960–2005 mean (Bedsworth et al. 2018).

Temperature increases have not been consistent across California. Rapacciuolo et al. (2014) found that while temperatures generally warmed in California between the historical period (1900–1939) and modern period (1970–2009), increases in mean annual temperature were greatest in Southern California, an area roughly corresponding to the extent of the South Coast large-scale genetic population in Gustafson et al. (2022). During that period the mean annual maximum temperature increased in Southern California but decreased in much of central and Northern California (Rapacciuolo et al. 2014). Projections of future temperature conditions at specific locations in California are available from the State of California's Cal-Adapt program (https://cal-adapt.org/). Table 5 presents results for a representative location in each of the four broad mountain lion genetic groups areas described in Gustafson et al. (2022) from Cal-Adapt's Local Climate Change Snapshot (https://cal-adapt.org/tools/local-climate-change-snapshot/). Three measures of change in environmental temperature are presented: Annual Average Maximum Air Temperature (AAT_{MAX}), Annual Average Minimum Temperature (AAT_{MIN}), and Number of Extreme Heat Days per Year (EHD)[7]. For each measure, a baseline value modeled from measurements recorded from 1961–1990 is presented, along with modeled future values for the end of the 21st century (2070–2099). Averaged modeled values for the High Emissions scenario (known as Representative Concentration Pathway 8.5)—which most closely tracks current emissions trends—are presented, along with the range of averages from all the model runs. The sites chosen as representative of the broad-scale genetic groups are Willits, CA (NC), Placerville, CA (SN), Atascadero, CA (CC), and Fallbrook, CA (SC). Models for all temperature metrics of the four representative sites suggest substantial warming will occur at the sites during the 21st century.

Table 5. Baseline and projected changes in Annual Average Maximum Temperature (AAT_{MAX}), Annual Average Minimum Temperature (AAT_{MIN}), and Number of Extreme Heat Days (EHD) per year for four representative sites in the North Coast (NC), Sierra Nevada (SN), Central Coast (CC), and Southern Coast (SC) areas identified by Gustafson et al. (2022). Model data are derived from Cal-Adapt's Local Climate Change Snapshot tool, accessed November 2021. The CC group incorporates CC-N, CC-C, and CC-S, and the SC group is made up of SA, EPR, and SGSB. (For more detail, see Figs. 5 and 6).

Metric	Model/Projection Years	NC	SN	CC	SC
AAT_{MAX} (°F)	Modeled Average (1961–1990)	68.4	71.6	71.7	74.6
AAT_{MAX} (°F)	Projected Average (2070–2099)	75.8	80.3	79.3	82.4
AAT_{MAX} (°F)	Projected Range	70.8–78.3	76.8–83.9	76.6–82.7	79.3–85.7
AAT_{MIN} (°F)	Modeled Average (1961–1990)	38.9	47.7	41.9	50.5
AAT_{MIN} (°F)	Projected Average (2070–2099)	46.1	55.7	49.1	58.1
AAT_{MIN} (°F)	Projected Range	42.2–48.7	52.5–58.9	46.4–51.6	55.4–60.5
EHD (Days/Yr.)	Modeled Average (1961–1990)	3	3	5	4
EHD (Days/Yr.)	Projected Average (2070–2099)	27	53	42	45
EHD (Days/Yr.)	Projected Range	2–48	29–79	22–73	24–94

[7] AATMAX is calculated as the average of the maximum daily air temperatures recorded at a site over the entire year. AATMIN is likewise calculated as the average of all minimum daily temperatures for the year. The number of extreme heat days per year (EHD) is the modeled number of days when the daily maximum temperature is above a location-specific threshold temperature for the site. The threshold for a site is defined as the 98th percentile value of historical daily maximum temperatures (from 1961–1990, between April and October) observed at the location.

Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation in California, with some areas getting a greater proportion of annual precipitation delivered by intensive atmospheric river storms, while others face an increased likelihood of extreme drought primarily due to rising temperatures (Cayan et al. 2005; Williams et al. 2015; Gershunov et al. 2019; Huang et al. 2020; OEHHA 2022). Similar to temperature rises, recent changes in precipitation and water availability have also not occurred equally throughout California. In the past century, Southern California experienced a decline in average total annual precipitation, while much of central and Northern California had an increase (Rapacciuolo et al. 2014). With increased temperatures and decreased precipitation, the southern third of the state (including the southern Sierra Nevada) experienced a dramatic increase in mean annual climatic water deficit—the amount of water plants would use if it were available in the soil – between the early 20th century (1900–1939) and the late 20th century (1970–2009) (Ibid.).

Increasing severity and frequency of drought is another consequence of climate change in California. From 2014–2017, 25-80% of California experienced extreme or exceptional drought and there was another serious drought period from 2021–2022 (Fig. 19; NIDIS 2022). Recent modeling predicts the average amount of drought from 2050–2099 in the southwestern U.S., inclusive of California, will likely exceed the Medieval-era megadrought between 1100–1300 CE, under both moderate and high greenhouse gas emissions models (Cook et al. 2015). The same study estimated the probability of a multidecadal (35-year) drought occurring during the late 21st century is greater than 80% (Ibid.). This would represent a climatic shift that not only falls outside of contemporary variability in aridity but would also be unprecedented in the past millennium (Ibid.).

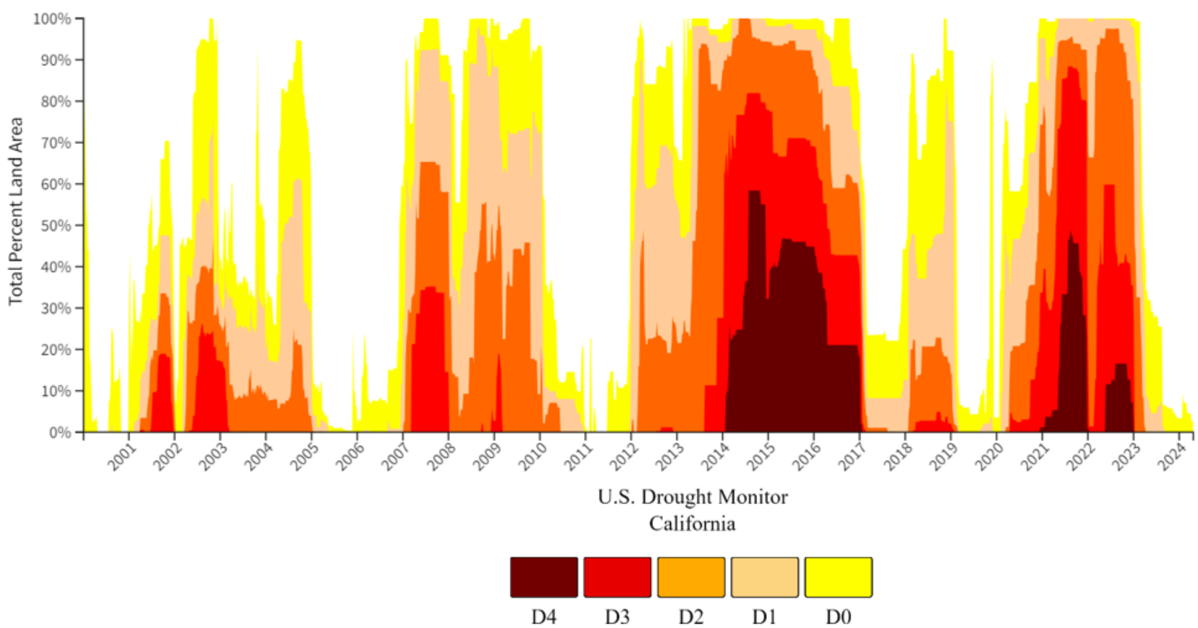


Figure 19. Percent of California land area in each Palmer Drought Index category, Jan 2000–April 2023. DO = Moderately Dry, D1 = Moderate Drought, D2 = Severe Drought, D3 = Extreme Drought, D4 = Exceptional Drought. Source: NIDIS (2024)

Drought can also exacerbate the effects of other environmental stressors. During the 2012–2017 drought, tree mortality increased dramatically and approximately 129 million trees died in California (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are also more prone to severe wildfires (CNRA 2016).

The frequency and extent of wildfire is influenced by factors including temperature, fuel loads, and fuel moisture (Carter et al. 2008). As temperatures have warmed and mountain snowpack has tended to melt earlier, large-wildfire frequency and duration have increased, and wildfire seasons have lengthened (Westerling et al. 2006; OEHHA 2018). California's top three years for total acreage burned by wildfire were 2018, 2020, and 2021, and all but two of the 20 largest fires recorded in California occurred during those years (OEHHA 2024b). A positive feedback loop between climate change and wildfires exists as wildfires can accelerate the impacts of climate change through the emission of short-lived climate pollutants like black carbon (soot) and methane that have a warming effect that is tens to thousands of times greater than longer-living carbon dioxide (the focus of many greenhouse gas reduction efforts). Short-lived climate pollutants are responsible for 40% or more of global warming to date, and 64% of black carbon emissions are sourced from wildfires (CNRA 2016). For more discussion of the impacts of fire on mountain lions, see section 4.7.

Research suggests that most suitable mountain lion habitat in California is moderately vulnerable to climate change (Thorne et al. 2016; Dellinger et al. 2020a). As previously discussed, mountain lion habitat could be degraded if increased wildfire frequency and intensity convert shrublands to grasslands, which are generally avoided by mountain lions (Burdett et al. 2010; Jennings et al. 2016; Riley et al. 2021). Further, aspects of climate change may impact mountain lions via influence on prey populations. For example, low rainfall has been found to negatively influence mule deer doe and fawn survival in parts of the western U.S., likely because there is less food available (Marshal et al. 2002; Bender et al. 2007; Monteith et al. 2014). With precipitation levels expected to become increasingly variable as the climate continues to change, mountain lion populations could be adversely impacted if their key prey species become less numerous. Reductions in the area and quality of suitable habitat and carrying capacity could negatively influence mountain lion population sizes and possibly gene flow.

Acute heat stress may also impact mountain lions and their prey. As large-bodied mammals, both mountain lions and deer may be sufficiently large enough not to be strongly affected directly by moderate increases in environmental temperature, which more drastically affect small-bodied mammals (Fuller et al. 2016; Naya et al. 2018). Further, the generally nocturnal habits of mountain lions and their prey may mitigate impacts from warmer environments. As mountain lions in California are currently able to survive across a variety of ecoregions and climatic conditions ranging from deserts to montane and coastal forests, their adaptability suggest broad near-term shifts in their distribution from the direct effects of a warming climate are unlikely.

4.10 Risks to Small, Isolated Populations

Small, isolated mountain lion populations—such as those in the Santa Monica Mountain portion of CC-S, and the SA and SGSB genetic populations, which are each estimated to number less than 75 individuals (Table 3)—are inherently vulnerable to extinction due to multiple factors. These factors may include demographic stochasticity[8], genetic drift[9], lack of immigration, and inbreeding, which can eventually lead to inbreeding depression[10]. Genetic drift and inbreeding both reduce genetic variation which can diminish the ability of a population to adapt to changes in the environment (Primack 1993; Reed and Frankham 2003). Each of these effects can amplify the impact of the other effects, further reducing population size and accelerating local extinction in what has been termed an extinction vortex (Primack 1993).

4.10.1 Demographic and Environmental Stochasticity

Reproduction and survival rates vary among individuals and between years in wildlife populations. This variation leads to demographic stochasticity, which tends to average out in large populations but has a much greater effect on the rate of growth or decline in small populations. If a small population declines, subsequent generations become even more susceptible to demographic stochasticity. Additionally, unpredictable changes in the natural environment can cause the size of small populations to vary dramatically while larger, more widely distributed populations would remain more stable because these changes normally occur only in localized areas of the entire population's geographic range (Primack 1993). For example, changes in vegetation, abundance of resources, or disease and parasite exposure can cause the size of small, isolated wildlife populations to fluctuate wildly, possibly leading to local extinction (Primack 1993). Additionally, natural disasters such as droughts, fires, and severe storms can lead to dramatic population changes when populations are small and isolated to one location.

While the statewide population of mountain lions is large enough that demographic and environmental stochasticity is unlikely to be an issue, the smaller and more isolated populations (those in the Santa Monica Mountains portion of CC-S, and the SA and SGSB genetic populations) are potentially vulnerable to those impacts. Of specific concern are the increasingly large and severe fires leading to direct death or injury or significant habitat changes (see section 4.7). For example, the Woolsey Fire in 2018 burned about 39,235 ha (96,949 acres) in the center and western part of the Santa Monica Mountains National Recreation Area. According to the National Park Service, two of the 11 mountain lions with working radio-collars in and around the Santa Monica Mountains at the time of the Woolsey Fire succumbed to the fire or its impacts (Blakey et al. 2022). In such a small population (Table 3), the impact of just one event like the Woolsey Fire on the population could be substantial, especially if the animals killed or adversely affected were breeding adults.

4.10.2 Inbreeding and Genetic Drift

Inbreeding and genetic drift can both result in decreased genetic variation in wildlife populations. Deleterious alleles (maladaptive genes) can be present at low frequency even in large, healthy

---

[8] Population changes such as sex and age ratios resulting from random variation in birth and death rates.

[9] Change in frequency of an existing gene variant in the population due to random chance. Genetic drift may cause gene variants to disappear completely and thereby reduce genetic variation. It could also cause initially rare alleles to become much more frequent and even fixed (NIH 2024).

[10] Reduced biological fitness (health and fertility) resulting from the concentration of deleterious alleles in the population from the mating of closely related individuals.

populations. But as populations become smaller, these maladaptive genes can increase in relative frequency, and populations may suffer the effects of inbreeding depression, resulting in offspring with a reduced ability to survive and reproduce (Frankham 2005; Harding et al. 2016). Genetic drift may also lead to the loss of beneficial alleles or the fixation of deleterious alleles in a small population due to a limited breeding pool (Hedrick and Kalinowski 2000). Deleterious fixed alleles can result in decreased fitness for all individuals and lead to population declines (Hedrick and Kalinowski 2000; Frankham 2005).

Multiple genetic studies have shown that certain mountain lion genetic populations along the southern coast of California have particularly low genetic variation (Ernest et al. 2003; Ernest et al. 2014; Riley et al. 2014; Gustafson et al. 2019; Gustafson et al. 2022) which may be the result of habitat fragmentation and genetic isolation. Linkage decay analysis by Gustafson et al. (2022) showed evidence of inbreeding between closely related[11] individuals in at least four of the fine scale genetic populations (see details in section 4.9.4 below). Saremi et al. (2019) investigated mountain lion genomes and found additional evidence of recent inbreeding among closely related individuals (i.e., long runs of homozygosity) in the Santa Monica and Santa Cruz Mountains.

However, the results of Gustafson et al. (2022) suggest the problems of inbreeding and homozygosity do not occur in all California populations. Several larger California populations (e.g., Sierra Nevada) display little evidence of inbreeding (see section 4.9.4 below for details). Additionally, genetic variation in the broad-scale genetic populations may minimize the impacts of inbreeding depression in many of the fine-scale populations if gene flow can be enhanced (Gustafson et al. 2022). This conclusion is consistent with the results of Saremi et al. (2019) that indicated even though inbreeding had reduced variation in the genomes of many individual mountain lions, these low-heterozygosity genome regions were generally not shared between populations. These studies suggest genetic restoration is possible even among genetically depauperate populations. When considering that genetic variation is high in the WSN and ESN genetic populations (Gustafson et al. 2022), there is potential for long-term persistence of mountain lions throughout much of the state if adequate habitat can be protected and habitat connectivity can be restored and/or enhanced to facilitate increased genetic exchange between the genetic populations in the Sierra Nevada and those within the petitioned area (see Section 10.1 for more detail).

4.10.3 Loss of Genetic Variation

High levels of genetic variation have been shown to be positively correlated with survival and reproduction rates and decreased extinction risk (Hedrick and Kalinowski 2000; Reed and Frankham 2003). The concept of effective population size[12] (N_e) is useful for understanding the likelihood that a population will lose genetic variation through genetic drift or inbreeding. Ne is the size of an ideal population that would result in the same level of inbreeding or genetic drift as that of the population under study (Palstra and Ruzzante 2008). N_e is determined by several factors and its value is generally significantly smaller than the census population (i.e., the number of animals actually breeding in a

[11] "A common ancestor less than three generations ago" (Saremi et al. 2019) (i.e., first-cousins or closer).

[12] The number of individuals in a population that are contributing to the next generation (i.e., reproducing and passing on their genes).

population is usually significantly fewer than the total number of animals in the population; Palstra and Ruzzante 2008).

Both Franklin (1980) and Soulé (1980) reviewed the genetic considerations fundamental to species conservation. They proposed two primary considerations related to population viability: 1) an immediate danger in small populations due to inbreeding (i.e., inbreeding depression), and 2) the longer-term loss of additive genetic variation that would limit future evolutionary change (i.e., evolutionary potential). Their work led to the common adoption of what is now referred to as the 50/500 rule in conservation biology. Under this framework, in the absence of gene flow, a N_e of at least 50 should be maintained to avoid inbreeding depression in the short term for large mammal species (Harmon and Braude 2010). Franklin (1980) suggested that with a N_e below 500, genetic variance for complex traits would be lost significantly faster than it could be renewed by mutation. Soulé (1980) added that this size (500) was required to maintain sufficient genetic variation for populations to evolve to changing environments in the longer term (evolutionary potential).

Since then, the importance of conserving quantitative genetic variation has gained recognition, although there is disagreement about the appropriate value for N_e. Frankham et al. (2014) suggested that $N_e = 50$ would be raised to at least $N_e = 100$ to prevent inbreeding depression over short time scales (~5 generations). Frankham et al. (2014) also summarized several independent lines of theoretical and empirical evidence suggesting that at least $N_e = 1000$ is required to maintain evolutionary potential in perpetuity.

Regardless of whether $N_e = 50$ or $N_e = 100$ is used as a benchmark, nearly all the genetic populations within the petitioned area are below the population size needed to avoid inbreeding depression in the short term (Table 6). True extinction risk is often the result of the complicated interaction of both genetic and demographic factors. Recent analyses reveal that a minimum of 7,923 km^2 (3,059 mi^2) of protected suitable habitat[13] or 14,591 km^2 (5.633 mi^2) of overall suitable habitat is needed to allow mountain lions to maintain an $N_e \geq 50$ (Dellinger et al. 2020b). According to Dellinger et al. (2020b), the Central Coast (roughly equivalent to CC-C) is the only area where the mountain lions within the petitioned area occupy an area larger than this suitable habitat threshold; however, because of potential future development pressures, it is unknown whether the threshold will continue to be met over the long term. Dellinger et. al.'s conclusions (2020b) suggest that the long-term viability of mountain lions in the other genetic populations may be reduced unless suitable habitat and/or connectivity to other genetic populations is increased (Benson et al. 2016; Benson et al. 2019). While there are examples of small wild populations that persist below the suggested threshold, at least in the short term, it is not known whether the genetic populations within the petitioned area, facing increasing isolation and with low genetic variation, will ultimately maintain long-term viability (see examples in Harding et al. 2016)

[13] Dellinger et al. (2020b) considered all public lands and private lands overlain with conservation easements "protected".

Table 6. Estimated population (CDFW unpublished data) and effective population sizes of genetically distinct mountain lion populations identified in Gustafson et al. (2019). The boundaries used to calculate the population sizes come from Dellinger et al. (2020b). Estimates from Gustafson et al. (2019) are adapted from Table 3 and include parametric 95% confidence intervals. Estimates from Gustafson et al. (2022) are adapted from their Table 1 and confidence intervals were not reported.

Genetic Population	Estimated census size	Estimated N_e (Gustafson et al. 2019)	Estimated N_e (Gustafson et al. 2022)
Central Coast North	174	16.6 (15.1-18.2)	19
Central Coast Central	393	56.6 (47.4-69.0)	26.9
Central Coast South	50	2.7 (2.5-2.9)	4.1
San Gabriel/San Berardino	74	5 (3.3-6.4)	2.3
Santa Ana Mountains	52	15.6 (13-18.7)	3.5
Eastern Peninsular Range	297	31.6 (29.1-34.4)	14.8

An important metric of genetic variation is expected heterozygosity (H_E)[14]. Adequate genetic variation is important for maintaining evolutionary potential, as variation is the raw material that allows populations to adapt to changing conditions over generations. The amount of heterozygosity in California mountain lion genetic populations is highly variable (Gustafson et al. 2019; range of H_E = 0.33–0.53; based on microsatellite loci), but lower on average than other western states, including Wyoming, Nevada, Arizona, Utah, Colorado, and New Mexico (range of H_E = 0.49–0.59; (Anderson et al. 2004; McRae et al. 2005; Andreasen et al. 2012)). Compared to California, mountain lion populations in these states show less population genetic structure due to higher rates of gene flow, which in turn counteracts the effect of genetic drift in reducing heterozygosity (Anderson et al. 2004; McRae et al. 2005). The lower overall heterozygosity, as well as the large variance in heterozygosity among local genetic populations, observed in California is most likely driven by barriers to dispersal such as mountain ranges and contemporary patterns of urban and transportation development (Ernest et al. 2003; Gustafson et al. 2019; Gustafson et al. 2022).

Assessing heterogeneity among the four broad-scale mountain lion groups in California, Gustafson et al. (2022) found they have retained substantial heterozygosity, particularly in the Sierra Nevada region with its large stretches of undeveloped contiguous habitat (Dellinger et al. 2020b). Multiple genetic investigations have now demonstrated the importance of the Sierra Nevada region as a reservoir of genetic variation (Ernest et al. 2003; Gustafson et al. 2019; Gustafson et al. 2022). Bi-directional migration rate models based on genetic data indicated the WSN genetic population has served as a significant source of migrants into other regions of California, importantly the EPR, CC-N, and SGSB (Fig. 4; Gustafson et al. 2019).

Isolated populations can also become structured through natural selection as locally adaptive genes become more prevalent in the population. However, mountain lions are long-distance dispersers and

[14] Heterozygosity refers to having inherited two different alleles for a particular trait compared to homozygosity, in which the inherited alleles are identical at a given location of the genome.

inhabit all major mountain ranges in California (Dellinger et al. 2020b), suggesting local adaptation may be unlikely, despite current connectivity challenges. Gustafson et al. (2022) found no evidence for local adaptive differences among the four broad-scale geographic mountain lion groups, or among the 10 fine-scale genetic populations. Though the appropriateness of using reduced representation genome sequencing data (in this case, restriction site-associated DNA sequencing data) to detect local adaptation has been questioned within the scientific literature (Lowry et al. 2017), this approach has been employed successfully in other studies (Catchen et al. 2017). The results of Gustafson et al. (2022) found no evidence for local adaptive traits warranting specific conservation status, nor risk of outbreeding depression resulting from the mixing of genetic groups as a result of active management (e.g., translocations) (Frankham et al. 2011). However, the South Coast group contained some private alleles which were not found in other genetic groups and which should be conserved to help preserve statewide genetic variation (Gustafson et al. 2022).

While genetic risks may significantly increase a small population's risk of extinction, implementation of a well-planned conservation strategy can substantially mitigate risks associated with small populations. A comprehensive plan for long term viability should include the principles of representation, resiliency, and redundancy (Shaffer and Stein 2000; Wolf et al. 2015).

4.10.4 Genetic Impacts on the Populations Within the Petitioned ESU

Heterozygosity within the genetic populations of petitioned ESU is highly variable. Of the broad-scale groups, SC and CC have relatively low genetic variation while SN and NC have retained sufficient variation to be capable of serving as sources of genetic rescue under various management scenarios (e.g., improved connectivity, assisted gene flow). Maintaining and enhancing connectivity within and among broad-scale groups has the potential to counteract the effects of genetic drift and inbreeding to at-risk coastal genetic populations.

Sierra Nevada Group

Gustafson et al. 2019 and 2022 consider the Sierra Nevada region to be a major source of genetic diversity for mountain lions in California. This group is of critical importance to sustaining statewide gene flow as the Tehachapi range at its southern end is the only known area where there is current gene flow from outside the petitioned area into the CC and SC groups. Enhancing connectivity through the Transverse Ranges, including the Tehachapi, Sierra Pelona, San Gabriel, and San Bernardino Mountains, represents a critical conservation priority (Gustafson et al. 2019)

Central Coast Group

The three fine-scale genetic populations in the Central Coast Group differ significantly in their levels of genetic variation. The CC-C has the highest diversity with the Central Coast Group and the largest N_e estimates, though neither N_e estimate exceeds 100. The CC-N and CC-S genetic populations have low estimated N_e and represent areas of genetic management concern because the area they inhabit contains insufficient suitable habitat to sustain a mountain lion population with $N_e \geq 50$ (Gustafson et al. 2019; Dellinger et al. 2020b; Gustafson et al. 2022).

Central Coast-North. Lack of connectivity and inbreeding are concerns in CC-N. Gustafson et al. (2022) found evidence of close inbreeding in CC-N, which is consistent with the whole genome sequencing results of Saremi et al. (2019) from the Santa Cruz Mountains which suggested close and recent inbreeding led to runs of homozygosity in the lion genomes. A long-term research project in the Santa Cruz Mountains has collared 147 adult and juvenile mountain lions with GPS and/or VHF collars over the past 15 years. During that time no collared animal has left the Santa Cruz Mountains to the east across the Coyote Valley to the Diablo Range or to the south across Highway 101 to the Gabilan Range (pers. comm C. Wilmers 2024). This suggests that there is very limited current connectivity between the major mountain ranges in CC-N, and further inbreeding is a concern.

Central Coast-Central. The CC-C population is currently the largest and most genetically robust of the genetic populations within the petitioned ESU, with N_e estimates of 57 (Gustafson et al. 2019) and 27 (Gustafson et al. 2022; Table 6). However, the amount of suitable habitat in the area that is currently conserved (6,780 km^2; 2,618 $mi.^2$) is more than 1,000 km^2 below the threshold Dellinger et al. (2020b) considered necessary to support an $N_e \geq 50$ and long-term population stability. Additionally, bi-directional migration rate models indicate CC-C serves as the most significant source of migrants to CC-S, and along with WSN, is one of only two occasional sources of migrants to CC-N and SGSB (Gustafson et al. 2019). This suggests protecting CC-C is key to maintaining the entire Central Coast Group and for maintaining what little genetic connectivity remains between the Central Coast Group and the South Coast Group (Figs. 4, 9, 10). Thus, maintaining or expanding this genetic population and its connectivity to adjacent genetic populations is critical for the long-term viability of the entire petitioned ESU.

Central Coast-South. As with CC-N, Gustafson et al. (2022) and Saremi et al. (2019) found evidence of close inbreeding in CC-S. Within CC-S, the Santa Monica Mountains in particular appear to have very low genetic variation and are exhibiting both genetic and phenotypic evidence of inbreeding (Ernest et al. 2014; Riley et al. 2014; Benson et al. 2019; Gustafson et al. 2019; Gustafson et al. 2022; Huffmeyer et al. 2022). This population is one of two in the petitioned ESU (see SA below) to have the lowest genetic variation observed for the species globally, apart from the endangered Florida panther (Riley et al. 2014). There are multiple known cases of close inbreeding, for example a male that had kittens with daughters, granddaughters, and great granddaughters (Riley et al. 2018a, S. Riley pers. comm. 2024). Phenotypic evidence of inbreeding depression in the form of kinked tails, failed descension of the testes, and abnormal sperm morphology have been observed. These irregularities have also been observed in Florida panthers (Roelke et al. 1993; Ernest et al. 2014; Huffmeyer et al. 2022). Freeway traffic and urban development have largely isolated the Santa Monica Mountains from animals in the rest of CC-S and therefore from the rest of the Central Coast and from the Sierra Nevada groups, severely limiting contemporary gene flow (Riley et al. 2014). For example, 2009 was the last time a mountain lion was documented crossing U.S. 101 and entering the Santa Monica Mountains (Benson et al. 2016). That male bred successfully and increased the genetic diversity of the Santa Monica Mountain population (Riley et al. 2014). Similarly, very few animals have been documented dispersing from the main body of the Santa Monica Mountains. A male lion, identified as P-22, which established a territory in Griffith Park in 2012 after migrating from the western Santa Monica Mountains, almost certainly crossing U.S. 101 and I-405 along the way, was the most famous of these. He died in 2023 without fathering cubs; however, in 2024, another mountain lion of unknown origin was sighted in Griffith Park (Gammon 2024). Models predict a 16–28% probability of the extirpation of the Santa Monica Mountains population within 50 years if immigration levels remain the same or are reduced, in part due the impacts of inbreeding depression (Benson et al. 2016; Benson et al. 2019). In contrast, in the CC-S genetic population north of U. S. 101, two radio collared males dispersed from their natal range, crossed highways, and established home ranges as adults in the area of the Santa Susana Mountains, Simi Hills, and Los Padres National Forest (Riley et al. 2014). Therefore, the threat of isolation and potential inbreeding depression is more acute in the Santa Monica Mountains than in the CC-S genetic cluster as a whole.

South Coast Group

The South Coast Group is comprised of 3 genetic populations: Santa Ana Mountains (SA), Eastern Peninsular Range (EPR), and the San Gabriel/San Bernardino Ranges (SGSB).

San Gabriel/San Bernardino. The SGSB genetic population has low observed genetic variation, a very small estimated N_e (2.3–5; Table 6), and exhibits evidence of inbreeding (Gustafson et al. 2019; Gustafson et al. 2022). Additionally, the SGSB area is comprised of two discreet mountain ranges that area separated by roads and largely surrounded by urbanized areas and desert containing little shrub or tree cover. This isolation increases the genetic population's risk of inbreeding depression (Gustafson et al. 2019).

Santa Ana Mountains. The SA genetic population has an estimated N_e of 3.5–15 and concerningly low genetic variation (Gustafson et al. 2019; Gustafson et al. 2022) and available suitable habitat (Dellinger et al. 2020b). Along with the Santa Monica Mountains population, the SA has the lowest genetic variation of any known mountain lion population other than Florida panthers (Ernest et al. 2014; Riley et al. 2014; Gustafson et al. 2019). Like the Santa Monica Mountains, genetic and phenotypic evidence of inbreeding depression in the form of kinked tails and teratospermia (> 60% abnormal sperm production) has been observed in the SA (Ernest et al. 2014; Huffmeyer et al. 2022). As with the Santa Monica Mountains, the main barriers to movement appear to be freeways and adjacent urban/developed areas, which have limited gene flow in recent decades (Ernest et al. 2014; Riley et al. 2014; Vickers et al. 2015; Huffmeyer et al. 2022). While there is genetic evidence that individual animals from EPR historically were able to successfully move into the SA and breed (see the full red and half red samples in the Santa Ana Mountains in Fig. 10), that connectivity may no longer be viable due to the strength of I-15 as a barrier between the populations as traffic and nearby development have increased in recent years (Vickers et al. 2015). For example, a thirteen-year study (2001–2013) that collared 74 mountain lions in the SA and EPR observed only one animal move between the populations, and that individual was killed for depredating sheep before it could breed and introduce genetic material to the group (Vickers et al. 2015). The impact of this isolation and inbreeding has led to an estimated "16–21% probability of local extinction in the (Santa Ana Mountains) due purely to demographic processes over 50 years with current low levels or no immigration" (Benson et al. 2019).

Eastern Peninsular Range. The EPR genetic population has an estimated N_e of 15–32 and shows little evidence of inbreeding (Gustafson et al. 2019), although there has been a report of teratospermia (Huffmeyer et al. 2022). The EPR appears to have retained sufficient variation to be capable of serving as a source of genetic rescue for other genetic populations (Gustafson et al. 2019; Gustafson et al. 2022), and could perform an important role in increasing connectivity and gene flow within the broad-scale SC group if connectivity is improved (Figs. 4, 10). The EPR is the only genetic population known to exchange migrants with the Santa Ana Mountains, and management actions which enhance gene flow between these areas are critical to SA's population viability. Gene flow between EPR and the adjacent SGSB genetic population appears limited. The degree of dispersal from Arizona, Nevada, and Mexico into EPR remains unknown (Gustafson et al. 2019). Connectivity between EPR and adjacent populations in Mexico and Arizona may be curtailed by physical barriers along the border and the damming and major channelization of the Colorado River. Immigration and emigration patterns of mountain lions in the eastern area of EPR have not been studied, and mountain lion density may be low in that area. Some gene flow may occur across the Colorado River from the Kofa National Wildlife Refuge into California, and one mountain lion has been documented moving between EPR and Mexico, suggesting genetic connection to Mexico may exist (Vickers et al. 2015; W. Vickers, unpublished data).

In summary, multiple genetic populations in the petitioned area are at risk from genetic factors associated with small, isolated populations. However, these genetic populations identified in Gustafson et al. (2019) are nested within two broader-scale genetic groups identified by Gustafson et al. (2022) that each contain more robust, but still less than ideal levels of genetic diversity. This suggests that if connectivity can be improved among the smaller, nested genetic populations and between CC, SC, and SN, low genetic variation in the at-risk populations can still be mitigated with intentional management.

5. Existing Management

5.1 Land Ownership within the Petitioned Southern California/Central Coast ESU

The area of the petitioned ESU is approximately 15,273,700 ha (37,742,134 acres) (Table 7). Approximately 52% of the area is public land and 48% is private. The Bureau of Land Management (BLM) manages the largest amount of land at 21%, followed by the U.S. Forest Service (9%), the National Park Service (6%), the Department of Defense (5%), and the California Department of Parks and Recreation (3%). Local (city or county) and nonprofit special districts combined represent 5% of the public land. Tribal lands total 167,700 ha (414,396 acres), which is 1% of the non-private land within the petitioned ESU (Table 7, Fig. 20).

Public (and private) lands are managed for many different purposes including recreation, extractive uses (timber harvest and mining), grazing, and wildlife habitat. Thus, while some specific projects on public lands may not benefit mountain lions, most public lands in California are managed for multiple uses including wildlife conservation and sustainability.

Table 7. Land ownership within the petitioned Southern California/Central Coast ESU, percentage of total ESU area by manager, and percentage of public land area by manager in the petitioned ESU.

Land Ownership within Petitioned Evolutionarily Significant Unit	Hectares	Acres	% of total land	% of public land
Total Public Land	7,905,421	19,534,644	51.8%	—
Total Private Land	7,368,327	18,207,458	48.2%	—
U.S. Bureau of Land Management	3,183,887	7,867,525	20.8%	40.3%
U.S. Forest Service	1,430,387	3,534,548	9.4%	18.1%
U.S. National Park Service	928,264	2,293,781	6.1%	11.7%
U.S. Department of Defense	781,100	1,930,132	5.1%	9.9%
California State Parks	435,636	1,076,476	2.9%	5.5%
Nonprofit, Special District, and Joint	383,076	946,597	2.5%	4.8%
Local (City or County)	231,070	570,984	1.5%	2.9%
Tribal Land	168,135	415,469	1.1%	2.1%
California Department of Fish and Wildlife	111,462	275,428	0.7%	1.4%
California State Lands Commission	97,683	241,379	0.6%	1.2%
U.S. Bureau of Reclamation	57,731	142,656	0.4%	0.7%
U.S. Fish and Wildlife Service	39,090	96,594	0.3%	0.5%
Other State	32,864	81,207	0.2%	0.4%
California Department of Water Resources	15,183	37,518	0.1%	0.2%
Other Federal	9,853	24,348	0.06%	0.1%

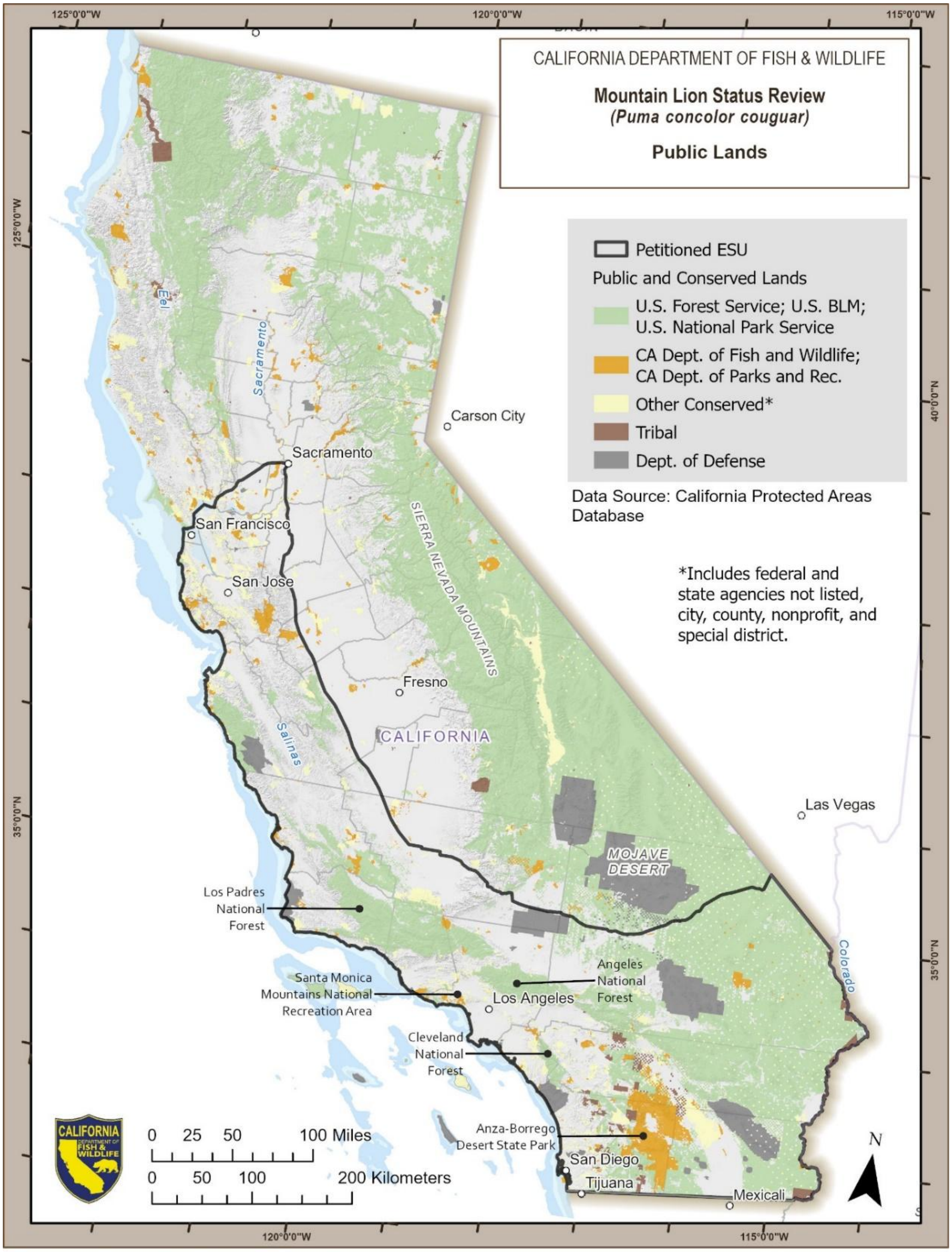


Figure 20. Public and tribal lands within the petitioned Southern California/Central Coast mountain lion ESU.

5.2 California Wildlife Protection Act

California voters through Proposition 117 adopted the California Wildlife Protection Act of 1990 (Act), codified in part as Fish and Game Code section 4800, et seq. Among other things, the Act specifically called out the loss of deer, mountain lion, and other wildlife habitat within California's mountain ranges and foothills, including the Simi Hills, and the Santa Lucia, Santa Susana, Santa Monica, San Gabriel, San Bernardino, San Jacinto, and Santa Ana Mountains in Southern California as well as the need to preserve habitat corridors to maintain the genetic integrity of California's wildlife. The Act, through the establishment of the Habitat Conservation Fund, included an ongoing annual appropriation of $14,500,000 for the acquisitions of deer and lion habitat in those areas. More generally, the Act emphasized the use of funds to acquire habitat needed to maintain connectivity between isolated or fragmented habitats to promote the genetic integrity of wildlife populations. To date, the Act's Habitat Conservation Fund has protected nearly 405,000 ha (1,000,000 ac.) of habitat across the state, including over 76,890 ha (190,000 ac.) of habitat within the petitioned ESU (California Wildlife Conservation Board unpublished data). The Act also designated mountain lions as specially protected mammals and prohibited their taking, injury, possession, or sale, except for instances where a lion represents an imminent threat to public safety or has damaged livestock or other property damage.

5.3 State and Federal Land Use Laws

The laws and regulations governing actions within the mountain lion's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California, and while they may not specifically address mountain lions, they may indirectly provide some level of protection for the species and its habitat. The primary environmental laws are summarized below.

5.3.1 California Environmental Quality Act (CEQA)

The California Environmental Quality Act (CEQA) requires state and local agencies to identify, analyze, and consider alternatives to, and to publicly disclose environmental impacts from, projects over which they have discretionary authority (Pub. Resources Code, § 21000 et seq.). CEQA requires an agency find that projects may have a significant adverse effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380). CEQA establishes a duty for public agencies to avoid or minimize such potentially significant adverse effects where feasible (Cal. Code Regs., tit. 14, § 15021), and it differs substantially from the National Environmental Protection Act in requiring potentially significant adverse effects be mitigated to a less than significant level unless the lead agency adopts a statement of overriding considerations. In practice, implementation of CEQA by state and local governing bodies typically results in projects incorporating impact avoidance, minimization, and mitigation measures into project design and construction. A lead agency is not required to make a mandatory finding of significance conclusion for a project unless it determines on a project-specific basis that 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; or substantially reduce the number or restrict the range of an endangered, rare or threatened species. Under CEQA, a lead agency should identify and evaluate potential impacts to mountain lions, and if the impacts are found to be significant, mitigate them under the Biological Resources section of an environmental document prepared pursuant to CEQA or adopt a statement of overriding considerations.

Another important component of CEQA is the requirement that governing bodies disclose and consider project-related impacts that when considered alone may not be significant, but when viewed in concert with other past, present, and foreseeable related projects cumulatively result in a significant impact to the environment (i.e., cumulative impacts; Cal. Code Regs., tit. 14, § 15355). This requirement often results in the incorporation of wildlife movement corridors into local development and infrastructure projects (e.g., open space setbacks along stream corridors and property lines) which can provide opportunities for mountain lions to pass through urban and suburban landscape, although such corridors are not always wide enough or vegetated with adequate shrub and tree cover to encourage use by mountain lions.

Section 21080.5 of the Public Resources Code provides that a regulatory program of a state agency shall be certified by the Secretary for Resources as being exempt from the CEQA requirements for preparing EIRs, negative declarations, and initial studies if the Secretary finds that the program meets the same criteria as CEQA. A certified regulatory program (CRP) remains subject to other provisions in CEQA such as the policy of avoiding significant adverse effects on the environment where feasible. These CRPs include the regulation of timber harvest by CAL FIRE and the State Board of Forestry through the Forest Practice Act; the regulation of coastal development permits by the California Coastal Commission through the California Coastal Act of 1976, Division 20 (commencing with Section 30000) of the Public Resources Code and the preparation, approval, and certification of local coastal programs as provided in Sections 30500 through 30522 of the Public Resources Code; and the pesticide regulatory program administered by the Department of Pesticide Regulation and county Agricultural Commissioners. While these CRPs are exempt from some of the procedural requirements of CEQA, courts have consistently held that they remain subject to the broad policy goals and substantive standards of CEQA, including requirements to consider feasible alternatives and cumulative impacts and to recirculate environmental review documents in certain circumstances.

5.3.2 Z'Berg–Nejedley Forest Practice Act

The Z'Berg–Nejedley Forest Practice Act was originally enacted in 1973 to ensure that forest practices, including timber harvesting, are undertaken in a manner that will also preserve and protect California's fish, wildlife, forests, and streams. The Forest Practice Rules are regulations that implement the provisions of the Z'Berg–Nejedley Forest Practice Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. CAL FIRE enforces these laws and regulations governing timber harvesting and other forest practices on state and private land. The only area within the petitioned ESU where commercial timber harvest commonly occurs is the redwood forest zone of Santa Cruz County and nearby minor areas of San Mateo and Santa Clara Counties (CDTFA 2021). The CC-N genetic population occurs in these areas.

5.3.3 Natural Community Conservation Plans and Habitat Conservation Plans

Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs) are federally and state authorized conservation plans that permit incidental take of species listed under the federal Endangered Species Act (ESA) or CESA, respectively. Take authorization may be applied to species not currently listed but which may become listed as threatened or endangered over the term of the plan, which is typically 25–75 years. Non-federal entities can obtain authorization for take of federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of an HCP pursuant to Section 10 of the ESA. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. An NCCP identifies and provides for the protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs in California that include mountain lions as a covered species; all four are also NCCPs, but only three of those NCCPs include mountain lion as a covered species.

The 1998 San Diego Multiple Species Conservation Program (MSCP) is a 50-year NCCP/HCP that covers 233,099 ha (576,000 acres) in the southwestern portion of San Diego County and includes mountain lion as a covered species. The Program includes coverage for mountain lions as 81% of the core areas (± 42,492 ha, ± 105,000 acres) that will be conserved contain lion habitat, and the core areas have multiple connections to help maintain ecosystem balance. While the MSCP generally notes linkage areas were designed to accommodate "large animal movement," it does not identify linkages designed for mountain lions or contain specific measures designed to protect them. While the MSCP addresses specific design criteria for linkages, and road crossings/under crossings are included in subarea plans, not all subarea plans are complete.

The San Diego Water Authority NCCP/HCP also includes mountain lion as a covered species. The Plan Area encompasses 401,448 ha (992,000 acres) in western San Diego and southwestern Riverside Counties. The plan includes general conditions to avoid and minimize impacts to habitat linkages and wildlife movement corridors and includes habitat-based mitigation for unavoidable impacts. The plan estimates that approximately 139 ha (344 acres) of potential mountain lion habitat could be impacted over the 55-year permit term with approximately 284 ha (702 acres) of potentially suitable habitat provided within the existing Preserve Area.

The Orange County Transportation Authority NCCP/HCP (OCTA Plan) lists the mountain lion as a covered species for purposes of the federal HCP, but not for purposes of the NCCP permit. The Plan covers all of Orange County (2,070 km^2; 800 $mi.^2$). The OCTA Plan contains four "Species Goals" intended to offset impacts to mountain lions, including: (1) acquiring 410 ha (1,013 acres) of suitable habitat; (2) realigning fencing near the Highway 241 toll road; (3) funding for the North Coal Canyon Restoration Project; and (4) a "wildlife crossing policy" requiring pre-construction surveys to ensure existing crossings "maintain or improve functionality" if modified by new freeway projects. However, the OCTA Plan does not require the construction of specific wildlife crossings.

The Western Riverside County Multiple Species HCP/NCCP, which covers approximately 510,227 ha (1,260,800 acres) in western Riverside County and proposes to set aside 202,343 ha (500,000 acres) for habitat, also lists the mountain lion as a covered species. Plan implementation is expected to result in the loss of 53,418 ha (132,000 acres) of suitable mountain lion habitat and includes three biological objectives to mitigate these impacts related to the Conservation Area, Conservation Area Linkages, and maintaining or improving dispersal route functionality.

5.4 Local Ordinances

There are three local ordinances within the petitioned ESU that are relevant to mountain lions.

5.4.1 Ventura County Habitat Connectivity and Wildlife Movement Ordinance

Ventura County's Wildlife Connectivity Ordinances were adopted by the Ventura County Board of Supervisors in 2019 to facilitate wildlife connectivity and minimize habitat fragmentation for mountain lions, mule deer, California gnatcatchers (*Polioptila californica*), bobcats, least Bell's vireos (*Vireo bellii pusillus*), California red-legged frogs (*Rana draytonii*), and other species. Two of the linkages targeted in the Connectivity Ordinances are the Santa Monica Mountains—Sierra Madre Mountains connection and the Sierra Madre Mountains—Castaic Connection, which together connect wildlife habitat in the Santa Monica Mountains, Santa Susana Mountains, Simi Hills, and Los Padres National Forest. While implementation of the Connectivity Ordinances should help wildlife to move more easily through private lands between core habitat areas, it would not address connectivity across major roads and highways, which is outside its jurisdiction (Country of Ventura Resource Management Agency 2024).

5.4.2 Los Angeles County Significant Ecological Areas Ordinance

The Los Angeles County Significant Ecological Areas Program recently updated its Significant Ecological Areas (SEAs) Ordinance. The ordinance is intended to protect biodiversity in SEAs from incompatible development and ensure that projects reduce habitat fragmentation and edge effects by providing technical review of impacts and requiring mitigation. Like Ventura County's Connectivity Ordinance, the SEAs designations can lead to compact development and allow wildlife to move across private lands more easily between core habitat areas. However, the SEA ordinance is not specifically designed to protect mountain lions (Los Angeles County Planning (LACP) 2023).

5.4.3 City of Los Angeles Draft Wildlife Ordinance

The City of Los Angeles Department of City Planning has developed draft regulations for the protection of wildlife within the city limits, including the promotion of wildlife movement corridors. One stated goal of the draft regulations is to improve wildlife mobility and connectivity opportunities along waterways, ridgelines, and natural open spaces. The Wildlife Pilot Study is intended to result in regulations that will help to preserve wildlife and promote habitat connectivity on small to medium size residential developments in a pilot study area in the Santa Monica Mountains between the 405 and 101 freeways (Los Angeles County Planning (LACP) 2024).

5.5 Management on Federal Lands

5.5.1 National Environmental Policy Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. The Department is not aware that the mountain lion is afforded any federal special status, and as such, impacts to the species are not required to be considered during NEPA analysis. The law directs federal agencies to adopt all practical means to minimize or mitigate adverse effects when selecting preferred alternatives or justify not doing so.

5.5.2 National Forest Service and Bureau of Land Management

The U.S. Department of Agriculture's Forest Service is responsible for developing forest management plans consistent with the National Forest Management Act requirements. These plans guide land use and development within national forests and grasslands in a way that balances use and protection of natural resources to support ecological, social, and economic sustainability. Within the petitioned Southern California/Central Coast ESU, the USFS has adopted Forest Management Plans for the Los Padres, Angeles, San Bernardino, and Cleveland National Forests. These plans identify conservation strategies for mountain lion related to land acquisition, preventing habitat fragmentation, monitoring, and fire management. The Forest Service also manages several Wilderness Areas in the major National Forests within the petitioned area. Wilderness Areas are the most protected public lands in the US. Extractive uses are prohibited, as well as building roads or structures. The Angeles National Forest has five Wilderness Areas, the Cleveland National Forest has four Wilderness Areas, the Los Padres National Forest has 10 Wilderness Areas, the San Bernardino NF has eight Wilderness Areas. National Forest Wilderness in the petitioned ESU area totals approximately 485,000 ha (1.2 million acres).

The U.S. Department of Interior's Bureau of Land Management prepares Resource Management Plans to provide broad-scale direction for managing public lands in accordance with the principles of multiple use and sustained yield, as mandated by the Federal Land Policy and Management Act. These plans establish goals, objectives, and decisions for air quality, biological resources, cultural resources, lands with wilderness characteristics, paleontological resources, visual resources, water resources, fire ecology and management, trail and travel management, lands and realty, land use authorizations, livestock grazing, minerals management, recreation and visitor services, and areas of critical environmental concern. Within the petitioned Southern California/Central Coast ESU, adopted BLM plans include the Southern Diablo Mountain Range RMP, the Central Coast of California RMP, the Carrizo Plain National Monument RMP, the Clear Creek RMP, the South Coast RMP, the West Mojave RMP, the Eastern San Diego County RMP, the Santa Rosa and San Jacinto Mountains National Monument RMP, the Northern and Eastern Colorado Desert Coordinated Management Plan, and the Desert Renewable Energy Conservation Plan. While these plans may not specifically address mountain lions, they generally provide some level of protection for wildlife habitat. The BLM manages several Wilderness Areas within the petitioned area totally approximately 117,000 ha (290,000 acres), especially in the desert regions between the San Bernardino Mountains and the Arizona border.

5.5.3 Military Bases

The Sikes Act was established in 1960 to ensure conservation and protection of natural resources used by certain federal agencies, including the Department of Defense. The U.S. Congress amended the Sikes Act in 1997 requiring the Department of Defense to develop and implement Integrated Natural Resources Management Plans. These plans outline how each military installation will manage its significant natural resources holistically while maintaining military readiness. Since these lands are often protected from access and use by the public, they may contain large tracts of undeveloped land and thus be an important tool for species conservation and habitat connectivity especially in the desert regions. Military bases within the petitioned Southern California/Central Coast ESU include Fort Hunter Liggett, Camp Roberts, Camp San Luis Obispo, Vandenberg Space Force Base, Marine Corps Base Camp

Pendleton, Naval Weapons Station Seal Beach, March Air Reserve Base, Marine Corps Air Station Miramar, Naval Air Facility El Centro, Chocolate Mountain Aerial Gunnery Range, and other installations.

5.5.4 National Parklands

The guiding principles for managing biological resources on the U.S. Department of the Interior's National Park Service lands include maintenance of animal populations native to park ecosystems (NPS 2006). The NPS also commits to work with other land managers on regional scientific and planning efforts. NPS management plans provide direction and guidance on a variety of issues including resource preservation, visitor use, development, and boundary management. These plans generally specify management objectives and may vary in the type of plan, ranging from a general management plan to wilderness plans to strategic facility investment plans. For example, the Santa Monica Mountains National Recreation Area General Management Plan (GMP) provides a framework for the area's management, administered by the National Park Service, California State Parks, and the Santa Monica Mountains Conservancy. The GMP includes mountain lions as a "park species of concern" and includes construction best management practices, facility siting, fire management, vegetation, and habitat connectivity strategies intended to mitigate project impacts. However, the GMP does not include specific actions for mountain lions. Extensive mountain lion research has been carried out by The Santa Monica Mountains National Recreation Area under the leadership of Dr. Seth Riley.

Other NPS lands within the petitioned areas, such as Carrizo Plains National Monument, Fort Ord National Monument, Pinnacles National Park, Mojave National Preserve, and Golden Gate National Recreational Area, provide habitat and important habitat corridors for mountain lions.

5.6 Management on State Lands

5.6.1 California Department of Fish and Wildlife

The Department is responsible for over 445,000 ha (1,100,000 acres) of fish and wildlife habitat, managed through 749 properties throughout the state, including 111,462 ha (275,428 acres) within the petitioned ESU. These properties provide habitat for a rich diversity of fish, wildlife, and plant species and include representatives of most major ecosystems in the state.

Most Department lands are classified as either Wildlife Areas or Ecological Reserves. Wildlife Areas are acquired for the conservation of wildlife and the habitats on which they depend, and to provide opportunities for recreational uses that are compatible with those conservation goals (Fish & G. Code, §§ 1525–1530, 1745). Ecological Reserves are acquired primarily for the purpose of protecting rare and endangered native species and specialized habitat types (Id., § 1580). Certain public uses, deemed compatible with those goals, are authorized for ecological reserves—typically this includes hiking on established trails to observe native plants and wildlife (Id., § 1584). The Department prepares land management plans for Wildlife Areas and Ecological Reserves which are subject to public review under CEQA prior to being finalized.

The 167 Department properties within the petitioned Southern California/Central Coast ESU range from a fishing access property of less than 1 acre to the 117,197-acre Santa Rosa Wildlife Area in Riverside County. Of particular interest are Department properties in the coastal mountains of San Diego County, including Rancho Jamul Ecological Reserve, Sycuan Peak, Crestridge Ecological Reserve, and Hollenbeck

Canyon Wildlife Area. Mountain lion densities appear to be high in these areas as indicated by the concentration of vehicle strikes (Fig. 11). The Santa Margarita River Ecological Reserve was rated as the best potential site for a wildlife crossing over I-15 to help link the Santa Ana Mountains to the Palomar Mountains in the Eastern Peninsular Range (Riley et al. 2018b). Other significant Department properties within the petitioned ESU include the Cottonwood Creek, Cañada de Los Osos and San Luis Reservoir Wildlife Areas in Merced and Santa Clara Counties; the Chorro Creek Ecological Reserve in San Luis Obispo County; the Burton Mesa Ecological Reserve in Santa Barbara County; and San Jacinto Wildlife Area in Riverside County.

5.6.2 California State Parks

California's State Park System encompasses more than 607,000 ha (1.5 million acres) in approximately 280 parks. These parks are managed for public use and enjoyment and species and habitat protection through an integrated program of planning, restoration projects and evaluation, ongoing maintenance, and long-term monitoring.

A state park must have an approved general plan before major park facilities can be developed. These general plans direct the long-term management of the park. Some parks may also develop a more specific resource management plan. Big Basin Redwoods State Park in Santa Cruz County designates mountain lions as a species of special management concern, and the Park's Management Guidelines call for the protection of known wildlife habitat linkages to permit movement of wildlife, increase species abundance and diversity, and monitor the functionality of core wildlife habitat areas and wildlife linkages (California State Parks (CSP) 2013). Big Basin Redwoods State Park and surrounding parks including The Forest of Nisene Marks, Año Nuevo, Henry Cowell Redwoods, Wilder Ranch, Portola Redwoods, and Castle Rock State Park encompass over 22,250 ha (55,000 acres) of the Santa Cruz Mountains in the CC-N. Anza-Borrego Desert State Park in the EPR is the largest park in the state system at over 240,000 ha (600,000 acres) and contains over 161,000 ha (400,000 acres) of land managed as wilderness. Park system-wide management goals include being proactive in biological conservation and managing for subspecies, evolutionary units, ecologically functional units, populations, or other levels of biological organization to conserve biodiversity; and management that encourages natural ecological process such as hydrologic processes, wildfire, and biotic community interactions to continue. Other wildlife-related goals and guidelines include species inventory and monitoring programs, protection of special status plants and animals, control of non-native plants and animals, and the protection of habitat buffers and movement corridors (CA Parks 2005). Other notable parks within the petitioned Southern California/Central Coast ESU boundary include Butano, Garapata, Andrew Molera, Julia Pfeifer Burns, Portola, Henry W. Coe, Henry Cowell, Castle Rock complex, Montaña de Oro, Point Mugu, Malibu Creek, Topanga, Chino Hills, Lake Perris, and Cuyamaca Rancho.

5.6.3 Management on County and City Lands

Although generally smaller in size than conserved state and federal land units, city and county owned and managed lands conserve many key linkage areas or expand and buffer adjacent conservation lands. For example, a series of properties owned by the City of Los Angeles—including Runyon Canyon Park, Franklin Canyon Park and Stone Canyon and Encino Reservoirs—conserve portions of the easternmost extent of the CC-S and provide partial linkage to Griffith Park (also owned by the City of Los Angeles).

And Ventura County's Happy Camp Canyon Regional Park conserves an important part of the southern Santa Susana Mountains that may serve as a key piece of future linkages between the Santa Monica Mountains/Simi Hills and the Santa Susanas. In the Santa Anas, parks and preserves owned and managed by Orange County serve as linkages and buffers to larger conserved areas in the Sana Ana Mountains. Important units include Whiting Ranch and Irvine Ranch Open Space Preserves and the Ronald Casper Wilderness Park. In the coastal EPR of San Diego County, the County's open space preserves in the Otay area and mitigation bank in Marron Valley complement the Department's Rancho Jamul Ecological Reserve and the BLM's Otay Wildlife Management Area to create a large block of contiguous conserved lands in the San Ysidro Mountains adjacent to the Mexican border.

5.7 Management in Neighboring States and Nations

5.7.1 Arizona

Mountain lions are found throughout Arizona in desert and forested mountain habitat. They are not considered endangered or threatened in Arizona and are classified as a big game species by the Arizona Game and Fish Department (AGFD), with regulated hunting zones throughout the state. The population was recently estimated at 1,166 to 1,175 (95% CI = 622-2,558) adults and subadults statewide exclusive of the 28% of the state that is tribal land (Howard et al. 2020). Mountain lions have recently expanded into previously unoccupied areas in western Arizona near the California border where they were previously thought to be transient including the Kofa, Castle Dome, New Water, Palomas, and Eagle Tail Mountains where no evidence of mountain lions was detected during 1987 surveys (Thompson et al. 2008; Naidu et al. 2011).

The AGFD collects age and sex information and genetic material from harvested mountain lions to monitor populations and to evaluate metapopulations, connectivity and dispersal. Mountain lions are regulated by several statutes and Arizona Game and Fish Commission Orders. It is unlawful to harvest a female lion with kittens or to harvest a spotted kitten in Arizona. AGFD has established several mountain lion management zones in the state with harvest thresholds that require closing the season when the threshold is reached. Five different zones exist on the western border of Arizona abutting the California boundary, with a total of eight separate harvest units within those zones. For the 2022–2023 harvest season, the threshold quota for each of these units ranged from 3–17 mountain lions. AGFD has analyzed harvest data and considers the mountain lion population to be stable to increasing in many parts of the state.

5.7.2 Nevada

Mountain lions are classified as a game mammal in Nevada and both sexes can be hunted under special regulations. Hunting is allowed statewide, except for on the Sheldon National Antelope Refuge and within specific hunt zones in the Las Vegas area. There was a limit of 247 mountain lions in 2023–2024. From 1987 to 2015 the estimated mean population size statewide was 3,000–4,000, with the population generally found to be stable (Mahoney and Benson 2021). Andreasen et al. (2012) found that mountain lion populations in western Nevada commonly interbreed with individuals in the Sierra Nevada of California, and those populations are somewhat isolated from other Nevada populations by inhospitable playas in the Lahontan Basin. The authors also found that the Sierra Nevada population appears to receive more mountain lions from central and eastern Nevada than it contributes in return. In contrast, Gustafson et al. (2019) found evidence of more movement from the Sierra Nevada to Nevada than vice versa.

5.7.3 Mexico

Mountain lions are distributed throughout Mexico in many areas and habitats including mountains, deserts, sub-tropical and tropical forests, and deciduous dry, conifer, and oak forests (Valdez and Ortega-Santos 2019). Populations are found in most states except in urban areas with large human populations and areas of intensive agricultural production, including central Mexico and much of the Mexican Altiplano (Chávez and Ceballos 2014).

Threats to mountain lion survival in Mexico include habitat fragmentation, prey depletion, and illegal hunting (Valdez 1999; Rosas-Rosas et al. 2003; Rosas-Rosas et al. 2008). Additionally, widespread cattle ranching, agriculture expansion, and unlawful human settlement in protected natural areas threaten their survival in the long term (Galindo et al. 2016). Ranchers often resort to predator control without following a scientific management plan due to a lack of federal and state conservation intervention programs (Rosas-Rosas et al. 2003; Rosas-Rosas et al. 2008; Rosas-Rosas and Valdez 2010; Chávez and Ceballos 2014).

Despite the international border wall, some contemporary connectivity is known to exist between EPR and the contiguous Mexican lion populations where there is not a US Border fence (Vickers et al. 2015). While the 226 km (140 mi.) border is largely fenced, significant areas, primarily in more rugged mountainous terrain occupied by mountain lions, remain unfenced. In 2009, a radio collared male from EPR crossed into Mexico at an unfenced section (Fig. 21). However, it is unknown if he fathered cubs in Mexico, and genetic exchange between lion populations on either side of the border has not been examined in close detail. Genetic contributions from Mexico to EPR in the absence of concerted mountain lion conservation efforts in northern Mexico are not ensured, and cooperative international wildlife conservation efforts should be explored to ensure the persistence of this linkage.

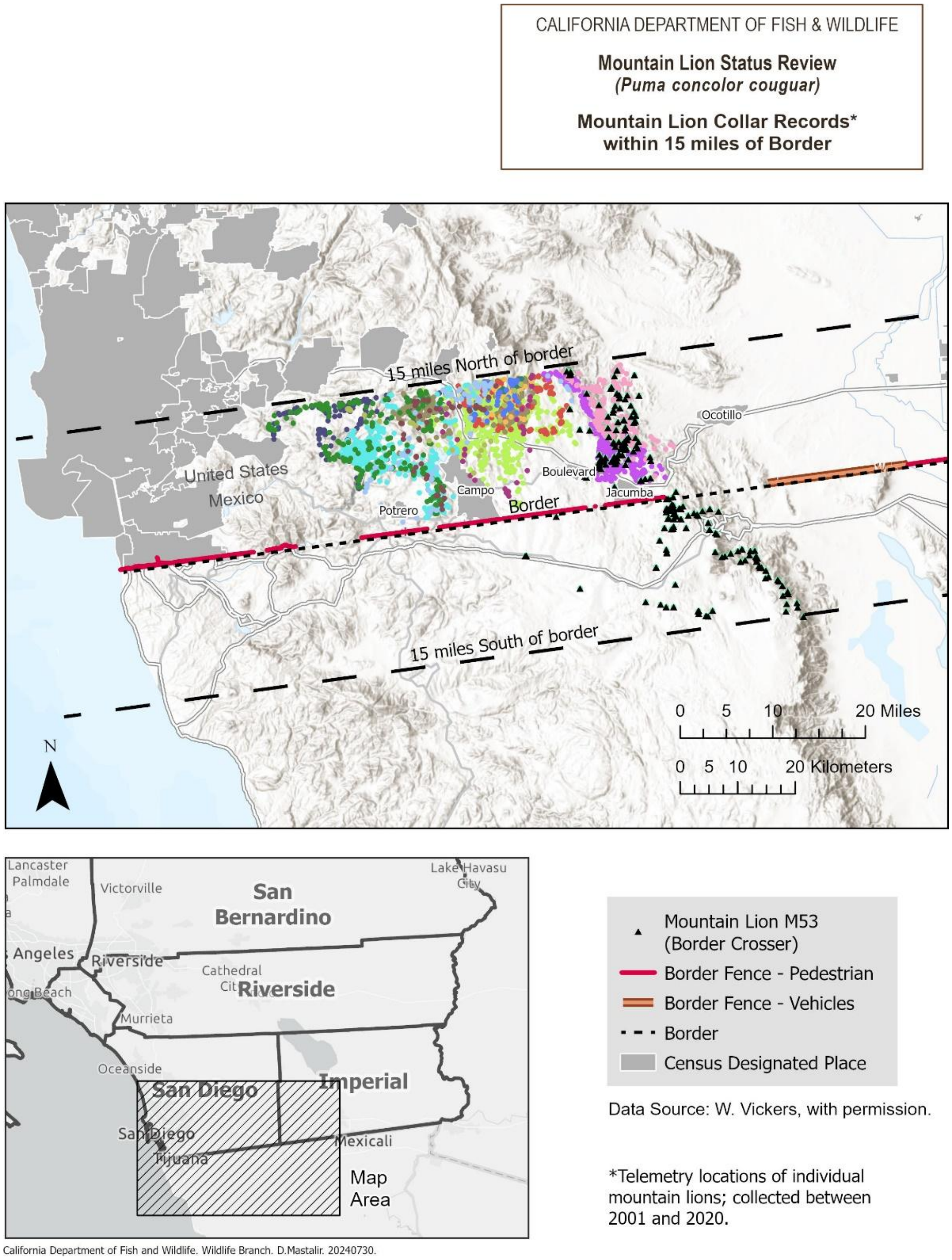


Figure 21. US/Mexico border showing locations of GPS-collared mountain lions within 15 miles of the border, including M53, the only tracked mountain lion to have crossed the border (W. Vickers data used with permission). Locations of border fences are also shown. The sections marked pedestrian are made of materials designed to stop the movement of people which would likely present a significant barrier to mountain lions. The vehicle fence likely does not create a significant barrier to mountain lions.

6. Assessment of Listable Groups

6.1 Assessment of Evolutionary Significant Units

The petitioners propose listing the petitioned area, which includes the approximate area occupied by six genetic populations, as a single ESU. Alternatively, they request the Commission consider whether any of the six genetic populations, individually or in combination, comprise one or more ESUs and meet the criteria for listing under CESA (see Fig. 1).

To determine whether a population could be considered an ESU under CESA, the Department has typically followed the general approach used by the federal government for the ESA (Waples 1991) which consists of two main criteria:

1) The population must be substantially reproductively isolated from other conspecific population units.
2) It must represent an important component in the evolutionary legacy of the species.

For criterion 1, isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in the different population units. It must also be of substantial ecological/genetic importance to the species as a whole (criterion 2). To make the determination for criterion 2, the following questions are relevant:

a) Is the population genetically distinct from other conspecific populations?
b) Does the population occupy unusual or distinctive habitat?
c) Does the population show evidence of unusual or distinctive adaptation to its environment?

Waples (1991) highlights the following types of information as useful for answering the above questions[15]

1) Genetic traits. Examples include presumably neutral characters detected by protein electrophoresis or DNA analyses as well as other genetically based traits that are more difficult to quantify.
2) Phenotypic traits. Examples include morphological and meristic characters, occurrence of parasites, and disease and parasite resistance.
3) Life-history traits. Examples include time, size, and age at reproduction; reproductive behavior; fecundity; migration patterns; and timing of emergence and outmigration.
4) Habitat characteristics. This category includes such physical characteristics of habitat encountered during the entire life cycle.

Waples (1991) notes:

"The existence of substantial genetic differences from other conspecific populations based on protein electrophoresis or DNA analyses would strongly suggest that evolutionarily important, adaptive differences also exist. The failure to find such differences (or the absence of genetic

[15] Waples's examples are written to be specifically relevant to Pacific salmon, so the Department has altered the language to make them more applicable to terrestrial organisms.

data) would not rule out the possibility that such adaptive differences exist, but it would place a greater burden of proof on data for other characters. Data for habitat characteristics should be interpreted in a similar fashion: habitat differences suggest (but do not prove) the possibility of adaptive differences, whereas the inability to detect habitat differences constrains the scope of possible local adaptations but does not prove they do not exist. In evaluating data for phenotypic and life-history traits, every effort should be made to account for environmental effects that are manifested in periods shorter than one generation (and therefore do not reflect adaptations)."

When evaluating the petition, CDFW's first consideration was whether the petitioned ESU meets the criteria for being considered an ESU. The second consideration was whether any of the populations within the petitioned ESU area meet the definition of an ESU, singly or in combination.

It is important to understand the adaptive differences described in the ESU criteria are unlikely to develop when populations are isolated over short time scales (i.e., decades, or even hundreds of years). Mountain lions occupy much of California, except for heavily urbanized areas, intensively farmed areas of the Central Valley, and low elevation areas of the southern deserts. As noted earlier, when the landscape is permeable, they can disperse over long-distances (Sweanor et al. 2000; Hawley et al. 2016) and they inhabit all major mountain ranges in California (Dellinger et al. 2020b). This widespread distribution and dispersal potential suggest local adaptation is unlikely to develop, and there is little evidence of morphological, mitochondrial, or adaptive genomic differences between mountain lions within the petitioned ESU or any of the genetic populations and the broader statewide population to suggest the presence of distinct evolutionary lineages (Gustafson et al. 2022). While gene flow between the petitioned ESU and the NC and SN groups is limited, it does still occur (Gustafson et al. 2019; Gustafson et al. 2022). Several of the fine-scale genetic populations are small and somewhat isolated as connectivity to the statewide population has been drastically reduced in the last 50–100 years due to expanding human development. However, based on current scientific information there are no groups of mountain lions within the petitioned ESU boundary that have been isolated for much longer periods such that they represent important portions of the evolutionary legacy of the mountain lion species.

The Department used several lines of genetic and ecological evidence to evaluate the potential ESU, however, taken as a whole, the genetic evidence does not support applying the ESU concept to the overall petitioned area nor to any of the genetic populations individually, as a subspecies or ESU for the following reasons:

1) There is only one recognized subspecies of mountain lion in North America (*P. c. cougar*) based on mitochondrial DNA data (Culver et al. 2000; Caragiulo et al. 2014; Kitchener et al. 2017), suggesting a reduced potential for adaptive localized genetic variation among North American mountain lion populations.
2) Genetic investigations conducted by Gustafson et al. (2022) failed to detect local adaptation, suggesting that the identified California genetic populations do not represent an important component of the evolutionary legacy of the species.
3) Genetic data indicate habitat fragmentation and dispersal barriers have recently limited the ability of mountain lions to move freely between certain geographic areas and local populations in Southern California and the central coast area (Gustafson et al. 2019). However, this fragmentation has mostly occurred within the last 200 years and has not yet resulted in genetic

differentiation sufficient to represent an important component of the evolutionary legacy of the species. Gustafson et al. (2022) found no outlier loci, which, when present, suggest local adaptation (Ibid.). The same study used SNPs to characterize variation across more of the genome, which suggests many of these local genetic populations separated by barriers have considerable shared ancestry (Figs. 7, 8) and are more genetically similar than was suggested by the result of Gustafson et al. (2019).

While the Department concludes that the mountain lion populations within the petitioned area do not comprise one or more listable ESUs, the Department recognizes that several of those populations are imperiled due primarily to small population sizes and isolation. In the sections below the Department uses other criteria to further evaluate whether mountain lions within the petitioned area warrant potential listing under CESA.

6.2 Assessment of Distinct Population Segments

While the petition is focused on ESUs and the Department has recommended listing ESUs in the past, the Department has also previously recommended listing other sub-species entities, such as DPSs (e.g., Southern California steelhead) and clades (e.g., foothill yellow-legged frog). The U.S. Fish and Wildlife Service (USFWS) and NMFS (the Services) have also identified and listed DPSs pursuant to the ESA and have developed a policy for evaluating DPSs pursuant to the ESA (61 Fed Reg. 4722-4725 (February 7, 1996)). Per that policy, a DPS is a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. DPSs have been used 137 times by USFWS to list imperiled populations rather than listing a species across its full range. Examples from California include the Southern Sierra Nevada fisher (85 Fed. Reg. 29532-29589 (May 15, 2020)), the Peninsular bighorn sheep (63 Fed. Reg. 13134-13150 (March 18, 1998)), and the Sierra Nevada bighorn sheep (64 Fed. Reg. 19300-19309 (April 20, 1999)). While the ESU designation and supporting policy has primarily been applied to fish populations, the DPS designation has been more widely applied to, and policy is more relevant for, terrestrial species.[16]

To guide its evaluation of whether a possible DPS might warrant listing as threatened or endangered, the Services first evaluate two elements to determine if the population segment should be considered a DPS:

1) Discreteness of the population segment in relation to the remainder of the species.
2) Significance of the population segment in relation to the remainder of the species.

If the population segment being considered is a DPS, then the Services then evaluate its conservation status (i.e., is the population segment, if treated as if it were a species, endangered or threatened?) (61 Fed. Reg. 4722-4725 (February 7, 1996)).

The elements are interpreted as follows:

Discreteness: A population segment may be considered discrete if it meets either of two conditions:

[16] The Department has previously found DPSs to be a helpful approach for assessing certain populations and concludes it is an appropriate approach to consider for mountain lion.

a) It is markedly separated from other populations of the same taxon because of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
b) It is delimited by an international government boundary, and there are significant differences between the countries in control of exploitation, management of habitat, conservation status, or regulatory mechanisms.

Significance: If a population segment is found to be discrete under one or more of the above conditions, its biological and ecological significance will then be considered. This consideration may include, but is not limited to, the following:

a) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.
b) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon.
c) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range.
d) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Imperiled Status: If a population segment is found to be both Discrete and Significant, and if treated as a species, could it be found to be threatened or endangered based on the listing factors established in the ESA?

Adopting this approach, the Department evaluated the petitioned area to determine if it should be considered a DPS.

6.2.1 Boundary Assessment

Considering the petitioned area as a potential DPS is consistent with the Petitioners' interest in examining the status and viability of major genetic groupings of mountain lions in California and is also consistent with prior Department evaluations of portions of widely distributed species' ranges. The Department has previously recommended listing the Southern California steelhead DPS for listing, as well as several clades (groups descended from a common ancestor) of foothill yellow-legged frog (*Rana boylii*). As a first step in the DPS assessment, the Department considered the boundary of the petitioned ESU. The boundary must be supported by the best available science and be demarcated unambiguously. After consideration, the Department developed a potential DPS boundary that is modified from the ESU boundary proposed in the petition.

The petitioned ESU boundary includes extensive areas of California's southeastern deserts in eastern San Bernardino, Riverside, and Imperial Counties where mountain lion detections are few. Although Gustafson et al. (2019) and Gustafson et al. (2022) include this area in the EPR, the authors did not examine genetic material from mountain lions east of the Eastern Peninsular Mountains (see sample locations in Fig. 6). Mountain lions are known to occur in the desert regions of California and in Death Valley National Park (Lundgren et al. 2022), but camera trap data suggest they exist at low densities (Dellinger et al. 2019). Genetic material from the eastern deserts has not been systematically collected, and, consequently, mountain lions in those areas have not been assigned to a genetic population nor has local gene flow been characterized.

The next nearest location from which genetic samples have been analyzed is the Mojave Desert region of southern Nevada (Andreasen et al. 2012). In a statewide genetic study of mountain lion population structure, Andreasen et al. (2012) found that animals from southern Nevada were genetically similar to individuals from the Great Basin and the Sierra Nevada region of California. However, the analysis did not include samples from the EPR or other genetic populations within the petitioned area, so it did not shed light on the genetic relationships between the mountain lions of EPR and Nevada. Another study compared samples from the coastal areas of the SC group (including EPR) and southwest Arizona (Naidu 2015). There was minimal evidence of gene flow between the mountain lions in the coastal area of the SC group and those along the border or in Arizona. In fact, the individuals sampled in south coastal California were found to be more genetically similar to those sampled from the North Rim of the Grand Canyon than those directly across the desert in southwest Arizona (Naidu 2015). However, the study had a small sample size, and did not include samples from the inland desert regions of California. Therefore, the results provide little information regarding the genetic assignment of mountain lions in the desert regions of California.

Due to this limited information, it is not currently possible to assign the mountain lions occupying the deserts of southeastern California to one of the genetic populations described by Gustafson et al. (2019). Since mountain lions in this region cannot be assigned to the petitioned genetic populations, the Petitioners' boundary which included the deserts east of the Peninsular Ranges would not meet the DPS criteria for discreteness as mountain lions in those deserts may belong to other genetic populations. The Department, therefore, does not find it appropriate to include large portions of the Mojave and Sonoran deserts within the area to be assessed as a DPS. When considering where to bound the proposed DPS, the Department also evaluated the distribution of suitable mountain lion habitat in the Mojave and Sonoran Deserts (Dellinger et al. 2020) as well as the distribution of verified mountain lion camera trap detections from recent Department monitoring projects related to drought impact monitoring and bobcat management. The petitioned ESU boundary extended from the Tehachapi Mountains east along I-15 to the Nevada border and then south along the Colorado River to Mexico, while our proposed Central Coast and Southern California DPS boundary instead runs south from the Tehachapi Mountains and then closely follows the eastern bases of the San Gabriel, San Bernardino, and Little San Bernardino Mountains before extending south along the western edge of the Salton Sea (Fig. 22).

The petitioned ESU boundary also includes an area of intensively farmed agricultural land in San Joaquin, Sacramento, and Solano Counties. This area contains little native vegetation and little cover for mountain lions, and while there are few contemporary records of mountain lions occurring there, they are likely transient individuals. Therefore, this area is not included in the proposed DPS (Fig. 22). For a more detailed description of the proposed Central Coast and Southern California DPS boundary see section 9 (Listing Recommendation).

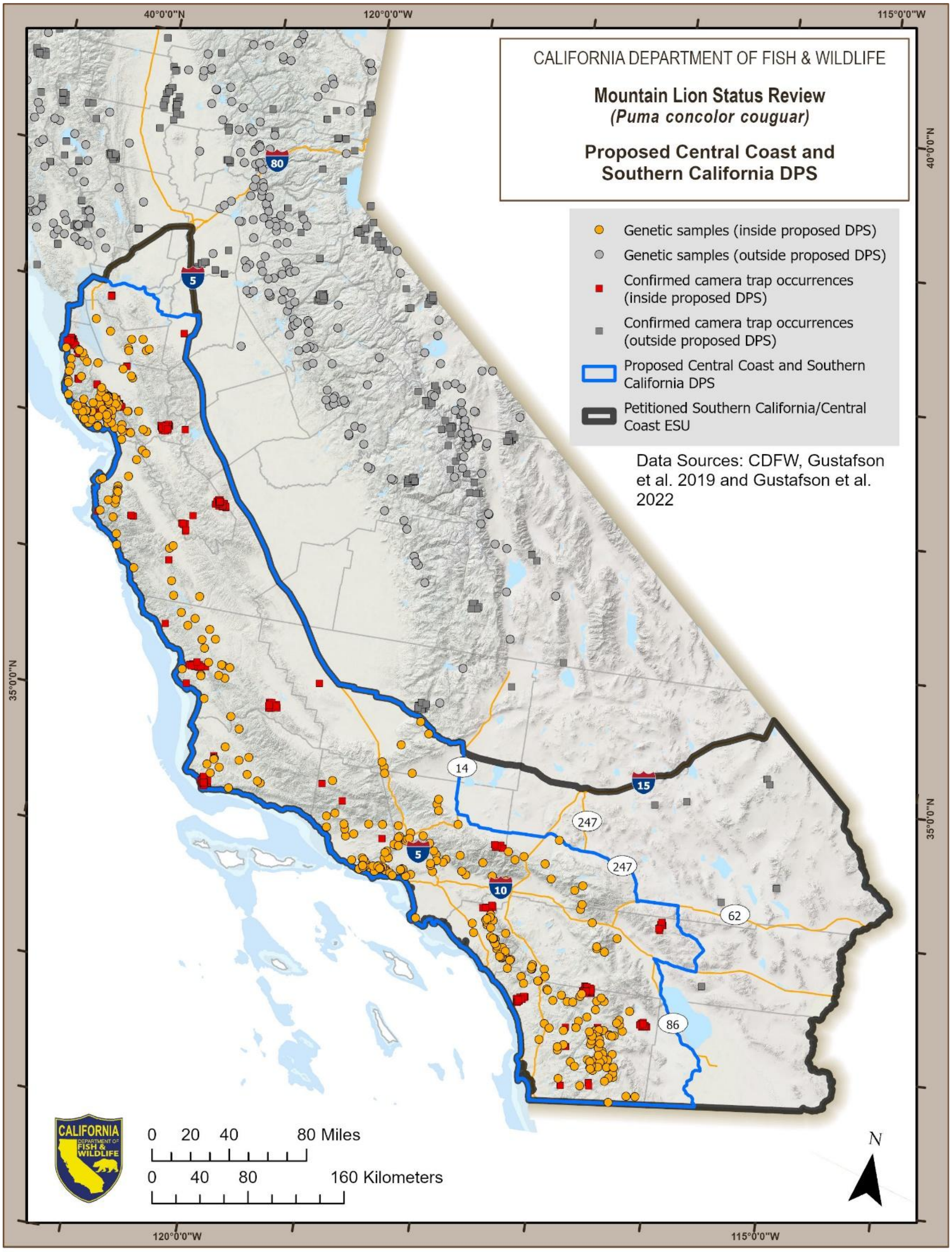


Figure 22. Proposed boundary of Central Coast and Southern California Distinct Population Segment.

6.2.2 Assessment of Proposed DPS Discreteness

The first test of whether a portion of a species' range constitutes a DPS is whether the population segment is discrete or markedly separate from the remainder of the species range. The Department concluded the proposed DPS is a discrete population based upon the evidence below.

Physical, physiological, ecological, or behavioral factors:

- Physical boundaries separating mountain lion populations within the evaluated DPS from other lion populations include the San Francisco Bay and Sacramento-San Joaquin Delta, the intensive agriculture in the Central Valley, large areas of unsuitable habitat in portions of the inland deserts in the east, high density urban areas, the wall along parts of the southern border with Mexico, and significant highways such as Interstates 5, 10, and 15. These are not absolute barriers but, in combination with existing geographic and habitat features, represent sufficient hindrance to gene flow that the mountain lions within the potential DPS represent two of the four broad-scale distinct genetic groups in California identified by Gustafson et al. (2022). These two broad-scale groups (SC and CC) are moderately genetically differentiated from the other broad-scale groups in California as measured by F_{ST} values (see section 2.4). This points to separation and isolation of the populations over time due to the barriers discussed above. There is evidence of historical gene flow between the genetic populations in the evaluated DPS and the Western Sierra Nevada (which is in turn connected with the Eastern Sierra Nevada and North Coast) in the ancestry assignment data using SNPs (see section 2.4). The Tehachapi Mountains and surrounding areas are considered the only area where contemporary gene flow is known to occur between the evaluated DPS and the other genetic populations in California (via the western Sierra Nevada Mountains; Fig. 10). Current substantial barriers to mountain lion movement in that area include I-5 and Highway 58, the latter of which is identified by the Department as an area of top priority for connectivity for mountain lions (Fig. 12, Vickers unpublished data).
- Connectivity between mountain lions in the EPR and those in Baja California, Mexico and Arizona is poorly understood. Although most of the 226 km (140 mi.) border with Mexico is fenced, portions in the rugged San Ysidro and Jacumba Mountains remain unfenced. Mountain lions have been observed on the California–Baja California border (J. Dellinger pers. comm.), and in 2009, one GPS-collared study animal was documented crossing the border multiple times in the vicinity of Jacumba, California, indicating the opportunity for the cross-border exchange of individuals still exists (Fig. 21, Vickers et al. 2015). In the Mojave and Sonoran deserts, sporadic detections of individuals suggest at least the potential for genetic exchange between mountain lions in the EPR and those living along the Colorado River in California and Arizona. However, such movement has not been studied or confirmed to date.

International Border: The assessment of discreteness in the federal DPS policy includes the criterion of the presence of an international border. However, the jurisdiction of CESA is the State of California, and considerations of differences in management or regulatory mechanisms across borders are not usually a major part of the listing decision process. In this case, however, the border between California and Mexico is relevant to the EPR genetic group. While portions of the international border are marked by walls and fences that attempt to manage human migration, significant sections of the border, including a large section of the Eastern Peninsular Mountains, remain unfenced (Fig. 21). However, the status of the mountain lion population in Baja California, Mexico, and the frequency of lion movement across the border is unknown. One collared mountain lion is known to have crossed from the Eastern Peninsular Range into Mexico and back in 2009. While the frequency of genetic exchange between Californian and Mexican mountain lion populations is unstudied and unknown, it is likely that the border wall serves as a semi-permeable obstacle to lion movements. However, without more information about gene flow, California should not make assumptions about Mexican mountain lions' contribution to genetic diversity in the EPR and South Coast populations.

6.2.3 Assessment of Proposed DPS Significance

Having established that the proposed DPS is a discrete population, the Department next evaluated the biological and ecological significance of the segment in consideration using the following factors.

Unique Ecological Setting: While there are diverse environments including many unique plants and vegetation types within the proposed DPS, the relevance of these unique areas to the mountain lion—an adaptable, wide-ranging, habitat generalist—is unclear. The mountain lion's primary prey (deer) occurs across the many habitats of the potential DPS and there is little evidence that mountain lions have adapted their general behaviors or occupied different ecological niches to exploit specific habitat types. Mountain lions typically have large home ranges that may include many habitat types, and an individual lion may disperse and establish a home range dominated by a habitat type other than the one that dominated its home range when it was a juvenile. Mountain lions within the proposed DPS largely make use of habitats that are compositionally and structurally similar to habitats outside the evaluated DPS, and they tend to exhibit the same hunting, feeding, breeding, and denning behaviors both within and beyond the proposed DPS boundary, including making use of the interface between natural habitats and cities by occasionally occupying urban and suburban areas.

Gap in Range: The evaluated DPS represents 97,230 km^2 (37,541 mi^2), which is 23.7% of the state of California. The loss of the mountain lions from this area would be a significant overall loss in range in California and would further limit the statewide population's connectivity with populations in Mexico and Arizona. Within the petitioned area, mountain lions occur in many mountain ranges, valleys, deserts, parks, and Wilderness areas, and the loss of the largest carnivore from these areas would fundamentally change wildlife community dynamics across a large portion of the state.

Only Surviving Natural Occurrence: Mountain lions within the proposed DPS are not the only surviving natural occurrence of the species in the state.

Markedly Different Genetic Characteristics: The petitioned area consists of two of the four broad genetic groups identified in Gustafson et al. (2022), which are "moderately differentiated from each other based on F_{ST} estimates." Those two broad groups can be further divided into six smaller genetic populations. While there are multiple lines of evidence that these genetic groups have different characteristics from each other and from the groups outside of the petitioned area, to date there is no evidence that these discernible genetic differences are evidence of adaptations to local conditions (see section 2.4 Genetic Structure).

Conclusion: The mountain lions in the petitioned area are markedly separated from other populations in the state due to natural and human-created barriers. There are six distinct genetic populations in the petitioned area that broadly nest into two broad-scale genetic groups that are discernible from those in the rest of the state. The mountain lion population within the petitioned area is significant due to its markedly different genetic characteristics, and the very large, geographically diverse area that it occupies, comprising nearly one quarter of California's land area. Therefore, the petitioned area meets the criteria to be considered a Distinct Population Segment and treated as a subspecies for CESA listing purposes.

6.2.4 Assessment of Whether Proposed DPS is Imperiled

The final test for determining if listing a population segment as a DPS is warranted is assessing whether the population segment, if treated as species, could be found to be threatened or endangered. The Department estimates the total population of the six genetic populations within the proposed DPS to be 947 mountain lions (95% CI: 777–1,123). Each of the genetic populations has some degree of isolation from, and limited genetic exchange with neighboring populations. Thus, mountain lions within the proposed DPS are not a single, well-mixed population. For long-term conservation planning, effective population size (N_e) is a better metric for evaluating the risks of isolation and inbreeding than census population size. The estimated total effective population size of these six genetic populations combined has been estimated in two studies: N_e = 70.6 (Gustafson et al. 2022), and N_e = 128 (Gustafson et al. 2019). However, the petitioned area is not a single intermixed population, instead it is a collection of smaller, somewhat isolated genetic populations which each have effective population sizes that are too low to prevent the risks of inbreeding over the long-term. This fact, coupled with the other threats to the genetic populations such as vehicle strikes, management killing, diseases, and the interrelated effects of fire and climate change has led the Department to conclude that the proposed DPS is imperiled.

See Section 7 for a more detailed discussion of threats.

6.3 Assessment of Significant Portion of Range

CESA provides that the Department and the Commission must consider whether a species is endangered or threatened "throughout all, or a significant portion, of its range." (Fish & G. Code, §§ 2062, 2067.) If the Commission ultimately determines a species is endangered or threatened throughout all of its range, the Commission need not analyze whether the species warrants listing throughout a significant portion of its range, an area subsumed within the entire range. For purposes of this analysis, the "range" to be assessed depends on the level at which listing is being analyzed by the Department and the Commission (i.e., the entire species, an ESU, a DPS, or another subspecies unit). Petitioners submitted a petition requesting the listing of one or more ESUs of mountain lions located in areas of the Southern California and the Central Coast. The Department has considered the petitioned unit(s) and determined that the correct subspecies unit for mountain lions in this area of California is a DPS, not an ESU. The Department recommends that the Commission list the entirety of the proposed DPS described in Sections 6 and 9 and shown in Figure 22. Therefore, an analysis of whether a significant portion of the species' range within the described DPS warrants listing is not required.

7. Summary of Listing Factors

CESA's implementing regulations identify key factors relevant to the Department's analysis and the Commission's decision on whether listing a species as threatened or endangered is warranted. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i)).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

7.1 Present or Threatened Modification or Destruction of Habitat

The main threats affecting mountain lions in the proposed DPS are habitat loss and fragmentation from historical and ongoing transportation infrastructure development (including residential and commercial structures, intensive agriculture, highways and freeways, high-speed rail lines, canals, and reservoirs), and lack of sufficient connectivity between remaining habitat patches, which has resulted in isolated populations with reduced genetic exchange. The amount of suitable habitat available to mountain lion populations has been significantly reduced in and adjacent to areas such as the Central Valley, San Francisco Bay area, and the greater Los Angeles and San Diego urban areas. Over time significant barriers have developed which impede mountain lion movement and isolate populations, and ongoing residential and commercial development is projected to exacerbate isolation. The lack of sufficient gene flow between isolated populations has resulted in inbreeding in some smaller populations which may reduce survival and reproductive fitness, as evidenced by physical abnormalities in some mountain lions in the small and isolated Santa Ana and Santa Monica Mountains populations.

Long-term maintenance of genetic variation within the genetic populations in the proposed DPS is reliant on habitat conservation and connectivity. Maintenance and enhancement of gene flow between the proposed DPS and the larger, more genetically diverse mountain lion populations in the Sierra Nevada through the Tehachapi Mountains is required to maintain viable populations in the proposed DPS. Additionally, there needs to be increased connectivity between and within the fine-scale genetic populations in the proposed DPS to counteract or prevent the negative impacts of inbreeding.

As noted earlier in this report, some smaller genetic populations have well-documented significant risk factors at this time. In the most isolated habitat patches (e.g., Santa Monica Mountains, Santa Ana Mountains), it is estimated that there is a substantial probability of local extirpations within less than 50 years in the absence of efforts to improve habitat connectivity and remove barriers to movement. Developing broad wildlife crossing infrastructure will require adequate funding and concerted and sustained commitment by many parties to ensure proper design, placement, maintenance and monitoring of crossing structures for effectiveness.

7.2 Overexploitation

From the early 20th century until 1964, mountain lions were a bountied predator in California. During the bounty period approximately 12,580 mountain lions were killed across California. When California bounties ended in 1964, mountain lions were classified as a nuisance or vermin species and mountain lions could be killed year-round without a hunting license and with no limits, but there was no longer paid incentive for removal. Lions were classified as game and two legal hunting seasons were held in 1970 and 1971 before a legislative moratorium on hunting was enacted. In 1986, mountain lions were reinstated as a game species, but before a hunting season was held a ballot initiative (Proposition 117) approved by California voters classified mountain lions as a "specially protected mammal species" in 1991 (Fish & G. Code, § 4800). That classification continues today.

Poaching and other unpermitted take is rarely reported but has been observed in the CC-S, SA, and EPR as well as in the CC-N. 26 out of 199 mortalities from known causes in the years 1974–2020 were due to poaching, a 2%-3% annual rate of mortality. Overexploitation alone likely poses little threat to the statewide population or to any of the genetic populations, although additive mortality from poaching may exacerbate the inherent threats faced by small, isolated populations.

7.3 Predation

As large-bodied predators, adult mountain lions in California are subject to little predation pressure. Gray wolves sometimes kill both adult and juvenile mountain lions, and black bears are known to occasionally kill mountain lion kittens but rarely adults. However, predation by wolves and black bears is not known to be a significant cause of California mountain lion mortality nor is it known to threaten the persistence of lion populations. Therefore, and given the current absence of gray wolves within the proposed DPS, predation is not currently considered to present a significant threat to California mountain lion populations, although this topic may need to be revisited if wolf packs establish within the proposed DPS in the future.

7.4 Competition

Black bears and gray wolves are known to sometimes displace mountain lions from their kills, which potentially forces mountain lions to expend additional energy hunting to procure more prey. Given the current absence of wolves in the proposed DPS, wolf competition currently has no effect on central coast or Southern California lion populations. The potential impact of black bears in these areas remains unknown and warrants further study. Within the proposed DPS, intraspecific competition between mountain lions is likely the chief source of competition. In the Santa Monica Mountains within the CC-S, intraspecific conflict has been identified as the leading cause of mortality for the nearly isolated population. Statewide, there is a 3% risk of annual mortality attributable to intraspecific strife resulting from competition. Intraspecific aggression appears to be a significant mortality factor where individual mountain lions occupy small patches of suitable habitat within habitat-limited landscapes, and therefore, this form of competition should be considered a threat to lion populations in the Santa Monica and Santa Ana Mountains.

7.5 Disease

Mountain lions are susceptible to various viral, bacterial and parasitic pathogens. While there are documented lion mortalities and sickness from multiple pathogens, mortalities from disease alone are not likely to threaten the genetic populations in the proposed DPS. Diseases pose a less than 1% annual mortality risk to California mountain lions. The Department does not consider disease, in isolation, a significant threat to the species in California. However, pathogens may be harmful to individuals and small populations, and, when combined with other threats (e.g., habitat loss and fragmentation, climate change, wildfires, inbreeding and genetic drift, etc.), their impacts potentially further reduce the likelihood of long-term persistence for small, isolated mountain lion populations.

7.6 Other Natural Occurrences or Human-related Activities

7.6.1 Vehicle-Related Mortality

Vehicle-related mortality is the second most frequent cause of known death for mountain lions in California. It is difficult to accurately assess the actual magnitude of the problem due to lack of systematic data collection. One estimate is that 100 mountain lions are killed every year by vehicle strikes, while a more recent report puts that number at 70 per year during the period from 2015 to 2022. Between 2001-2013 vehicle strikes were the leading known cause of death for radio collared mountain lions in SA, and the second leading known cause of death in EPR. In the Bay Area (CC-N), vehicle strikes are also a significant source of mortality. California State Routes (SR)-12, SR-17, SR-1, and especially Interstate-280 have high numbers of mountain lion mortalities. The 20 mile stretch of I-280 northwest of San Jose was the deadliest highway in California for mountain lions from 2015-2022 with 20 reported deaths. Well-designed wildlife crossing structures in association with fencing to funnel animals to the crossing can reduce vehicle-related mortalities. While such structures are costly and require careful planning, an undercrossing on Highway 17 in the Santa Cruz Mountains (CC-N) has been completed, construction of the Wallis Annenberg Wildlife Crossing is underway in the CC-S, and several other structures are being planned in the EPR. If wildlife crossing structures and fencing become widespread within the proposed DPS, mortality from vehicle strikes may be substantially reduced.

7.6.2 Permitted Take

From 1974 to 2020, permitted take of mountain lions was the leading known cause of death for radio collared mountain lions statewide. Permitted take is primarily composed of lethal lion removals in response to depredation of livestock and pets, although lethal removals to protect endangered bighorn sheep populations and lethal removals for human safety are also included in the category. However, changes in 2017 and 2020 to the Department’s approach to issuing mountain lion depredation permits have significantly reduced the number of animals killed statewide in recent years. Under current management, occasional lethal take of individual mountain lions due to repeated depredations on a single property or for public safety in the proposed DPS is foreseeable and may exacerbate the detrimental effects associated with habitat loss, small population size and limited genetic exchange, and other threats in isolated mountain lion populations such as the Santa Monica Mountains, SGSB and SA.

7.6.3 Toxicants

Mountain lions throughout California are exposed to toxic chemicals in their environment which can be lethal, debilitating, or have no clinical effect, depending on the quantities ingested. Lions with toxicant-impaired functions may be more susceptible to other forms of mortality such as starvation and vehicle strikes. Lions can encounter ARs used to control vertebrate pests throughout the state, including remote locations where legally prohibited rodenticides are used to protect illicit cannabis plantations. Necropsies have verified that nearly all tested mountain lions in California have been exposed to ARs. While toxicants are not known to directly cause significant mortality statewide, their effects may be additive to other sources of mortality. In the relatively small population in the Santa Monica Mountains National Recreation Area, AR toxicosis was the third leading cause of death after vehicles strikes and intraspecific strife.

7.6.4 Wildland Fire and Fire Management

The effect of wildfire on mountain lions is complex. Fire is a regular ecological process in many California vegetation types, and many native plants display adaptations to fire such as thick fire-resistant bark, post-fire crown-sprouting, and smoke-induced seed germination. Many native plants grow vigorously after wildfires, which can improve forage for deer, the main prey of mountain lions. Mountain lion response to recently burned areas appears variable with one study showing use of burned landscapes more frequently than expected based on availability during the first nine years following a wildfire, and others showing less use during the first few years post fire, then more use as vegetation recovers over time. Wildfires can also cause mountain lion injury and direct mortality, which is likely additive to other sources of mortality. Fires are projected to become more frequent and severe as the climate changes, potentially resulting in the conversion of some preferred mountain lion woodland and shrubland habitat to grasslands, which are documented to be largely avoided by lions. The impact of wildfire on the statewide mountain lion population or on individual genetic populations is difficult to predict; however, small lion populations in some relatively small mountain ranges (e.g., the Santa Monica and Santa Ana Mountains) may be vulnerable to large, severe fires (e.g., the Woolsey Fire Los Angeles and Ventura Counties in 2018) that could substantially modify large areas of extant lion habitat rapidly, and large fires in key connectivity zones such as the Tehachapi Mountains may temporarily reduce the probability of genetic exchange between populations.

7.6.5 Climate Change

Projections indicate the California climate will continue to warm, and precipitation events will become less predictable and droughts more frequent. These changes will influence the condition and distribution of vegetation types and the animal communities that depend upon them. For example, warming temperatures and/or changing precipitation patterns could affect the quality and density of forage plants relied on by deer in certain areas, thereby potentially affecting mountain lion density. However, the Department is not aware of any bioclimatic modeling studies investigating projected changes in the geographic range of the mountain lion nor their main prey species (mule deer) based on climate variables. As large-bodied mammals, it may be that both mountain lions and mule deer are sufficiently large enough not to be adversely affected directly by moderate increases or decreases in environmental temperature, which more drastically affect small-bodied mammals with higher surface area to volume ratios. The generally nocturnal habits of mountain lions and their prey also help alleviate impacts from warmer environments. Mountain lions are known to occur across a wide variety of ecoregions ranging from deserts to temperate and coastal rainforests in California demonstrating their ability to tolerate a wide range of climates. The mountain lion's body size, foraging habits, and climatic breadth suggests the direct effects of climate change are unlikely to lead to near-term shifts in distribution of the species or population declines.

7.6.6 Risks to Small, Isolated Populations

Small, isolated populations are inherently vulnerable to extinction due to demographic stochasticity, inbreeding depression, and genetic drift. In small populations, these factors, individually or collectively, can result in a loss of genetic variability and a reduced genetic capacity for the population to adapt to changes in the environment. A lack of immigration can also prevent isolated populations from recovering from stochastic extinctions or population declines, independent of genetic effects. In wildlife populations, genetic variation has been shown to be strongly correlated with high survival and reproduction rates, as well as decreased extinction risk. Genetic effects can amplify the impact of the other identified threats and random environmental effects to further reduce population sizes and accelerate populations towards extirpation in what has been termed an extinction vortex.

There are an estimated 947 mountain lions (95% CI: 777–1,123) in the proposed DPS area, with some of the areas like the CC-C and EPR estimated to contain hundreds of mountain lions. However, the smaller and more isolated areas like CC-S, SA, and SGSB each have estimated populations of fewer than 75 individuals each. These genetic populations have effective population sizes less than 50 and may already be adversely affected by inbreeding. In contrast CC-C, and EPR genetic populations show little evidence of inbreeding. Enhancing gene flow between the genetic populations in the proposed DPS and the Sierra Nevada broad-scale group would enhance the potential of long-term persistence of mountain lions throughout the proposed DPS, but until connectivity is significantly improved, the risks associated with small populations will threaten the long-term persistence of mountain lions in the proposed DPS.

8. Protection Afforded by Listing

It is the policy of California to conserve, protect, restore, and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). If the Commission votes to list mountain lion populations as threatened or endangered under CESA, the act would prohibit take[17] except under certain circumstances where both CESA and Fish and Game Code section 4800, et seq. allow CDFW to authorize take.

Additional protection of mountain lions following listing would also occur during required state and local agency environmental review under the California Environmental Quality Act (CEQA). CEQA requires affected public agencies to avoid or substantially reduce project related environmental effects and contains specific requirements for analyzing and mitigating impacts to listed species. Where significant impacts are identified under CEQA, the Department expects the required avoidance, minimization, and

[17] "Take" is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86).

mitigation measures included in approved projects will afford additional protections that would be absent if mountain lions are not listed.

CESA listing may also result in increased priority for limited conservation funds such as those administered by the Wildlife Conservation Board, Local Assistance, and State Wildlife Grants, along with land acquisition assistance from non-governmental organizations (NGOs) such as The Nature Conservancy.

9. Listing Recommendation

CESA directs the Department to prepare this report regarding the status of the mountain lion in the petitioned Southern California/Central Coast ESU based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department, based on its analysis, to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Id., § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Id., § 2067).

The Legislature left to the Department and the Commission, which are responsible for providing the best scientific information and for making listing decisions, respectively, the interpretation of what constitutes a "species or subspecies" under CESA (*Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156 Cal.App.4th 1535, 1548-49; *Central Coast Forest Assn. v. Fish & G. Com.* (2018) 18 Cal. App. 5th 1191, 1198-99). The Commission's authority to list necessarily includes discretion to determine what constitutes a species or subspecies (Id. at p. 1237).

The Department has determined, based upon the best available scientific evidence, that there is currently insufficient evidence that the mountain lions within the petitioned area and the genetic populations within the petitioned area boundary meet the criteria to be considered ESUs. The petitioned ESU, or any combination of its genetic populations, cannot be considered ESUs because they are not both substantially isolated from other populations *and* important components of the evolutionary legacy of the mountain lion species. Although movement of individuals beyond the petitioned area is increasingly restricted, there has been some gene flow between the petitioned ESU and other mountain lion populations, and neither the petitioned ESU nor the genetic populations within it are totally reproductively isolated. Nor are the mountain lions within the petitioned area sufficiently genetically or morphologically differentiated from the larger California population to suggest the presence of distinct evolutionary lineages or evolutionarily important differences. Therefore, the Department concludes there is insufficient scientific evidence to classify the portions of the California mountain lion population petitioned for listing as one or several ESUs.

The Department also examined the petitioned ESU area and population through the lens of federal DPS policy. While the Department did not find the petitioned area to meet the federal criteria to be considered a DPS, the best available scientific evidence shows that a separate but similar area is discrete and biologically significant and meets the criteria to be considered a DPS. Furthermore, evidence indicates that mountain lions in the proposed DPS will become imperiled if management actions do not conserve habitat and restore connectivity between the genetic populations within the DPS as well as with the larger statewide population. Therefore, the Department recommends that the Central Coast and Southern California DPS of mountain lions, as delineated below, be listed as threatened under California law.

The Department's proposed DPS boundary (Fig. 22) would deviate from the petitioned ESU boundary near Mojave California where the petitioned ESU boundary runs east along Highway 58 to Interstate 15 to the California-Nevada border. Instead, the Department proposes a boundary that extends south from Mojave along Highway 14 to its intersection with Highway 138, then east to the intersection with Highway 18, along Highway 18 (which briefly becomes 7th Street in Victorville) to its intersection with Highway 247 in Lucerne Valley, then along Highway 247 to Highway 62, east along Highway 62 to Utah Trail/Park Boulevard/Pinto Basin Road south through Joshua Tree National Park to Interstate 10, then west along I-10 to Highway 86, and south along Highway 86 to the Westside Main Canal of the Imperial Irrigation District near Brawley, then south along the Westside Main Canal to its intersection with the All American Canal; from that intersection due south to the Mexico border and then west to the Pacific coast.

The Department also recommends deviating from the boundary at Interstate 5 near Stockton and using Highway 4 to the west as the DPS boundary until it intersects with Highway 160, then north along 160 to the Contra Costa County line, and from there along the Contra Costa and San Francisco County lines (which are in the middle of San Pablo and San Franciso bays) to the Pacific Coast.

The Department recommends including parts of the Tehachapi Mountains south of Highway 58 in the proposed threatened DPS (as was proposed as the boundary for the petitioned ESU). The genetic characteristics of mountain lions in this and adjacent areas show evidence of connectivity between the primary genetic populations within the DPS and the Western Sierra Nevada genetic population. Therefore, the Department concludes the area is critical for maintaining connection between the proposed DPS and the rest of the state. Highway 58 has been identified as a major barrier to movement of mountain lions (CDFW 2022c), and recent GPS collar location data indicated most lions with home ranges adjacent to or near the highway do not cross it (Vickers unpublished data). Therefore, Highway 58 appears to be the functional boundary between the large Western Sierra Nevada genetic population and smaller genetic populations of the central and south coast of California, and as such, the area south of the highway should be considered part of the proposed threatened DPS.

10. Management and Recovery Action Recommendations

California's statewide mountain lion population is complex and diverse. Large areas of the state appear to have robust, genetically diverse, and well-connected lion populations (e.g., NC and SN groups) while other populations show evidence of inbreeding depression and genetic isolation (e.g., SA, Santa Monica Mountains of the CC-S Genetic investigations have demonstrated the importance of the Sierra Nevada region as a reservoir of genetic variation and a source of migrants into other regions of California (Ernest et al. 2003; Gustafson et al. 2019). The overarching goals of mountain lion management in the state should be:

- Maintaining and enhancing landscape connectivity between robust core populations and the smaller, more isolated populations within the proposed threatened Central Coast and Southern California DPS
- Protecting important patches of remaining habitat within the DPS from development and enhancing degraded habitats where feasible
- Reducing human-related mortality rates within the populations of the DPS

Increased connectivity would help offset the risks to small populations that result from demographic and genetic factors. Benson et al. (2019) found that sustaining mountain lion populations in isolated mountain ranges in greater Los Angeles (Santa Monica and Santa Ana Mountains) is feasible with relatively modest increases in landscape connectivity.

One area critical to restoring and maintaining genetic exchange between genetic populations is the Tehachapi Mountains which serve as the link between the relatively robust Western Sierra Nevada genetic population and the more tenuous Transverse Range populations in the CC-S and SGSB. Mitigating the barriers of Highway 58 and Interstate 5 to allow safer and easier dispersal across those roads should be considered high priorities, as well as the conservation of suitable habitat in the Sierra Pelona, Topatopa, and San Emigdio Mountains. Another critical area is the connection between EPR and SA. The EPR is the only genetic population known to exchange migrants with the SA population, and management actions which enhance gene flow between these areas will be critical to the sustainability and recovery of mountain lions in SA. Dispersal into and out of EPR is limited and the degree of dispersal across the border between the U.S. and Mexico remains unknown (Gustafson et al. 2019). While self-sustaining connectivity through a network of corridors, highway wildlife crossings, and habitat patches with functional ecosystem processes would be ideal for long term sustainability, assisted gene flow between populations through targeted translocations should be considered as a short-term management action to augment the genetic variation of the most isolated small populations.

The specific recommendations below are compiled from sources including the Petitioners, mountain lion researchers, Gustafson et al. (2022), the Department, and others, and are designed to facilitate the above goals.

10.1 Connectivity

- Identify the most strategic locations for wildlife crossing structures at existing roads and highways to improve wildlife connectivity and permeability, and design and build those structures while also protecting adjacent habitat to ensure perpetual wildlife access to the crossing structures and connections (South Coast Wildlands 2008). Crossing infrastructure should include, but is not limited to, overcrossings, underpasses, culverts, and exclusionary fencing that guides animals to safer crossing areas (Vickers et al. 2015). The following crossing locations have been identified by mountain lion experts and should be among the top priorities for the implementation of crossing infrastructure:
    1) Highway 58 near the town of Tehachapi

2) I-5 between the Grapevine and Gorman
3) I-15 Freeway at Temecula Creek Bridge to enhance the Palomar Linkage and connect the Santa Ana and Eastern Peninsular Range (Ernest et al. 2014; Gustafson et al. 2017; Zeller et al. 2017; Riley et al. 2018b)
4) I-280 between San Bruno and Cupertino, which is the "deadliest highway for mountain lions in California" according to Shilling et al. (2023)
5) Highway 101 in the Coyote Valley south of San Jose and at the recently conserved Rocks Ranch in Monterey and San Benito Counties
6) Highway 152 at Pacheco Pass
7) I-15 Freeway at the Santa Margarita Ecological Reserve near Temecula.

- In recognition of the importance of the Sierra Nevada region as a reservoir of genetic variation and significant source of migrants into other regions of California (Ernest et al. 2003; Gustafson et al. 2019; Gustafson et al. 2022), acquire, maintain, and enhance corridors and patches of suitable habitat linking the SN, CC-S, and SGSB, as well as corridors that connect the SA and EPR populations to one another and to SGSB. Emphasize the retention and expansion of protected habitat in the Tehachapi, Sierra Pelona, San Emigdio, Santa Ana, Santa Monica, and San Gabriel Mountains.
- Encourage land use and planning agencies at federal, state, county, and local levels of government to identify important corridors within their area of concern, to develop management plans, and to analyze connectivity impacts from projects, especially in the Tehachapi and Sierra Pelona Mountains (Gustafson et al. 2019) and between the SA and EPR (Vickers et al. 2015).
- Explore conservation translocations of outbred animals (i.e., genetic rescues) to quickly increase genetic variation in small, isolated mountain lion populations such as the Santa Monica Mountains (CC-S) and SA (Johnson et al. 2010). Translocations should only be used as a short-term strategy to help rescue declining populations from the adverse genetic effects of isolation and small population size (e.g., inbreeding). Translocations should not be considered a substitute for actions needed to support self-sustaining viable, genetically diverse populations over the long term, such as removing barriers and increasing landscape connectivity.
- Fund monitoring programs to evaluate the success of wildlife crossing structures, including monitoring the genetic variation and movements of mountain lion populations on either side.
- Dedicate sufficient funding from the Wildlife Conservation Board, Habitat Conservation Fund, and other state funding sources towards acquiring key mountain lion and wildlife habitat and for establishment of highway crossing infrastructure.
- Encourage the maintenance and restoration of riparian vegetation and habitats in the DPS to provide prey habitat, resting and feeding cover, and viable movement corridors between remaining patches of mountain lion habitat. This could include limiting water diversions in these areas if such diversions adversely affect riparian vegetation and wildlife communities.

10.2 Research and Monitoring

While the recommendations below apply statewide, priority should be given to projects that enhance understanding of mountain lion populations and behaviors in the proposed DPS.

- Periodically replicate genetic analyses similar to Gustafson et al.'s (2019 and 2022) work to monitor genetic variation within the genetic populations and signals of mountain lion immigration and emigration.
- Investigate whether heritable local adaptations are present within any of the identified broad-scale and/or fine-scale mountain lion genetic populations.
- Determine mountain lion distribution, abundance, resource selection at multiple spatial scales, movements and dispersal patterns, foraging ecology, and landscape genetics in the Sonoran and Mojave deserts, including the lower Colorado River region. Work collaboratively with tribes, adjacent states, Baja California, universities, other government entities (e.g., Caltrans, BLM, NPS, State Parks, USGS, Military), IUCN and IUCN Species Survival Commission Cat Specialist Group, and other NGOs.
- Develop rigorous population estimates for the individual genetic populations using available demographic data and/or population modeling techniques.
- Monitor wildfire responses to assess how mountain lions, other carnivores, and their prey will be affected by changes in fire frequency and severity.
- Evaluate trans-highway movements, resource selection, home range placement, and vehicle-related mortality of adult and subadult mountain lions (Cougar Management Guidelines Working Group 2005; McKinney 2011). Focus primarily on interstates in the South Coast Group (i.e., I-5, I-10, I-15, 101, 405).
- Investigate the influence of variation in black bear seasonal density on mountain lion kill rates and prey selection, habitat use, and kitten and adult survival. Also investigate areas where bears and mountain lions overlap with gray wolves to understand interactions.
- Design and fund collaborative surveillance programs to rapidly detect, diagnose, and determine the significance of disease outbreaks and emerging diseases such as avian influenza.
- Continue AR screening of livers from mountain lion carcasses to further study the locations and effects of AR exposure on mountain lion health and mortality. Continued monitoring should also measure the effectiveness of regulatory changes intended to reduce exposure of non-target wildlife to rodenticides (Rudd et al. 2018).
- Investigate potential correlations between habitat, genetics, and prevalence of health and disease issues.
- Refine understanding of the conditions associated with human-mountain lion conflict hotspots.
- Assess efficacy of non-lethal measures for mitigating/deterring mountain lions from depredating domestic animals.

10.3 Regulations and Policy

- Work with the California Department of Pesticide Regulation to improve the regulation of, and foster improved management of, second-generation ARs such as brodifacoum, bromadiolone, difenacoum, and difethialone to reduce mountain lion exposure, with an emphasis on Southern California and central coast mountain lion habitat areas and linkages and explore outreach efforts on this issue.
- Improve law enforcement for areas where second-generation AR use is restricted to ensure compliance with the state's regulations.

10.4 Partnerships and Coordination

- Continue to collaborate with Caltrans and others to analyze how projects in the State Highway Operation Protection Program and State Transportation Improvement Program can be designed to facilitate wildlife connectivity through wildlife passage features such as culverts, under crossings, overcrossings, bridges, directional fencing, scuppers, barrier breaks, roadside animal detection systems, signage, etc.
- Continue to collaborate with Caltrans and the Road Ecology Center at UC Davis to help collect and analyze roadkill data to identify hotspots where mountain lions, deer, and other animals are killed. Investigate funding channels for creating an open access statewide roadkill database for data download and analysis as needed by multiple interested parties.
- Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems and native vegetation by buffering the riparian areas to allow use by mountain lions and their prey. Conditions and measures should include provisions for the long-term management of such areas to maintain their viability as wildlife corridors and minimize wildfire threat and human disturbances. Promote efforts to restore riparian ecosystems and protected lands in the vicinity of wildlife crossing structures.

10.5 Public Education

- Continue to promote awareness and education regarding mountain lions, human safety, pet and livestock conflict prevention, pesticide exposure, and conservation messaging throughout the central coast and Southern California.
- Develop and implement outreach and education activities to promote use of predator-resistant enclosures for domestic animals (Vickers et al. 2015).

Literature Cited

Allen, M. L., L. M. Elbroch, D. S. Casady, and H. U. Wittmer. 2015. Feeding and spatial ecology of mountain lions in the Mendocino National Forest, California. California Fish and Game 101:51-65.

Allen, M. L., L. M. Elbroch, and H. U. Wittmer. 2021. Can't bear the competition: Energetic losses from kleptoparasitism by a dominant scavenger may alter foraging behaviors of an apex predator. Basic and Applied Ecology 51:1-10.

Allen, M. L., H. U. Wittmer, and C. C. Wilmers. 2014. Puma communication behaviours: Understanding functional use and variation among sex and age classes. Behaviour 151:819-840. 10.1163/1568539X-00003173

Anderson, C. R., F. G. Lindzey, and D. B. McDonald. 2004. Genetic structure of cougar populations across the Wyoming Basin: Metapopulation or megapopulation. Journal of Mammology 85:1207-1214.

Andreasen, A. M., K. M. Stewart, W. S. Longland, J. P. Beckmann, and M. L. Forister. 2012. Identification of source-sink dynamics in mountain lions of the Great Basin. Molecular Ecology 21:5689-5701. 10.1111/j.1365-294X.2012.05740.x

Bartnick, T. D., T. R. van Deelen, H. B. Quigley, and D. Craighead. 2013. Variation in cougar (*Puma concolor*) predation habits during wolf (*Canis lupus*) recovery in the southern Greater Yellowstone Ecosystem. Canadian Journal of Zoology 91:82-93. 10.1139/cjz-2012-0147

Bedsworth, L., D. Cayan, F. Guido, L. Fisher, and S. Ziaja. 2018. California's Fourth Climate Change Assessment Statewide Summary Report. https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94-108.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. The Journal of Wildlife Management 59:228-237.

Beier, P., and R. H. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California.

Beier, P., D. Choate, and R. H. Barrett. 1995. Movement patterns of mountain lions during different behaviors. Journal of Mammalogy 76:1056-1070.

Beier, P., S. P. D. Riley, and R. M. Sauvajot. 2010. Mountain lions (*Puma concolor*). Pages 141-155 in S. P. D. Riley, B. L. Cypher, and S. D. Gehrt, editors. Urban carnivores: ecology, conflict, and conservation. Johns Hopkins University Press.

Bender, L. C., L. A. Lomas, and J. Browning. 2007. Condition, survival, and cause-specific mortality of adult female mule deer in north-central New Mexico. Journal Of Wildlife Management 71:1118-1124. 10.2193/2006-226

Benson, J. F., K. D. Dougherty, P. Beier, W. M. Boyce, B. Cristescu, D. J. Gammons, D. K. Garcelon, J. M. Higley, Q. E. Martins, A. C. Nisi, and S. P. Riley. 2023. The ecology of human-caused mortality for a protected large carnivore. Proceedings of the National Academy of Sciences 120. 10.1073/pnas

Benson, J. F., P. J. Mahoney, J. A. Sikich, L. E. K. Serieys, J. P. Pollinger, H. B. Ernest, and S. P. D. Riley. 2016. Interactions between demography, genetics, and landscape connectivity increase extinction probability for a small population of large carnivores in a major metropolitan area. Proceedings of the Royal Society B: Biological Sciences 283. 10.1098/rspb.2016.0957

Benson, J. F., P. J. Mahoney, T. W. Vickers, J. A. Sikich, P. Beier, S. P. D. Riley, H. B. Ernest, and W. M. Boyce. 2019. Extinction vortex dynamics of top predators isolated by urbanization. Ecological Applications 29. 10.1002/eap.1868

Benson, J. F., J. A. Sikich, and S. P. D. Riley. 2020. Survival and competing mortality risks of mountain lions in a major metropolitan area. Biological Conservation 241:108294-108294. 10.1016/J.BIOCON.2019.108294

Blakey, R. V., J. A. Sikich, D. T. Blumstein, and S. P. D. Riley. 2022. Mountain lions avoid burned areas and increase risky behavior after wildfire in a fragmented urban landscape. Current Biology 32:4762-4768.e4765. 10.1016/j.cub.2022.08.082

Bornstein, S., T. Mörner, and W. M. Samuel. 2001. *Sarcoptes scabiei* and sarcoptic mange. Pages 107-119 in.

Bruce, J. C. 1953. Cougar Killer. Comet Press Books.

Brunet, M. J., K. L. Monteith, K. S. Huggler, J. G. Clapp, D. J. Thompson, P. W. Burke, M. Zornes, P. Lionberger, M. Valdez, and J. D. Holbrook. 2022. Cats and dogs: A mesopredator navigating risk and reward provisioned by an apex predator. Ecology and Evolution 12:1-15. 10.1002/ece3.8641

Burdett, C. L., K. R. Crooks, D. M. Theobald, K. R. Wilson, E. E. Boydston, L. M. Lyren, R. N. Fisher, T. W. Vickers, S. A. Morrison, and W. M. Boyce. 2010. Interfacing models of wildlife habitat and human development to predict the future distribution of puma habitat. Ecosphere 1. 10.1890/ES10-00005.1

CAL FIRE. 2020. 2020 Incident Archive. Available from: https://www.fire.ca.gov/incidents/2020 (Accessed: 5/21/2024)

California Department of Fish and Wildlife (CDFW). 2013. Human/Wildlife Interactions in California: Mountain Lion Depredation, Public Safety, and Animal Welfare 2013-02. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=68271&inline

California Department of Fish and Wildlife (CDFW). 2014. Ecosystem Restoration Program Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions.

California Department of Fish and Wildlife (CDFW). 2015. California State Wildlife Action Plan 2015 Update.

California Department of Fish and Wildlife (CDFW). 2017. Human/Wildlife Interactions in California: mountain lion depredation, public safety, and animal welfare. Amendment to Department Bulletin 2013-02. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=153021&inline

California Department of Fish and Wildlife (CDFW). 2020a. Amendment to DB2017-17 boundaries and regional guidance team requirements. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=177324&inline

California Department of Fish and Wildlife (CDFW). 2020b. Memo from Wildlife and Fisheries Deputy Director and Law Enforcement Division Chief to Regional Managers regarding statewide mountain lion depredation approach. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=228087

California Department of Fish and Wildlife (CDFW). 2022a. California Natural Diversity Database (CNDDB), Special Animals List.

California Department of Fish and Wildlife (CDFW). 2022b. Mountain lion Depredation Report (2020-2022). https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=217926

California Department of Fish and Wildlife (CDFW). 2022c. Restoring California's Wildlife Connectivity 2022.

California Department of Fish and Wildlife (CDFW). 2023. Caltrans, California Department of Fish and Wildlife and Brightline Agree to Build Wildlife Overcrossings for Rail Project. Available from: https://wildlife.ca.gov/News/Archive/caltrans-california-department-of-fish-and-wildlife-and-brightline-agree-to-build-wildlife-overcrossings-for-rail-project (Accessed: 5/17/24)

California Department of Fish and Wildlife (CDFW). 2024a. Human-Wildlife Conflicts. Available from: https://wildlife.ca.gov/hwc (Accessed: June 20 2024)

California Department of Fish and Wildlife (CDFW). 2024b. Report to the Fish and Game Commission regarding findings of necropsies on mountain lions taken under depredation permits in 2023. Wildlife Health Laboratory, Wildlife Branch, Wildlife and Fisheries Division.

California Department of Fish and Wildlife (CDFW). 2024c. Verified Mountain Lion-Human Attacks. Available from: https://wildlife.ca.gov/Conservation/Mammals/Mountain-Lion/Attacks#:~:text=The%20CDFW%20defines%20a%20mountain%20lion%20attack%20as,the%20injuries%20were%20caused%20by%20a%20mountain%20lion. (Accessed: 6/10/24)

California Department of Fish and Wildlife (CDFW). 2025. Report to the Fish and Game Commission Regarding Findings of Necropsies on Mountain Lions Taken Under Depredation Permits in 2024

California Department of Food and Agriculture (CDFA). 2009. AgVision 2030: Agricultural Land Loss & Conversion. https://www.cdfa.ca.gov/agvision/docs/Agricultural_Loss_and_Conservation.pdf

California Department of Forestry and Fire Protection (CALFIRE). 2010. California's Forests and Rangelands: 2010 Assessment.

California Department of Tax and Fee Administration (CDTFA. 2021. Timber Production Figures (Table 16b). Available from: https://www.cdtfa.ca.gov/dataportal/charts.htm?url=PropTaxTimberProductionStats (Accessed: 5/17/24)

California Department of Water Resources (DWR). 2024. Agriculture. Available from: https://water.ca.gov/Water-Basics/Agriculture (Accessed: 5/20/2024)

California High-Speed Rail Authority. 2024. San José to Merced. Available from: https://hsr.ca.gov/high-speed-rail-in-california/project-sections/san-jose-to-merced/ (Accessed: August 5 2024)

California Natural Resources Agency (CNRA). 2016. Safeguarding California: Implementation Action Plan.

California State Parks (CSP). 2013. General Plan and Final Environmental Impact Report for Big Basin Redwoods State Park.

Caragiulo, A., I. Dias-Freedman, J. A. Clark, S. Rabinowitz, and G. Amato. 2014. Mitochondrial DNA sequence variation and phylogeography of Neotropic pumas (*Puma concolor*). Mitochondrial DNA 25:304-312. 10.3109/19401736.2013.800486

Carter, L., S. Cohen, N. Grimm, and J. Hatfield. 2008. Weather and Climate Extremes in a Changing Climate, Regions of Focus: North America, Hawaii, Caribbean and US Pacific Islands.

Catchen, J. M., P. A. Hohenlohe, L. Bernatchez, W. C. Funk, K. R. Andrews, and F. W. Allendorf. 2017. Unbroken: RADseq remains a powerful tool for understanding the genetics of adaptation in natural populations. Molecular Ecology Resources 17:362-365. 10.1111/1755-0998.12669

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent changes toward earlier springs---Early signs of climate warming in western North America. Watershed Management Council Networker:3-7.

Chávez, C., and G. Ceballos. 2014. Puma (*Puma concolor)*. in G. Ceballos, editor. Mammals of Mexico. John Hopkins University Press.

Cook, B. I., T. R. Ault, and J. E. Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Science Advances 1. 10.1126/sciadv.1400082

Cougar Fund. 2023. The Cougar Fund- State by State. Available from: https://cougarfund.org/our-work/advocacy/state-by-state/ (Accessed: 5/29/24)

Cougar Management Guidelines Working Group. 2005. Cougar management guidelines. 1st edition. Wild Futures, Bainbridge Island, WA.

Country of Ventura Resource Management Agency. 2024. Habitat Connectivity and Wildlife Corridor. Available from: https://vcrma.org/en/habitat-connectivity-and-wildlife-movement-corridors (Accessed: 5/22/24)

Culver, M., W. E. Johnson, J. Pecon-Slattery, and S. J. O'Brien. 2000. Genomic ancestry of the American puma (*Puma concolor*). Journal of Heredity 91:186-197. 10.1093/jhered/91.3.186

Currier, M. J. P. 1983. *Felis concolor*. Mammalian Species:1-7. 10.2307/3503951

Dawson, T. P., S. T. Jackson, J. I. House, I. C. Prentice, and G. M. Mace. 2011. Beyond predictions: biodiversity conservation in a changing climate. Science 332:53-58.

Dellinger, J. A., B. Cristescu, J. Ewanyk, D. J. Gammons, D. Garcelon, P. Johnston, Q. Martins, C. Thompson, T. W. Vickers, C. C. Wilmers, H. U. Wittmer, and S. G. Torres. 2020a. Using mountain lion habitat selection in management. Journal Of Wildlife Management 84:359-371. 10.1002/jwmg.21798

Dellinger, J. A., N. W. Darby, and S. G. Torres. 2019. Factors influencing occupancy and detection rates of mountain lions in the Mojave Desert of California. Southwestern Naturalist 63:248-255.

Dellinger, J. A., K. D. Gustafson, D. J. Gammons, H. B. Ernest, and S. G. Torres. 2020b. Minimum habitat thresholds required for conserving mountain lion genetic diversity. Ecology and Evolution 10:10687-10696. 10.1002/ece3.6723

Dellinger, J. A., D. K. Macon, J. L. Rudd, D. L. Clifford, and S. G. Torres. 2021a. Temporal trends and drivers of mountain lion depredation in California, USA. Human-Wildlife Interactions 15:162-177.

Dellinger, J. A., J. L. Rudd, B. Furnas, M. Buchalski, A. Heeren, V. Monroe, and D. L. Clifford. 2021b. Interim mountain lion conservation assessment – Full Report. Sacramento, CA.

Dellinger, J. A., and S. G. Torres. 2020. A retrospective look at mountain lion populations in California (1906-2018). California Fish and Wildlife Journal 106:66-85.

Dickson, B. G., and P. Beier. 2002. Home-range and habitat selection by adult cougars in Southern California. Journal Of Wildlife Management 66:1235-1245.

Dickson, B. G., J. S. Jenness, and P. Beier. 2005. Influence of vegetation, topography, and roads on cougar movement in Southern California. Journal Of Wildlife Management 69:264-276.

Elbroch, L. M., J. M. Ferguson, H. Quigley, D. Craighead, D. J. Thompson, and H. U. Wittmer. 2020. Reintroduced wolves and hunting limit the abundance of a subordinate apex predator in a multi-use landscape. Proceedings of the Royal Society B: Biological Sciences 287. 10.1098/rspb.2020.2202

Elbroch, L. M., and A. Kusler. 2018. Are pumas subordinate carnivores, and does it matter? PeerJ 6.

Elbroch, L. M., P. E. Lendrum, M. L. Allen, and H. U. Wittmer. 2015a. Nowhere to hide: Pumas, black bears, and competition refuges. Behavioral Ecology 26:247-254. 10.1093/beheco/aru189

Elbroch, M. L., P. E. Lendrum, J. Newby, H. Quigley, and D. J. Thompson. 2015b. Recolonizing wolves influence the realized niche of resident cougars. Zoological Studies 54:1-11. 10.1186/S40555-015-0122-Y

Environmental Protection Agency (EPA). 2017. Updates to the demographic and spatial allocation models to produce Integrated Climate and Land Use Scenarios (ICLUS) Version 2.

Ernest, H. B., W. M. Boyce, V. C. Bleich, B. May, S. J. Stiver, and S. G. Torres. 2003. Genetic structure of mountain lion (*Puma concolor*) populations in California. Conservation Genetics 4:353-366.

Ernest, H. B., T. W. Vickers, S. A. Morrison, M. R. Buchalski, and W. M. Boyce. 2014. Fractured genetic connectivity threatens a Southern California puma (*Puma concolor*) population. PLoS ONE 9. 10.1371/JOURNAL.PONE.0107985

Fitzhugh, E. L., and W. P. Gorenzel. Biological status of mountain lions in California. 1986 1986.

Foley, J., L. Serieys, N. Stephenson, S. Riley, C. Foley, M. Jennings, G. Wengert, W. Vickers, E. Boydston, and L. Lyren. 2016. A synthetic review of notoedres species mites and mange. Parasitology 143:1847-1861.

Foley, J. E., P. Swift, K. A. Fleer, S. Torres, Y. A. Girard, and C. K. Johnson. 2013. Risk factors for exposure to feline pathogens in California mountain lions (*Puma concolor*). Journal of Wildlife Diseases 49:279-293. 10.7589/2012-08-206

Frankham, R. 2005. Genetics and extinction. Biological Conservation 126:131-140. 10.1016/j.biocon.2005.05.002

Frankham, R., J. D. Ballou, and M. D. B. Eldridge. 2011. Predicting the probability of outbreeding depression. Conservation Biology 25:465-475.

Frankham, R., C. J. A. Bradshaw, and B. W. Brook. 2014. Genetics in conservation management: Revised recommendations for the 50/500 rules, Red List criteria and population viability analyses. Biological Conservation 170:56-63. 10.1016/j.biocon.2013.12.036

Frankham, R., D. A. Briscoe, and J. D. Ballou. 2002. Introduction to conservation genetics. Cambridge University Press.

Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135-149 in M. E. Soulé, and B. Wilcox, editors. Conservation Biology: An Evolutionary-Ecological Perspective. Sinauer Associates, U.S.A., Sunderland, Massachusetts.

Frankson, R., L. E. Stevens, K. E. Kunkel, S. M. Champion, D. R. Easterling, W. Sweet, and M. Anderson. 2022. California State Climate Summary 2022. NOAA Technical Report NESDIS 150-CA. Silver Springs, Maryland.

Fuller, A., D. Mitchell, S. K. Maloney, and R. S. Hetem. 2016. Towards a mechanistic understanding of the responses of large terrestrial mammals to heat and aridity associated with climate change. Climate Change Responses 3:1-19. 10.1186/s40665-016-0024-1

Gabriel, M. W., L. W. Woods, R. Poppenga, R. A. Sweitzer, C. Thompson, S. M. Matthews, J. M. Higley, S. M. Keller, K. Purcell, R. H. Barrett, G. M. Wengert, B. N. Sacks, and D. L. Clifford. 2012. Anticoagulant rodenticides on our public and community lands: Spatial distribution of exposure and poisoning of a rare forest carnivore. PLoS ONE 7:e0140640-e0140640. 10.1371/JOURNAL.PONE.0040163

Gabriel, M. W., L. W. Woods, G. M. Wengert, N. Stephenson, J. M. Higley, C. Thompson, S. M. Matthews, R. A. Sweitzer, K. Purcell, R. H. Barrett, S. M. Keller, P. Gaffney, M. Jones, R. Poppenga, J. E. Foley, R. N. Brown, D. L. Clifford, and B. N. Sacks. 2015. Patterns of natural and human-caused mortality factors of a rare forest carnivore, the fisher (*Pekania pennanti*) in California. PLoS ONE 10. 10.1371/JOURNAL.PONE.0140640

Galindo, F., D. Williams, D. González-Rebeles, C. Zarza, H. Ávila-Flores, R. Olea-Perez, and G. Suzán. 2016. Conservation and Livestock Production in Tropical Mexico. in A. A. Aguirre, and R. Sukumar, editors. Tropical Conservation: Perspectives on Local and Global Priorities. Oxford University Press.

Gammon, K. 2024. ‘P-22’s spirit’: new mountain lion seen in LA over a year after celebrity cougar’s death. in The Guardian. London, England.

Gangadharan, A., S. Pollock, P. Gilhooly, A. Friesen, B. Dorsey, and C. C. St. Clair. 2017. Grain spilled from moving trains create a substantial wildlife attractant in protected areas. Animal Conservation 20:391-400. 10.1111/acv.12336

Garcia, R. A., M. Cabeza, C. Rahbek, and M. B. Araújo. 2014. Multiple dimensions of climate change and their implications for biodiversity. Science 344. 10.1126/science.1247579

Gershunov, A., T. Shulgina, R. E. Clemesha, K. Guirguis, D. W. Pierce, M. D. Dettinger, D. A. Lavers, D. R. Cayan, S. D. Polade, and J. Kalansky. 2019. Precipitation regime change in Western North America: the role of atmospheric rivers. Scientific Reports 9:9944.

González-Orozco, C. E., L. J. Pollock, A. H. Thornhill, B. D. Mishler, N. Knerr, S. W. Laffan, J. T. Miller, D. F. Rosauer, D. P. Faith, D. A. Nipperess, H. Kujala, S. Linke, N. Butt, C. Külheim, M. D. Crisp, and B. Gruber. 2016. Phylogenetic approaches reveal biodiversity threats under climate change. Nature Climate Change 6:1110-1114. 10.1038/nclimate3126

Grigione, M. M., P. Beier, R. A. Hopkins, D. Neal, W. D. Padley, C. M. Schonewald, and M. L. Johnson. 2002. Ecological and allometric determinants of home-range size for mountain lions (*Puma concolor*). Animal Conservation 5:317-324. 10.1017/S1367943002004079

Grinnell, J. 1914. Yuma cougar (*Felis oregonensis browni*, Merriam). Pages 251-253 in An Account of the Mammals and Birds of the Lower Colorado Valley. University of California Publications in Zoology.

Grinnell, J., J. S. Dixon, and J. M. Linsdale. 1937. California Mountain Lion. Pages 533-589 in Fur-bearing mammals of California: Their natural history, systematic status, and relations to man. University of California Press, Berkeley, California, USA.

Gupta, R. C. 2012. Veterinary toxicology: basic and clinical principles. Academic Press.

Gustafson, K. D., R. B. Gagne, M. R. Buchalski, T. W. Vickers, S. P. D. Riley, J. A. Sikich, J. L. Rudd, J. A. Dellinger, M. E. F. LaCava, and H. B. Ernest. 2022. Multi‐population puma connectivity could restore genomic diversity to at‐risk coastal populations in California. Evolutionary Applications. 10.1111/eva.13341

Gustafson, K. D., R. B. Gagne, T. W. Vickers, S. P. D. Riley, C. C. Wilmers, V. C. Bleich, B. M. Pierce, M. Kenyon, T. L. Drazenovich, J. A. Sikich, W. M. Boyce, and H. B. Ernest. 2019. Genetic source–sink dynamics among naturally structured and anthropogenically fragmented puma populations. Conservation Genetics 20:215-227. 10.1007/s10592-018-1125-0

Gustafson, K. D., T. W. Vickers, W. M. Boyce, and H. B. Ernest. 2017. A single migrant enhances the genetic diversity of an inbred puma population. Royal Society Open Science 4. 10.1098/rsos.170115

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. Volume II. The Ronald Press Company, New York.

Harding, L. E., J. Heffelfinger, D. Paetkau, E. Rubin, J. Dolphin, and A. Aoude. 2016. Genetic management and setting recovery goals for Mexican wolves (*Canis lupus baileyi*) in the wild. Biological Conservation 203:151-159. 10.1016/j.biocon.2016.09.018

Harmon, L. J., and S. Braude. 2010. Conservation of small populations: effective population sizes, inbreeding, and the 50/500 rule. An introduction to methods and models in ecology, evolution, and conservation biology 47:546-555.

Harmsen, B. J., R. J. Foster, S. M. Gutierrez, S. Y. Marin, and C. P. Doncaster. 2010. Scrape-marking behavior of jaguars (*Panthera onca*) and pumas (*Puma concolor*). Journal of Mammalogy 91:1225-1234. 10.1644/09-MAMM-A-416.1

Hawley, J. E., P. W. Rego, A. P. Wydeven, M. K. Schwartz, T. C. Viner, R. Kays, K. L. Pilgrim, and J. A. Jenks. 2016. Long-distance dispersal of a subadult male cougar from South Dakota to Connecticut documented with DNA evidence. Journal of Mammalogy 97:1435-1440.

Hedrick, P. W., and S. T. Kalinowski. 2000. Inbreeding depression in conservation biology. Annual Review of Ecology and Systematics 31:139-162.

Hosea, R. C. 2000. Exposure of non-target wildlife to anticoagulant rodenticides in California. Proceedings of the Vertebrate Pest Conference 19. 10.5070/v419110029

Howard, A. L., M. J. Clement, F. R. Peck, and E. S. Rubin. 2020. Estimating mountain lion abundance in Arizona using statistical population reconstruction. Journal Of Wildlife Management 84:85-95. 10.1002/jwmg.21769

Huang, X., D. L. Swain, and A. D. Hall. 2020. Future precipitation increase from very high resolution ensemble downscaling of extreme atmospheric river storms in California. Science Advances 6:1-14. 10.1126/sciadv.aba1323

Huffmeyer, A. A., J. A. Sikich, T. W. Vickers, S. P. D. Riley, and R. K. Wayne. 2022. First reproductive signs of inbreeding depression in Southern California male mountain lions (*Puma concolor*): Signs of inbreeding depression in California mountain lions. Theriogenology 177:157-164. 10.1016/j.theriogenology.2021.10.016

Hunter, L. 2015. Wild cats of the world. Bloomsbury Publishing.

Iriarte, J. A., W. L. Franklin, and W. E. Johnson. 1990. Biogeographic variation of food habits and body size of the America puma. Oecologia 85:185-190.

Jennings, M. K., R. L. Lewison, T. W. Vickers, and W. M. Boyce. 2016. Puma response to the effects of fire and urbanization. Journal Of Wildlife Management 80:221-234. 10.1002/jwmg.1018

Jessup, D. A., K. C. Pettan, L. J. Lowenstine, and N. C. Pedersen. 1993. Feline leukemia-virus infection and renal spirochetosis in a free-ranging cougar (*Felis concolor*). Journal of Zoo and Wildlife Medicine 24:73-79.

Johnson, W. E., D. P. Onorato, M. E. Roelke, and E. D. Land. 2010. Genetic restoration of the Florida panther. Science 329:1641-1645.

Karandikar, H., M. W. Serota, W. C. Sherman, J. R. Green, G. Verta, C. Kremen, and A. D. Middleton. 2022. Dietary patterns of a versatile large carnivore, the puma (*Puma concolor*). Ecology and Evolution 12:1-11. 10.1002/ece3.9002

Keeley, J. E. 2005. Fire as a threat to biodiversity in fire-type shrublands. Pages 97-106 in B. E. Kus, and J. L. Beyers, editors. U.S. Forest Service General Technical Report, Albany, California, USA.

Keeley, J. E., and A. D. Syphard. 2016. Climate change and future fire regimes: Examples from California. Geosciences (Switzerland) 6. 10.3390/geosciences6030037

Keeley, J. E., and A. D. Syphard. 2017. Different historical fire-climate patterns in California. International Journal of Wildland Fire 26:253-268. 10.1071/WF16102

Keeley, J. E., and A. D. Syphard. 2021. Large California wildfires: 2020 fires in historical context. Fire Ecology 17. 10.1186/s42408-021-00110-7

Kertson, B. N., R. D. Spencer, and C. E. Grue. 2013. Demographic influences on cougar residential use and interactions with people in western Washington. Journal of Mammalogy 94:269-281. 10.1644/12-mamm-a-051.1

Kitchener, A. C., W. Breitenmoser, E. Eizirik, A. Gentry, L. Werdelin, A. Wilting, N. Yamaguchi, A. V. Abramov, P. Christiansen, C. Driscoll, and J. W. Duckworth. 2017. A revised taxonomy of the *Felidae*: the final report of the Cat Classification Task Force of the IUCN Cat Specialist Group. Cat News.

Kucera, T. E. 1998. Yuma mountain lion (*Felis concolor browni*). California Department of Fish and Game, Sacramento, CA, USA.

Kusler, A., L. M. Elbroch, H. Quigley, and M. Grigione. 2017. Bed site selection by a subordinate predator: an example with the cougar (*Puma concolor*) in the Greater Yellowstone Ecosystem. PeerJ e4010.

Laing, S. P. 1988. Cougar habitat selection and spatial use patterns in southern Utah. University of Wyoming, Laramie, Wyoming, USA.

Langridge, R. 2018. Central Coast Region Summary Report: California's Fourth Climate Change Assessment. University of California, Santa Cruz.

Lazzeri-Aerts, R., and W. Russell. 2014. Survival and recovery following wildfire in the southern range of the coast redwood forest. Fire Ecology 10:43-55. 10.4996/fireecology.1001043

Leopold, A. 1966. A Sand County Almanac. Oxford University Press Inc.

Lewis, J. S., L. LeSueur, J. Oakleaf, and E. S. Rubin. 2022. Mixed-severity wildfire shapes habitat use of large herbivores and carnivores. Forest Ecology and Management 506:119933.

Lindzey, F. G., W. D. Van Sickle, B. B. Ackerman, D. Barnhurst, T. P. Hemker, and S. P. Laing. 1994. Cougar population dynamics in southern Utah. Journal Of Wildlife Management 58:619-624.

Linnell, J. D., J. Odden, M. E. Smith, R. Aanes, and J. E. Swenson. 1999. Large carnivores that kill livestock: do" problem individuals" really exist? Wildlife Society Bulletin:698-705.

Litovitz, T. L., W. Klein-Schwartz, and K. S. Dyer. 1998. 1997 Annual report of the American Association of Poison Control Centers toxic exposure surveillance system. The American Journal of Emergency Medicine 16:443-497.

Logan, K. A. 2019. Puma population limitation and regulation: What matters in puma management? Journal Of Wildlife Management 83:1652-1666. 10.1002/jwmg.21753

Logan, K. A., and L. L. Irwin. 1985. Mountain lion habitats in the Big Horn Mountains, Wyoming. Wildlife Society Bulletin 13:257-262.

Logan, K. A., and L. L. Sweanor. 2001. Desert puma: evolutionary ecology and conservation of an enduring carnivore. Island Press.

Logan, K. A., and L. L. Sweanor. 2010. Behavior and social organization of a solitary carnivore. Pages 105-117 in M. Hornocker, and S. Negri, editors. Cougar ecology and conservation. University of Chicago Press.

Los Angeles County Planning (LACP). 2023. Significant Ecological Areas Program. Available from: https://planning.lacounty.gov/long-range-planning/significant-ecological-areas-program/ (Accessed: 5/22/24)

Los Angeles County Planning (LACP). 2024. Wildlife Ordinance. Available from: https://planning.lacity.gov/plans-policies/wildlife-pilot-study (Accessed: 5/22/24)

Lowry, D. B., S. Hoban, J. Kelley, K. E. Lotterhos, L. K. Reed, M. C. F. Antolin, and A. Torfer. 2017. Breaking RAD: an evaluation of the utility of restriction site-associated DNA sequencing for genome scans of adaptation. Molecular Ecology Resources 17:142-152. 10.1111/1755-0998.12635

Lundgren, E. J., D. Ramp, O. S. Middleton, E. I. F. Wooster, E. Kusch, M. Balisi, W. J. Ripple, C. D. Hasselerharm, J. N. Sanchez, M. Mills, and A. D. Wallach. 2022. A novel trophic cascade between cougars and feral donkeys shapes desert wetlands. Journal of Animal Ecology:1-10. 10.1111/1365-2656.13766

Maehr, D. S., E. C. Greiner, J. E. Lanier, and D. Murphy. 1995. Notoedric mange in the Florida panther (*Felis concolor coryi*). Journal of wildlife Disease 31:251-254. 10.7589/0090-3558-31.2.251

Mahoney, P. J., and J. F. Benson. 2021. An Integrated Population Model for mountain lions based on harvest data in Nevada. Available from: https://www.ndow.org/wp-content/uploads/2021/11/Project-42.pdf (Accessed: July 17 2024)

Maletzke, B. T., R. Wielgus, G. M. Koehler, M. Swanson, H. Cooley, and J. R. Alldredge. 2014. Effects of hunting on cougar spatial organization. Ecology and Evolution 4:2178-2185. 10.1002/ece3.1089

Mansfield, T. M., and R. A. Weaver. 1989. The status of mountain lions in California. Transactions of the Western Section of the Wildlife Society 25:72-76.

Maroni, M., C. Colosio, A. Ferioli, and A. Fait. 2000. Biological monitoring of pesticide exposure: a review. Toxicology 143:1-118.

Marshal, J. P., P. R. Krausman, V. C. Bleich, W. B. Ballard, and J. S. McKeever. 2002. Rainfall, El Niño, and dynamics of mule deer in the Sonoran Desert, California. The Journal of Wildlife Management 66:1283-1289.

McClanahan, K. A., B. N. Duplisea, J. A. Dellinger, and M. W. Kenyon. 2017. Documentation of mountain lion occurrence and reproduction in the Sacramento Valley of California. California Fish and Game 103:7-14.

McIvor, D. E., J. A. Bissonette, and G. S. Drew. 1995. Taxonomic and conservation status of the Yuma mountain lion. Conservation Biology 9:1033-1040.

McKinney, T. D. 2011. Cougar Research and Management Needs. in J. A. Jenks, editor. Utah State University, Logan, Utah.

McLean, D. D. 1954. Mountain lions in California. California Fish and Game 40:146-166.

McMillin, S., M. S. Piazza, L. W. Woods, and R. H. Poppenga. New rodenticide on the block: Diagnosing bromethalin intoxication in wildlife. 2016.

McMillin, S. C., R. C. Hosea, B. F. Finlayson, B. L. Cypher, and A. Mekebri. 2008. Anticoagulant rodenticide exposure in an urban population of the San Joaquin kit fox. Proceedings of the Vertebrate Pest Conference 23:163-165. 10.5070/v423110369

McRae, B. H., P. Beier, L. E. Dewald, L. Y. Huynh, and P. Keim. 2005. Habitat barriers limit gene flow and illuminate historical events in a wide-ranging carnivore, the American puma. Molecular Ecology 14:1965-1977. 10.1111/j.1365-294x.2005.02571.x

Meinke, C. W. 2004. Mountain lion habitat use relative to human activities in and around Redwood National and State Parks of northwest California. Humbolt State University.

Merriam, C. H. 1919. Is the jaguar entitled to a place in the California fauna. Journal of Mammalogy 1:38-40.

Miller, N. L., and N. J. Schlegel. 2006. Climate change projected fire weather sensitivity: California Santa Ana wind occurrence. Geophysical Research Letters 33:1-5. 10.1029/2006GL025808

Mitchell, C. I., K. T. Shoemaker, T. C. Esque, A. G. Vandergast, S. J. Hromada, K. E. Dutcher, J. S. Heaton, and K. E. Nussear. 2021. Integrating telemetry data at several scales with spatial capture–recapture to improve density estimates. Ecosphere 12. 10.1002/ecs2.3689

Monteith, K. L., V. C. Bleich, T. R. Stephenson, B. M. Pierce, M. M. Conner, J. G. Kie, and R. T. Bowyer. 2014. Life-history characteristics of mule deer: Effects of nutrition in a variable environment. Wildlife Monographs:1-62. 10.1002/wmon.1011

Moss, W. E., M. W. Alldredge, K. A. Logan, and J. N. Pauli. 2016. Human expansion precipitates niche expansion for an opportunistic apex predator (*Puma concolor*). Scientific Reports 6. 10.1038/srep39639

Murphy, K. M. 1983. Relationships between a mountain lion population and hunting pressure in western Montana pressure in western Montana. University of Montana.

Naidu, A. 2015. Where mountain lions traverse: Insights from landscape genetics in southwestern United States and northwestern Mexico.

Naidu, A., L. A. Smythe, R. W. Thompson, and M. Culver. 2011. Genetic analysis of scats reveals minimum number and sex of recently documented mountain lions. Journal of Fish and Wildlife Management 2:106-111. 10.3996/042010-JFWM-008

National Human Genome Research Institute (NIH). 2024. Genetic Drift. Available from: https://www.genome.gov/genetics-glossary/Genetic-Drift#:~:text=Genetic%20drift%20is%20the%20change%20in%20frequency%20of,to%20become%20much%20more%20frequent%2C%20and%20even%20fixed. (Accessed: July 15 2024)

National Integrated Drought Information System (NIDIS). 2022. California-Nevada Drought Status Update. Available from: https://www.drought.gov/drought-status-updates/california-nevada-drought-status-update-2 (Accessed: 5/22/24)

National Integrated Drought Information System (NIDIS). 2024. Drought.gov: California. Available from: https://www.drought.gov/states/california (Accessed: 5/22/24)

National Park Service (NPS). 2006. Management of National Park Service Programs. NPS.
National Park Service (NPS). 2021. Puma Profiles: Notable Deaths. Available from: https://www.nps.gov/samo/learn/nature/puma-profiles-notable-deaths.htm (Accessed: 5/21/24)
Naya, D. E., H. Naya, and C. R. White. 2018. On the interplay among ambient temperature, basal metabolic rate, and body mass. American Naturalist 192:518-524. 10.1086/698372
Newberry, J. S. 1857. Reports on the geology, botany, and zoology of Northern California and Oregon. Washington D.C.
Niedringhaus, K. D., J. D. Brown, K. M. Sweeley, and M. J. Yabsley. 2019. A review of sarcoptic mange in North American wildlife. International Journal for Parasitology: Parasites and Wildlife 9:285-297.
Nisi, A. C., J. F. Benson, and C. C. Wilmers. 2022. Puma responses to unreliable human cues suggest an ecological trap in a fragmented landscape. Oikos. 10.1111/oik.09051
Office of Environmental Health Hazard Assessment (OEHHA). 2018. Indicators of Climate Change in California. California Environmental Protection Agency.
Office of Environmental Health Hazard Assessment (OEHHA). 2022. Indicators of Climate Change in California, Fourth Edition. California Environmental Protection Agency.
Office of Environmental Health Hazard Assessment (OEHHA). 2024a. Air Temperatures. Available from: https://oehha.ca.gov/climate-change/epic-2022/changes-climate/air-temperatures (Accessed: July 28 2024)
Office of Environmental Health Hazard Assessment (OEHHA). 2024b. Wildfires. Available from: https://oehha.ca.gov/climate-change/epic-2022/impacts-vegetation-and-wildlife/wildfires (Accessed:
Palstra, F. P., and D. E. Ruzzante. 2008. Genetic estimates of contemporary effective population size: What can they tell us about the importance of genetic stochasticity for wild population persistence? Molecular Ecology 17:3428-3447. 10.1111/j.1365-294X.2008.03842.x
Paterson, S. 2008. Notoedric mange (feline scabies). Pages 115-135 in S. Paterson, editor. Manual of Skin Diseases of the Dog and Cat. Blackwell Publishing, Oxford, UK.
Paul-Murphy, J., T. Work, D. Hunter, E. McFie, and D. Fjelline. 1994. Serologic survey and serum biochemical reference ranges of the free-ranging mountain lion (*Felis concolor*) in California. Journal of Wildlife Diseases 30:205-215. 10.7589/0090-3558-30.2.205
Peebles, K. A., R. B. Wielgus, B. T. Maletzke, and M. E. Swanson. 2013. Effects of remedial sport hunting on cougar complaints and livestock depredations. PLoS ONE 8:e79713. 10.1371/journal.pone.0079713
Peltier, D. M., M. S. Carbone, M. Enright, M. C. Marshall, A. M. Trowbridge, J. LeMoine, G. Koch, and A. D. Richardson. 2023. Old reserves and ancient buds fuel regrowth of coast redwood after catastrophic fire. Nature Plants 9:1978-1985.
Penrod, K. L., and T. Smith. 2022. At-risk habitat and critical linkages for mountain lions in southern California. Science and Collaboration for Connected Wildlands and Center for Large Landscape Conservation.
Pierce, B. M., and V. C. Bleich. 2003. Mountain Lion (*Puma concolor*). Pages 744-757 in G. A. Feldhamer, J. A. Chapman, and B. C. Thompson, editors. Wild mammals of North America: Biology, management, and conservation. The Johns Hopkins University Press., Baltimore, Maryland.
Pierce, B. M., V. C. Bleich, and R. T. Bowyer. 2000. Social organization of mountain lions: does a land-tenure system regulate population size? Ecology 81:1533-1543.
Plaza, P. I., V. Gamarra-Toledo, J. R. Euguí, and S. A. Lambertucci. 2024. Recent changes in patterns of mammal infection with highly pathogenic avian Influenza A (H5N1) virus worldwide. Emerging Infectious Diseases 30:444.

Primack, R. B. 1993. Essentials of conservation biology. Sinauer Associates Inc., Sunderland, Massachusetts, USA.

Quigley, H., and M. Hornocker. 2009. Cougar population dynamics. Pages 59-75 in M. Hornocker, and S. Negri, editors. Cougar: ecology and conservation. University of Chicago Press.

Rapacciuolo, G., S. P. Maher, A. C. Schneider, T. T. Hammond, M. D. Jabis, R. E. Walsh, K. J. Iknayan, G. K. Walden, M. F. Oldfather, D. D. Ackerly, and S. R. Beissinger. 2014. Beyond a warming fingerprint: Individualistic biogeographic responses to heterogeneous climate change in California. Global Change Biology 20:2841-2855. 10.1111/gcb.12638

Reed, D. H., and R. Frankham. 2003. Correlation between fitness and genetic diversity. Conservation Biology 17:230-237.

Riley, S. P., J. G. Moriarty, J. A. Sikich, and J. Brown. 2018a. NPS Wildife Report for CDFW 2016-18. National Park Service, Santa Monica Mountains National Recreation Area.

Riley, S. P. D., C. Bromely, R. H. Poppenga, F. A. Uzal, L. Whited, and R. M. Sauvajot. 2007. Anticoagulant exposure and notoedric mange in bobcats and mountain lions in urban southern California. Journal Of Wildlife Management 71:1874-1884. 10.2193/2005-615

Riley, S. P. D., L. E. K. Serieys, J. P. Pollinger, and J. A. Sikich. 2014. Individual behaviors dominate the dynamics of an urban mountain lion population isolated by roads. Current Biology 24::1989-1994.

Riley, S. P. D., J. A. Sikich, and J. F. Benson. 2021. Big cats in the big city: spatial ecology of mountain lions in greater Los Angeles. Journal Of Wildlife Management 85:1527-1542. 10.1002/jwmg.22127

Riley, S. P. D., T. Smith, and T. W. Vickers. 2018b. Assessment of wildlife crossing sites for the Interstate 15 and Highway 101 freeways in southern California.

Robinette, W. L., J. S. Gashwiler, and O. W. Morris. 1961. Notes on cougar productivity and life history. Journal of Mammalogy 42:204-217.

Roelke, M. E., J. S. Martenson, and S. J. O'Brien. 1993. The consequences of demographic reduction and genetic depletion in the endangered Florida panther. Current Biology 3:340-350.

Rosas-Rosas, O. C., L. C. Bender, and R. Valdez. 2008. Jaguar and puma predation on cattle calves in northeastern Sonora, Mexico. Rangeland Ecology and Management 61:554-560. 10.2111/08-038.1

Rosas-Rosas, O. C., and R. Valdez. 2010. The role of landowners in jaguar conservation in Sonora, Mexico. Conservation Biology 24:366-371. 10.1111/j.1523-1739.2009.01441.x

Rosas-Rosas, O. C., R. Valdez, L. C. Bender, and D. Daniel. 2003. Food habits of pumas in northwestern Sonora, Mexico. Wildlife Society Bulletin 31.

Royle, J. A., R. B. Chandler, R. Sollmann, and B. Gardner. 2013. Spatial capture-recapture. Academic press.

Rudd, J. L., D. L. Clifford, B. L. Cypher, and J. M. Hull. 2020a. Use of flumethrin-impregnated collars to manage an epidemic of sarcoptic mange in an urban population of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*). Journal of Zoo and Wildlife Medicine 51:631-642.

Rudd, J. L., B. Crossley, A. Mete, L. Woods, O. Gonzales-Viera, N. Streitenberger, R. Moeller, K. Watson, R. Roberts, P. Johnston, D. Garcelon, E. Paton, and D. L. Clifford. 2024. Mortalies associated with highly pathogenic Avian Influenza H5N1 in California wild mammals, in The Wildlife Society Western Section Annual Meeting.

Rudd, J. L., S. McMillin, M. W. Kenyon Jr., R. H. Poppenga, and D. L. Clifford. 2019. Anticoagulant rodenticide exposure in California mountain lions (*Puma concolor*), in The Wildlife Society Western Section Annual Meeting.

Rudd, J. L., S. C. McMillin, M. W. Kenyon, D. L. Clifford, and R. H. Poppenga. 2018. Prevalence of first and second-generation anticoagulant rodenticide exposure in California mountain lions (*Puma concolor*). Proceedings of the Vertebrate Pest Conference 28:240-243. 10.5070/v42811046

Rudd, J. L., K. Rodgers, and N. Shirkey. 2020b. 2020 Summary of pesticide exposures & mortalities in wildlife. California Department of Fish & Wildlife

Rudd, J. L., and K. Rogers. 2021. Anticoagulant rodenticide exposure in non-target wildlife. in.

Rudd, J. L., K. Rogers, and B. Munk. 2021. 2021 Summary of pesticide exposures & mortalities in non-target wildlife. California Department of Fish & Wildlife.

Rudd, J. L., K. Rogers, and N. Shirkey. 2022. 2022 Summary of pesticide exposures & mortalities in non-target wildlife. California Department of Fish & Wildlife.

Ruth, T. K., and K. Murphy. 2009. Diet and prey selection of a perfect predator. in M. Hornocker, and S. Negri, editors. Cougar Ecology and Conservation. University of Chicago Press, Chicago.

Saremi, N. F., M. A. Supple, A. Byrne, and J. A. Cahill. 2019. Puma genomes from North and South America provide insights into the genomic consequences of inbreeding. Nature 10:1-10.

Serieys, L. E. K., T. C. Armenta, J. G. Moriarty, E. E. Boydston, L. M. Lyren, R. H. Poppenga, K. R. Crooks, R. K. Wayne, and S. P. D. Riley. 2015. Anticoagulant rodenticides in urban bobcats: exposure, risk factors and potential effects based on a 16-year study. Ecotoxicology 24:844-862. 10.1007/s10646-015-1429-5

Serieys, L. E. K., J. Foley, S. Owens, L. Woods, E. E. Boydston, L. M. Lyren, R. H. Poppenga, D. L. Clifford, N. Stephenson, J. Rudd, and S. P. D. Riley. 2013. Serum chemistry, hematologic, and post-mortem findings in free-ranging bobcats (*Lynx rufus*) with notoedric mange. Journal of Parasitology 99:989-996. 10.1645/12-175.1

Serieys, L. E. K., A. J. Lea, M. Epeldegui, T. C. Armenta, J. Moriarty, S. Vandewoude, S. Carver, J. Foley, R. K. Wayne, S. P. D. Riley, and C. H. Uittenbogaart. 2018. Urbanization and anticoagulant poisons promote immune dysfunction in bobcats. Proceedings of the Royal Society B: Biological Sciences 285. 10.1098/rspb.2017.2533

Shaffer, M. L., and B. A. Stein. 2000. Safeguarding our precious heritage. in B. Stein, L. S. Kutner, and J. S. Adams, editors. Precious Hheritage: The status of biodiversity in the United States. Oxford University Press.

Shilling, F., D. Waetjen, and W. T. Vickers. 2023. California Wildlife-Vehicle Conflict Report P-22 Edition.

Sitton, L. W. 1977. California mountain lion investigations with recommendations for management.

Smallwood, K. S. 1994. Trends in California mountain lion populations. Southwestern Naturalist 39:67-72. 10.2307/3672195

Smith, J. A., Y. Wang, and C. C. Wilmers. 2016. Spatial characteristics of residential development shift large carnivore prey habits. Journal Of Wildlife Management 80:1040-1048. 10.1002/jwmg.21098

Soulé, M. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-169 in M. E. Soulé, and B. A. Wilcox, editors. Conservation biology: an evolutionary-ecological perspective.

South Coast Wildlands. 2008. South Coast Missing Linkages: A Wildland Network for the South Coast Ecoregion. http://www.scwildlands.org.

Stephens, F. 1906. California Mammals. The West Coast Publishing Company, San Diego, CA.

Stoner, D. C., W. R. Rieth, M. L. Wolfe, M. B. Mecham, and A. Neville. 2008. Long-distance dispersal of a female cougar in a Basin and Range landscape. Journal Of Wildlife Management 72:933-939. 10.2193/2007-219

Stoner, D. C., J. O. Sexton, D. M. Choate, J. Nagol, H. H. Bernales, S. A. Sims, K. E. Ironside, K. M. Longshore, and T. C. Edwards. 2018. Climatically driven changes in primary production propagate through trophic levels. Global Change Biology 24:4453-4463. 10.1111/gcb.14364

Sweanor, L. L., K. A. Logan, and M. G. Hornocker. 2000. Cougar dispersal patterns, metapopulation dynamics, and conservation.

Sweitzer, R. A., S. H. Jenkins, and J. Berger. 1997. Near-extinction of porcupines by mountain lions and consequences of ecosystem change in the Great Basin Desert. Conservation Biology 11:1407-1417.

Sykes, J. E. 2014. Feline panleukopenia virus infection and other viral enteritides. Pages 187-194 in J. E. Sykes, editor. Canine and Feline Infectious Diseases. Elsevier Health Sciences.

Syphard, A. D., V. C. Radeloff, T. J. Hawbaker, and S. I. Stewart. 2009. Conservation threats due to human-caused increases in fire frequency in mediterranean-climate ecosystems. Conservation Biology 23:758-769. 10.1111/j.1523-1739.2009.01223.x

Syphard, A. D., V. C. Radeloff, J. E. Keeley, T. J. Hawbaker, M. K. Clayton, S. I. Stewart, and R. B. Hammer. 2007. Human influence on California fire regimes. Ecological Applications 17:1388-1402.

Thompson, R. A., J. O. D. Munig, C. Laberge, and S. Poppenberger. Proceedings of the Ninth Mountain Lion Workshop. 2008.

Thorne, J. H., R. M. Boynton, A. J. Holguin, J. A. E. Stewart, and J. Bjorkman. 2016. A climate change vulnerability assessment of California's terrestrial vegetation. Sacramento, CA, USA.

Thurman, L. L., K. Alger, O. LeDee, L. M. Thompson, E. Hofmeister, J. M. Hudson, A. M. Martin, T. A. Melvin, S. H. Olson, and M. Pruvot. 2024. Disease ‐ smart climate adaptation for wildlife management and conservation. Frontiers in Ecology and the Environment:e2716.

Torres, S. G., T. M. Mansfield, J. E. Foley, T. Lupo, and A. Brinkhaus. 1996. Mountain lion and human activity in California: testing speculations. Wildlife Society Bulletin 24:451-460.

Uzal, F. A., R. S. Houston, S. P. D. Riley, R. Poppenga, J. Odani, and W. Boyce. 2007. Notoedric mange in two free-ranging mountain lions (*Puma concolor*). Journal of Wildlife Diseases 43:274-278. 10.7589/0090-3558-43.2.274

Valdez, R. 1999. Jaguar. in S. Demarais, and P. R. Krausman, editors. Ecology and management of large mammals in North America.

Valdez, R., and J. A. Ortega-Santos. 2019. Wildlife ecology and management in Mexico. Texas A&M University Press.

Veklerov, K. 2018. Orphaned mountain lion cubs at Oakland Zoo part of trend in California. in San Francisco Chronicle.

Ventura County. 2019. Ordinances 4537 and 4539.

Verhagen, J. H., R. A. M. Fouchier, and N. Lewis. 2021. Highly pathogenic avian influenza viruses at the wild–domestic bird interface in europe: Future directions for research and surveillance. Viruses 13. 10.3390/v13020212

Vickers, T. W., J. N. Sanchez, C. K. Johnson, S. A. Morrison, R. Botta, T. Smith, B. S. Cohen, P. R. Huber, H. B. Ernest, and W. M. Boyce. 2015. Survival and mortality of pumas (*Puma concolor*) in a fragmented, urbanizing landscape. PLoS ONE 10. 10.1371/JOURNAL.PONE.0131490

Vickers, T. W., T. Smith, and B. Cohen. 2017. Mountain lion (*Puma concolor*) connectivity in the north San Diego county Multi-Species Conservation Plan area.

Vickers, W., and D. Garcelon. 2022. U.C. Davis – Southern and northeastern California cougar projects - 2021 annual report.

Wang, Y., J. A. Smith, and C. C. Wilmers. 2017. Residential development alters behavior, movement, and energetics in an apex predator, the puma. PLoS ONE 12. 10.1371/journal.pone.0184687

Waples, R. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of "Species" under the Endangered Species Act. Marine Fisheries Review 53:11-22.

Washington Department of Fish and Wildlife (WDFW). 2022. Cougars give as good as they get with Washington wolves. Available from: https://wdfw.medium.com/cougars-give-as-good-as-they-get-with-washington-wolves-ecb00ec61338 (Accessed:

Wengert, G. M., M. W. Gabriel, S. M. Matthews, J. M. Higley, R. A. Sweitzer, C. M. Thompson, K. L. Purcell, R. H. Barrett, L. W. Woods, R. E. Green, S. M. Keller, P. M. Gaffney, M. Jones, and B. N. Sacks. 2014. Using DNA to describe and quantify interspecific killing of fishers in California. Journal Of Wildlife Management 78:603-611. 10.1002/jwmg.698

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940-943. 10.1126/SCIENCE.1128834

White, L. A., J. D. Forester, and M. E. Craft. 2018. Disease outbreak thresholds emerge from interactions between movement behavior, landscape structure, and epidemiology. Proc Natl Acad Sci U S A 115:7374-7379. 10.1073/pnas.1801383115

Wikipedia. 2024. Southern California. Available from: https://en.wikipedia.org/wiki/Southern_California (Accessed: June 20 2024)

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. 10.1002/2015GL064924

Williams, D. F. 1986. Yuma mountain lion (*Felis concolor browni*). In: Mammal Species of Special Concern in California.

Williams, J. N., H. D. Safford, N. Enstice, Z. L. Steel, and A. K. Paulson. 2023. High - severity burned area and proportion exceed historic conditions in Sierra Nevada, California, and adjacent ranges. Ecosphere 14. 10.1002/ecs2.4397

Williams, S. E., L. P. Shoo, J. L. Isaac, A. A. Hoffmann, and G. Langham. 2008. Towards an integrated framework for assessing the vulnerability of species to climate change. PLoS Biology 6. 10.1371/JOURNAL.PBIO.0060325

Wilmers, C. C. 2014. Mountain view puma (46m) killed on Highway 280. Available from: https://www.santacruzpumas.org/2014/10/mountain-view-puma-46m-killed-on-highway-280/ (Accessed: June 25 2024)

Wilmers, C. C., Y. Wang, B. Nickel, P. Houghtaling, Y. Shakeri, M. L. Allen, J. Kermish-Wells, V. Yovovich, and T. Williams. 2013. Scale dependent behavioral responses to human development by a large predator, the puma. PLoS ONE 8. 10.1371/JOURNAL.PONE.0060590

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 65:200-207.

Yap, T., B. Cummings, and J. P. Rose. 2019. A petition to list the southern California/Central Coast Evolutionarily Significant Unit (ESU) of mountain lions as threatened under the California Endangered Species Act (CESA).

Young, S. P., and E. A. Goldman. 1946. Puma, mysterious American cat. The American Wildlife Institute, Washington, D.C.

Zeller, K. A., T. W. Vickers, H. B. Ernest, and W. M. Boyce. 2017. Multi-level, multi-scale resource selection functions and resistance surfaces for conservation planning: Pumas as a case study. PLoS ONE 12. 10.1371/JOURNAL.PONE.0179570

Appendix A – Acronyms, Abbreviations, and Definitions

Caltrans – California Department of Transportation

CAL FIRE – California Department of Forestry and Fire Protection

CDFW – California Department of Fish and Wildlife

CEQA – California Environmental Quality Act

CESA – California Endangered Species Act

Commission – Fish and Game Commission

Department – California Department of Fish and Wildlife

Distinct Population Segment (DPS) – A vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species.

Effective Population Size (Ne) – The number of individuals in a population that effectively participate in producing the next generation.

Evolutionary Significant Unit (ESU) – A term related to the federal Endangered Species Act originally applied to anadromous fish populations that designates a population that is substantially reproductively isolated from conspecific populations *and* represents an important component of the evolutionary legacy of the species.

F_{ST} – Fixation index. A statistic that measures population differentiation based on genetic structure.

Fine-Scale Genetic Populations – Populations of conspecifics whose growth rate depends predominantly on local births and deaths rather than immigration. Genetic populations discussed in this report include:

Central Coast North (CC-N) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes mountain lions in the Santa Cruz Mountains and east bay hills, extending south to approximately the Monterey County line.

Central Coast Central (CC-C) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which generally includes the mountain lions in the coastal mountain ranges from southern Monterey Bay to Ventura County.

Central Coast South (CC-S) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes the mountain lions in the Santa Monica Mountains, Santa Susana Mountains, Sierra Pelona Mountains, and Simi Hills.

Eastern Peninsular Range (EPR) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes the mountain lions in eastern San Diego County to the Colorado River and the border with Arizona and is bounded on the south by the border with Mexico.

Eastern Sierra Nevada (ESN) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes the mountain lions in the mountains of San Diego County, extending east possibly as far as the Colorado River and the Arizona border, and bounded on the south by the border with Mexico.

Nevada (NV) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which encompasses mountain lions in most of the state of Nevada.

San Gabriel and San Bernardino Mountains (SGSB) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses and includes mountain lions in the San Gabriel and San Bernardino mountain ranges.

Santa Ana Mountains (SA) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses that encompasses mountain lions in the Santa Ana Mountains.

Western Sierra Nevada (WSN) – The genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses that includes mountain lions from the Oregon border through the Cascades and Sierra Nevada Mountains to the Tehachapi Mountains and includes the Sierra Nevada foothills and much of the Central Valley.

Genetic Groups / Broad-Scale Genetic Groups – The four genetic groups for which Gustafson et al. (2022) found the strongest support through SNP analysis. These groups include:

Central Coast Group – Mountain lions from the San Francisco Bay and Sacramento-San Joaquin Delta south through the Santa Monica Mountains inclusive of Gustafson et al.'s (2019) Central Coast-North, Central Coast-Central, and Central Coast-South genetic populations.

North Coast Group – Mountain lions north of San Francisco Bay through the Coast Ranges to border with Oregon. Largely coincident with Gustafson et al.'s (2019) North Coast genetic population.

Sierra Nevada Group – Mountain lions from the Klamath, Cascades, and Sierra Nevada mountains from the Oregon border south through the Tehachapi Mountains inclusive of Gustafson et al.'s (2019) Western Sierra Nevada and Eastern Sierra Nevada genetic populations.

Southern Coast Group – Mountain lions in the San Gabriel and San Bernardino, Santa Ana, and Eastern Peninsular mountains inclusive of Gustafson et al.'s (2019) San Gabriel-San Bernardino, Santa Ana, and Eastern Peninsular Range genetic populations.

Microsatellite Markers – Repetitive segments of DNA scattered throughout the genome in noncoding regions between genes or within genes.

NMFS – National Marine Fisheries Service

NPS – National Park Service

Principal Component Analysis (PCA) – A statistical multivariate technique which transforms a large number of correlated variables into few uncorrelated variables which represents the whole data set.

Single Nucleotide Polymorphism (SNP) – a variation in nucleotides at a single position in a DNA sequence among individuals.

State Wildlife Action Plan – California's comprehensive plan for examining the health of wildlife populations and prescribing actions to conserve wildlife and vital habitat before they become more rare and more costly to protect.

USFS – U.S.D.A. Forest Service

USFWS – United States Fish and Wildlife Service

WDFW – Washington Department of Fish and Wildlife

APPENDIX B – Solicitation of information and comments received

Tribal Notification and Information Solicitation

Pursuant to Fish and Game Code section 2074.4, the California Department of Fish and Wildlife (Department) and the California Fish and Game Commission (Commission) notified affected and interested parties and solicited data and comments on the petitioned action to list mountain lions in central and southern California as one or more threatened or endangered evolutionarily significant units (ESU) under the California Endangered Species Act (CESA).

Tribal notifications were distributed by letter and email to tribes identified by the Native American Heritage Commission as having a cultural or traditional affiliation within the geographic area of the mountain lion. The tribal notice for the status review was dated May 13, 2020, and is provided at the end of this Appendix.

The Department received six comments in response to tribal notifications.

Summary of Tribal Comments Received

All six tribal responses came via email, and four tribes were supportive of protecting mountain lions, while the San Manuel Band of Mission Indians (SMBMI) stated they did not need to consult with the Department, and the Yocha Dehe tribe indicated a cultural interest in the mountain lion and the petitioned ESU. A brief summary of the tribal input is provided below.

San Manuel Band of Mission Indians (SMBMI) - stated "the SMBMI does not elect to consult with CA DFW on the status review of mountain lions in California".

Pala Band of Mission Indians - Pala agrees the mountain lions need protections...and Pala actively works to protect their lands and have cooperated with researchers such as Dr. Vickers, and they hope no undue burdens will be placed on their management on Tribal lands and that their sovereignty is respected in all decisions on this ESU.

Dunlap Band of Mono Indians - Dirk Charley (Tribal Secretary) spoke via telephone with Department staff on June 10, 2020, with an elder tribal member listening in. Notes from the conversation were recorded for the record by the Department at Mr. Charley's request. Summary of Mr. Charley's comments:

We admire and respect mountain lions; a creature of beauty; we know where they live and we don't disturb their caves and dens; we don't see them as a threat; humans have always lived with them; they should not be bountied, there are too few of them; we leave them alone; they have remained in the same number. He added that he worked as a firefighter for the USFS in the past and was able to see a mountain lion in the San Gabriel mountains while flying over the area in a helicopter in 1979-1980.

Rincon Band of Luiseño Indians - In their July 16, 2020 letter to the Department, the tribe asked to be notified and updated throughout the review process. They support listing of the mountain lion as an endangered species and consulted with the Department on June 24, 2020.

Yocha Dehe Cultural Resources - "The Cultural Resources Department has reviewed the [Mountain Lion ESU Review Policy] policy and concluded that it applies to areas within the aboriginal territories of the Yocha Dehe Wintun Nation. Therefore, we have a cultural interest and authority in the proposed policy and would like to receive updates on the policy".

Santa Ynez Band of Chumash Indians - "The Chumash people have a special relationship with Mountain Lions and support this continued CESA listing". Their ancestral land is near the highway 101 Wallis-Annenberg overcrossing that is now under construction. They attached a large report depicting connectivity maps from the Santa Monica Mountains to points north toward the Simi Hills, Los Padres National Forest, and the Santa Clara River (State of the Linkage Report: East Branch of the Santa Monica-Sierra Madre Mountains Connection, dated January 2021).

All communications are on file with the Department and can be provided on request by emailing wildlifemgt@wildlife.ca.gov.

Public Solicitation

Pursuant to Fish and Game Code section 2074.4, the Department and Commission notified affected and interested parties and solicited data and comments on the petitioned action to list mountain lions in central and southern California as one or more threatened or endangered ESUs under CESA.

Requests for information were distributed by several methods:

On May 1, 2020, the Commission published a Notice of Findings regarding the candidacy and status review of the petitioned mountain lion ESU in the California Regulatory Notice Register (Cal. Reg. Notice Register 2000, No. 18-Z, p. 692).

On May 21, 2020, at the request of the Department, Fish and Game Commission staff utilized their confidential CESA Interested Parties list to notify interested parties of the initiation of the status review and to solicit data and comments on the petitioned action from interested and affected parties. Comments were directed to the Department contact.

Notifications were sent to the Petitioners (Center for Biological Diversity and Mountain Lion Foundation), and researchers studying mountain lions in California.

Notifications were sent to California Assemblyman Frank Bigelow, California Senator Henry Stern, California Cattlemen’s Association, California Building Industry Association, California Association of Winegrape Growers, California Farm Bureau Federation, and California Woolgrowers Association.

Notifications were sent to 27 county-level Fish and Game Commissions and 32 county Board of Supervisors offices in California from counties within and adjacent to the petitioned area.

State of California departments notified included Caltrans, Pesticide Regulation, Parks and Recreation, and Food and Agriculture.

Federal agencies notified included select military bases, U.S. Forest Service, National Park Service, and the Bureau of Land Management. Additionally, the U.S. Geological Survey and the U.S. Fish and Wildlife Service (USFWS) in southern California was notified. The USFWS then forwarded the notice to the southern California Tri-County Connectivity Group via email.

Environmental entities notified included Defenders of Wildlife, National Wildlife Foundation, and the Sierra Club. Multiple county and city land managers, land trusts and conservancies were also notified. The Coachella Valley Association of Governments was also notified.

The public notification can be found at the end of this Appendix.

Summary of Public Comments Received

The Department received 253 letters or emails in total, including 226 form letters in support of listing from the public, some of whom were affiliated with Born Free USA, or In Defense of Animals. The Humane Society of the United States sent a letter in support of listing. Six letters were from state or local governments, though some were only acknowledgement of receipt of notice. Caltrans commented that they would like to work in partnership with the Department to minimize mountain lion mortality from vehicle strikes and to cooperate on building safe crossing structures for mountain lions. California State Park biologists provided information on lion distribution on State Parks lands. Mountain lion researchers in California provided reports of their work, publications, roadkill information, and various maps, for example, home ranges and dispersal paths of mountain lions. Dr. Fraser Shilling at UC Davis Road Ecology Center provided lion roadkill locations.

The Center for Biological Diversity sent two supplemental comment letters after their initial response to the public notice and provided e-copies of the literature they cited. Tanya Diamond with Pathways for Wildlife sent reports and roadkill data for the San Francisco Bay Area. One respondent needed assistance in engaging with the method to communicate with the Commission and provide comments on the petition. Six of the responses were from the public with no affiliation noted and were in support of listing. Other letters or emails supported research and connectivity efforts for mountain lions in the petitioned ESU but did not directly advocate for listing.

Two respondents sent similar emails in opposition to the ESU petition for listing of mountain lions in regard to the significant impact mountain lions can have on deer, bighorn sheep, and pronghorn antelope populations, along with livestock and pets.

The Department also received two substantive comments as follows:

The Tulare County Board of Supervisors sent a letter to register their opposition to the mountain lion ESU petition. Their concerns included the potential for impacting new development and limiting construction, along with changing how state and local agencies plan and build infrastructure which in turn could lead to higher costs and bigger roadblocks to development. They also voiced concern that listing could threaten local government’s ability to thrive in a changing economy.

The Colusa County Fish & Game Advisory Commission requested that the petition to list the evolutionary significant unit (ESU) of mountain lions be denied. Their email stated that mountain lions are already protected in the State of California, and additional protections will only be detrimental to the other species, such as deer that have been negatively impacted by the lion population in the State.

All communications are on file with the Department and can be provided on request by emailing wildlifemgt@wildlife.ca.gov.

APPENDIX C – External Peer Review Comments

Pursuant to Fish and Game Code section 2074.6, the review process included independent peer review of the draft status review by persons in the scientific/academic community acknowledged to be experts on mountain lions and related topics and possessing the knowledge and expertise to critique the scientific validity of the status review contents. Appendix C contains the version of the status review sent to external reviewers, specific input provided to the Department by the individual peer reviewers, and the Department's written response to the input (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). Independent experts that reviewed the Status Review are listed below (Table C1).

Table C1. Status Review peer reviewers.

Name	Affiliation
Seth Riley	National Park Service
Winston Vickers	University of California Davis
Chris Wilmers	University of California Santa Cruz
Holly Ernest	University of California Davis University of Wyoming
Paul Beier	Northern Arizona University

Comments by external reviewers are below, along with responses from the Department. Line numbers refer to the lines in the version of the status review sent to external reviewers (available at the end of the Appendix).

GENERAL COMMENT (Riley): Overall, the draft status review is an impressive document, covering a great deal of different topics about science and conservation related to mountain lions in the state, and in the coastal areas in particular. We appreciate the large amount of work that many folks in the Department have put into producing it. I enjoyed reading it and thinking about all of these important issues. I have many comments about the document, which I hope are helpful as you work to finalize it. Most of my comments, and all of the more substantive ones, I have put into the excel spreadsheet that you provided. There are also some comments or suggestions that are more minor, such as grammatical suggestions, typos that I noticed, or references that need more information. If those would also be useful, we could figure out a way to communicate those, just let me know. Although I have more than 180 comments overall, I will note that there is some repetition, since a particular comment is relevant in multiple places in the document (for example, mentioning that we have directly documented cases of close inbreeding in our study population). I will note also that in places where I suggest referencing or including mention of work that we have been involved with or results that we have found, it is because I think doing so would add clarity and value to the document, not to increase our citations or draw further attention to our work. Overall, in reference to the specifics of the California Endangered Species Act and its implementing regulations that you reference in your letter of November 2, 2023, I would agree with the conclusion that for mountain lions in parts of the petitioned area, including in the South Coast DPS that is proposed on p.102 of the document, they are in serious danger of becoming extinct due to the causes of loss of habitat and especially the continued fragmentation of their remaining habitat, which represents a "human-related activity."

Relative to the approach of evaluating Distinct Population Segments, I agree that this approach makes sense, and I definitely think it was valuable to evaluate smaller units that just the entire petitioned area. We do have thoughts on the boundaries of a potential South Coast DPS, as we provide below.

I would say the most significant comment that we have overall is that we believe that another management unit would be valuable to consider for listing as a distinct population segment, or rather as part of the proposed South Coast DPS. And that based on the current criteria, along with some other criteria that we believe are worthy of consideration, we believe that such a management unit may also qualify for listing in the same way that the current document proposes to list the Southern Coast DPS (p.100-103, map p.102). Specifically, we would propose extending the northern border of the proposed South Coast DPS to the west from where Highway 14 crosses the Santa Clara River, across the 5 Freeway and along the Santa Clara River and Highway 126 through Lake Piru, Fillmore, and Santa Paula to Ventura. This would mean that the South Coast DPS would include the Santa Monica Mountains, where we have been studying the species intensively for the last almost 22 years, and where the population is largely isolated from other areas of suitable habitat and faces multiple current challenges. Importantly, the DPS would also include the two areas of habitat to the north of the Santa Monica Mountains, the Simi Hills, which are north of the 101 Freeway but south of Highway 118, and the Santa Susana Mountains, which are north of Highway 118 and south of Highway 126 and the Santa Clara River. The Simi Hills and the Santa Susana Mountains both have mountain lions and mountain lion habitat currently, and they are critical areas for maintaining and improving connectivity between the Santa Monica Mountains and all other areas throughout the state. We would further propose that the Management Unit, and therefore the listed DPS, also include a 10 km wide buffer north of Highway 126, since it is critical that connectivity be maintained across this highway as well.

This management unit could be called something like “Santa Monicas to Los Padres” since the focus is on the Santa Monica Mountains, but in order to preserve mountain lions in them, the Simi Hills, the Santa Susana Mountains, and indeed the area along Highway 126 and the Santa Clara River, are all critical to connect the Santa Monicas and Los Padres National Forest.

We believe that this Santa Monicas to Los Padres management unit would potentially warrant being listed as part of the South Coast group, based on the criteria presently in the draft status review. However, we also propose that some other criteria for “significance” are worthy of consideration, along with the ones currently listed on p. 79. In terms of the criteria currently in the document, we believe the Santa Monica Mountains population clearly represents a discrete population, based on physical, genetic, and behavioral criteria. Physically, it is separated from all other areas to the north by the 101 Freeway, one of the largest and most heavily trafficked freeways in the state, and indeed in the country. Behaviorally and ecologically, we have documented very low levels of successful dispersal between the Santa Monica Mountains and other natural areas to the north. And we have documented strong genetic differentiation and low genetic diversity in the Santa Monicas. In terms of significance, we believe that the Santa Monica Mountains and the surrounding areas represent a “unique and unusual ecological setting,” as indicated in criterion a), because they represent a case of mountain lions in Los Angeles, a megacity of more than 10 million people. This is the only case in the state, or across their range, where mountain lions occupy such a setting, and there is only one other megacity in the world, Mumbai, India, that is occupied by a large felid (leopards). Wildlife in urban landscapes face unique challenges for survival and coexistence in the face of so many people and the human infrastructure, including things like freeways, that accompanies them. Though mountain lions persist on the edges of some other urban areas, such as Seattle, WA or Denver, CO, nowhere is the metropolitan area as large and fragmented, and the challenge as great, as in Los Angeles.

Aside from this criterion of a unique and unusual ecological setting for the taxon, we think there are three other criteria that it would be valuable to also consider for “significance”, both for our proposed Santa

Monicas to Los Padres MU and for other proposed MUs as well. The first is a criterion related to ecological role. Mountain lions represent the only apex carnivore that regularly preys on the largest herbivores in the system, generally adult mule deer, in many parts of California. While it is the mandate of the National Park Service to protect all species in the parks, and we believe that they are all important for a fully functional ecosystem, mountain lions are the only species that fills its role. Predators can affect their prey both by directly killing and eating them, but also through behavioral effects that can be widespread and profound. Although we may not fully understand all of the ways that mountain lions affect their prey populations, including their main prey, mule deer, losing them from an ecosystem removes this important role. We propose that mountain lion populations are of significance wherever they are filling that role of primary predator on the largest ungulate prey. Their loss would be significant blow to the ecology of any place in California where they disappeared, with the exception perhaps of far northern parts of the state where wolves are reestablishing themselves. This would mean that in MUs such as the Central Coast North, including the Santa Cruz Mountains, where mountain lions are markedly separate and imperiled (based on Table 7 in the draft document), they would potentially also be deemed "significant" based on this ecological role.

Another biological criterion that we think is worthy of consideration is whether the MU serves a critical role in connecting to other populations in the state. Perhaps this is similar enough to criterion b), about loss of the MU representing a significant gap in the range of the taxon, that it could be incorporated into this criterion, but we think for mountain lions in California, explicitly mentioning the importance of connectivity between populations is important. Based on this criterion, the Central Coast South MU (depending on where it is considered to be located exactly, see comment below about defining MUs) would be significant, because it represents connection between the entire Central Coast and the Tehachapi Mountains, and therefore the whole rest of the northern part of the state, including the Sierras (WSN and ESN) and the North Coast. A potential Santa Monicas to Los Padres MU would also be significant from a connectivity point of view, because it would represent the only place for connection between the Central Coast broadly and the San Gabriels-San Bernardinos MU, and therefore to the rest of the South Coast Group (including the Santa Anas and the Eastern Peninsular Ranges).

Finally, the last criterion that we think is worthy of consideration is not biological, but we think is also relevant for conservation, and that is whether the population is of significance culturally to the people of the area. We would argue that the mountain lion population of the Los Angeles area is extremely important to those living in Southern California, and that it would be a great loss to them, and indeed to the people of the State of California more broadly, if the species disappeared from the Santa Monica Mountains and the Los Angeles area. This significance was specifically manifested by the outpouring of grief and concern about the fate and eventual death of mountain lion P-22, who we tracked for more than 10 years in Griffith Park, including the filling of the Greek Theater above Hollywood for his celebration of life. But the care and concern is not just for this individual lion, but for the species in the area more broadly. This is manifested by the success of the SaveLACougars Campaign to help fund the Wallis Annenberg Wildlife Crossing, and by the huge interest from the public and from the media in the Los Angeles Area and far beyond, in the mountain lions of the Santa Monica Mountains and surrounding areas. It is an amazing fact that mountain lions persist in the megacity of Los Angeles, and it represents not just a unique ecological setting, but also a part of our wild heritage that many might have thought was lost in a place like Los Angeles, but wonderfully is not. The successful coexistence of humans and a large felid in Los Angeles also shows us what is possible for wildlife and people. If mountain lions can survive in Los Angeles, then perhaps we can make it work for wildlife populations overlapping with human populations anywhere. Along with the other criteria, we believe that the mountain lions of the Santa Monicas are significant based on a potential cultural criterion.

One other general comment, which comes up also multiple times in my specific comments, is that we think it is important to clearly delineate where the management units in the document are located. Genetic populations can, and do, have potentially fuzzy boundaries, which can depend on factors like how intensive the sampling is in particular areas or whether an individual animal might be a disperser from another population or how strong the differentiation is for particular genetic markers. However, while it may make sense to generally base management units on genetic data, in the end it needs to be clear where a management unit, if it is to serve a management purpose, begins and ends. Currently the document does not draw these boundaries, that I have seen, but I think it is important to make them clear. This is especially important for example for the boundary between Central Coast South and Central Coast Central, or between the San Gabriels-San Bernardinos and the Eastern Peninsular Ranges. The boundaries can certainly be reevaluated and changed over time, but if we are to evaluate the management units and whether they are discrete, and how they relate to each other, we need to know where they are.

RESPONSE: Many of these comments are addressed individually and in more detail later in this document. Given the comments received as a whole from external reviewers, the Department reworked the status review. Major changes relevant to the broad comments here are that we no longer use the Management Unit framework, and the expansion of the area the Department recommends that should be listed to include CC-S including the Santa Monica Mountains.

GENERAL COMMENT (Beier): The writing is clear. Words are used appropriately. Well cited. The authors explained how the concept of Evolutionary Significant Unit works poorly for wide-ranging mammals under CESA. The authors could have used this to simply walk away from the task, but instead of taking that cowardly exit, they used the conceptual framework of Distinct Populations Segment. I greatly respect the thoughtful hard work that the authors put into this difficult assignment.

The main difficulty with the MU/DPS approach is that all these DPS's have arisen in the last century – a flash of time – and this part of California continues to experience such rapid changes in land use that the map could be dramatically different in 25 years. By the time these areas qualify as DPS, the better-off units may be endangered and some endangered units may be extinct... I wish we had a conceptual framework that does not have the 20-30 year time lag of the DPS framework. Populations in the Santa Anas, Santa Monicas, San Gabriels, and San Bernardinos have not been separated enough to qualify as DPS, and by the time they do qualify (in 20-30 years when genetic data lets us recognize them as DPS's), it may be too late to save them. Your report acknowledges this problem, e.g., Section 7.1 states "In the most isolated habitat patches (e.g., Santa Monica Mountains, Santa Ana Mountains), it is conceivable that local extirpations may occur in the absence of efforts to improve habitat connectivity and remove barriers to movement. Management intervention to develop a broad wildlife crossing infrastructure, including the protection and enhancement of large blocks of suitable habitat on each side of crossing facilities, to link MUs would increase connectivity and potentially alleviate the genetic and stochastic risks associated with small populations. Such an effort will require adequate funding and concerted and sustained commitment by many parties to ensure proper design, placement, maintenance, and monitoring for effectiveness." Translation: "Santa Monicas and Santa Anas do not qualify as DPS, so somehow without waiting for DPS status, "many parties" (CalTrans, County land-use planners, P&Z Commissions, City Councils) must "do something."

Your charge was to determine if any of the petitioned populations qualify as ESU or DPS, and not to tell these "many parties" what to do today (before these popns qualify as DPS). But please do tell these Many Parties that the main things they must do is control land development and mitigate barrier effects of roads, canals, high-speed rail, etc. If Many Parties don't take such steps, in another 20 years, we will be going through this same process all over again. CDFW is not obliged to prevent urbanization, freeways, railroads, and intensive agriculture from causing future endangerment. But without a doubt, increasing connectivity among all MU's is the best action, and local land use planners and CalTrans are the key parties that can prevent DPS's from emerging.

RESPONSE: Due to this and other feedback, the Department reworked the status review and the areas mentioned are now included in the area recommended for listing, and there is a section on connectivity in the management and Recovery Action Recommendations section 10.1.

GENERAL COMMENT (Ernest): The staff and biologists at the California Department of Fish and Wildlife (CDFW) are to be commended for their work to compile and summarize information they gathered related to mountain lion ecology and research in California, in a report dated August 2023 in response to the 2019 "ESU Petition" for listing threatened populations. The CDFW report lists some of the many converging threats to coastal California mountain lions, threats which are acting in multiple and additive ways to degrade population viability throughout the California Central Coast and South Coast habitats. However, there are critical deficiencies in the CDFW proposal for mountain lions. The best scientific evidence and the projections for land use changes, and human-caused factors including climate change in California provide strong evidence that the geographic areas and mountain lion populations in the 2019 ESU Petition are appropriate for threatened listing protection. All of these regions have unique biota including endemic plant and animal species with which mountain lions have evolved.

The Southern Coast populations and the Central Coast populations are now effectively cut off from natural genetic interchange from other mountain lion populations. The Pacific Ocean bounds the west, the Central Valley and Mojave and Sonoran Deserts bound most of the east with effectively no, San Francisco Bay and Delta, major urban and industrial regions, and the border with Mexico bound the north and south.

One of the last vestiges of a critical migration corridor, necessary for genetic interchange with the Sierra Nevada - the Tehachapi Mountains - is rapidly closing due to massive housing developments in progress. The Central Coast habitats are now an island habitat, as are the South Coast Ranges. Declines and loss of mountain lions, a keystone species, in these areas would be a devastating loss in biodiversity and cultural history.

Therefore, not only the South Coast populations (Santa Ana Mountains and Eastern Peninsular Ranges) and the populations in the Transverse Ranges, but also the Central Coast Populations (those in the Santa Monica Mountains, the intervening Central Coast population, and north to the Santa Cruz population) warrant ESU status (substantially reproductively isolated from other conspecific population and represent an important component in the evolutionary legacy of the species) and/or DPS threatened listing per findings of "discreteness", "significance", and "conservation status".

In summary, the CDFW proposal is insufficient to protect mountain lions in the Central Coast Ranges, Transverse Ranges, and the South Coast Ranges. These populations are suffering "cuts by a thousand knives" from the threats outlined in the CDFW report, in the comments laid out here, and I'm sure, by other reviewers' comments. It is vitally important to recognize is importance of the very tenuous Tehachapi Mountains corridor to both the Central Coast Populations and those of the Transverse Ranges (including San Gabriel and San Bernardino Mountains), and South Coast Ranges (Santa Ana and Peninsular Ranges). Designation of Management Units alone as proposed by CDFW, without state threatened listing, is insufficient to prevent further degradation of intact populations for this keystone animal and its habitats. Listing protection is warranted for all mountain lion populations listed in the 2019 Petition. These populations fulfill requirements for an ESU for each of the Central Coast and the South Coast: substantially reproductively isolated from other conspecific population and represent an important component in the evolutionary legacy of the species). Each of the Central Coast and the South

Coast also fulfill the requirements for a DPS for each (per findings of “discreteness”, “significance”, and “conservation status”.

RESPONSE: Many of these comments are addressed individually and in more detail later in this document. Given the comments received as a whole from external reviewers, the Department reworked the status review. Major changes relevant to the broad comments here are the inclusion of the Tehachapis in the area recommended for listing, and we are no longer using the Management Unit framework. The Department’s conclusion as to whether the petitioned area qualifies as an ESU remains the same, and the argument can be found in section 6.1.

GENERAL COMMENT (Vickers): The California Department of Fish and Wildlife (hereafter the Department) personnel who undertook this review were faced with a monumental task, and I commend them for doing so. I am sure there were many people involved who undertook it with care and professionalism and they have my personal appreciation. Most of my comments either address methodological issues, choices of data, or conclusions based on their guidelines wherein I felt that other information should have also been given weight in the decision making. Though the genetic divisions in Gustafson 2019 and 2022 are a sensible organizing principle in evaluation of the risk to these six petitioned populations (collectively the ESU or individual ESU's in the petition but converted to Management Units in the Department's evaluation), it is wise to not lose sight of the fact that these genetic divisions exist predominantly because of manmade infrastructure on the landscape. This includes both highways and development of all sorts, much of which has been governed in its placement over time by very local land use decisions notwithstanding broader implications for this particular species, Puma concolor, or the mountain lion. The petition maintains that unless some modifications of current and future infrastructure decision-making occurs, and further fragmentation of the populations is prevented - especially in and between key connecting and source populations - that genetic deterioration will continue. That view is hard to dispute. The question at hand for reviewers is whether the conclusions the Department comes to when examining the question of additional legal protections for any or all of the six subpopulations is scientifically as sound as possible using current information. At several points in the report there is phraseology emphasizing the evidence of genetic exchange in the past suggesting that it will occur into the future, yet if that exchange had been happening at adequate levels up to now most of the current genetic divisions would not be there, and the Department would not be going through this exercise. . Current and expected changes in the state's development patterns and infrastructure should also be taken into account, though they are not a part of the formal decision making. Where I felt it appropriate I have pointed out expected impacts that I am aware of. Throughout the report, statements are made about census populations of the MU's that are being addressed - those population estimates are consistently based on one paper's estimates of Ne when not only is that regarded by geneticists as a misuse of that statistic, but it is suspect due to dramatically different values that are derived using Ne's from other analyses. I suggest that population estimates based on the Department's own research should be presented as well with information on strengths and weaknesses of all techniques since those estimates will be a part of how success or failure to prevent decline in these populations in the future is judged. Though population estimates did not enter directly into the decision matrix relating to Threatened listing determinations, population size is obviously a critical metric in the smaller populations, and one that needs to be monitored over time. The danger of an extinction vortex occurring with any of the smaller populations is always going to be present unless more substantial connectivity and in some cases lowered mortality rates are accomplished. In my opinion, use of MU's versus ESU's should be explained in more detail in the document. At numerous points in the report the comment is made that loss of one population or another would not significantly reduce the range of the species, however, both the central coast and south coast groups, and the ESU as a whole, seem to represent significant portions of the overall statewide mountain lion habitat in acreage terms, however some terms like "significant" are not well defined when used at this and some other junctures. Given that the inherent meaning of the California Endangered Species Act is to prevent extirpation of wildlife populations, including subpopulations, it is odd that in this case the most at risk individual MU's are not being recommended in the report to be given extra protections. Obviously, the source populations for those smaller MU's are also both at risk and similarly isolated genetically, and dynamic increases in the built landscape that are inevitable in California make it more likely that they could become more so. A final broad concern is that in the final analysis matrix for the decisions regarding Threatened listing for any given MU, some of the most pertinent factors that go into population viability analyses (PVA's) such as survival rates, genetic factors such as inbreeding coefficients, heterozygosity, allelic richness, etc. were not included in the decision matrix at all. In my opinion, these factors are important in making the listing decision because they inform the likely trajectory of populations under current conditions absent further protections. Finally one challenging aspect of the evaluation of the CC-C and CC-S MU's was the question of where the Tehachapi Range fell within the MU structures. That range was noted multiple times in the report as an absolutely critical linkage for all six MU's that within the proposed ESU, but it didn't seem to be factored into the evaluations of either the CC-C or CC-S MU's as regards their importance as "gap" or "Significant" populations, which in turn was important in the decisions relating to being designated as Threatened. Other specific comments follow below.

RESPONSE: Many of these comments are addressed individually and in more detail later in this document. Given the comments received as a whole from external reviewers, the Department reworked the status review. Major changes relevant to the broad comments here are that we no longer use the Management Unit framework, the inclusion of the Department's most recent estimates of population size, and the expansion of the area the Department recommends that should be listed to include CC-C, CC-S, and the Tehachapis.

GENERAL COMMENT (Vickers): A final comment is that it seems to be acknowledged that these populations are as genetically restricted and isolated as they are from "business as usual". Thus an expectation that things will improve without intervention seems unreasonable. Perhaps, what may apply broadly to these populations in colloquial terms is the saying that "if you are in a hole, first stop digging".

RESPONSE: Noted

Line 84 (Ernest): The CDFW proposal also omitted sufficient protection for the increasingly bottlenecked migration corridor in the Tehachapi Ranges and Transverse Ranges, that comprise the last significant link of genetic interchange with the Sierra Nevada to the central and south coast populations. This will leave the Central Coast and South Coast Populations as fragmented habitat islands now, cut off from historic linkages for mountain lions that now lie heavily impacted Central Valley, San Francisco Bay and Delta regions, Los Angeles, San Diego, and adjacent urban, industrial, and agricultural areas. Without listing protection as geographically outlined by the ESU petition (which included alternate options in addition to a single ESU), these populations will continue on their population declines.

RESPONSE: Based on these and many other comments, the Department reevaluated the criteria for the recommendation and the area recommended for listing now includes the Tehachapis.

Line 293 (Vickers): Add the word "mountain" before "lion" and do so throughout the manuscript where it has been left out.

RESPONSE: Done

Lines 362-363 (Riley): This description of the Central Coast South population does not make sense, to include the Sierra Pelona Mountains, since these are on the other side of Highway 5, north of Highway

14. Highway 5 is a major barrier to mountain lion movement and gene flow, based on the work that we did on regional mountain lion genetics, in Riley et al. 2014, and in the Gustafson et al. papers, with animals in the San Gabriels and San Bernardinos being clearly differentiated from the Central Coast populations. Does the petition propose that the Sierra Pelona Mountains are part of Central Coast South? Either way, this does not make sense to include with the Santa Monicas, Simi Hills, and Santa Susanas. I'm wondering if the intent was to have the Sierra Madre Mountains, which are the next range north of the Santa Susanas, in the southern part of Los Padres National Forest, be included in the Central Coast South population? That would make much more sense. Either way, that would be the way to characterize it in this document generally, I think. The green areas in Figure 1, representing CC-S, definitely go up north of Highway 126 and the Santa Clara River into the Sierra Madre Mountains and Los Padres. Based on the genetic figures for southern California, figures 17 and 18, the Sierra Pelona samples would belong more with the Tehachapis and southern Sierra Nevada, it looks like.

RESPONSE: These descriptions of the geographic areas for the genetic populations are rough and meant to orient the reader, not to provide firm boundaries. Due to other comments from reviewers the Department reworked the status review, and the boundary of CC-S is less relevant.

Line 374-375 (Riley): Somewhere, the specific boundaries of the different Management Units that you are considering need to be made clear. They are not clear, in Figure 1, which is just the map from Gustafson et al. 2019. And the colors in the map are only as good as the coverage of genetic samples in the study, which though it was a huge number of samples and a great study overall, was certainly far from total coverage across the areas where mountain lions are present in the state. And so that limits exactly where these populations can be defined. But for management units, there need to be actual boundaries, it certainly seems to me. So I think it's important for those to be clear, somewhere in this document, at least once the Management Units are introduced on P. 75, which is not currently the case, I don't think. Incidentally, the Management Unit that we are proposing to be considered, the Santa Susana Mountains, the Simi Hills, and the Santa Monica Mountains, is very clearly delineated by major roads.

RESPONSE: Due to reviewer comments the Department reworked the status review and no longer uses the Management Unit framework. The genetic populations from Gustafson et al. 2019 and 2022 are discussed, but establishing firm boundaries is not necessary for the recommendation.

Line 445 (Riley): Does this "intraspecific predation" refer specifically to the killing and eating of kittens? If so, it would be good to make that clear. There is also intraspecific conflict between adult males and other animals, especially subadults, which is mentioned later in the document, and has been an important source of mortality in the Santa Monicas, especially early in the study (Riley et al. 2014, Benson et al. 2020). We have also documented predation on kittens by adult males, as I presume you mean that here.

RESPONSE: Text changed to “Adult males are also known to kill kittens, yearlings, subadults, and occasionally other adults (Logan and Sweanor 2010; Riley et al. 2014; Benson et al. 2020).”

Line 447 (Riley): It would be good to cite this statement about lower survivorship in dispersing animals, I think. It is definitely something that we have seen in our population, lower survival in subadults than in other age classes (Benson et al. 2016, Benson et al. 2020).

RESPONSE: Text changed to “Survivorship of dispersing mountain lions is low relative to adults with established home ranges (Benson et al. 2016; Benson et al. 2020), and dispersing young are more likely than resident mountain lions to be involved in depredation incidents or other conflicts with humans as they try to find prey without the advantage of an established home range (Torres et al. 1996).”

Line 465 (Riley): What does "numerous" mean here? It would be good to give the actual number, I think.

RESPONSE: "Numerous" is a direct quote from the paper, exact numbers aren't provided.

Line 477 (Riley): Riley et al. 2021 is not currently in the Lit Cited, so it needs to be added. Our averages, as given in this reference, are actually a bit higher than this, 370 km2 for adult males, and 135 km2 for adult females. Also, it would probably be valuable to add some other references from CA here, for home range size, such as a Wilmers and a Vickers reference. Home range sizes are similar, but not the same, in different areas; for example they are on average a bit smaller in Chris' study in the Santa Cruz Mountains. And Melissa's paper (Grigione et al.) is from 20 or so years ago, so it would be missing these more recent long-term studies. Finally, as regards this statement about home range size varying with prey density, it may be true, although I don't know how well documented it is. It would be worth citing, if possible (maybe Grigione et al. say that?). I think it's likely to be much more true of female home ranges, whereas males are generally more focused on having large home ranges to overlap as many females as possible, is the thought.

RESPONSE: Text changed to "Average home range size in California varies substantially depending on sex, season, and area of the state. The average male home range size is larger than the average female home range size. Home ranges change size depending on season and tend to be larger in the Sierra Nevada compared to the Coastal Ranges. In the Santa Ana Mountains and the Eastern Peninsular Range, Zeller et al. (2017) found that home range size varied from 41–497 km^2 (16–192 mi.^{2}; mean = 231 km^2; female mean = 188 km^2; male mean = 316 km^2). In the Santa Monica Mountains and surrounding areas, Riley et al. (2021) found the average home range size was 134 km^2 (52 mi.^{2}) for females and 372 km^2 (144 mi.^{2}) for males. In contrast, in the Sierra Nevada mountains the average home range size for females in summer was 541 km^2 (209 mi.^{2}) and 349 km^2 (135 mi.^{2}) in winter (Grigione et al. 2002). For males it was 723 km^2 (279 mi.^{2}) in summer and 469 km^2 (181 mi.^{2}) in winter. While male home ranges can overlap spatially, male mountain lions are territorial, making temporal overlap between males rare (Logan and Sweanor 2001). However, males attempt to overlap their home ranges with multiple female home ranges to enhance breeding opportunities (Logan and Sweanor 2010)."

Line 485-489 (Riley): Ken Logan has a recent paper in JWM (2019, vo. 83:1652), that looks comprehensively at what regulates mountain lion populations. It would definitely be valuable to look at and cite this paper, I think, for both of these last two sentences.

RESPONSE: text changed to "Given the importance of females to population growth, and because one male can breed with multiple females, mountain lion populations can be primarily limited by prey availability (Pierce et al. 2000; Logan and Sweanor 2001; Logan 2019)."

Line 482 (Riley): Somewhere in this section, probably in this paragraph, I think it's important to mention that in general for mountain lions all young males, and 1/2 of young females, disperse. This is a really important fact about mountain lions, both in general and specifically relative to connectivity and conservation, that I find that I often mention. I generally cite Logan and Sweanor 2010, from the Cougar book (Hornocker and Negri) for that.

RESPONSE: Text changed to "Mountain lions are known to move long distances while dispersing. One subadult male was documenting moving 2,450 km (1,522 mi.) from South Dakota to Connecticut (Hawley et al. 2016). Vickers et al. (2015) documented numerous southern California study animals dispersing > 80 km (50 mi.), and one young male moved approximately 150 km (93 mi.) from California south into Baja California, Mexico and back. Most long-distance dispersers are thought to be young males in search of available mates (Hawley et al. 2016). "

Line 501 (Riley): The Riley et al. 2014 reference here should be replaced by Blakey et al. 2022, which is the paper that talks about the fire and the mortality associated with it.

RESPONSE: Due to this and other feedback, this section has been extensively re-written.

Line 502 (Riley): We have documented many more cases of deaths from rodenticide poisoning since the 2007 paper. The best citation might be Benson et al. 2020 (in Biol Conserv, which would need to be added to the Lit Cited), which mentions 5 cases. You could also cite our reports to CDFW, specifically the ones covering 2018-2019 and 2019-2021. We have documented 7 total cases so far, 6 among collared animals and one uncollared.

RESPONSE: Due to this and other feedback, this section has been extensively re-written. Benson et al. 2020 has been added.

Line 502-504 (Riley): A few things about this sentence. First, and most importantly, it's not very useful in general to talk about raw numbers of mortalities from different causes, such as that 24% of deaths were from unknown causes. The raw numbers are misleading, and when you have data on how long he animals are tracked, computing rates of mortality, as was done in the paper, is a much more accurate and unbiased way to discuss the results. Second the specific statement here is not correct - it says 24% of tracked animals died of unknown causes, when in fact it was 24% of total deaths (64/263) - whereas it would be 11% of tracked animals (64/590, though that is even less useful to report). But also, I'm not sure what the point of this statement is, about the percentage of unknown mortalities being much larger than that for any other specific causes. That is true in just about any study of wildlife survival and mortality causes, for a number of reasons; it is often hard to determine what the cause of mortality is, despite intense vigilance and effort. The work that is included in the Dellinger et al. 2021b report and updated and made more rigorous in the Benson et al. paper is an amazing compilation of data on survival and mortality causes, unlike any that I know of for this species, for sure, and for many others as well. Since there are many different specific causes of mortality, and "unknown" is a broad category that is going to necessarily include many different things, it is not surprising that it would be large. If you did want to look at raw numbers of mortalities, I think perhaps one of the most striking things is that management killing alone, at 23%, makes up essentially the same percentage as the unknown category (24%). But as I said at the beginning, it is much more valuable to look at rates than numbers, and I'm also not sure what the point of this sentence is, so I would recommend deleting it.

RESPONSE: Due to this and other feedback, this section has been extensively re-written

Line After 504 or 521 (Vickers): Also note the effect on mountain lion survival that was exerted by patterns of voting on environmental issues as documented in Benson et al. 2023. Should Table 2 be based on Benson et al. 2023, or values from that analysis also included?

RESPONSE: Due to this and other feedback, this section has been extensively re-written

Line 505-511 (Riley): A few things about this paragraph. Most importantly, these are the same data that were analyzed in much more detail and more comprehensively, i.e. with a more complete dataset, in the paper on survival rates and mortality causes, Benson et al. 2023, and that paper should really be cited here. For example, just from our study alone, I know there were some animals that we followed that didn't make it into the analyses for the Dellinger 2021b report, but that did for the PNAS paper. I have spoken with both Justin, who is the senior author on the paper (by the way, many authors, including Justin, are currently left off of the citation in the Lit Cited), and John about this, and they would be happy to discuss it as well, if that would be helpful. The paper is also peer-reviewed, published in a very highly regarded journal, and more accessible to readers than the report, which are also good reasons to cite it. Also, the Dellinger et al. reference here is the wrong one, it should be 2021b, not 2021a (same thing for line 516). The 2021a reference is the report about depredation, not the one that includes survival rates. That is also leading to some confusion about the years included. The depredation report, 2021a, does go back to 1972 and 1973 apparently, but the survival data, both for the Dellinger et al. 2021b report and for the Benson et al. paper, goes back to 1974 - so the survival analyses in the report are not "expanded" relative to the paper, and in fact, as I said, the paper includes more animals and mortalities than the report (e.g., the paper includes 263 deaths, while the report, as cited on line 507, includes just 246). Finally, just a comment about the organization of the section: it seems like this paragraph should go at the beginning of the section, as opposed to at the end, since it is presenting important overall information about survival of the species for the state.

RESPONSE: Due to this and other feedback, this section has been extensively re-written.

Line 513 (Riley): Again, it would be important to cite the detailed analyses of these same, but actually more complete and updated, data in Benson et al. 2023 here, along with the Dellinger et al. report.

RESPONSE: Due to this and other feedback, this section has been extensively re-written

Line 541 (Riley): I think we would say that mountain lions need sufficient tree or shrub cover to help them stalk and hunt deer, more than because those are areas that are favored by deer. Deer certainly use them too, although deer are often more abundant in areas with more open structure, such as grasslands, or at least a mix. We are working currently to learn more about what deer use and prefer in our region.

RESPONSE: Have added the text "and promotes cover for stalking"

Line 559 (Riley): I'm guessing that you mean "non-breeding" here, instead of "breeding"? Also, somewhat of a preference and stylistic thing, but my understanding is that in formal writing, "and/or" is discouraged at this point. In this case, I think you can definitely use "or." One thing that's interesting to think about in terms of "non-breeding" animals. In some cases, they may be capable of breeding, but just don't have any opportunities to do so. This is currently true of any animals that disperse out into the Midwest, east of Nebraska, or to the East Coast. There just aren't conspecifics out there for them to mate with. This was also true for P22, in Griffith Park. We tracked him there for 10 years, but we're confident that there were never any other lions there, including any females, and so he just didn't have any breeding opportunities. Same thing is likely true for a male lion that has been documented many times over the last few years in the eastern Santa Monicas, between 405 and the Hollywood Freeway (101, as it heads to downtown LA).

RESPONSE: Text changed to "may include non breeding or dispersing individual"

Line 563 (Riley): Justin's paper in JWM (Dellinger et al. 2020a), and so I presume what was in the 2021b reference as well, presented habitat selection patterns, not habitat use patterns, which are not the same thing. Selection involves examining use vs. availability, whereas use is the information on what the animals actually used. Selection analyses are very common and certainly valuable. Although personally I think it would be great if habitat use data was more regularly reported as well. For example, in the Burdett et al. paper (cited in this document), they found that chaparral was not selected for, since it's use was similar to its availability, but since it was the most common vegetation type, clearly it was important to the species.

RESPONSE: The quote comes from the 2021 conservation assessment, have added a definition of habitat selection in the footnotes.

Line 581 (Riley): It might be worth citing our recent habitat use and selection paper here, Riley et al. 2021 (which is currently cited elsewhere, but still needs to be added to the Lit Cited), since we directly addressed the use of selection of these scrub habitats, including both coastal sage scrub and chaparral in particular. We did not separate out chaparral into different ages, but chaparral was consistently both the most used and most strongly selected vegetation type for all age and sex classes. So we certainly did not see evidence that there was chaparral that they were avoiding. As you say here, this statement from Burdett et al was speculation. We did also find that they avoided open parts of the landscape such as grasslands and landscaped areas such as golf courses or cemeteries (what we call "altered open" areas). We found that they were very rarely actually in urban areas, and in fact were often far from them, but we did find that from a distance-based perspective, they were closer to urban areas than expected, perhaps because deer are often in or close to developed areas such as low density residential areas.

RESPONSE: Have included suggested reference. Text now reads "Riley et al. (2021) found that mountain lions in the Santa Monica Mountains and surrounding areas selected "chaparral, riparian woodland, and coastal sage scrub. The two features of the landscape that they consistently avoided were grasslands and altered open areas, which were also the most open portions of the landscape. These results are consistent with previous work showing that mountain lions select areas with dense stalking cover and avoid open areas to facilitate hunting success." However, Burdett et al. (2010) speculated that dense, mature late seral chaparral may be avoided because mule deer prey cannot easily move through such stands and thus may select against them."

Line 603 (Riley): One point that I want to make clear about the genetics of mountain lions in the Santa Monica Mountains and the surrounding area, and the two state-wide Gustafson et al. papers that we participated in. In our 2014 paper (Riley et al. 2014), we found clear differentiation between mountain lions north and south of the 101 Freeway, before male P12 crossed the freeway in early 2009. After P12 crossed, survived, and began regularly mating in the Santa Monicas, that differentiation was not as strong, since he was clearly genetically assigned to the population north of the freeway. The Gustafson et al. papers used samples up through 2015 for our population (see Methods in Gustafson et al. 2022), so this was at the height of the influence of P12. It was also the case, for various reasons, that a number of the earliest samples from the Santa Monica Mountains were not included in the Gustafson et al papers. So it is potentially not surprising that the Santa Monica Mountains came out, in those statewide analyses, as part of the Central Coast South Cluster. Those papers gave a picture at a certain point in time, as of 2015. But as I've said multiple times in other comments, we then documented repeated cases of P12 mating with his daughters, close inbreeding events which would both reduce genetic diversity and increase the genetic similarity of animals in the Santa Monicas. And effective genetic dispersal in and out of the Santa Monicas has continued to be very rare. So doing the analyses with samples from a few years earlier, say 2010, or a few years later, say 2020, might give different results about genetic differentiation between the Santa Monicas and areas north. The genomic work happening at UC Santa Cruz, as well as work we are doing currently with UC Davis, will shed further light on the current situation, genetically. Regardless, we know from dispersal and tracking data that mountain lions in the Santa Monicas are a very small population isolated by a massive and busy freeway (Riley et al. 2014), that we have seen physical evidence of potential inbreeding depression (Huffmeyer et al. 2022), and that the population is in significant danger of going extinct, based just on demography, and especially if inbreeding depression worsens (Benson et al. 2016).

RESPONSE: CC-S is now included in the area recommended to be listed, which makes the details of genetic isolation of the Santa Monicas less relevant to the listing recommendation as a whole. The Department has included more details of the evidence of inbreeding in the Santa Monica Mountains later in the status review.

Line 603 (Riley): I think the Ernest et al. 2014 and Riley et al. 2014 papers might also be worth citing here. They aren't about the entire state, the way the Ernest et al. 2003 and the Gustafson et al ones are, but they are definitely about gene flow between different areas of the state, and in fact between different areas that are very relevant to the petitioned area.

RESPONSE: References added.

Line 608-635 (Vickers): The blanket statement that microsatellites operate on a scale of 100s of years and SNPs on 1,000s-to-10,000s of years is not accurate. Microsatellites mutate more quickly and have other characteristics that can inform contemporary population assessments, but because of interpretation differences between labs and other deficiencies, the information those analyses produce may or may not be as pertinent to the questions at hand as SNP analyses - though they too are subject to variation based on a number of other factors.

RESPONSE: Due to this and other feedback, the references of the time scales have been removed.

Line 610-614 (Vickers): The sentence "Though these populations show significant genetic differentiation, they are not fully isolated (Fig. 3)." is true but "full" isolation is not necessary for populations to continue to decline in heterogeneity and inbreeding levels, and be at risk of extirpation secondary to inbreeding depression and other factors. Benson et al. 2019 shows that though the populations in the Santa Ana and Santa Monica Mountains have some low level of current connectivity, that they will continue to decline in genetic diversity and be at significant risk of extirpation if current levels of genetic introduction are not improved. If the gene flow between the populations were as vigorous as the next sentence seems to suggest, the populations would not have become differentiated / separated genetically and as at risk of decline as they now are. Though some genetic exchange has occurred in the recent past and may be continuing, levels of gene flow have not been adequate to prevent the current genetic structural isolation from developing in the first place. In my opinion, it is safe to assume that absent improvements in current rates of gene flow that further genetic differentiation and deterioration will occur not only in the SA MU and SMM/CSU MU as predicted in Benson et al. 2019, but also in the other petitioned populations.

RESPONSE: This section has been rewritten and this sentence is no longer in the document.

Line 616 (Beier): A staggering amount of information, clearly displayed. Thank you, Gustafson et al. (2019)!

DOES NOT REQUIRE A RESPONSE

Line 631(Riley): So, the two Gustafson et al. papers that we did, are obviously two papers that used different genetic markers. But I think it's a bit misleading to say that they are two entirely different studies. They used the same overall sample of animals, it's just that the 2022 paper used a smaller number of them, less than 1/2. So it is not like the two papers and analyses were on different animals, or from different places in the state. I think it's important to make that clear somewhere. At the moment, the impression is that they are two entirely independent studies, which is not the case.

RESPONSE: The first sentence of the methods section of Gustafson et al. 2022 states "We obtained 354 tissue samples collected by the California Department of Fish and Wildlife between 2011–2017 from pumas which had never been used in any previous genetic survey. Therefore the majority of samples were novel. A smaller proportion of samples from Gustafson 2019 were reused in the 2022 study. These were limited to "the Los Angeles region of southern California"

Line 635-637 (Vickers): The following blanket statement "SNPs are known to resolve population genetic structure with higher resolution and greater statistical power than the microsatellites that were used in the 2019 study (Narum et al. 2013, Vendrami et al. 2017, Hohenlohe et al. 2018)." may or may not be true dependent on numerous factors including the wildlife population, qualities and quantifies of each set of SNPs or Msats, genetic diversity in the populations, genetic bottleneck demography, and more. Thus the statement should be reworded as with the statement about timescales noted above (lines 608-635).

RESPONSE: This section has been rewritten and no longer includes this sentence.

Line 661 (Vickers): From the report line 661 "the CC-S genetic population is of critical importance to sustaining statewide gene flow because of the intersection of dispersal corridors connecting the SN, CC, and SC broad scale genetic populations." thus it seems incongruous not to regard it as a critical "gap" later in the same document (lines 2586-2608) , especially given that the Santa Monica Mountains at-risk population is contained within it.

RESPONSE: This section has been rewritten, and this sentence has been removed.

Line 662 (Riley): I totally agree about the importance of the CC-S group for connectivity for the state overall, both for connections of the coast to the Sierras, and therefore to the North Coast, and for connections to the San Gabriels and thereby to the rest of the South Coast Group. As we say later, we think the CC-S area overall may be important enough to consider for listing because of this importance for connectivity.

RESPONSE: Due to this and other feedback, CC-S is now in the area proposed for listing

Line 663 (Riley): This statement indicates the value of the SNP data, along with the microsat data, for evaluating relatively recent land use changes, such as anthropogenic development, and their effects on connectivity and landscape genetics. I mention this here because later there is a statement about SNP data not being useful for these kinds of changes, which I disagree with, and which I have discussed with other population genetics researchers, who also don't feel that it is true.

RESPONSE: Have reworked this section and references to the time scale that can be illuminated by SNP and microsatellites data.

Line 667 (Riley): What is the relevance and meaning of this "horseshoe"? It's not clear to me why this matters, and what it means that the South Coast Group and the Santa Monica Mountains are not part of it, as mentioned at the end of the paragraph.

RESPONSE: Have reworked section to remove mention of a horseshoe.

Line 678 (Riley): As I also say in other places, it is reasonable to use genetic data to guide the determination of management units, but somewhere the actual boundaries of these management units need to in fact be delineated. Genetic clusters can, and do, have somewhat nebulous boundaries, based on exactly how intensive the sampling is in particular areas, and any particular sampled mountain lion can also potentially be a disperser from somewhere else. So the boundaries of genetic clusters can be fuzzy. But the boundaries of a management unit need to be real and understood, I would argue, if management may vary between them. Right now, nowhere in this document are the boundaries of the MUs made clear, that I know of. This is especially important for the boundaries between the various MUs in the petitioned area, such as between CC-N and CC-C, between CC-C and CC-S, between CC-S and SG-SB, and between SG-SB and EPR.

RESPONSE: Due to feedback on our previous lack of consideration of the whole petitioned area as a DPS, the Department evaluates the petitioned area as a whole and the Management Unit framework is no longer necessary to the assessment of what areas to potentially list. This section has been deleted.

Line 669 (Vickers): This line has an example of a tendency within the whole report to mix descriptions of the CC-S MU between referring to it as CC-S MU and referring to it as the Santa Monica Mountains (SMM) population, even though the CC-S MU extends substantially to the north of the SMM. This leads to some confusion later since the small SMM population is treated as its own entity in some of the report, but is generally characterized as a part of the rest of the CC-S MU. By evaluating the SMM population's justification for listing as Threatened only if the CC-S MU as a whole is listed ignores the Benson et al. 2019 work and makes the assumption that the Wallis Annenberg wildlife bridge under construction over US 101 assures adequate connectivity to remove the risk to the SMM population segment. That assumption is unproven at this point and that should be noted. Also see my comments later in the report regarding the CC-S MU.

RESPONSE: There is increased specificity about when the document is referring to the animals within in CC-S genetic population, the broad area of CC-S, or specifically the Santa Monica Mountains. The recommendation for listing now includes CC-S.

Line 670 (Vickers): In Gustafson et al. 2019, allelic richness for all six populations proposed for listing as threatened was significantly below the values found for the ESN, WSN, and NC MU's . In the Gustafson et al. 2022 paper, allelic richness corrected for sample size was similarly significantly lower for all 6 petitioned populations than the ESN and WSN populations, though this is a less valuable parameter in SNP analyses than in microsatellites. Allelic richness is important for assessing population stability and risk of decline but is not mentioned at all in this report. Other genetic parameters such as heterozygosity, inbreeding coefficients, etc. that vary between the populations are discussed, but values are not factored ultimately into the population assessments used to make the determination about Threatened status. I suggest that this should be corrected and that genetic factors other than connectivity be included in evaluation of each MU in order to present the most complete picture possible of the risks to the various petitioned MU's. This can also inform expectations of population trajectories in the absence of the extra protections afforded by the Threatened listing - i.e. a "steady as she goes" situation.

RESPONSE: The Department uses effective population size estimates as one factor in evaluating risk. Other measures of genetic diversity mentioned in the comment do not have general 'rules of thumb' regarding how low levels can be before there is risk. Therefore discussing additional metrics of genetic diversity would be more descriptive rather than helpful in assessing risk and informing the recommendation.

Line 672-717 (Vickers): This comment refers to the section on Management Units, which is no longer included in the status review. The Department considers the justification for using the DPS criteria as outlined in section 6.2 to be sufficient.

Line 692 (Riley): All of these factors are especially challenging for the population in the Santa Monicas: habitat loss and fragmentation, vehicle mortality, wildfire impacts, and mortality from rodenticides. The one exception is depredation mortality.

RESPONSE: Noted, and the impacts of these threats on the Santa Monicas are mentioned in Section 4 Factors affecting the ability to survive and reproduce.

Line 700 (Riley): The lack of dispersal into or out of the Santa Monicas is another important way in which they are discrete from other areas to the north. As we mention first in Riley et al. 2014 but have also continued to document since then, there is very little successful dispersal in or out of the Santa Monicas. As we discuss in more detail later, we suggest considering the Santa Monicas as an MU as well, or more specifically the Santa Monicas, Simi Hills, and Santa Susana Mountains, since the latter two areas are critical for persistence of the Santa Monicas, as an MU called "Santa Monicas to Los Padres."

RESPONSE: The area mentioned is included in our updated recommendation for listing, which removes the relevance of defining the boundaries of this particular management unit.

Line 710 (Riley): So based on this measure, since none of the 6 MUs have at least 10% migration between them, it seems like they should all be determined to be "discrete," in the Table later in the document, Table 7 on page 81. Why would this criterion not be used, or at least discussed and included, in that assessment?

RESPONSE: Based on feedback from external reviewers, The Department no longer uses the Management Unit framework, nor do we evaluate whether the individual genetic populations meet the criteria of being a DPS, and have removed the mentioned table.

Lines 714-717 (Vickers): The text suggests that the SNP data from Gustafson et al. 2022 is less suitable than the data from Gustafson et al. 2019 for defining MU's for evaluation in the rest of the report. The report also eschews use of the Gustafson et al. 2022 for certain aspects of the evaluation because it is more informative of more ancient genetic structure, yet many samples used in the 2022 analysis were quite contemporary. Also, despite the statement in the report that the Gustafson et al. 2022 analysis is less suitable for individual MU evaluations, later in the report the Department chooses to group MU's into Central and South Coast Groups based on the Gustafson et al. 2022 data.

RESPONSE: Based on feedback from external reviewers, the Management Unit framework is no longer used.

Line 745-747 (Riley): What were these estimates, of 600 mountain lions and 2,400 mountain lions based on? I think at least some indication of where they come from would be valuable.

RESPONSE: Text amended to read “McLean (1954) presented bounty numbers from 1907-1950 and estimated there were 600 mountain lions in California at the time. Over a decade after the end of the bounty period, Sitton (1977) estimated that there were approximately 2,400 mountain lions in California.”

Line 752 (Riley): I don't think Paul and Winston would refer to the Santa Anas as rural, would they? There are certainly places there that would feel more rural, but in general, Paul's study of lions in the Santa Anas in the early 90's is considered to be the first ever study of mountain lions in a more urban landscape! And that is certainly how Winston has portrayed work there as well, and I know he and his colleagues have followed animals going close to and even into developed areas.

RESPONSE: This section has been deleted.

Line 755 (Riley): The better reference for survival rates in our study would be Benson et al. 2020 (Biol Conserv. 2020 241:108294), which is where we directly measured and report survival rates for the first 18 years of our study and for 58 tracked animals.

RESPONSE: This section has been deleted.

Line 757-760 (Vickers): Benson et al. 2023 actually found that the SA MU population survival rate fell within cluster 1 in his statewide survival analysis. Cluster 1 is the cluster with the greatest human presence and a higher survival rate than cluster 2, which included the EPR MU - one that exists in an area of more rural development overall. Definition of what constitutes a population "sink" might be useful here if either MU is being characterized that way. This should also apply to discussions of the other MU's.

RESPONSE: This section has been deleted.

Line 760 (Riley): The Benson et al. 2023 paper also provides survival rates from areas across the state, in the most comprehensive analysis of mountain lion survival in CA to date. So it seems like that could be valuable to discuss more in this section if it is addressing survival.

RESPONSE: The sections on survival and mortality have been reworked to focus on Benson et al. 2023.

Lines 762-798 (Vickers): The Department relies strictly on extrapolation from Ne to arrive at approximate population census numbers for the MU's in the document. Though the Department cites its use in the case of the Florida panther as justification, it is my understanding that Ne is not in fact regarded by most geneticists as an appropriate way to arrive at those population numbers. My comments regarding Ne and its most appropriate use for this overall evaluation may be seen elsewhere in the review. The Department's own current and former scientists in concert with most of the mountain lion researchers in the state have calculated population density values for the populations in the geographic regions covered by the proposed ESU. The Department utilizes one of the outputs from that modeling when it lists the statewide population as 3,242. That population estimate is derived from two of the three models that were developed in that effort. A breakdown of estimated population levels in each of the petitioned population segments as a function of all three models, alongside values derived from the Ne's in both Gustafson papers, would be most informative to readers and the most complete presentation of information known at this time.

RESPONSE: Due to this and other feedback this section has been extensively reworked. The Department uses an estimate based on fecal DNA data only because it is the method in which there is the most confidence. Adding telemetry data to the model would potentially bias the estimates high. The Department has a contract with UC Berkeley to better figure out how to incorporate telemetry data into the population estimates. The Department’s estimate has not yet peer reviewed and may receive feedback and change before publication in a peer reviewed journal. Included are populations level estimates based on SCR modelling and removed were estimates of population size based on effective population size. While it would be possible to present multiple population estimates with a discussion of the strengths and weakness of each method, that sort of technical discussion is more appropriate in the peer reviewed literature and would not change the end outcome, that there are multiple small populations that are isolated and face a variety of threats.

Line 766 (Vickers): The models utilized to date in the Department's statewide population estimate are pending peer review and result in a range of values for the statewide estimate depending on the model. These should be included in the discussion here with ranges and comparisons to the Ne-based population values derived from different Ne values in various analyses.

RESPONSE: Due to this and other feedback this section has been extensively reworked. The Department uses an estimate based on fecal DNA data only because it is the method in which there is the most confidence. Adding telemetry data to the model would potentially bias the estimates high. The Department has a contract with UC Berkeley to better figure out how to incorporate telemetry data into the population estimates. The Department’s estimate has not yet peer reviewed and may receive feedback and change before publication in a peer reviewed journal. Included are populations level estimates based on SCR modelling and removed were estimates of population size based on effective population size. While it would be possible to present multiple population estimates with a discussion of the strengths and weakness of each method, that sort of technical discussion is more appropriate in the peer reviewed literature and would not change the end outcome, that there are multiple small populations that are isolated and face a variety of threats.

Line 770 (Vickers): This statement is not accurate that populations could not be estimated for each of the petitioned populations. The fecal DNA study that the Department cites to state a statewide population estimate was conducted in such a way as to provide the ability to estimate density of the lion populations in each of the six petitioned population segment areas or MU's as the Department is defining them. As an example, density estimates from that study averaged from 1.5-1.84 animals per 100 sq km, resulting in a population estimate of 30 - 37 animals in the SA MU. This is consistent with other studies that have been done in the range (Beier et al. 1993, Vickers et al. 2022). It is possible to calculate these values for each petitioned area and I would recommend that those values be included in the report for comparison with the values derived from Ne that are presented.

RESPONSE: Due to this and other feedback this section has been reworked. The estimate based on fecal

DNA data is the method in which the Department has the most confidence. Included are populations level estimates based on SCR modelling and removed are estimates of population size based on estimated population size.

Line 774 (Vickers): The following statement "Effective population size essentially estimates the number of breeding adults in a population that successfully pass their genes on to future generations, recognizing that only a portion of adult animals in a population breed (see section 4.9.3 for more information on Ne)." is not accurate. The wording may be from literature that is commonly misinterpreted, and if used to predict population census size tends to be inaccurate due to the variation in factors that influence Ne. Presenting the values simplistically as a direct way to predict population census is not appropriate. As can be seen from comparisons of the multiple estimates of Ne from the two Gustafson papers that the resulting population census statewide or in any of the genetic clusters would vary widely. From Waple 2022, "Few doubt that effective population size (Ne) is one of the most important parameters in evolutionary biology, but how many can say they really understand the concept? Ne is the evolutionary analog of the number of individuals (or adults) in the population, N. Whereas ecological consequences of population size depend on N, evolutionary consequences (rates of loss of genetic diversity and increase in inbreeding; relative effectiveness of selection) depend on Ne. Formal definitions typically relate effective size to a key population genetic parameter, such as loss of heterozygosity or variance in allele frequency. However, for practical application to real populations, it is more useful to define Ne in terms of 3 demographic parameters: number of potential parents (adult N), and mean and variance in offspring number. Defined this way, Ne determines the rate of random genetic drift across the entire genome in the offspring generation. Other evolutionary forces (mutation, migration, selection)-together with factors such as variation in recombination rate-can also affect genetic variation, and this leads to heterogeneity across the genome in observed rates of genetic change. For some, it has been convenient to interpret this heterogeneity in terms of heterogeneity in Ne, but unfortunately, this has muddled the concepts of genetic drift and effective population size. A commonly repeated misconception is that Ne is the number of parents that actually contribute genes to the next generation (NP). In reality, NP can be smaller or larger than Ne, and the NP/Ne ratio depends on the sex ratio, the mean and variance in offspring number, and whether inbreeding or variance Ne is of interest."

RESPONSE: Due to this and other feedback this section has been reworked and no longer uses Ne to estimate population size. The discussion of effective population size has been moved to section 4.10.3 Loss of Genetic Variation. The definition now reads "Ne is the size of an ideal population that would result in the same level of inbreeding or genetic drift as that of the population under study (Palstra and Ruzzante 2008). Though Ne is determined by several factors, it is generally significantly less than the census population (i.e., the number of animals actually breeding in a population is usually significantly fewer than the total number of animals in the population; Palstra and Ruzzante 2008, Table 6). "

Line 778 (Ernest): Effective Population Size, Ne, should not be used to infer or in any way calculate census size, N – Table 3 – this table and all references to such calculations of N from Ne in the report should be deleted from use in the CDFW proposal. See Waples 2022. Ne is an index calculated on genetic data in this case (or demographic data in other cases) but has too many generalizing assumptions that mountain lions do not meet, to in anyway infer the number of lions in a population.

RESPONSE: Thanks to this and other feedback this section has been reworked and no longer uses Ne to estimate population size.

Line 779 (Vickers): As noted above, the population estimates in Table 3 are not calculated using a well-supported technique. The assumption in the report that the breeding structure of the Florida panther at a time in the past is identical to the current breeding structure in each of the California populations is inappropriate. Each population estimate has major assumptions built in. I suggest that the report should list (in tables) Ne estimates from both Gustafson et al. analyses (2019 and 2022) and possibly those based on earlier work (Ernest et al. 2014, Benson et al. 2019) along with explanations of the deficiencies and cautions related to use of Ne when applied to population census estimation. Substantial variation in values can arise from differences in algorithms, sample selection, microsatellite selection, SNP selection, and level of inbreeding present, as well as other factors. As an example relating to Ne, the population estimates based on the two Gustafson analyses vary substantially for many of the subpopulations being assessed. An example is the SA MU population, where the 2019 value of 15.6 for the SA Ne results in an estimated adult population of 31-62, whereas the Ne calculated in the 2022 paper for the SA population of 3.5 results in an adult population estimate of 7- 14. Because populations lose heterozygosity at the rate of -1/(2Ne), SNP estimates put that rate at 1/7 whereas microsatellites put it at 1/40ish. Because Gustafson et al. 2019 and 2022 used the LDNe metric means based on linkage disequilibrium, SNP's would provide more information for that estimate. This suggests that the Ne of 3.5 in Gustafson et al. 2022 is likely more accurate, though the resulting population estimate is lower than suggested by recent total population estimates derived from non-invasive sampling and telemetry studies in the SA MU (Vickers et al. 2022, Vickers and Dellinger unpublished data). The two analyses may be substantially different because the Gustafson et al. 2019 analysis used fewer microsatellites that are not closely linked, the usual goal of a microsatellite project. Also, many contemporary samples were used in the 2022 SNP analysis, which included many of the offspring of M86, a male who produced eleven offspring that were in the sample set (Gustafson et al. 2018). This would have reduced Ne due to the 1:1 breeding ratio. Population estimates for the six petitioned MU's that result from density estimates developed by present and former Department personnel and statewide researchers should also be presented in the Table with the acknowledgement that these estimates are not just adult animals, but they do give a comparison point and likely a more accurate overall picture of the populations in the petitioned ESU's/MU's.

RESPONSE: Due to this and other feedback this section has been reworked and no longer uses Ne to estimate population size. The discussion of effective population size has been moved to section 4.10.3 Loss of Genetic Variation. The definition now reads "Ne is the size of an ideal population that would result in the same level of inbreeding or genetic drift as that of the population under study (Palstra and Ruzzante 2008). Though Ne is determined by several factors, it is generally significantly less than the census population (i.e., the number of animals actually breeding in a population is usually significantly fewer than the total number of animals in the population; Palstra and Ruzzante 2008, Table 6). "

Line 791: The estimate of 12-24 adult mountain lions in the Santa Anas based on the Ne of 6 in Benson et al (derived from telemetry studies and calculations based on available habitat) is substantially below the adult population estimate of 31-62 in Table 3. More recently in 2021 and 2022, spatial mark-recapture based density estimates from non-invasive sampling (hair and scat) resulted in estimates of approximately 30 to 40 individuals (not all adults) (Vickers et al 2022, Vickers and Dellinger unpublished data). Scat based individual ID's lack age information, so it is presumed that those numbers are representing all animals above young kittens, thus the adult population would be expected to be substantially lower, and unlikely to be within the range of 31-62 adults in Table 3. Calculations of the likely territorial adult population based on habitat availability and territory sizes in the SA MU (Benson et al. 2019), also are substantially lower than the values in Table 3.

RESPONSE: Based on these and other comments, there are no longer estimate population size based on effective population size. Instead estimates are derived from a statewide model, presented in Table 3.

Line 798 (Vickers): Add Gustafson et al. 2022 to the references there.

RESPONSE: Done

Line 815 (Riley): What is the "South Coast Province"? Where does that include? This is not a term that I'm familiar with.

RESPONSE: Have modified text to read "Development impacts have been extensive in the greater San Francisco Bay area, Sacramento, and San Joaquin valleys (water diversions, agricultural development, and residential development), and the Los Angeles Basin and adjacent mountain ranges south to San Diego (residential, commercial, agricultural, and industrial uses). "

Line 827 (Riley): I think you need a reference, or 2 or 3, here that are actually focused on fragmentation, instead of referencing the Wildlife Action Plan which, though it may mention it, is not a publication that is addressing fragmentation. There are probably some references in there that could work. Same thing with the next sentence.

RESPONSE: The information in this section is relatively broad, and the SWAP is the most up to date statewide resource for these issues.

Line 838-840 (Riley): What are you defining as "southern California" and the area where there are 24 million people? I think this needs to be clear.

RESPONSE: Added reference to Wikipedia's page on Southern California which lists population from the 2020 census and the 10 counties in the area.

Line: 857 (Vickers): Add Burdett et al. 2010 after "2030" at the end of the sentence

RESPONSE: Done

Line 863 (Riley): I would add "across the 5 Freeway" or something like that, after "CC and WSN MUs", since you're mentioning I-15. Also, the Huffmeyer et al. reference is for the SAs, as well as for CC-S. It might also be worth adding something to the end of the paragraph about isolation in the Santa Monicas, like: "In the Santa Monica Mountains and Santa Susana Mountains of CC-S, there is evidence of restricted movement and gene flow from the 5, 101, and 405 Freeways."

RESPONSE: Text altered to "Similar connectivity challenges occur due to Interstate 5 between the CC and WSN MUs. Recently published information on reproductive and morphological abnormalities in mountain lions indicate inbreeding in the CC-S, SA, and EPR (Huffmeyer et al. 2022). "

Line 872 (Vickers): Add "to" after "projected"

RESPONSE: Done

Line 880 (Riley): Yes, and along with the potential for increased intraspecific aggression, we have also documented many cases of very close inbreeding between fathers and daughters, which although it may occur occasionally in other populations, seems much more common in our small, isolated one. It was documented in Riley et al. 2014, but also in our report to CDFW covering the mountain lion study from 2013-2016.

RESPONSE: This section has been reworked. The information about inbreeding is mentioned in section 4.10.4 Genetic Impacts on the Populations Within the Petitioned ESU.

Line 910 (Vickers): Add "of" after "proportion"

RESPONSE: Done

Line 912 (Riley): How many home ranges was this based on? Is there a reference for this? Is it also the Meinke reference? This reference is incomplete in the Lit Cited (as are a number of other references; they all need to be double-checked), it is unclear what it is - a thesis? A report?, Nor is there any information about how readers can acquire it.

RESPONSE: Meinke reference issue fixed. Text altered to "A study of nine mountain lion home ranges in the redwood forest of northwest California found mountain lions used forest areas with a greater proportion of fragmentation and edge more frequently than areas of more contiguous forest; however, lions generally avoided areas of active timber harvest operations (Meinke 2004)."

Line 927 (Riley): We should make sure that you all have all of our vehicle mortality records. We worked with Esther and others to provide them, but based on the map in Figure 6, it looks like some are missing. Also, we had a really bad year for lion mortality in general, and from vehicles in particular, from early 2022 through early 2023. 15 lions died, 9 collared ones, and most of those were from vehicles. It says here that it is just through 2021, so maybe you aren't including those, but we can certainly provide them if it is useful.

RESPONSE: Map updated.

Line 939-940 (Vickers): The SA MU does not "include the greater Los Angeles metropolitan area" - it is considered to be a portion of that area, as are the CCS and SGSB MU's. In contrast it is probably correct to state that the greater San Diego Metropolitan area is included within the EPR MU, since in contrast to the SA MU (Santa Ana Mountains only) the EPR MU encompasses multiple mountain ranges both surrounding and far from the San Diego metropolitan area.

RESPONSE: The Department is no longer using the Management Unit framework. Text changed to "From 1981 to 2013, reported vehicle strikes accounted for 53% (50/94) of known mountain lion deaths in the SA genetic group (which includes parts of the greater Los Angeles metropolitan area) and 30% (46/154) in the EPR genetic group (which includes the greater San Diego metropolitan area) (Vickers et al. 2015)."

Line 940 (Riley): This gets again to the question of what the boundaries of the MUs are. I definitely wouldn't think that the SA MU includes the Los Angeles Area broadly, and certainly not the north and west parts of LA which are in the Santa Monica Mountains and adjacent to the Santa Susana Mountains. Vehicles have also become the major source of morality in the Santa Monica Mountains and surroundings. This could be mentioned maybe at the end of the paragraph. If a Santa Monica Mountains MU is considered, then maybe something like: "Vehicles have also become the largest source of mortality in the Santa Monicas to Los Padres MU (Benson et al. 2020, NPS Report 2024)." In our next report which we will be providing soon, we will document the large amount of mortality, especially from vehicles, that we have seen since early 2022.

RESPONSE: The Department is no longer using the Management Unit framework. Text changed to "From 1981 to 2013, reported vehicle strikes accounted for 53% (50/94) of known mountain lion deaths in the SA genetic group (which includes parts of the greater Los Angeles metropolitan area) and 30% (46/154) in the EPR genetic group (which includes the greater San Diego metropolitan area) (Vickers et al. 2015)."

Line 942 (Vickers): Replace "tertiary" with "secondary"

RESPONSE: Done

Line 945-955 (Riley): So, a few things about this paragraph. Overall, it feels pretty confusing, because there are many different numbers given from different areas, with different, but often overlapping years. So it is pretty hard to tell what's going on. Also, Shilling and Vickers 2023 is cited, but this is not in the references, so not sure if this should be Shilling et al. 2023, or if there is a reference missing.

RESPONSE: This paragraph has been reworked and reference has been updated.

Line 963 (Vickers): This phenomenon also occurred in the SA MU in February of 2021 when an adult female was killed by a car on a surface street in south Orange County, and her two approximately six month old offspring were subsequently captured. One of the offspring was also struck and sustained bony injuries that required surgery. The uninjured individual was GPS collared and released by CDFW after a period of months in isolation at a rehabilitation facility. The individual that had surgery ultimately was kept in captivity rather than being released due to acclimation to humans.

RESPONSE: Noted

Line 963 (Riley): It might be valuable to also mention a story from the Santa Susana Mountains that we documented, at the end of this paragraph. In the Rocky Peak area of the 118 Freeway, between Simi Valley and the San Fernando Valley, adult female P39 was hit and killed in early December 2016. We had marked a litter of her kittens the previous summer, P50, P51, and P52, so they were about 5 months old. A couple of weeks after P39 died, P52 was killed in the same stretch of 118, and then a few weeks after that, P51 was killed in the same area. There is a good crossing in the area, specifically a hiker and equestrian tunnel at Corriganville Park, but they did not use it. We are currently doing a study with Caltrans to better understand connectivity in this area, and we are hoping to improve the fencing in this stretch, to keep animals off the freeway and funnel them towards crossings. This story was documented in our report to CDFW covering 2016-2018, which could be cited for reference.

RESPONSE: Noted, but this is a bit more detail than is useful for this document.

Line 967 (Vickers): Sentence beginning "Dr. Winston Vickers" could be changed to "Dr. Winston Vickers has observed that the data from numerous GPS collared mountain lions in the SA MU has indicated that they have encountered three regional freeways that surround the SA MU (I-5, I-15, SR 91) on multiple occasions, and ranged up and down along them before turning back. This has occurred with mountain lions going east and approaching Interstate 15, north approaching SR 91, and west approaching Interstate 5. Only three GPS-collared mountain lions have crossed I-15, the critical barrier between the SA MU and the EPR MU genetic groups during the 19 years that the UC Davis researchers have studied mountain lions in the SA MU . All three crossed west to east (from the SA MU into the EPR MU), and all three were dispersal age animals (two males and one female). Of the three, one was killed on a depredation permit in the EPR MU within 3 weeks, the other two returned to the SA MU after a short period and did not cross the freeway again before their collars dropped off as scheduled. Two uncollared mountain lions have been recorded crossing I-15 on cameras monitoring crossing structures at Temecula Creek and culverts south of that location. Those individuals crossed I-15 west to east, but no mountain lions have been recorded crossing east to west despite numerous photos of mountain lions being captured alongside the east side of the freeway. Gustafson et al. (2019) detailed genetic evidence of three mountain lions whose genetic origins were in the EPR MU. Evidence of offspring production was only detected for one of the three (UC Davis M86). That animal appeared to have produced eleven offspring and enhanced the genetic diversity of the population (Gustafson et al. 2019). Though one GPS collared mountain lion has crossed SR 91 from the main body of the Santa Ana Range into the Chino Hills and back several times, the Chino Hills are completely surrounded by development and do not provide a pathway to the SGSB MU to the north. A few GPS collared mountain lions have crossed under I-5 toward the ocean from the body of the Santa Ana Range, but have only been able to access small areas of coastal scrub between the freeway and the ocean, with no ability to connect from there to any other populations. (W. Vickers unpublished data)"

RESPONSE: Have added some of the text, now reads "For example, GPS data from collared mountain lions in the Santa Ana Mountains have revealed that on multiple occasions lions approached one of the three regional freeways that surround the mountains (I-5, I-15, SR-91), only to range back and forth along them before turning back (W. Vickers unpublished data). Only three GPS-collared mountain lions have crossed I-15, the critical barrier between the SA and the EPR genetic populations, during the 19 years that UC Davis researchers have studied mountain lions in the Santa Anas. All three crossed west to east (from SA into the EPR), and all three were dispersal age animals (two males and one female).

However, crossing a major barrier like a road does not guarantee the individual will stay or breed in the new area. Of the three who crossed I-15, one was killed on a depredation permit in the EPR within 3 weeks, while the other two returned to the SA after a short period and did not cross the freeway again before their collars dropped off as scheduled (W. Vickers unpublished data). Two uncollared mountain lions have been recorded crossing I-15 on cameras monitoring crossing structures at Temecula Creek and culverts south of that location. Those individuals also crossed I-15 west to east, but no mountain lions have been recorded crossing east to west despite numerous photos of mountain lions being captured along the east side of the freeway (W. Vickers unpublished data). Though one GPS-collared mountain lion has crossed SR-91 from the main body of the Santa Ana Mountains into the Chino Hills and back several times, the Chino Hills are completely surrounded by development and do not provide a pathway to the San Gabriel Mountains to the north. "

Line 970 (Riley): We have definitely seen this same thing repeatedly with young lions in the Santa Monicas, where they are "bouncing off" the freeway and the development along it, in what looks like "frustrated dispersal." You could cite Riley et al. 2014 for that, or some of our reports to CDFW, or S. P. D. Riley personal communication.

RESPONSE: Reworked this section and deleted this sentence.

Line 978-985 (Riley): A few things for this paragraph: the South Coast Missing Linkages Project was for the Southern California region, not for the state, though there was also a Missing Linkages Report from 2000 for the whole state. It would be good to cite the report on line 980, which would be South Coast Wildlands 2008 (let me know if you need help finding it). Also, in reference to Ventura County, I think it would be worth saying a bit more here: "Specifically, Ventura County has passed an ordinance that mandates the consideration of impacts to wildlife movement for projects within the linkage areas." And on line 985, when you say "the corridor", I don't think it's clear what you mean exactly. Maybe you could cite Figure 7, and put a circle or something around the area that you mean?

RESPONSE: Altered text to read "In 2008, the South Coast Missing Linkages Project identified areas in the coastal areas of southern California where linkages are needed (Fig. 7)." reference to South Coast Wildlands 2008 reference added.

Line 990 (Riley): What does "make the crossing more natural and acceptable to wildlife" mean? This isn't clear. It is definitely important to preserve natural habitat on both sides of crossing sites whenever possible, as that it makes it more likely to be used. It is also valuable to make the crossing itself feel as natural as possible, by vegetating it, if possible. Not sure if one, or both of these meanings are intended.

RESPONSE: Altered text to " However, funding to implement wildlife crossing projects, including land acquisition to preserve natural habitat on both sides to make the crossing more acceptable to wildlife, has been limited to date. "

Line 991 (Vickers): Suggest adding "with appropriate fencing, and lack of fencing near existing crossing structures" after "crossings"

RESPONSE: Done

Line 993 (Ernest): The CDFW proposal makes an unsupported assumption that the future Wallis-Annenberg Wildlife Crossing will largely mitigate road kills and lack of gene flow caused by heavy traffic on busy multi-lane highways. There is no guarantee that mountain lions will use it and avoid all other local highway crossings; there is no guarantee that it will greatly lower mountain lion road mortalities; there is no guarantee that this crossing alone with solve gene flow problems. The single Wildlife Crossing is a necessary start, but it is in no way sufficient to stop degradation of Santa Monica population viability.

RESPONSE: Altered text to "Together, these crossings should help facilitate the movement of mountain lions between the Santa Cruz Mountains in CC-N and the Gabilan Mountains in CC-C"

Line 993 (Riley): I would add after "vehicle strikes" here something like: "and especially to the barrier effects on movement and gene flow." As mentioned in other comments later, for major, busy freeways, animals are less likely to attempt to cross them, and so while they can certainly result in some mortality if animals do try, their major effects are more as barriers than sources of mortality. Often smaller highways and major secondary roads are more important for mortality - that is what we have found in terms of number of moralities in our area (see also another comment, which includes numbers).

Line 995 (Riley): After "2022" here, you could add an update if you want: "The structure over the freeway is due to be finished at the end of 2024 and the full crossing, including the approaches and the crossing over adjacent Agoura Road, at the end of 2025."

RESPONSE: Text changed to "The crossing, including the approaches and the crossing over adjacent Agoura Road, is expected to be completed in late 2026"

Line 996 (Riley): It would be more accurate to say "…facilitate genetic exchange throughout the CC-S MU and between CC-S and CC-C, and ideally between CC-S and SN."

RESPONSE: Text changed to "The overpass will help facilitate mountain lion movement between the Santa Monica Mountains and the Simi Hills and could ultimately contribute to genetic exchange throughout the CC-S genetic population, between CC-S and CC-C, and ideally between CC-S and WSN"

Line 997 (Riley): I think this sentence about minimizing vehicle mortality needs to be modified. Reducing vehicle mortality is really not the main goal of this crossing, though it certainly can be for some crossings, and may be for the Highway 17 crossing, for example. Though lions, and other wildlife, are occasionally hit on 101 and other large freeways, it is smaller highways and secondary roads that are more often the sources of vehicle mortality, as animals are reluctant to even try to cross these major freeways. It will certainly be the case that in the vicinity of the crossing, we hope to minimize, and ideally even eliminate, animals coming on to the freeway and being killed. But animals, including mountain lions, will continue to be killed by vehicles in the Santa Monicas and Simi Hills, especially on smaller roads, which is where more of them occur already. This will not mean that the crossing is in some way a failure - the main goal of this crossing is to provide connectivity between the Santa Monicas and the Simi Hills, and thereby to other areas, for mountain lions and for all other species, as you state well in the previous sentence. We do hope that there is some reduction in mortality for subadult mountain lions, from vehicles and potentially from other sources such as intraspecific strife, once they are better able to disperse out of the Santa Monica Mountains, and therefore aren't trying to disperse in other areas, including sometimes across 101 or other roads.

RESPONSE: Altered text to "It may also minimize some local vehicle-related mortality on Highway 101"

Line 1001 (Vickers): Suggest adding "In addition, initial design and environmental studies are being completed for a new crossing structure across I-15 south of Temecula, and improvements to the Temecula Creek passageway that is currently in existence in that critical corridor area but is currently heavily impacted by humans. Other connectivity studies are being initiated along I-10 in the area that is critical to mountain lion movement between the EPR MU and SGSB MU in order to guide potential improvements to connectivity across that freeway. (Vickers personal communication"

RESPONSE: Done

Line 1045 (Riley): Where does this definition come from? I think it would be good to give a citation if possible. Also, when you say "negative impacts to one or more species," are humans considered to be one of the "species"? Clearly negative effects on humans are a critical part of this conflict, so I think that needs to be clear.

RESPONSE: Have changed text to CDFW's definition. Text now reads "Human-wildlife conflicts “occurs when humans and wild animals interact in an unwanted or unsafe way” (CDFW 2024). "

Line 1051 (Riley): What does it mean for a mountain lion to be "taken non-lethally"? I think that needs to be made clear, as that will not be intuitive for many readers.

RESPONSE: Added this text " Nonlethal methods involve modifying the natural behavior of the animal, for example through hazing with hounds or an air horn."

Line 1060 (Vickers): Suggest adding "Benson et al. (2023) determined that lethal take secondary to depredation permits was the number one cause of death for GPS collared mountain lions in California, and that human-associated mortality was additive versus compensatory".

RESPONSE: This sentence "From 1972 to 2020, at least 3,694 mountain lions were removed in depredation incidents (Dellinger et al. 2021b), and it was the leading cause of attributable mortality of collared mountain lions (Benson et al. 2023)" was added three paragraphs later.

Line 1064 (Riley): Does this mean that more than one animal could be taken on a single depredation permit in the past? That wasn't clear, I don't think.

RESPONSE: Modified text to read "The most noteworthy change in management action reflected in this approach was specifying that instead of multiple, only one mountain lion could be taken under a single depredation permit"

Line 1079 (Riley): Is there a period of time that must elapse between the first or second depredation events and the implementation of non-lethal measured, before a lethal permit can be issued because of another depredation event? If so, it would be good to mention what that is, and if not, I think that would be important to mention as well.

RESPONSE: This section has been deleted.

Line 1082 (Riley): How many of these 3,637 were determined to be related to public safety? I assume it is some subset of the 1,327 that were classified as "potential human conflict"? How is "potential human conflict" defined? It think it is important to be clear here, especially about public safety incidents. I'm also wondering what "general nuisance" means.

RESPONSE: The data are self-reported by the public and not vetted. Therefore reporting the incidence numbers would be potentially misleading. Information about reporting categories was added to a footnote. Added more detail about human conflict in section 4.4.3 about public safety including text “Specifically, a threat to public safety is when a mountain lion “exhibits one or more aggressive behaviors directed toward a person that is not reasonably believed to be due to the presence of responders.” (Fish & G. Code, § 4801.5, subd. (b).) From 1986 to April 2024 there were 25 reported mountain lion attacks on humans in California, 4 of them fatal (CDFW 2024c). The Department has records of 10 mountain lions being euthanized following attacks on humans in California between 2000 and 2024 (reliable records prior to 2000 are unavailable).”

Line 1092 (Riley): What percentage of permits resulted in lethal removals in the state overall? If it was 8.6% within the proposed ESU area, is this very different from what was happening generally?

RESPONSE: The section has been rewritten and the relevant sentence has been removed. See response above for new text.

Line 1094 (Riley): How many lions have been lethally removed for public safety reasons?

RESPONSE: Added the text "Since 2000, 10 mountain lions have been euthanized following attacks on humans in California."

Line 1098 (Riley): This seems pretty speculative, that depredations have increased for these reasons. It certainly seems reasonable, but is it based on anything? If so, it would be worth saying, or giving a citation.

RESPONSE: This part of the sentence has been deleted.

Line 1108 (Riley): I think you need to be a bit careful with a couple of things here. I think you want to use he past tense here, since the 2019 report is 5 years old and the data would have been older than that. What is this based on, to say that "approximately 33% of them were dispersers", from Steve's paper (Torres et al.)? Really the only way to know if they were dispersing is to have followed them from when they were born, or at least when they were with their mothers, which I'm sure is essentially never happening in these cases. They could potentially be said to be "of dispersal age" or something like that.

RESPONSE: Have reworked, text now says "For example, from 1981 to 2013 in the Santa Ana Mountains and the Eastern Peninsular Range, 3.4 times as many males were taken for depredation than females (Vickers et al. 2015). Because males are more likely to disperse than females, depredation removal may thus further inhibit adequate gene flow between mountain lion populations in southern California by removing the animals most likely to move between genetic populations (Vickers et al. 2017)."

Line 1113 (Riley): OK, this is fair enough that many of the "primary gene dispersers" are lost if many of the depredation cases are dispersing males. However, as I also mentioned elsewhere, young females disperse too. This is something that we have documented, and the thought is that generally 1/2 of young females disperse, along with all of the young males. As I said, we generally cite Logan and Sweanor 2010 (from the Cougar book) for that. So young females can be gene dispersers. We have one female that dispersed from the Santa Monica Mountains all the way up to Los Padres National Forest (P33).

RESPONSE: Have reworked, now says "Because males are more likely to disperse than females, depredation removal may thus further inhibit adequate gene flow between mountain lion populations in southern California by removing the animals most likely to move between genetic populations (Vickers et al. 2017)."

Line 1115-1123 (Riley): A few things about this paragraph. At the beginning, what does "most" were sheep and goats mean? I would just give the numbers. Also, I think the language in this paragraph should really be past tense. Even though it was pretty recent, Dellinger et al. 2021a is still covering data through 2019, so we know what happened with that data, but we can't assume it is still the case. Also, in terms of subadults taking over and creating conflicts, I think it's worth also citing the Weilgus work from Washington for this idea. He became a controversial guy, but it doesn't mean he didn't produce valuable work with important conclusions and implications. Finally, though it may often indeed be subadults involved with depredations, we have definitely documented adult males taking livestock when available as well, including sometimes repeatedly, when domestic animals continued to be unprotected (e.g., P45).

RESPONSE: Based on this and other feedback, section has been altered to read "Interestingly, researchers have noted that at the county level, mountain lion depredation rates increased by 9% for every lion removed through a depredation permit the prior year (Dellinger et al. 2021a). This general pattern of increased depredations in an area the year after mountain lion removal was also seen in Washington state, though removals were done via sport hunting and therefore less targeted to individual mountain lions that may have been involved in depredations (Peebles et al. 2013). Dellinger et al. (2021a) suggested this pattern could be a result of subadults moving to territories vacated when resident adults were removed. Research shows subadults can be more likely to use areas closer to people (Kertson et al. 2013), but evidence that subadults mountain lions have less well-developed hunting skills and are more likely to target easily killed domestic animals is not conclusive (Linnell et al. 1999; Peebles et al. 2013). "

Line 1148-1152 (Riley): I think the first part of this paragraph is a bit misleading. While it is true that the management mortality rate was roughly equal to all natural mortality causes, that seems to be a bit selective of the results. Management killing was the number one cause of mortality, and all human-caused mortality was twice that of natural mortality, which was affecting population-level survival. Though population modeling is needed to fully understand the impacts of different kinds of mortality, human-caused mortality generally, of which management killing was the most important element, was additive. Though the North Coast and Sierra Nevada populations are likely generally doing well, I think it's important to acknowledge the human-caused mortality could reduce the ability of these large populations to continue to serve as sources for the smaller fragmented populations. Especially if management killing is preferentially killing dispersing males, as you mention earlier in the section. Also, there is an "of" missing in the first sentence.

RESPONSE: We deal with management killing in this paragraph, but we expanded our discussion of Benson et al. (2023)'s results in section 3.1.1. on sources of mortality to include a mention of how human caused mortality in general is additive. Management killings in the North Coast and Sierra Nevada may reduce gene flow to the petitioned area but management killing has decreased in recent years (see newly added Figure 14), and therefore the impact of management killings on dispersal may be greatly reduced. Without specific data it is hard to say either way. Editing suggestion was completed.

Line 1163-1165 (Beier): These lines have pale gray highlighting.

RESPONSE: Fixed

Line 1168 (Riley): The "until recently" should be dropped here. There is still no population of bears in the Santa Monicas. We did have one bear, BB12, that was in the Santa Monicas for a while, but he then crossed 101, visited the Santa Susanas (where he likely came from), was headed back south, and sadly was hit by a car.

RESPONSE: Done

Line 1169 (Riley): It think it's important to put the word "can" between "wolves" and "affect" here. These studies come from one particular area, wolves and mountain lions certainly coexisted for a long, long time throughout North America and continue to do so in many places, and in the abundance model in Elbroch et al. 2020, wolf abundance was important, but human hunting also mattered, which does not occur in CA. Also, the mountain lion harvest numbers for the intermountain west states where wolves have reestablished have actually remained steady or increased since wolves have arrived. This would not be possible if wolves were having a consistent and significant negative effect on mountain lion populations. Also, the Elbroch et al. 2015 paper is about bears, as opposed to wolves, so it wouldn't be cited here.

RESPONSE: Done, and replaced Elbroch et al 2015 with the other Elbroch et al 2015 paper about wolves.

Line 1176 (Riley): Yes, I think coyotes scavenging lion kills is unlikely to have much impact on what the lions are getting from them, depending on when they start feeding from them. And in fact, trying to feed from lion kills is dangerous for the coyotes. We have documented a number of cases where coyotes were also killed by lions at deer kill sites, and in eastern Oregon (Rupprecht et al. 2021) they documented quite a bit of coyote mortality from cougars, similar to what they mention in this WY study.

If a coyote is killed while attempting to scavenge from a lion kill, that could actually add to the resources for the lion in that case! Although in Rupprecht et al. they did document quite a lot of scavenging by the coyotes, but it was unclear how much it was affecting resources for the cougars.

RESPONSE: Noted.

Line 1180 (Riley): As I mentioned elsewhere, this should be modified a bit, since more recently, vehicles and toxicants have caught up to intraspecific aggression in terms of importance as mortality sources in our area, and even more recently vehicles have overtaken both. You could just say "was" instead of "has been" here, , and then at the end of the sentence, add: ", although more recently, vehicles and toxicants have reached similar levels as mortality causes (Benson et al. 2020)."

RESPONSE: Done

Line 1187 (Riley): It would be good to cite Benson et al. 2020 here too, since the years given here are 2002-2018, but the Riley et al. 2014 reference didn't cover that whole time period.

RESPONSE: Done

Line 1233 (Riley): Again, I think it would be better to use the past tense here, as in "Second-generation ARs were more commonly detected…"

RESPONSE: Done

Line 1236 (Riley): Why is the percentage with three or more compounds given here, as opposed to four, or five, or six? I think the most relevant measure to give Is just the percentage of animals that were exposed to more than one compound, because that means they were exposed more than once. And that number is even more impressive, at 86% (213/247). I'm not sure how much more meaning there is from showing two vs. three compounds, but there is a lot of meaning gained from 0 or 1 to 2, I think.

RESPONSE: The data has been updated through the year 2022 and text adjusted to present proportion for mountain lions with 2 or more ARs detected. Text now reads " The Department's Wildlife Health Lab detected AR exposure in 94.2% (343/364) of tested mountain lion livers submitted between 2016 and 2022 (Fig.15; Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022; CDFW unpublished data). Second-generation ARs were more commonly detected than first-generation ARs, despite a 2014 California regulatory change restricting second-generation AR use to certified pesticide applicators (Rudd et al. 2018; Rudd and Rogers 2021). Eighty-five percent of the mountain lion livers (306/364) tested had two or more different ARs present at the time of death, with 52.2% (190/364) of individuals testing positive for three or four different ARs, which indicates multiple exposure events are common (Fig. 16; Rudd et al. 2020b; Rudd and Rogers 2021; Rudd et al. 2021; Rudd et al. 2022; CDFW unpublished data) " Figure 16 also updated

Line 1237 (Riley): There was some work evaluating rodenticide exposure in mountain lions across the state that covered earlier years, specifically from 2003 to 2015, which I think would be worth mentioning at the end of this paragraph, or rather right before the last sentence. This was also work led by Bob Poppenga at the toxicology lab at CAHFS, the senior (last) author on the Rudd et al. 2018 publication, and also involving CDFW folks, specifically Stella McMillin. If you included it, it could say something like this:

"This 96% exposure level was actually higher than the 82% (103/125) exposure found in an earlier sample of mountain lion livers from across the state from 2003 to 2015 (Poppenga et al. unpublished data). Sixty-seven percent (84/125) of livers tested i this earlier sample had multiple different ARs present."

RESPONSE: The 2003-2015 data set was received from the reviewer, re-examined to calculate AR exposure metrics, and compared to the 2016-2022 dataset. The text was revised accordingly to: The 94.2% (343/364) total exposure prevalence recorded between 2016 and 2022 is higher (X2 = 14.8, p < 0.001) than the 82.4% (103/125) exposure prevalence found in mountain lion livers analyzed from across the state between 2003 and 2015 (Poppenga et al. unpublished data). In samples from 2003–2015, 67.2% (84/125) of livers indicated exposure to multiple AR compounds, which was lower than the exposure prevalence rate in livers tested between 2016 and 2022 (X2 = 15.4, p < 0.001).

Line 1237 (Riley): I think the end of the paragraph should be modified to say something like "To date, there was not a consistent observable pathological condition associated solely with AR exposure in the livers of necropsied mountain lions (Rudd et al. 2018). However, multiple mountain lions have been determined by state pathologists to have died from coagulopathy associated with AR exposure." As discussed on the next page, we have had multiple mountain lions in our area that have been determined to have died from AR exposure as a result of coagulopathy, upon necropsy by the pathologists at the state-wide pathology lab at CAHFS.

RESPONSE: This sentence was deleted.

Line 1248 (Riley): Though it may mention it, this Kopanke et al. paper is really about something else, other than reduced coagulopathic effects in felids. I think a more appropriate reference here would be the Gupta 2012 reference, if it mentions it, or something like that. I know of two earlier references that mention the reduced susceptibility in cats, the Roder 2001 "Veterinary Toxicology" book, and the Morgan et al. 2003 "Handbook of Small Animal Practice" (both cited in Riley et al. 2007, if that is helpful).

RESPONSE: This sentence was deleted.

Line 1257 (Riley): A couple of things about this first sentence. Most importantly, it was not us, the National Park Service, that concluded that these 7 deaths were associated with toxicosis and coagulopathy from AR exposure. It all but one case (P04, in 2004, who we were not able to safely extract from the field, so we did a field necropsy), these mountain lions were transported to the California Animal Health and Food Safety Lab's San Bernardino branch, and the necropsy, including the decision about cause of death, was from the pathologist at CAHFS, not by the National Park Service. Even in the case of P04, we consulted about the necropsy with CAHFS and submitted samples. We are happy to provide CAHFS reports for all seven of these cases, if that is helpful.

RESPONSE: The sentence has been revised to… In the Santa Monica Mountains National Recreation Area (CC-S), the deaths of seven mountain lions since 2004 were associated with AR exposure and toxicosis (Riley et al. 2007, NPS 2021)…

Line 1259 (Riley): It would be worth adding an update here, I think, after the first sentence, since we have more recent data in the Benson et al. 2020 Biological Conservation paper showing that AR toxicosis was a leading cause of death in our population up through 2019. Something like: "Through 2019, AR toxicosis was a leading cause of death for mountain lions in the population, along with vehicles and intraspecific strife (Benson et al. 2020)."

RESPONSE: Text added "In the Santa Monica Mountains National Recreation Area (CC-S), the deaths of seven mountain lions since 2004 have been associated with AR exposure and toxicosis (Riley et al. 2007; NPS 2021). Between 2002 and 2019, out of 26 known deaths of adults and subadults in that population, 5 were from AR toxicosis (Benson et al. 2020)"

Line 1262 (Riley): For this sentence, along with Riley et al. 2007, it would be good to cite the more recent work on this question, Serieys et al. 2015 and Serieys et al. 2018, both of which are already in the Lit

Cited.

RESPONSE: Reference changed to Serieyes et al. 2015

Line 1264 (Riley): We documented another case of this, actually with four full-term fetuses. It would be worth adding this case to this paragraph and to Table 4 on the next page. Specifically, adult female P54 was hit and killed by a vehicle in June, 2022, and both she and all 4 of her full-term fetuses had been exposed to multiple AR compounds.

RESPONSE: We thank the reviewer for contributing this additional case. We have added that case, attributed to NPS, and also added more recent CDFW data to this section. Revised text: Fetal AR exposure occurs in mountain lions, as exposure was detected in four of eight (50%) instances where both pregnant female mountain lions and fetal or placental tissues were tested (Table 4; CDFW unpublished data; National Park Service (NPS) unpublished data). Many toxic substances, including ARs, can adversely affect fetal development and survival at doses that may not produce toxic effects in the mother (Gupta 2012). Fetuses are also typically more susceptible to AR toxicity because the placenta is the only source of vitamin K for the fetus (Gupta 2012). AR-related coagulopathy and toxicity was not observed in any of the examined fetuses with AR exposure (Rudd et al. 2020, CDFW and NPS unpublished data).

Line 1271 (Riley): As mentioned in the last note, it would be worth adding P54 from our study to this table. She was exposed to 5 different compounds, and all 4 of her fetuses were exposed to multiple compounds. We can provide the specific compounds and the residue levels for inclusion in the table.

RESPONSE: same as above comment

Line 1278 (Riley): I think it would really be important to mention in this paragraph, or better yet, in a new, separate paragraph, that many cases of exposure of mountain lions to another rodenticide, bromethalin, have been documented in recent years. So far, we have tested 21 animals for bromethalin exposure an 12 have been positive. Bromethalin use has increased significantly in recent years as a result of the ban on ARs, and so has the detection of exposure in non-target wildlife by the CAHFS toxicology lab, according to Bob Poppenga at CAHFS and CDFW folks at the Wildlife Investigations Lab. We don't know what the secondary effects could be, and this emphasizes the point of the last sentence of the paragraph here, about more research being needed on other toxicants. Also, minor point, there is no "Rudd et al. 2019" in the Lit Cited. I'm presuming Rudd et al. 2018 was intended maybe?

RESPONSE: A section on bromethalin exposure in mountain lions has been added to the document.

Line 1296 (Riley): This is certainly true that a major disease outbreak could be "catastrophic," especially for a small population. However, there has never been a major disease outbreak documented in this species, that I have ever seen. So while it is of course important to be aware of the potential for disease, mountain lions specifically, and perhaps so-called solitary felids more generally may be less susceptible to epizootics that could affect many animals. This may be because they are not very social and live at such low densities.

RESPONSE: Wording changed to "However, small, isolated mountain lion populations are at greater risk of experiencing population-level impacts from disease, which could reduce their ability to persist into the future, especially when combined with other threats (Foley et al. 2013). "

Line 1305 (Riley): Since both of these studies were of seroprevalence, they are measuring the prevalence of exposure, not of infection, as stated on line 1392 in a couple of pages.

RESPONSE: Have altered text to read "Researchers have found antibody test-based infection prevalence in mountain lions to be low, " Line 1320 (Riley): I think just saying "other carnivores" here would be preferable. "Mesocarnivore" is a confusing term that is used in all kinds of different ways by different people and in different circumstances. As just one example that is relevant here, in the original coining of the term mesopredator, in Soule et al. 1988, coyotes were not a "mesopredator" but were in fact the larger predator (for the canyons of San Diego). They seem to randomly sometimes be included as "mesocarnivores" and other times not. If you want to define what you mean by the term it can be OK (or less objectionable, I would argue), but I think it really doesn't add anything here. You already say in the next sentence that these species can be prey of mountain lions.

RESPONSE: This section has been shortened and this paragraph deleted.

Line 1340-1341 (Riley): A couple of things here. I think it would be good to give a citation for this statement about FPV causing high mortality in domestic cats. It is interesting to note, in reference to my previous comment, that domestic cats and African lions, the two most social felids, are also the two where viral infections have caused significant mortality. Also, again, the Foley et al. paper was looking at seroprevalence, so it was detecting exposure to pathogens, as it says right in the title, as opposed to detecting the pathogen itself. This may seem like a minor technical difference, but I think it is an important one.

RESPONSE: Have deleted the sentence about domestic cat population. Sentence including the Foley citation has been changed to "Antibodies to FPV were detected in 36% of wild mountain lions from California sampled from 1991–2008 (Foley et al. 2013). "

Line 1364 (Riley): While this may have been mentioned in Janet's paper (Foley et al.), it seems like there is probably a better direct reference about bird flu evolving to be able to be transmitted between mammals.

RESPONSE: Have changed reference to "Volume 30, Number 3—March 2024 Emerging Infectious Diseases: Recent Changes in Patterns of Mammal Infection with Highly Pathogenic Avian Influenza A(H5N1) Pablo I. Plaza, Víctor Gamarra-Toledo, Juan Rodríguez Euguí, and Sergio A. Lambertucci https://wwwnc.cdc.gov/eid/article/30/3/23-1098_article

Line 1366 (Riley): It is important because of the zoonotic potential, but I would say more relevant in the context of this document is that avian flu causing regular infections, illness, and death in wildlife, specifically mountain lions, could be an issue for mountain lion populations, especially small ones, as you discussed early in the section. A disease that is coming from prey, and not from other lions, could potentially be more of an issue than one that requires contact between conspecifics. Lions are typically mostly ungulate eaters, mostly deer in CA, but they can obviously eat many different things, including birds, as happened in these cases.

RESPONSE: This section has been updated to include six cases and emphasize importance of continued monitoring.

Line 1375 (Riley): I see from the reference that this was in CA. Might be worth mentioning that in the text here, and even saying where (I assume from the eastern Sierras, since Tom is the lead author?).

RESPONSE: This paragraph has been deleted.

Line 1401 (Riley): It might also be worth mentioning that we have documented lepto exposure and infection in mountain lions in our small population in the LA area (Helman et al. 2023, Scientific Reports 13:14368). Not sure if the Straub et al. paper included any animals from our area or not.

RESPONSE: This paragraph has been deleted.

Line 1417 (Riley): I think it would be worth mentioning in this paragraph that we have documented notoedric mange in six mountain lions during the course of our study, including P22. These were females P33 and P53 and P65, subadult males P89 and P90 (kittens of P65), and adult male P22. In all cases the presence of notoedric mange was confirmed through CAHFS, the state lab, working with parasite folks at the Vet school at Davis. Importantly, we also recently documented the death of a mountain lion from notoedric mange, adult female P65, in March 2022, the first case of mortality from notoedric mange in a mountain lion that we know of.

RESPONSE: Text added "In the Santa Monica Mountains, there have been six known cases of notoedric mange, including one adult female who died of the disease in March of 2022 (S. Riley pers comm. March 2024) & "However, notoedric mange had a negative impact on the population of bobcats in CC-S in 2002-2004 (Riley et al 2007), and in 2019-2021 there has been regular mortality from mange (S. Riley pers. comm March 2024)."

Line 1416 (Riley): This is generally true, although we documented an epizootic of the disease in bobcats, which are also a solitary felid, and it had a major impact on our population of bobcats, as discussed in Riley et al. 2007. And although mange in bobcats later declined by 2008-2010, it increased again after that, and in recent years, 2019-2021, we have again seen regular mortality in bobcats from mange. Also, as I mentioned in the last comment, we have had our first mortality in a mountain lion from mange, with P65, and she shared it with her two older kittens, P89 an P90 (we don't know who had it first or who transmitted it to whom).

RESPONSE: Text added "In the Santa Monica Mountains, there have been six known cases of notoedric mange, including one adult female who died of the disease in March of 2022 (S. Riley pers comm. March 2024) & "However, notoedric mange had a negative impact on the population of bobcats in CC-S in 2002-2004 (Riley et al 2007), and in 2019-2021 there has been regular mortality from mange (S. Riley pers. comm March 2024)."

Line 1428-1432 (Riley): I think you really need a different reference here, something about fire and Mediterranean systems more generally. I'm sure Megan's paper mentions that, but it's not the appropriate reference here, I don't think. I just checked Jennings et al., and there are some good references in there that would make sense. Also, there are multiple Williams et al. references in the Lit Cited, but none of them are 2023. Finally, I think you want to have a reference at the end of the paragraph here, about deer response to fire, which shouldn't be too hard to find.

RESPONSE: Text altered to "Fire is a natural disturbance in many California ecosystems. " Lewis et al 2022 added as deer reference. Fixed Williams reference.

Line 1439 (Riley): Again, Megan's paper is valuable and a nice contribution about lions and fire. But it was not a paper about the frequency of fires, so I think you really need a reference that directly is addressing that here. This is also true on line 1461, and for sure on line 1464 about fire return frequencies. You have a number of references for Jon Keeley in the Lit Cited which could probably work well, including the 2005 one and maybe some of the more recent ones (Keeley and Syphard ones), and I know there are some others as well.

RESPONSE: This paragraph has been reworked and sentences deleted.

Line 1487 (Ernest): The CDFW Proposal does not sufficiently account for rapid and severe progression of impacts of climate change (wildfires, drought, floods on fire- and drought-damage landscapes, more extreme weather patterns, etc.), and massive housing and industrial developments in the works and near future that will reduce or eliminate quality and quantity of mountain lion habitat including key movement corridors. The CDFW report cites literature that is now antiquated with regard to wildfire and climate change in California, and thus doing so makes statements such as (page 50, starting line 1487): ", …burned areas likely continue to be used by mountain lions as redwoods are adapted to wildfire and trees commonly survive most wildfires and trees that succumb remain standing for decades. Additionally, redwood sprouts and seedlings are prolific following fires, numbering in the tens of thousands per hectare, and canopies develop rapidly (Lazzeri-Aerts and Russell 2014)."

RESPONSE: Due to reviewer comments, the Department has reworked the status review and the majority of the petitioned area is included in the area recommended for Listing. Which means that if approved by the Fish and Game Commission, the mountain lions in the area would get the full legal protections under CESA. Added some text in the section on redwoods and softened the language. It now reads "IIn the redwood forests of the Santa Cruz Mountains, mountain lions likely continue to use burned areas following most wildfires as redwoods are adapted to wildfire with trees frequently surviving low and moderate intensity wildfires and decay-resistant dead trees remaining standing for decades. In 2020, an unusually severe fire burned old growth redwoods in Big Basin Redwoods State Park north of Santa Cruz. Six months later, many trees were able to resprout, suggesting redwoods could have some resiliency to changing fire regimes (Peltier et al. 2023). Additionally, redwood sprouts and seedlings can be prolific following fires, numbering in the tens of thousands per hectare, and canopies can develop rapidly (Lazzeri-Aerts and Russell 2014). Consequently, dense cover favored by mountain lions for hunting and travel can develop within a few years following severe wildfire in these forests."

Line 1502 (Riley): I think it would be worth adding a bit here about the other collared lion that was lost during the Woolsey Fire, and to cite the sentence. You could add something like this to the end of the sentence: "…reasonably be attributed to wildfire-related injuries, and another collared lion disappeared as the fire passed through and is presumed to have died in the fire itself (Blakely et al. 2022)." You could also cite our report to CDFW that described these events (the report for 2018-2019), if you wanted.

RESPONSE: Text changed to "Vickers et al. (2015) documented the death of a collared mountain lion in the SA and one in the EPR due to burns from human-caused wildfires and, following the 2018 Woolsey Fire in the Santa Monica Mountains and Simi Hills, one collared lion was found in poor condition with burned feet and eventually died. Another collared lion disappeared and was presumed to have died in the same fire (Blakey et al. 2022)"

Line 1533 (Riley): Please also see the comment for page 20, about the importance of chaparral. As you say, this was speculation by Burdett et al., as opposed to something that they actually addressed in their study, i.e. they didn't have different classes of chaparral based on density or age (time since fire). We found in our recent paper on 15 years worth of data on habitat use and selection (Riley et al. 2021) that chaparral was the most heavily used and consistently selected vegetation type by mountain lions of all age and sex classes. And although we also didn't explicitly evaluate chaparral density, we had a range of different ages for chaparral across the life of the study. So I really don't think there's much evidence of mountain lions avoiding chaparral. Even in Burdett et al., chaparral was used about as much as it was available, and given that it was the most common vegetation type, that was a lot!

RESPONSE: Deleted relevant sentence

Line 1537-1539 (Riley): I don't think these are actually contradictory results at all, because the burned area after the Woolsey Fire was really essentially barren for much, if not all of that 15 months post-fire that we evaluated in Blakey et al. 2022. I think the better comparison is the one with Megan's paper (Jennings et al.) the you make at the beginning of the paragraph, but as you say there, they found that it was "the first few years" post-fire when lions were preferring it, and the kills were more likely in areas less than 6 years post-burn. Whereas again, our results from Blakey et al. were within just the first 15 months, and that fire, which was huge and intense, really moon scaped the whole area, so recovery has taken some time. Jennings et al. also mentions that lions were avoiding grasslands and sparser areas, and we also found that they avoided grasslands and altered open areas (landscaped areas such as cemeteries and golf courses) in our 2021 JWM paper. More work needs to be done on how vegetation structure specifically affects mountain lion habitat use and selection, something that we're working on with Rachel Blakey. But I don't think there's currently much evidence of chaparral being avoided, and there is good evidence of its importance, as well as of avoidance of areas with low cover.

RESPONSE: Rewrote. It now reads "A study in the Santa Monica Mountains and Simi Hills after the 2018 Woolsey fire showed that, in general, mountain lions avoided burned areas up to 15 months post fire (Blakey et al. 2022).

Line 1542 (Riley): As Jon Keeley and others have regularly argued, though it is really valuable in forested systems such as in the Sierra Nevada, prescribed fire is really not an appropriate tool at this point in scrubland systems (CSS and chaparral), where fire frequencies are already much higher than they should be, and where there is regular type conversion to other vegetation types, often invasive grasslands, as you mention in the next section. So I think it's important to make the distinction here between different ecosystem types. There is forest in some areas of the petitioned area, such as along the Central Coast, and in some farther east areas like the Eastern Peninsular Ranges, but much of it, especially in the South Coast Area, is really dominated by shrublands.

RESPONSE: Text now reads "Several strategies are employed in forested ecosystems including prescribed burns and mechanical fuels reduction"

Line 1549, 1637,1648 (Riley): Just a couple of minor things in this section: Bedsworth et al. is not in the Lit cited (line 1549). On line 1637, it's fine to have Jennings et al., but it might be worth having a couple of other references here about avoidance of grasslands, like maybe Burdett et al. 2010 and Riley et al. 2021, if you want to cover some time breadth and geography (at least in the south). And Fuller et al. 2016 is also not in the Lit Cited (line 1648).

RESPONSE: Fixed reference issues.

Line 1646 (Ernest): Similar problematic statements (as on page 50) and imply that climate change is unlikely to affect “large-bodied mammals” including mountain lions and deer. This statement is likely false in regard to “temperature” but perhaps more importantly are the diverse effects of climate change (not just “temperature”) on disease pathogens, plant communities, and so much more. The cited references for this are also proven outdated by recent climate change effects to California, and to the many newer citations in these regards. Recent wildfires show this thinking is no longer valid. Bowers et al 2024 outline climate change in its diverse ramifications for habitats in Central and Southern California – including drought, increasingly catastrophic wildfires, increasingly catastrophic atmospheric rivers (https://www.science.org/doi/10.1126/sciadv.adi7905). An example of massive housing developments are those slated for the Tejon Range/Tehachapi region (Jan 10, 2024 “…It marks the next stage of a constant progression that will see Tejon Ranch eventually become home to more than 35,000 homes…” on website as viewed January 21, 2024, https://tejonranch.com/news-events/)

RESPONSE: Added text about Tejon ranch development in section on urbanization "For example, there are 35,000 new homes planned adjacent to current development at Tejon Ranch in the Tehachapi Mountains near the southern end of the Central Valley (Tejon Ranch Company 2024). Their buildout would decrease the available undeveloped land in a relatively narrow corridor where mountain lions move between the western Sierra Nevada and the central coast and southern California (Penrod and Smith 2022; Tejon Ranch Company 2024)." Added text to section on infectious disease "Recent detections of emerging diseases in California mountain lions coupled with potential for future changes in the distribution of pathogens and disease vectors due to habitat modification and climate change supports the value of continued mortality monitoring and disease surveillance in this species (Thurman et al 2024). " We did not find any literature that specifically predicts threats of climate change to mountain lions, only papers that say things might change.

Line 1651 (Riley): I think you did a nice job with a relatively difficult subject in this section, and I agree that it doesn't seem likely that there will be too much of an effect of climate change on mountain lion distribution. We will see I guess. If there were more significant effects on mule deer, then of course that could in turn affect lions.

NO RESPONSE NEEDED

Line 1659 (Riley): I think it's important to add the lack of migration, or specifically immigration, to the factors that contribute to low genetic diversity and potential inbreeding depression, along with drift and inbreeding.

RESPONSE: Done

Line 1683-1688 (Riley): Yes, the Woolsey Fire in the Santa Monicas and Simi Hills in 2018 is a very real example of this. The Woolsey Fire burned 42% of the natural area in the Santa Monica Mountains and 66% of the natural area in the Simi Hills, and overall burned about 1/2 of the natural area within the two areas overall. It was really a devastating event, some effects of which are still being seen 5 years later. A couple of edits for this section - the fire was 39,234 HA, which is 96,949 acres. Also, although we were tracking 13 lions at the time, there were 11 mountain lions that we were tracking that were in danger of being affected by the fire - for example, P22, in Griffith Park, was far away from it. This is accurate to say that two lions died in or as a direct result of the fire, as I referenced for the previous section, but it was really 2 of 11, as opposed to 2 of 13. Also, definitely the best reference to use for this information is Blakey et al. 2022, which is already in the Lit Cited.

RESPONSE: Suggested changes were made

Line 1701 (Riley): I think the Ernest et al. 2014 and Riley et al. 2014 papers really need to be cited here, in a statement about the low genetic diversity of these two populations. The Gustafson et al. papers, discuss it too, certainly, but they are later, and are focused obviously on the whole state. These are the papers that established this issue for the Santa Anas and the Santa Monicas. And Holly's earlier paper in 2003, while important certainly, was not able to evaluate this, certainly not for the Santa Monicas.

RESPONSE: References added

Line 1702-1704 (Riley): We have DIRECTLY documented close inbreeding events multiple times in the Santa Monicas. In Kyle's paper, we can infer it from indirect evidence, but it is important to indicate, and it is much stronger, to say that we know it has been occurring. Specifically, we find kittens from a particular female, and then we use genetics to determine the father. We note cases in Riley et al. 2014, so that can be cited, but we have also documented multiple other cases of it since then. Specifically, we have documented multiple cases of adult male P12 mating with close relatives, including his daughters, grand-daughters, and great-granddaughters. These more recent cases could be cited as Riley et al. personal communication, if you want, but you could also cite reports that we have submitted to the Dept as part of our permit requirements. Specifically, the report covering 2016-2018 mentions a few cases. And in ongoing genetic work with UC Davis, we are documenting even more cases of this kind of close inbreeding.

RESPONSE: Added following text to section 4.10.4 "There are multiple known cases on close inbreeding, for example a male that had kittens with daughters, granddaughters, and great granddaughters (NPS 2018, S Riley pers comm 2014). "

Line 1706 (Riley): Minor thing, but I think it would be worth adding the word "long" here before "runs of homozygosity," as it is long runs that indicate more recent inbreeding.

RESPONSE: Made suggested change

Line 1716 (Riley): OK, but it is important to realize that we only evaluated two populations in Saremi et al., the Santa Cruz Mountains of CC-N, and the Santa Monica Mountains of CC-S, which are also two of the most distant of the smaller, low genetic diversity populations. Importantly, the Santa Ana Mountains and the San Gabriel-San Bernardino Mountains were not evaluated, so it's possible that these various southern California groups will be more similar in their pattern of inbreeding. The current work at UC Santa Cruz and as part of the California Conservation Genomics Project will shed more light on this.

RESPONSE: Noted

Line 1734 (Riley): Although the state-wide work and the Gustafson et al. samples are not from the same time, there are 5-10 years in between, at least, depending upon which Gustafson et al. samples you're talking about and when the scat surveys were done in a particular area. It's probably worth acknowledging that. This is a fair point, and definitely worth making, about census size being much larger than effective population size. I think it is important to acknowledge that estimating Ne from genetic data is a very indirect way of determining it, and there are some populations, such as ours in the Santa Monicas, and also the Santa Ana Mountains and maybe the Santa Cruz Mountains as well, were we have much more direct data on reproduction patterns that would provide a better estimate of Ne. Also, I know there has been a lot of interest and attention to state-wide estimate of the population, but I really don't know how much meaning that has, ecologically. I think it would be worth making comparisons between the census estimates and Ne's for different specific populations, especially in this document where the focus is on these coastal populations.

RESPONSE: This section and the discussion of effective population size has been reworked. The effective population size of individual genetic populations is no longer particularly relevant to the recommendation

Line 1731-1738 (Vickers): The draft analysis by Department and other statewide researchers that the 3,242 statewide population estimate in line 1732 was taken from also has a second population range that is higher based on one of the three models that were developed - that value range should also be noted with explanation. It should also be noted that both values are not yet peer reviewed. Also see my comments elsewhere regarding the use of Ne for population estimation and assumptions based on Florida panther research.

RESPONSE: We have reworked this section and the updated statewide estimate is no longer included here, but is instead is in section 3.2

Line 1733 (Vickers): The value of 483 in line 1733 is from Gustafson et al. 2019 and as noted includes some animals outside of California. The Ne being cited is much higher than the Ne total for the state (210) in Gustafson et al. 2022. See my earlier notes regarding detailing the full range of population estimates available and their sources, strengths, and weaknesses.

RESPONSE: This sentence and the number referenced has been deleted. Table 6 includes the two estimates of Ne for the genetic populations within the petitioned area

Line 1742 (Riley): So here, and throughout the document, there is a lot of going back and forth between citing the 2019 paper and citing the 2022 paper. I think it is not good practice generally, and could give the impression that the different papers are being cited selectively to make a particular point. In this case you were citing the 2019 paper repeatedly, and then now we have the 2022 one cited, but I don't think it's clear why. I think it's important to be clear why you are citing one over the other. You could also more regularly cite both together, depending on the point being made, which could potentially alleviate this issue.

RESPONSE: Have clarified throughout

Line 1742 (Riley): So when you mention "WSN" here, do you mean the Management Unit, or the genetic cluster? I think it is important to be clear what you mean generally, especially with the abbreviations. The only abbreviation for WSN in the appendix, that I could find, was for the management unit.

RESPONSE: Updated the document to include the phrase "genetic population" when referring to the genetic clusters and use just the abbreviation alone or explicitly name the geographic area when talking about the physical landscape. Have added the full name Western Sierra Nevada to the first time it is mentioned in the text.

Line 1743 (Vickers): Need more recent citations after the sentence regarding "controversial" use of and Ne level of 50 as a threshold for increased risk of extinction.

RESPONSE: Have rewritten the section on effective population size and include Frankham et al. 2014.

Line 1750-1751 (Riley): We specifically addressed this in two detailed analyses of population viability for the Santa Monicas and the Santa Anas, in Benson et al. 2016 and Benson et al. 2019. I definitely think it's important to mention these results here, in a mention of viability, and to cite these papers (which are already in the Lit Cited). Line 1745 mentions how "extinction risk is the result of the complicated interaction of both genetic and demographic factors," which is an important point, and that is what we were specifically able to evaluate in those population viability analyses.

RESPONSE: CC-S which includes the Santa Monica Mountains is now within the area recommended to be listed, and have added the citations.

Line 1752-1763 (Vickers): Heterozygosity is discussed at the state level and in comparison to other western states, but a table or discussion should address the lower levels in the SC and CC populations in Gustafson et al. 2022 versus the SN unit. The similarly low level in the NC unit when compared to the SN unit should be discussed as a cause for concern as well. The heterozygosity levels in the NC individual unit in Gustafson et al. 2022 is notably lower, and similar to the 6 petitioned MU's, when compared to the KC, ESN, and WSN units, a fact that should also be noted in this report.

RESPONSE: Noted. However the NC is outside of the petitioned area and does not appear to be a significant source of migrants into the petitioned area.

Line 1752-1763 (Riley): Somewhere in this paragraph, I think it's important to distinguish between expected and observed heterozygosity, say which one you are focusing on, and why.

RESPONSE: text changed to "An important metric of genetic variation is expected heterozygosity (HE) . "

Line 1756 (Riley): What is this "average"? I think it is important to say what it is here, so the reader can evaluate how it's lower than in other states.

RESPONSE: The sentence contains a range of averages for other states, and allows the reader to evaluate that California's range is generally lower than other states.

Line 1762 (Riley): I think it's important to say something about why the CA landscape is unique. I certainly think this is true, and that It's relevant for lion population genetics, but I'm pretty sure every state would say that, i.e. that they have a unique landscape.

RESPONSE: Text changed to "The lower overall heterozygosity, as well as the large variance in heterozygosity among local genetics populations, observed in California is most likely driven by barriers to dispersal such as mountain ranges and contemporary patterns of urban and transportation development"

Line 1766 (Riley): OK, it's really two genetic investigations, Holly's in the 2003 paper, and Kyle's in the 2019 and 2022 papers, depending a bit on how you define "investigation." The 2022 paper was using different markers, obviously, but it uses essentially the same samples, though a subset of them. I guess two is still "multiple," but it seems a bit misleading. Also, again in this paragraph, you start by citing the 2022 paper, but then switch over to the 2019 one. As I said, it would be better to be clear about why you're using one vs. the other, I think.

RESPONSE: Fixed

Line 1775 (Riley): I think it's definitely worth saying what the 2Ne-4Ne generations means in terms of number of generations, and in terms of number of years, maybe for a couple of populations, or you could give an average and range maybe.

RESPONSE: This paragraph has been deleted.

Line 1776 (Riley): Though I'm sure we mention it in there, I don't think Saremi et al. is really the appropriate reference for mountain lion generation time. Looking back at the paper actually, I don't see that we gave a citation for lion generation time, which is an oversight. Something from the 2010 Puma book would probably be good.

RESPONSE: This paragraph has been deleted.

Line 1782 (Riley): Which findings are you referring to here, by "these findings"? It's not really clear, I don't think. But overall for this paragraph, yes, I think it's hard to say too much about bottlenecks that may have occurred a long time ago, for many of these populations, and the bottleneck analysis using genetic data is again an indirect one, as opposed to knowing for sure that a population got very small at some point. It might be worth saying something about how recently the bottleneck may have been for some of the smaller populations, say for the Santa Anas especially, and CC-S.

RESPONSE: This paragraph has been deleted.

Line 1792 (Riley): I think it would be worth saying a bit more about what "unique alleles" were found in the SC genetic group. The 2022 paper is cited here, and it seems a bit odd to use the term "unique alleles" about SNP data. I guess that means that there were some loci that were polymorphic in the SC cluster that were not anywhere else? How many loci like that were found? And they were not found anywhere else? This makes me wonder about the 2019 paper, and to what extent there were private alleles found in any of the populations in that study. Either way, I think it would be worth mentioning.

RESPONSE: Text changed to "However, in the SC genetic group contained some private alleles not found in other genetic groups, which should be conserved to help preserve statewide genetic variation (Gustafson et al. 2022). "

Line 1795-1799 (Vickers): The statement in this sentence that acknowledges risks to a small population that are posed by inadequate genetic connectivity, then is followed by the statement that "a small population size ALONE (my capitalization) is not necessarily predictive of reduced population viability" is an odd statement to include, since the Department itself emphasizes again and again in this document the other significant risks to the petitioned populations - genetics, mortality rates, inadequate habitat levels, etc. This sentence seems to minimize risk for the smaller petitioned populations, even though the report lays out in clear detail the multitude of risks of decline that these petitioned populations face.

RESPONSE: Have altered text to read "While genetic risks may significantly increase a small population's risk of extinction, implementation of a well-planned conservation strategy can substantially mitigate risks associated with small populations."

Line 1798 (Riley): So this seems like a major and important statement, but it is currently just a one sentence throwaway line, it feels like. I think a lot more needs to be said here! What would this look like? Is this the plan? What would be represented? How would resilience be measured? What would be considered adequate redundancy? It is not enough to cite these references, I don't think.

RESPONSE: Noted, but getting into the details of a future plan is beyond the scope of this document.

Line 1801-1880 (Vickers): At this location in the report, the six individual MU's begin being discussed as consolidated into two populations based on Gustafson et al. 2022, but neither before this nor after, do there appear to be assessments of the entire group of the six smaller ESU's combined into one ESU or MU as was proposed in the CESA petition. The reasons for this exclusion did not appear to be explained in the report in my reading, and could be interpreted as somewhat arbitrary - it would be appropriate to explain further.

RESPONSE: Section 6.1 is the discussion of why the individual and combined populations do not qualify as an ESU. Due to this and other feedback from external reviewers, the entire petitioned area is evaluated as a DPS.

Line 1803 (Vickers): As noted earlier in the document, I suggest that Table 2 from Gustafson et al. 2019 and Table 1 from Gustafson et al. 2022 need to be included in this document on pages 21 and 22 to inform the reader about the best supported genetic parameters that are known about these populations. Those tables should be referenced here.

RESPONSE: Table 2 in Gustafson et al. 2019 is now included as Table 2

Line 1805 (Riley): Since there are only 4 broad groups, it's worth saying which ones are low, Central Coast and South Coast, and which ones are high, Sierra Nevada and North Coast. Especially because Figure 4 is 40 pages back! Incidentally, it's worth giving a page number here for Figure 4, for that same reason.

RESPONSE: Text modified to read "Of the broad-scale groups, SC and CC have relatively low genetic variation while SN and NC have retained sufficient variation to be capable of serving as sources of genetic rescue under various management scenarios (e.g., improved connectivity, assisted gene flow). "

Line 1808 (Riley): Sure, but maintaining and enhancing connectivity between these broad groups is easier said than done! Especially between NC and CC, through the Bay Area, and between SN and CC, through the Tehachapis and across 5. This is one reason why it might be important to extend protection to the northern part of CC-S, in Los Padres National Forest, as well. As I mention elsewhere as well, connecting all of the coastal populations to the rest of the state is really important, from a genetic point of view, and this Tehachapi connection is the main way that could occur, certainly to all of the Central Coast.

RESPONSE: Noted, and the Tehachapi connection is now included in the area recommended for listing.

Line 1820 (Vickers): See my notes elsewhere in the report regarding use of Ne for statements about population size.

RESPONSE: The inclusion of the estimated effective population size is linked to a statement about low genetic variation, and is part of the criteria for imperilment in the DPS framework which is why we keep it in this section.

Line 1821 (Riley): Yes, if the whole CC-S has a Ne of about 3, this area is clearly at significant risk. This is borne out by the PVA analysis in Benson et al. 2016, and also by the fact that we have documented multiple animals in the region of the Santa Monicas to the Santa Susanas with evidence of potential inbreeding depression, including distal tail kinks and high levels of teratospermia (Huffmeyer et al. 2022).

RESPONSE: Noted. We talk about CC-S and cite the results of Huffmeyer et al. 2022 further down in this section.

Line 1823 (Ernest): The citing of literature reporting “close inbreeding” in the Santa Monica Mountains (CC-S), Santa Cruz Mountains (CC-N), as well as Santa Ana Mountains – is really important. This is a late harbinger of populations that are too small and lacking gene flow from other populations – this is a call to more protection for these populations

RESPONSE: CC-S and CC-N are now in the area recommended for listing

Line 1823 (Riley): As mentioned before, we have actual direct documentation of close inbreeding in the Santa Monica Mountains, repeatedly, as opposed to the "evidence" of it, in Kyle's paper, and the "suggestion" of it, in the genome paper (Saremi et al., line 1826). We report it in Riley et al. 2014, and we have documented it repeatedly since then as well. Again, the way we have done it is by sampling kittens, when we know a female has given birth (we have now documented 27 litters of kittens at the den), and then determining who the father of the litter is by using genotyped samples from males in our study. We are also able to use GPS telemetry data to document mating events between males and females, although it's always important to verify the father using genetics, since females may consort with more than one male, and we are never following every animal in the population. Both here and previously, it should be noted that we have repeated known examples of this close inbreeding. We can compute the total number, and let you know what that is, if that would be useful. As I mentioned, for the ones since the 2014 paper you could cite Riley et al. unpublished data, but you could also potentially cite our reports to CDFW, specifically the one for 2016-2018 where we mention 2 specific cases. We are also currently doing work with graduate student Cass Rodriguez in Ben Sacks' lab at UC Davis to further document other and more recent examples.

RESPONSE: We have added more detail to this paragraph about evidence of inbreeding based on this and other reviewer comments.

Line 1828-1846 (Beier): This clearly states that the Central Coast South MU is a mess. How does it not qualify as a DPS?

RESPONSE: CC-S is now in the area recommended for listing

Line 1829 (Riley): The Huffmeyer et al. 2022 paper needs to be cited here, as it is really the only one that has documented signs of inbreeding depression similar to what was seen in Florida. In Ernest et al. 2014 they mention a tail abnormality, but it is not at all distal (see photo in the paper), and therefore not similar to the Florida panther cases and could more likely be a break.

RESPONSE: Reference added

Line 1830 (Riley): So this statement about the very low genetic variation, at a similar level to the Santa Anas, and lower than anywhere else other than in Florida Panthers, is about the Santa Monica Mountains specifically, and not the CC-S MU more broadly. This should be made clear in the text. In fact, if the CC-S MU includes Los Padres National Forest, than the variation would likely be quite a bit higher. And that would be even more true if the Sierra Pelona Mountains, E of Highway 5, were also included in CC-S (though as I said, I don't think it makes sense to do so). Again, it needs to be very clear what the boundaries of the different MUs are.

RESPONSE: We have reworked this section and clarify when the Santa Monica Mountains and not CC-S as a whole is relevant.

Line 1833 (Riley): Here, and in some other places, references are not in chronological order. I assume that is the intent in general, for them to be chronological? If so, it should be checked throughout, and made consistent. I definitely think chronological order make the most sense, as opposed to say alphabetical order (which these seem to be in).

RESPONSE: Done

Line 1834 (Riley): The Ernest et al. 2014 and Vickers et al. 2015 papers are not about CC-S, they are about the Santa Ana Mountains, so it wouldn't make sense to cite them here.

RESPONSE: Fixed

Line 1836 (Vickers): After "the" add "significant potential for"

RESPONSE: Have changed text to "Models predict a 16–28% probability of the extirpation of the Santa Monica Mountains population within 50 years if immigration levels remain the same or are reduced, in part due the impacts of inbreeding depression (Benson et al. 2016; Benson et al. 2019)

Line 1836 (Riley): Again, this modeling in Benson et al. 2016 (and 2019) is about the Santa Monica Mountains specifically, not CC-S more broadly.

RESPONSE: Have changed text to "Models predict a 16–28% probability of the extirpation of the Santa Monica Mountains population within 50 years if immigration levels remain the same or are reduced, in part due the impacts of inbreeding depression (Benson et al. 2016; Benson et al. 2019)

Line 1838-1842 (Vickers): It should be noted that the CC-C MU has inadequate levels of protected acreage relative to the amount spelled out in Dellinger et al. 2020 that is needed for long term stability of that source population for the CC-N and CC-S MU's. Development also threatens to bisect the CC-C MU

RESPONSE: Noted

Line 1839 (Vickers): After "inbreeding" add "though the percentages of the habitat that is conserved raises concerns about long term genetic stability and fragmentation. (Dellinger et al. 2020)"

RESPONSE: Done

Line 1842 (Riley): Again, this should say CC-S here, as opposed to the Santa Monica Mountains, since the Santa Monicas are only a part of CC-S, and in fact are the very farthest south, and distant from CC-C, part of it.

RESPONSE: Text has been changed to "Bi-directional migration rate models indicate the CC-C serves as a significant source of migrants for CC-N and CC-S "

Line 1845 (Riley): Yes, this is a good and important point, about maintaining connectivity to and within the CC-C MU. I would add, as you've stated on the previous page, that in particular, connectivity between CC-C and the Sierra Nevada, through the Tehachapis, is especially important.

RESPONSE: Noted

Line 1857 (Vickers): After "Riley et al 2014" add "Gustafson et al. 2019 and Ernest et al. 2014"

RESPONSE: Done

Line 1859 (Riley): Again, the one case of a kinked tail in the Santa Anas is very different, morphologically, from what they were seeing in Florida.

RESPONSE: Noted

Line 1861 (Riley): I think more detail would be valuable here about the results of the analyses in Benson et al. 2016 and 2019, especially since the Santa Anas are currently part of the group proposed for listing. This sentence isn't really true - for the Santa Anas there was a 16-21% of extinction in the models just based on demographic stochasticity. The high likelihood of extinction within 50 years would be if inbreeding depression sets in and affects survival and reproduction the way that it did in Florida.

RESPONSE: This paragraph has been reworked and the relevant text now reads " For example a thirteen-year study (2001–2013) that collared 74 mountain lions in the Santa Anas and EPR observed only one mountain lion move from the SA to the EPR, and that individual was killed for depredating sheep before it could breed and introduce genetic material to the group (Vickers et al. 2015). The impact of this isolation and inbreeding has led to a "16–21% probability of local extinction in the SAM due purely to demographic processes over 50 yr with current low levels or no immigration" (Benson et al. 2019)."

Line 1870 (Vickers): Add "and" after "Nevada"

RESPONSE: Done

Line 1877-1880 (Vickers): There is no reason to believe that maintenance of the status quo for any of these MU's will result in improvement or reconnection absent additional protections that can lead to concrete measures to enhance their survival and genetic connectivity. This paragraph and subsequent recommendations for the most part do not spell out what legal or policy drivers there are, in the absence of added legal protections associated with Threatened status, that will with some confidence lead to the desired improvements to genetic status and long term survival potential.

RESPONSE: The updated recommendation is for the majority of the petitioned area to be listed as Threatened with the resultant legal protections

Line 1878 (Riley): I would argue that there are two populations that are not currently "interconnected," the Santa Anas, and the Santa Monicas, or a Santa Monicas Management Unit, if that were to be considered. It is true that the Wallis Annenberg wildlife crossing will help connect the Santa Monicas to other areas, but it is not completed yet, and while we are confident that it will be effective for mountain lions and other species, I think it is not a good idea to presume that it has effectively connected the Santa Monicas to other areas before documenting it. And, as mentioned elsewhere, there are two other roads between the Santa Monicas and the larger source population of Los Padres National Forest and the Central Coast Central cluster. Finally, as you have also alluded to elsewhere in the document, I think that the San Gabriels/San Bernardinos area is potentially not that well connected to other areas. Though this MU would obviously be afforded protection by listing the South Coast Group as a DPS.

RESPONSE: Changed interconnected to 'somewhat connected'

Line 1900 (Riley): I think it is pretty hard to see what is going on in this map. For example it is hard to pick out the federal NPS, Forest Service, and BLM lands. Our park, Santa Monica Mountains NRA, is basically impossible to see. I think some brighter or more contrasting colors might be helpful. I understand that part of the issue is showing such a large area; perhaps there could be this one, and one showing just the southern California region, where it is potentially a bit more complex? Also, I'm wondering why the CDFW areas are labeled specifically? I understand they are Dept Lands, but I'm not sure they are particularly important in this context. But maybe I'm missing something? Finally a general comment, all of the maps need a north arrow and a scale bar, I think.

RESPONSE: Reworked this map.

Line 1906 (Riley): I think it's notable the Prop 117 and the California Wildlife Protection Act specifically called out the Santa Monica Mountains, the Simi Hills, and the Santa Susana Mountains, the region that we are proposing for potential consideration as a management unit, as areas of concern for mountain lions more than 30 years ago. We certainly believe that that concern continues to be warranted, and that there is plenty of evidence to support that.

RESPONSE: Noted

Line 1993 (Riley): A minor note: this sentence mentions 3 HCPs and 4 NCCPs, and that 3 of the 4 NCCPs include mountain lions. However, the next 4 paragraphs describe 4 plans, all of which seem to be both HCP/NCCPs, and all of which seem to include mountain lions. So potentially a bit of a discrepancy there.

RESPONSE: As is clarified further down "The Orange County Transportation Authority NCCP/HCP (OCTA Plan) lists the mountain lion as a covered species for purposes of the federal HCP, but not for purposes of the NCCP permit"

Line 2074 (Riley): Maybe a minor thing, but shouldn't the title here be "National Forest and BLM lands"? That would better match the ones in this section. And there are resource management plans for national parklands and for military bases too, so not sure why those would be called out here, but not in the other sections.

RESPONSE: Done

Line 2114 (Riley): I think the title here should just be "National Parklands" or "National Parks" or something like that. In the National Park Service, all units, regardless of specific title, are referred to as "parks." And most importantly, from the point of view of conservation, both generally and for mountain lions specifically, it really doesn't matter what the specific name of the park is, i.e., national park or national recreation area or national monument or national preserve (and there are others, like national scenic river, national parkway, etc.). The mandate is the same for all units: to preserve the lands of the national park system, and the resources within them, including the wildlife, for the enjoyment of future generations.

RESPONSE: Done

Line 2129-2132 (Riley): A couple of minor things here - on line 2129, this should say "Other NPS lands," since all of these places are managed by the National Park Service, not by some other federal agency. Also, there wouldn't be a "the" before "Golden Gate National Recreation Area," or before "Santa Monica Mountains National Recreation Area," just as there isn't in front of everything else on this list. Also, Muir Woods is not within the proposed zone, since it is north of San Francisco in Marin County.

RESPONSE: Done

Line 2134 (Riley): I wonder if it would be worth having a section of Land Conservancy lands in this State section, such as those of the Santa Monica Mountains Conservancy, in southern California. They are definitely an important player in a potential Santa Monica Mountain MU, in the CC-S MU, and in southern California generally. And perhaps there are other similar state land conservancies that are worth mentioning?

RESPONSE: Noted, however that is a level of detail that is beyond the scope of this document.

Line 2205 (Riley): A couple of notes here: Runyon Canyon is a city park, but Franklin Canyon is owned by MRCA and by the National Park Service. Encino Reservoir is west of the 405 Freeway and Stone Canyon Reservoir is east of it, although in our proposed Santa Monicas to Los Padres MU, it would all be included. We think this would be valuable, to include the eastern Santa Monicas, as well as Griffith Park, in the MU, and those areas are all certainly important to the City of Los Angeles.

RESPONSE: Noted

Line 2290 (Riley): Happy Camp is already part of an important linkage, although because it is in the Santa Susanas, as you say, it is really part of the linkage between the Santa Monica Mountains and Los Padres National Forest. Also, as I mentioned in row 45, it would be valuable to include something about the Santa Monica Mountains Conservancy. They have many really important areas, both for conservation overall, and for connectivity specifically. Of relevance here is that they actually own most of the important public lands in the Santa Susanas, specifically areas to the east, along Highway 5, in East and Rice Canyons and that area. I think it would also be worth mentioning, in this section, two other local Ventura County Open Space agencies that are important in a potential Santa Monicas to Los Padres MU, including in the Santa Monicas, Santa Susanas, and especially in the Simi Hills. These are Rancho Simi Recreation and Parks District (RSRPD) and Conejo Open Space Conservation Agency (COSCA). Let me know if it would be helpful to have more information about these two agencies.

RESPONSE: Noted. However that level of detail is bit too fine scale for this document

Line 2251 (Riley): I think this statement about our 2019 paper is a bit strong, i.e., that "Gustafson et al. found more lions emigrated from" the Sierras to Nevada than vice versa. It comes down to what genetic data means exactly, and what the population genetic methods can tell you. I think it's fine to say that "Gustafson et al. (2019) found evidence of more movement from the Sierras to Nevada than vice versa." Depending on the strength of the population differentiation, and how clearly an individual assigns to a different area than it was found in, it can certainly be good evidence that it was a migrant. But that is not the same as knowing that it moved, through radio-tracking (GPS or VHF), or by capturing it in both places.

RESPONSE: Text changed to suggestion.

Line 2290 (Riley): I don't think there is much evidence that jaguars have much of an impact on mountain lions. I am not a jaguar expert certainly, but they have broadly coexisted for many thousands of years across Central and South America, and continue to do so where jaguars are still present. I think citations are needed here at least.

RESPONSE: This section has been shortened and the relevant sentence deleted.

Line 2291 (Riley): I think it would be valuable to show on a map where connectivity may be present currently between CA and Mexico, if possible.

RESPONSE: Added Figure 21 which has a representation of the border and known crossings by mountain lions.

Line 2295 (Riley): I think it's important to be a bit more specific here, about what you're saying is implied by the SNP data, and in particular about local populations having "considerable shared ancestry" and being "more genetically similar than previously thought." Which local populations in particular are sharing this ancestry across barriers? And what is meany by "than previously thought"? Than thought after our 2019 microsat paper? This needs to be clear, I think.

RESPONSE: Text altered to read "The same study used SNPs to characterize variation across more of the genome, which suggests many of these local genetic populations separated by barriers have considerable shared ancestry (Figs. 7, 8) and are more genetically similar than was suggested by the result of Gustafson et al. (2019)

Line 2337 (Riley): We would propose a couple of other considerations about the significance of a population segment that we think are relevant, given this statement that "This consideration my include, but is not limited to, the following." One is the ecological importance of the species, or in this case of the population segment of the species. Mountain lions are a large carnivore, and more specifically, they are a large carnivore that is purely carnivorous, as opposed to omnivorous, and that specializes on large prey, specifically ungulates such as mule deer. Although wolves are making their way back into more of California, for large parts of the state mountain lions are the only species that fills this role, and that is likely to be the case for some time to come and perhaps permanently, if there are places that wolves are not able to recolonize and establish. My understanding is that there is evidence that wolves did not historically occupy all of California, especially the drier, southern parts, dominated by shrublands. Although coyotes, and sometimes even bobcats, will also kill deer, especially fawns, mountain lions are the dominant predator of ungulates in the state, and they will prey on other species as well, including other carnivores such as coyotes, raccoons, foxes, bobcats, and domestic cats. Given the normal densities of mountain lions relative to their various prey species, mountain lions may rarely have significant direct trophic impacts on their main prey populations. However, they can affect some populations through predation, such as rare bighorn sheep populations. And, they can certainly be affecting all of these different species from a behavioral perspective. More and more research, including in California, is investigating and finding ways that mountain lions and other predators may be affecting the behavior of various prey species. Most importantly from a conservation and ecological perspective, mountain lions are the only species that fills their role. While we may not understand all of the ways this role affects other species and the ecosystem more broadly, losing this species from any system is a major loss, we believe, and as we often say, not an experiment that we want to conduct. We believe that every species is important and worthy of conservation, and indeed, this is our mandate in the National Park System. However, it is also true that mountain lions, as the only apex predator regularly preying on ungulates and other large species, are particularly important to conserve from an ecological perspective. Another significant factor that we would propose for consideration is the importance of the population segment to the people of the area and to the state more broadly. In the case of the mountain lions of the Santa Monica Mountains and surrounding areas, people have learned about and followed the population very closely, and we believe care deeply about the continued presence of the species in the Santa Monica Mountains and in the Los Angeles Area more broadly. This was the case specifically with P22, as evidenced by the outpouring of concern and sadness upon his death in late 2022, including a full capacity celebration of life at the Greek Theater. While P22 was the most obvious symbol of lions in LA, and the animal that lived farthest into the city itself, people care about and follow the population more broadly. We believe that it would be a significant loss to the people of southern California and of the state overall if this population segment were lost, and so we would propose the importance of the population to the people of the area as another measure of significance. This is obviously different from the others, in terms of not being related to biological factors, but we think that biology is not the only factor that can be important in conservation. Finally, we think it is worth considering measuring significance by the importance of the management unit in terms of connecting other mountain lion populations. Criterion b, about a gap in the range, might cover this, but it's not clear to me how that criterion is being applied, and it doesn't seem like it is fully covering the importance of these connections. For example, the connection between CC-S, specifically the northern part along 5 in Los Padres National Forest near Gorman, and the Tehachapis, is critical for genetic connectivity for mountain lions across the state. And the connection between the Santa Susana Mountains and the San Gabriels is similarly critical for connecting the Central Coast populations to the South Coast Group. Though this connection is not very strong currently, there is current work going on to better understand and improve it, and that fact that it is not strong does not diminish its importance, I would argue.

RESPONSE: We no longer evaluate the genetic populations individually using the DPS framework. Instead, the whole petitioned area was evaluated and found qualified as a DPS using the existing criteria. Therefore expanding the criteria used in the assessment would not change the recommendation.

Line 2378 (Ernest): The CDFW proposal incorrectly downplays the ecological uniqueness of the Central Coast habitats, and implies that there is little there of ecological importance to mountain lion biology that is not found elsewhere. This is a false assumption as vast lists of endemic plant systems and island native plant systems demonstrate (see Calflora and California Native Plant Exchange online resources). Central Coast habitats are rich in unique ecosystem and biome features. Mountain lion prey evolved with and depend on those unique ecosystems and mountain lions evolved with and depend on the prey. For example, the Santa Lucia ecoregion … has "qualities include the southernmost native stands of the coast redwood, as well as the presence of several notable endemic species." (Reed Noss description as viewed 1/20/2024 https://www.oneearth.org/ecoregions/santa-lucia-montane-chaparral-and-woodlands/). There is a strong genetic signal that the coastal populations south of San Francisco Bay and Delta are distinct from other mountain lion populations in rest of California – see Fig 3 of Gustafson 2022.

RESPONSE: We no longer evaluate the genetic populations individually using the DPS framework. Instead we evaluated the whole petitioned area (including CC-C) and found it qualified as a DPS.

Line 2381 (Ernest): The CDFW proposal incorrectly implies that mountain lions in the Coast ranges lack unique adaptive evolutionary traits. There are no studies that address this issue with any accuracy. The published science cited by the CDFW report is not sufficient to rule out the local adaptations of California mountain lions to their habitats. 1) mitochondrial data and the citations are insufficient to infer anything about local adaptation. This citation and inference should be deleted.

RESPONSE: This section has been reworded and now states "1. There is only one recognized subspecies of mountain lion in North America (P. c. cougar) based on mitochondrial DNA data (Culver et al. 2000; Caragiulo et al. 2014; Kitchener et al. 2017), suggesting a reduced potential for adaptive localized genetic variation among North American mountain lion populations." The department's remaining conclusions about local adaptation are taken directly from published literature (i.e., Gustafson et al. 2019 and 2022).

Line 2435 – 2446 (Wilmers): The criteria for determining "Significance" date back to 1996 and require some updating. Ecological science has made important progress in understanding the significance of species since that time, and this needs to be reflected in the listed criteria. This is especially true for keystone species and apex predators. A keystone species, for instance, wasn't definitively defined until late 1996 (too late for inclusion into the USFWS list of significance criteria) as "one whose effect on ecosystems is large and disproportionately large relative to its abundance" (Power et al. 1996), and in the 1990s ecologists were still debating whether the impacts on ecosystems by top predators were confined to aquatic ecosystems (Strong 1992). But science has made great strides since then. There is now abundant evidence that apex terrestrial carnivores are keystone species through their direct and indirect effect on other species in an ecosystem (Estes et al. 2011). Removing apex terrestrial carnivores can have dramatic impacts on herbivores (Terborgh et al. 2001), trees (Ripple and Beschta 2008), stream erosion (Ripple and Beschta 2006), disease (Levi et al. 2012), carbon cycling (Wilmers and Schmitz 2016, Schmitz et al. 2018) and many other ecosystem processes (Ripple et al. 2014). Surely these impacts are of concern to California residents and should be considered when determining "Significance". The USFWS seems to have anticipated that evaluations of significance would change with new knowledge when they wrote (and the Department repeated – line 2445) "This consideration may include, but is not limited to, the following:" I therefore suggest a new category e) be added to the significance list (lines 2438 – 2446) which acknowledges the many advances in ecological science since the writing of these criteria. I propose that it read "Evidence that loss of the discrete population segment will lead to significant ecological impact".

RESPONSE: Noted.

Line 2435-2440 (Beier): Significance can derive from "Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon." I would argue that the urban sea thoroughly intertwined with several units (SA, SM/CCS) is a "most unusual ecological setting for the taxon" and thus qualifies as Significant. Anybody who sees the photo of P22 and the Hollywood sign appreciates this fact. Humans are part of ecosystems. And the humans in these ecosystems increasingly value mountain lions.

RESPONSE: Based on this and other feedback we evaluated the whole petitioned area as a DPS and the units mentioned are included in our updated recommended area for listing.

Line 2450 (Riley): We would like to propose another Management Unit that has not been evaluated to date, that we think is worthy of consideration for listing. Specifically, we would propose the "Santa Monica Mountains to Los Padres" Management Unit (or some similar name). Geographically, we would suggest that the northern line of the proposed Southern Coast Unit (p. 102, Fig. 19) be extended essentially along the Santa Clara River from where Highway 14 crosses over it in western Santa Clarita, along the Santa Clara River to the west to where it meets the ocean between Ventura and Oxnard. This means that the MU would then include the Santa Monica Mountains, the Simi Hills, and the Santa Susana Mountains. We would propose that the MU also include a buffer 10 km north of the Santa Clara River, as far west as Saticoy at the east end of Ventura, so that connectivity between the Santa Susana Mountains and Los Padres NF, the critical last step in the overall Santa Monicas to Sierra Madre Linkage, is preserved. In terms of the criteria for listing an MU, the Santa Monica Mountains themselves would be the main focus, but the Simi Hills and the Santa Susana Mountains are critical for the long-term persistence of mountain lions in the Santa Monica Mountains, since connectivity between the Santa Monicas and Los Padres, the site of the nearest large source population, is necessary because of the small size and isolation of the whole population. In terms of the criteria, the Santa Monica Mountains are discrete, because of the physical barrier of the large and very heavily trafficked 101 Freeway, which separates them from the Simi Hills, and thereby all other natural areas, to the north. There are also two other important roads in the MU, the 118 Freeway between the Simi Hills and the Santa Susanas and Highway 126 between the Santa Susanas and Los Padres NF. The discreteness of the Santa Monica Mountain population is also demonstrated by genetic data, first in Riley et al. 2014, and by dispersal data, see also comments for page 20, about population structure. In terms of significance, we would argue that the Santa Monicas to Los Padres MU is significant in 4 ways. The first is a) "an ecological setting that is unusual or unique for the taxon." This MU is the only place in the state, and in fact in the whole range of the species, where mountain lions persist in a megacity, i.e., a metropolitan area of 10 million or more people. And in fact it is one of two places on the planet where a large felid exists in a megacity, the other being Mumbai, India, where there are leopards. There are other urban areas where mountain lions exist on the fringes, such as Seattle, WA; Denver, CO; and Salt Lake City, UT. But none of these cities are nearly as large, sprawling, and crisscrossed by major freeways as Los Angeles. Mountain lions in the potential Santa Monicas to Los Padres MU, which includes the eastern Santa Monica Mountains (E. of the 405 Freeway) and Griffith Park, represent a "setting that is unique and unusual" for the taxon. There is also increasing evidence that animals in urban habitats are specialized to those habitats, and that they are more likely to stay and reproduce within these urban habitats, adding to their unique qualities. Along with criteria a), we would propose that a Santa Monicas to Los Padres MU is also significant in 3 other ways. One, it is the only species filling the apex carnivore role in the ecosystem; two, the population is extremely significant to the people of Los Angeles and the surrounding region; and 3) the MU represents a critical connection between the CC-C MU and the San Gabriel-San Bernardino MU, another relatively small and isolated MU. This connection would be primarily across Highway 5 south of Santa Clarita, and if connectivity could be increased, it could potentially be through the eastern Santa Monica Mountains, Griffith Park, and the Verdugo Mountains to the San Gabriels.

RESPONSE: The area mentioned is now recommended to be listed.

Line 2450 (Vickers): See earlier notes regarding the lack of examination in the report of the full set of MU's combined as proposed in the CESA listing to designated the entire ESU as Threatened.

RESPONSE: Section 6.1 is an evaluation of whether the petitioned populations meet the criteria to be considered an ESU either individually or collectively. Lines 2378-2380 state "Taken as a whole, the genetic evidence does not support applying the ESU concept to the overall petitioned area or any of the Management Units individually, as a subspecies or ESU for the following reasons:"

Line 2453 (Vickers): See note above under lines 1801-1880

RESPONSE: Section 6.1 is the discussion of why the individual and combined populations do not qualify as an ESU. Due to this and other feedback from external reviewers we evaluated the entire petitioned areas as a DPS.

Line 2453 – 2465 (Wilmers): The petitioners ask the department to consider listing six identified genetic populations of mountain lions along the central and southern coasts as a single ESU or alternatively whether any of the six populations individually or in combination comprise an ESU. I can understand the department treating these as DPSs instead of ESUs – this makes sense for the reasons they describe– but the department still needs to consider all six populations as a single DPS. This was clearly the intent of the petitioners and the departments lack of consideration of the merits for listing all six populations together as a single DPS seems like a major oversight.

Line 2470 (Ernest): The decision matrix Table 7 should be reworked given these multiple issues noted above.

RESPONSE: Done.

Line 2473 (Vickers): It seems reasonable to me to conclude that all 6 petitioned ESU/MU groups are markedly separated from each other based on the clear contemporary genetic separation in both Gustafson papers and the <10% gene transfer between them noted in lines 696-713 that was used to justify assessing the petitioned populations as individual MU's. The matrix presented here is puzzling in that each individual population is listed, and the two population groups, but not the entire petitioned ESU as a single entity. This is especially puzzling given that the report's first listed task was to evaluate the primary proposal in the CESA petition of establishing the six populations together as an ESU (or following the Department's scheme in this report, an MU) and to determine if it warranted being listed as threatened. Though using the larger population groupings from Gustafson et al. 2022 is one option, there are many others as the report notes, thus it is puzzling that an MU combining all 6 smaller MU's was not evaluated. Additionally, other MU groupings might also be considerations. The SMM/CC-S MU would generally be considered to be more associated with southern California than the central coast geographically and ecologically, and could very reasonably be included in the South Coast group MU as easily as the Central Coast group. MU's could be grouped by other measures as well, such as levels of risk of decline based on any number of factors and analyses that have been conducted. In the end, given the levels of risk of both similar and different types that each individual MU faces (habitat loss, and vulnerability to stochastic factors such as disease outbreaks, fire, and excess anthropogenic mortality, and the interdependence of each on several of the others for long term stability), it is my opinion that each population being examined is in fact both "discrete" and "significant", and that singly the CC-N, CC-S, SGSB, and SA MU's qualify as DSP's, and that by virtue of their criticality as gap populations to the other four, that the CC-C and EPR MU's should be similarly designated and protected with the Threatened Designation.

RESPONSE: Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it significant, thus the units mentioned are included in the updated recommended area for listing.

Line 2474 Table 7, and 2587-2591 (Beier): CC-S: In Table 7, think you could make the case that this unit earns a "Yes" for "markedly separated". Your rationale on 2587-2591 is reasonable, but I think a "yes" response is similarly reasonable.

RESPONSE: Due to the extensive feedback from reviewers and the reworking of the recommendation, Table 7 was no longer necessary and has been removed.

Line 2474 (Riley): We would propose to evaluate another Management Unit in this table, specifically the Santa Monicas to Los Padres MU, including the Santa Monica Mountains, Simi Hills, Santa Susana Mountains, and 10 km north of the Santa Clara River. We would argue that this MU would rank "Yes" under "Markedly separate", for the Santa Monica Mountains specifically; "Yes" under "Unique Ecological Setting" for its "unique and unusual" location in one of the largest and most intensively fragmented urban areas in the world; and "Yes" under two other important elements of "Significance": "Only apex carnivore species in the system" and "Significant value for the local human population." In turn, this would mean that it would be a "Yes" as constituting a DPS, and because it is also clearly threatened, it would be a "Yes" for "Imperiled," and therefore a "Yes" for warranting listing as a threatened or endangered DPS.

RESPONSE: Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it significant, thus the units mentioned are included in our updated recommended area for listing.

Line 2474 (Riley): A couple of other comments on this table: if the "Only apex carnivore species in the system" category were added for significance, then all of the Management Units would be significant. This may seem like an overly broad criterion, but I think it is indeed a valid one, as I mentioned previously, and that the disappearance of this species in any of these area would truly be a significant ecological loss. There are places in the state where that might not be the case because of wolf presence, but that is not currently the case here, and may not be for a long time, if ever, as I mentioned. So that would then mean, according to the table, that any management unit that is determined to be imperiled, would also warrant listing, which would include CC-N, CC-S, the Santa Anas, and SG-SB, along with the currently proposed ones (the EPR and the South Coast Group), or basically everything except for CC-C and the Central Coast Group. One other thought about the potential importance of the Central Coast Central Management unit: it is true that the Central Coast Central cluster is relatively large and seems in decent shape genetically and demographically, currently. However, with an effective population size of about 60 individuals, based on Table 3, and a population estimate of around 150 (same Table), it is not as secure as say the North Coast or Sierra Nevada populations. Given that the Central Coast Central population is currently the main source for both the CC-N and CC-S populations, both of which are imperiled, an argument could be made that it is really important to protect this Central Coast population as well, over the long-term to prevent further erosion or loss of the smaller ones to the north and south. So taking the longer view of protecting the whole coastal area overall might indicate the importance of protecting Central Coast Central as well. Something to consider at least. Finally, though the CC-S overall may not be, the Santa Monica Mountains are definitely markedly separate, we believe represent a unique ecological setting, and are certainly imperiled.

RESPONSE: Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it significant, thus the units mentioned are included in the updated recommended area for listing.

Line 2475 – 2522 (Wilmers): To determine whether or not each of the management units is markedly separate or discrete, the department relies on genetic data from Gustafson et al. (2019) and (2022) to make pie charts foreach animal showing the animal's genetic ancestry (Figs 15 and 16). They then use these pie charts to ask whether there is evidence of recent migration from other management units or populations. If there is evidence of recent migration into the management unit, the department then claims the management unit is not discrete. This is not a sufficient test. Just because there is some in migration does not mean that the population is not discrete (e.g. as measured by Structure tests).This would be like saying that coyotes and gray wolves are not separate species because they occasionally hybridize. A better test would be to ask whether the amount of in-migration is sufficient to counteract the effects of inbreeding on genetic diversity. This approach has been applied to the Santa Monica mountains population by Benson et al. (2016), but has not been applied to the other management units. Absent this test, the department should ask whether a) the management unit shows genetic structure which would indicate that habitat fragmentation is affecting the genetic composition of mountain lions, b) this structure has been increasing over time indicating that human induced landscape fragmentation is inducing said structure, and c) the activities that created this structure continue or are increasing over time (e.g. road building, vehicle travel, home building etc.).

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2485-2490 (Vickers): The sentences "The SNP data from Gustafson et al. 2022 represent more of the genome and reveal ancestry further back in time. The 2022 study informs questions about the amount of genetic material historically shared between MUs and retained genetic variation within individuals and extant MUs. However, the effects of relatively recent (i.e. within the last few centuries) land use changes that restrict connectivity between MUs is not revealed by such data." are not accurate in my understanding. Microsatellites that are selected for population genetics mutate much more quickly than SNPs, and have more sensitive abilities to determine kinship leading to population structure, but the time scales of change that are revealed by the two methods is substantially influenced by other factors. The Gustafson et al. 2022 analysis used numerous contemporary samples and can be utilized to inform more recent genetic connectivity.

RESPONSE: Due to these and other comments we have overhauled the discussion of Gustafson's 2 studies and time frames. The text addressed in this comment has been deleted.

Line 2490 (Riley): It is definitely my understanding that SNP data like the kind in Gustafson et al. 2022 certainly can be informative about relatively recent land use changes. I have confirmed this with collaborators that we work with on population genetics projects. And this was my understanding from Kyle, while working on this paper, and it is what we were thinking in that paper. Indeed, both the first and last sentences of the abstract mention the effects of urbanization and fragmentation on lion population genetics, which, in this paper, is obviously measured with SNPs. Moreover, there are multiple places in this current document that mention the importance of the SNP data for determining population structure across the state, including from anthropogenic, and therefore more recent, factors. So I'm not sure where this statement at the end of the paragraph is coming from. While microsats evolve relatively quickly, and therefore can be good indicators of more recent evolution of some kind, and individual SNPs may not be evolving quickly, there is great power in the use of 1,000s of SNPs as are commonly used in these studies, including this one. And looking at changes across that many loci can indeed reveal relatively recent changes such as changes in connectivity from land use. The SNP data is richer than the microsat data and can provide information about things that the microsats cannot, including deeper relationships and potentially selection, but that doesn't mean they can't also provide information about relatively recent changes. Indeed, these relatively recent changes would generally be largely or entirely a result of genetic drift, as opposed to mutation, and the large numbers of markers that you get from the SNP data give you an even better picture of genetic drift than the smaller number of microsats.

RESPONSE: Due to these and other comments we have overhauled the discussion of Gustafson's 2 studies and time frames. The text addressed in this comment has been deleted.

Line 2492 (Riley): Where did these maps come from? They clearly are using the data from our two papers, Gustafson et al 2019 and 2022, but they do not appear in either paper, at least in the main body. I think it's important to say explicitly that the data come from the papers, as is indicated by the figure captions, but that they were produced by others, and ideally who. Also, I think it's very hard to make out what is going on in the pie charts representing different individuals. I know there are already a lot of figures, but I think if there are important places to highlight with the pie charts, I think it would be important to zoom in closer.

RESPONSE: These maps were produced by the Department using the data from Gustafson et al. 2019 and 2022. We have tried to present them at a scale that is relevant for our purposes but also doesn't require too many individual maps.

Line 2516 (Ernest): This statement is not always true: “However, it (genetics) does not provide information about the extent of current connectivity”. The statement is false when genetic tools are used to determine kinship relations - then it can provide information on current connectivity - such as with genetic pedigrees as in in Ernest et al 2014, Riley et al 2014, Gustafson et al 2017.

RESPONSE: Due to these and other comments we have overhauled the discussion of Gustafson's 2 studies and time frames. The text addressed in this comment has been deleted.

Line 2526 (Vickers): Re Discreteness/Designation as Markedly Separate: To quote the wording in the report vis a vis the SA population when answering the question with "Yes"- "This population is classified as a fine-scale genetic group by Gustafson et al. (2019)". This designation as a separate population is the case for every one of the 6 petitioned populations, so to say that any of them are not discrete or separate throws into question the basic premise of basing these evaluations on the genetic grouping. That makes no sense to say that is the basis for some to be "discrete" and not others.

RESPONSE: Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2526 – 2536 (Wilmers): I agree with the categorization that this is a markedly separate population. However, the structure of this population is a bit more nuanced than presented in the department’s status review and in the two Gustafson et al papers (which suffered from a low sample size of animals east of hwy 101).Rather than lump individuals from east (i.e. the Diablo range) and west (i.e. the Santa Cruz Mountains) of the 101 together, recent genetic evidence suggests that these would be better described by two management units – let’s call them Central Coast North-East and Central Coast North-West. (Describe genetics). In an analysis led by my collaborators, Nicolas Alexandre, Megan Supple and Beth Shapiro, we sequenced whole genomes of 506 mountain lions from across California with a range of ~3-20x coverage and a mean ~12x coverage. The data used for estimation of "admixture proportions between populations" and the "estimated number of populations" in the attached figure comes from a set of ~5 million markers (SNPs) filtered for various quality metrics, which were then pruned to reduce computational burden and nonindependence of linked markers (N=~130K). Using a similar approach to Gustafson 2022, the analysis has identified a K value of 12 populations as best fitting the data. This is still an ongoing analysis and has some issues that still need to be resolved. For instance, there are many instances of highly related individuals in certain populations that need to be pruned out before resolution of even more subtle population structure is visible. However, we can already observe strong signals of structure in the following analysis that are a good starting point. For example, CC-N has a clear split to the east and west side of the 101. As well, we have collared 147 adult and juvenile mountain lions with GPS and/or VHF collars over the past 15 years in the Santa Cruz Mountains, and we have never had an animal leave the mountain range though connectivity to the east across the Coyote Valley to the Diablo range and to the south to the Gabilan range surely existed prior to the construction of Highway 101 and associated development.

RESPONSE: Noted. Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it met the criteria, thus substructure of the genetic populations is less relevant to the recommendation that it was previously.

Line 2537 (Vickers): For the reasons noted above, I feel that the parameters listed in 2537-2547 are inadequate to capture whether this population is in fact "Significant". Thus I believe that the answer here should be "Yes'

RESPONSE: Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2538 – 2548 (Wilmers): As described above in comment 1, the ecological impact of losing mountain lions needs to be assessed as their loss would almost surely result in significant ecological impacts in the Santa Cruz mountains and throughout the other MUs. As an apex predator, mountain lions (and the only apex predator in the MUs being considered) have a large and disproportionally large impact on ecosystems. When mountain lions (and jaguars) were lost from island fragments formed by the damming of a major river in Lagu Guri, Venezuela, herbivore populations ranging from rodents to monkeys increased 10 to 100 fold (Terborgh et al. 2001). In Yosemite valley, where mountain lions are largely excluded by heavy human presence, deer are now limiting the recruitment of young oak trees (Ripple and Beschta 2008). Similarly, in Zion National Park high human visitation excluded mountain lions from certain areas allowing for higher deer densities which reduced recruitment of cottonwood trees, increasing bank erosion and reducing hydrophytic plant, wildflower, amphibian, lizard and butterfly abundance (Ripple and Beschta 2006). Our own work has shown that that the loss of wolves from the north east of the US and consequent invasion of coyotes has had a profound impact on rates of Lyme disease (Levi et al. 2012). Given a similar ecological relationship between mountain lions and coyotes (Wang et al. 2015) as between wolves and coyotes (Levi and Wilmers 2012), it would not be surprising if the presence of mountain lions in coastal California contributes to the much lower incidences of Lyme disease here than occurs in the Northeast. Finally, pumas in our study area eat a lot of domestic cats (Smith et al. 2016) which reduces the prevalence of domestic cats where pumas occur (Wang et al. 2015). Given the substantial toll that domestic cats have on biodiversity (Loss et al. 2013, Lepczyk et al. 2023),losing mountain lions from these habitats will almost surely greatly magnify the impacts of domestic cats on biodiversity through mesopredator release (Crooks and Soule 1999)

RESPONSE: Noted. Based on extensive feedback from reviewers we evaluated the whole petitioned area as a DPS and recommend it for listing.

Line 2539 – 2540 (Wilmers): The department appears to have interpreted the first significance criteria (i.e. “Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.”) to me mean that if the dominant plant species (e.g. redwoods) are found elsewhere in California, then the ecological setting is not unusual or unique as if the only thing determining ecological uniqueness is the dominant plant species. This is overly simplistic. There are many things that comprise an ecological setting (including but limited to the dominant plant species) such as other plant and animal species, soil types, aquifers, slope, elevation, aspect, water bodies, the spatial scale of watersheds, human developed areas and much more. Determining the difference or uniqueness of two or more different ecological communities is something that is commonly done in ecology using ordination, dissimilarity or other techniques. I am not familiar with all the data the department has at its disposal, but at a minimum I would assume that they at least have species lists of the most common plants and animals in each study area. Based on the data they do have available, they should conduct an ecological uniqueness test that includes multiple (e.g. the 100 most common species) species and other ecological variables rather than one or two dominant plant species.

RESPONSE: Noted. Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population is significant is less relevant than it was in the version that went to external review.

Line 2540 (Vickers): See notes above re CC-N population.

RESPONSE: Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2541 – 2544 (Wilmers): I disagree that the loss of mountain lions in the Central Coast North population would not constitute a gap in range. First, the Central Coast North-West MU (see comment 4 above) is tenuously connected (though threatened by highway 101 and associated development) to the south across highway 101 to the Gabilan range and to the east across the Coyote Valley to the Diablo range. Losing the Central Coast North-West MU would thus create a gap for mountain lions trying to get from the Gabilan range to the Diablo range through the Santa Cruz Mountains. The Central Coast North-West and Central Coast North-East MUs are also connected to MUs north of the bay via the Golden Gate and Carquinez strait respectively. Dellinger et al. (2020) Fig 3 shows that mountain lion habitat from the Central Coast North-East MU abuts mountain lion habitat in the North Bay with only the Carquinez strait separating them. Conventional wisdom has held for along time that mountain lions don't swim, but this is wrong. Stratton et al. (2022) recently documented a GPS collared dispersing male swimming 1.1 km in the Puget Sound, Washington and was able to infer mountain lion swim distances of up to 2 km based on the pattern of occupancy of islands at different distances from the mainland. The Carquinez strait separating the north and south Bay Areas is only 0.8 km wide at Dillon point where a mountain lion could reasonably cross. Even the Golden Gate is less than 2km across and mountain lions do appear in the Presidio or nearby every few years. A water crossing at either site is surely a rare occurrence given the low bidirectional migration estimate between sites north and south of the Bay (0.003 from Table S2 Gustafson et al. 2019), but these rates of crossing have almost surely been reduced by human development along both shorelines and by ship traffic within the waterways.

RESPONSE: Noted. Based on this and other feedback we evaluated the whole petitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population qualifies as a gap in range is less relevant than it was in the version that went to external review.

Line 2546 (Riley): This seems like a judgement call, and I'm not sure that I agree with this conclusion, that there are not "markedly different genetic characteristics" based on the SNP data. The fact that Fig. 16, with SNP data, shows some evidence of potential shared ancestry farther back, doesn't mean that there aren't important genetic differences here, in the Santa Cruz Mountains. In fact, when I look at Fig. 16, and compare the Santa Cruz Mountains and CC-N to CC-C, they look quite different! How much difference is enough, to be "markedly different"? How is this being measured? It's not clear to me.

RESPONSE: Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2550 (Vickers): In the document, the word "threatened" is utilized to describe some of the six petitioned populations before the final recommendation that may decline to suggest Threatened status. Using the word "threatened" in multiple and conflicting ways is likely to be confusing to the reader. An example follows from the CC-N MU evaluation section: Imperiled? Threatened or Endangered: Yes. This is a small, isolated population with an effective population size of 16.6 and an estimated 33–66 adult animals. Conclusion: Evidence does not support a designation as a threatened or endangered DPS.

RESPONSE: Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2550 – 2551 (Wilmers): I agree that this population is threatened or endangered. In addition to the low effective and estimated population sizes, we have recently documented two adult mountain lions with kinked tails – a trait associated with inbreeding – in the Santa Cruz Mountains population.

RESPONSE: Noted.

Line 2552 (Wilmers): I disagree with this. Given my analysis above that the loss of mountain lions from this DPS would constitute both a 'gap in range' (Comment 7) and have a significant ecological impact (Comment 5), scientific evidence favors designation as a threatened or endangered DPS.

RESPONSE: Noted. Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2558 and 2586 (Vickers): The CC-C MU is bordered on the north by a discrete isolated population (CC-N MU), and on the south by the CC-S MU, itself containing one of the two most imperiled population segments (SMM) in the state, as well as at its margin the Tehachapi population which recent research suggests has significant restriction of connectivity due to major freeways (Vickers and Najera unpublished). Thus, it is my opinion that the CC-C MU is in fact discrete and likely becoming more so since its connection to the SN population is dependent on the Tehachapi Range, which is itself under threat from plans for high speed rail, SR 58 widening, and steadily increasing traffic on I-5, SR 58, and SR 14, as well as two large planned developments. These infrastructure elements all serve to further reduce connectivity for both the CC-C MU and CC-S MU to the east and south, and will be likely to exert more effects in the future. Given the dynamic negative challenges to connectivity occurring on the ground in that area (despite the Wallis Annenberg bridge over the 101 freeway that will benefit only the small SMM population), in my opinion the answer relating to the questions of discreteness/marked separation for both the CC-C and CC-S MUs should be "Yes".

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS. Therefore whether each individual genetic population qualifies as discrete is less relevant than it was in the version that went to external review.

Line 2560 (Riley): So the implication here is that there is enough gene flow between CC-N and CC-C that CC-C is not markedly separate, yet CC-N is, based on line 2526? That doesn't make sense, I don't think. Or is it that CC-C is not markedly separate just because of the connections in the South between CC-C and CC-S?

RESPONSE: Noted. Based on this and other feedback we evaluated the whole partitioned area as a DPS and found it met the criteria. Therefore whether each individual genetic population meets the criteria is less relevant than it was in the version that went to external review.

Line 2562 (Riley): This mention of CC-C ancestry in CC-S except for the Santa Monica Mountains provides further support for evaluating and potentially listing a separate Santa Monica Mountains MU, as we are suggesting.

RESPONSE: The Santa Monica Mountains are now in the area recommended for listing.

Line 2573 – 2576 (Wilmers): The department appears to use an effective population size (Ne) of less than 50 individuals in determining whether a DPS is potentially imperiled. This derives from the so called 50-500 rule proposed by Soule (1980) and Franklin (1980) nearly 45 years ago in which they recommended that a population of ≥ 50 individuals was necessary to avoid inbreeding depression in the short term and that a population of ≥ 500 individuals was necessary to maintain evolutionary potential in the long term. These thresholds were based on the opinions of animal breeders and limited data on laboratory animals. Since then however, numerous studies have shown that inbreeding depression can occur in populations with Ne's ≥ 50, and as such recent authors have suggested that a more appropriate limit of Ne ≥ 100 be set to avoid inbreeding in the near term (Frankham et al.2014). Similarly, several lines of theoretical and empirical evidence now suggest that an Ne ≥ 1000 is necessary to maintain evolutionary potential in perpetuity (Frankham et al. 2014). If an Ne ≥ 50is insufficient to prevent inbreeding, then surely it is too small to prevent imperilment. If the goal is simply to preserve mountain lion populations in the near term, then an Ne ≥ 100 should be the minimum to avoid imperilment, but if the goal is to maintain mountain lion populations in the long-term, then the department should aim for an Ne ≥ 1000. To achieve this later target would require maintaining and restoring connectivity among mountain lion populations throughout California and to neighboring states. Even if we are to accept an Ne ≥ 50 as the acceptable threshold, the department doesn't consider that the Ne estimate of 56.6 for the Central Coast Central MU taken from Table 2 of Gustafson et al (2019) has 95% confidence intervals (CIs) that included values < 50 (CIs 47.4 – 69). Furthermore, Gustafson et al (2022) estimates an Ne for the Central Coast Central of only 26.9. Taken together these point to the fact that the Central Coast Central population may well have an effective population size less than 50 and should be regarded as imperiled.

RESPONSE: Due to this and other comments, we use Frankham et al. (2014) suggested Ne=100 to prevent inbreeding depression over short timescales (~5 generations) as the criteria for imperilment.

Line 2577 (Vickers): Dellinger et al. 2020 found that key genetic elements (expected heterozygosity, allelic richness, and effective population size) that are recognized as significant to mountain lion population long term survival were all higher in habitat that was protected versus unprotected. It was surmised in that paper that this was the result of unprotected habitat being more prone to fragmentation and other anthropogenic factors that disrupt connectivity. Since the CC-C MU has the least percentage of habitat that is protected of the six MU's, its north-south intra-MU connectivity is vulnerable to development, and it is a critical gap between the CC-N MU and the CC-S MU, that it too should have the increased protection of threatened status.

RESPONSE: CC-C is now in the area recommended for listing.

Line 2585 – 2612 (Wilmers): How can the Central Coast South population be imperiled, but not discrete? This makes little sense. Either it is a discrete population that is imperiled (due to extremely low effective population size and inbreeding) or it is not discrete and not imperiled (because it has plenty of gene flow from other populations as the department suggests). It is hard to imagine how this population is showing such stark signs of inbreeding if it is not really discrete. The genetic (e.g. structure plot inset in Gustafson et al (2019) and other (e.g. high rates of malformed sperm and kinked tails) evidence suggest the population is both discrete and imperiled.

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS. Therefore whether each individual genetic population qualifies as discrete is less relevant than it was in the version that went to external review. This section has been deleted.

Line 2587 (Riley): Again, there is explicit acknowledgement of the Santa Monica Mountains being separated from the rest of CC-S, and therefore from CC-C, by "heavy urbanization," which includes freeways. This continues to indicate the importance of considering a Santa Monica Mountains MU.

RESPONSE: The Santa Monica Mountains are now in the area recommended for listing.

Line 2590 (Riley): I think this assessment of how much connection there is between CC-S and CC-C is premature. There really wasn't very good sampling of southern CC-C and northern CC-S for our statewide papers, because those samples just weren't available. More recently, through various efforts by the Dept, there are significantly more samples available, is my understanding. And as I said before, it is important to specify somewhere what the boundaries of the CC-S MU are. I don't think it makes sense to have the Sierra Pelona, across Highway 5, as part of CC-S. I don't think anyone in the area would consider the Sierra Pelona mountains, east of 5 and above Highway 14, as part of the "central coast." And I don't think it makes sense based on what we have seen of lion population genetics, both in our 2014 paper, and in these two statewide papers.

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS, which makes the discussion of the connectivity between the individual genetic populations less relevant, and this section has been deleted.

Line 2594 (Riley): As stated in a couple of previous comments, we believe that the Santa Monica Mountains specifically do indeed represent a unique ecological setting as the most intensely urbanized place in the state, and indeed in the country and hemisphere, where there are mountain lions or any large felid.

RESPONSE: The Santa Monica Mountains are now in the area recommended for listing.

Line 2596-2603 (Vickers): The way that the term "gap" is used in the report for assessing these populations is inappropriate in my view. Populations seem to only qualify if they are as links in a straight or curving chain of discrete links, but in fact each population south of the CC-N MU and east of the SA MU is a link that would create an insurmountable connectivity gap if that population were to be extirpated or if connectivity within or between the MU's were seriously disrupted by accumulated infrastructure. Interestingly, the most critical linking population area or "gap" (as noted by the Department in the report) is the Tehachapi Range, and though it is included in the proposed ESU, it exists at that margin of the CC-S and CC-C MU's but the report does not classify it as to what MU it belongs to. This is partially due to the low numbers of genetic samples that were available from there for the Gustafson analyses. More samples are now available from research by UC Davis there in the last year and those may help define their most appropriate grouping. However, since the status of that Range has a bearing on the designation for the CC-S and CC-C MU's, it may be necessary to include it in both in my opinion. If included in the CC-S MU it makes that MU clearly a "gap" area. The lack of definition of where that population falls makes proper classification of the CC-S MU difficult. Recent UC Davis research suggests that the population across the Tehachapis is to some degree restricted in free movement between the SN and the CC-C and CC-S MU's (Vickers and Najera unpublished). The report seems to be treating the Tehachapi Range population as part of the CC-C MU connection to the SN when in fact the western end of the Tehachapis falls on the border between the CC-C and CC-S MU's, and thus may be functionally a part of both, and critical to both. In these sentences however, the CC-S MU is depicted as just the SMM population despite earlier in the document and in the genetics analyses the CC-S MU includes mountain lions substantially north of US 101 and perhaps to the Tehachapis. So assuming that the Tehachapi Range is at least functionally a marginal part of the CC-S, the CC-S could also be classified as a "gap" population. It is a given that disappearance of that Tehachapi population, or loss of what diminished connectivity there is across that Range, would in fact leave the biggest gap of all in connectivity for the genetic health of all six MU's. In my opinion this answer for the CC-S should instead be "Yes" for all of these reasons.

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS, which makes the discussion of the gaps between the individual genetic populations less relevant, and this section has been deleted.

Line 2597 (Riley): I disagree that losing CC-S does not represent a significant gap in the range, although as I said, I'm not really clear on how this "gap in range" criterion is being applied. Most importantly though, I definitely think that CC-S is critical for connectivity to other MUs. Again, this may depend a bit on where CC-S is considered to be, but assuming that the northern part of CC-S is the Los Padres National Forest area around Gorman and Frasier Park, which based on Fig. 1, it would be, than it would be the connection between the entire Central Coast area and the Sierras, and therefore the rest of the state (other than the South Coast). CC-S also includes the connection between the coast and SG-SB, and therefore to the whole South Coast area (SAs, EPR). So really you could argue that CC-S is the most important MU for connectivity in the entire state, certainly in the petitioned area. It is true, as stated on line 2600, that the connection to SGSB is currently very limited, but in my opinion that does not mean that we should give up on it, nor does it diminish the importance of the connection. On the contrary, I would argue that it is especially important that healthy populations of lions exist on both sides, so that if we're able to improve connectivity, the improvement will still be useful for this species. And there are currently efforts underway to improve connectivity across 5, and ideally 14 too, for wildlife generally and for mountain lions specifically. Finally, while it is true that the Wallis Annenberg Wildlife Crossing is under construction and will significantly improve connectivity between the Santa Monica Mountains and areas north (last sentence here), I don't think that means we should assume its success at significantly assisting the mountain lion population before it is even finished, let alone before we have been able to monitor its use and ultimately how the lion population responds. And as we've stated elsewhere, though 101 is the biggest and most significant barrier for the Santa Monica Mountains, there are two other roads between the Santa Monicas and Los Padres, the 118 Freeway and Highway 126, across which connectivity is also important.

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS, which makes the discussion of the gaps between the individual genetic populations less relevant, and this section has been deleted.

Line 2601 (Beier): "Connectivity across highway 101 linking the Santa Monica Mountains to the Simi Hills will be significantly improved following the completion of the Wallis Annenberg wildlife overpass, which will promote gene flow within the southern portion of this MU." I do hope this is true, but we don't really know this yet.

RESPONSE: That sentence has been deleted.

Line 2612 (Riley): As we've mentioned, we have direct evidence of extensive close inbreeding in the Santa Monica Mountains population, within CC-S. This is mentioned for the SAs (line 2683), so it should also be mentioned here. We mentioned two cases of it in Riley et al. 2014, and we also reported on three other cases in our Report to the Dept, specifically covering the years 2016-2018. So this could be cited instead of a personal communication.

RESPONSE: This section has been deleted, and details of inbreeding in the Santa Monica Mountains has been added to section 4.10.4

Line 2612 (Riley): Mountain lions in CC-S are indeed imperiled, and there are a number of other sources of data other than the statewide papers. We investigated the viability of the population in a very detailed and comprehensive way for the Santa Monica Mountains, using the best available empirical data on demography and genetics, in Benson et al. 2016 and 2019. I think it is important to mention and cite these results here. Specifically we found that over the next 50 years there was a 20% chance of extinction just based on demography along, because of the isolation and small size of the population in the Santa Monicas. And when genetics were taken into account, if inbreeding depression reached a similar level as seen in Florida, there was essentially a 100% (99.7) chance of extinction over 50 years, with a median time to extinction of 15 years. Also, as mentioned in previous comments, we have directly documented close inbreeding, i.e. mating between close relatives, multiple times in the Santa Monicas (Riley et al. 2014, NPS reports).

RESPONSE: CC-S is now in the area recommended for listing.

Line 2613 (Riley): As mentioned in other comments, we believe that the mountain lion population in the Santa Monica Mountains is both discrete and significant. It is discrete, based on physical separation and genetic evidence, and it is significant as the most urban population of the species in the state and beyond; as the only apex predator in the system; and because of its significance to the people of the Los Angeles Area.

RESPONSE: The Santa Monica Mountains are now in the area recommended for listing.

Line 2613 (Wilmers): I disagree that the Central Coast Group is not discrete. It is hard to understand how the department came to this determination. The discriminant analysis of principal components plot (Fig. 3, page21) shows clear genetic structure differentiating the Central Coast from other populations in the state. There is no natural reason for this genetic structure to occur – were it not for the activities of humans, there is no reason that a wide-ranging species capable of dispersing 100s of miles would show such population structure. The cause is human development in the form of highways, row crop agriculture and urban areas fragmenting habitat and making it more difficult for mountain lions to disperse from one area to another. That there might be occasional migrants into the population from outside the Central Coast MU does not negate its discreteness as evidenced by the strong genetic structure, low effective population sizes and multiple lines of evidence of inbreeding (described above and in the status review). Finally, the department suggests that the Los Padres National Forest provides connectivity to public land east of the MU without mentioning that this is bifurcated by highway 5 – one of the busiest interstates in the United States and getting busier every day. Substantial sprawl is expected to continue along the I5 with a new community of 12k homes being planned for the Tejon ranch in the Tehachapi at the part of I5 purportedly providing connectivity to the Central Coast Group.

RESPONSE: Noted. Based on reviewer feedback we evaluated the whole petitioned area as a DPS, which makes the discussion of discreteness of the individual genetic populations less relevant, and this section has been deleted.

Line 2619-2623 (Beier): Here you assert that the Central Coast Group is not markedly separate. Figure 3 suggests that it is quite separate. One could argue "Yes" just as strongly. Remember, there is a time lag between land use changes and genetic response. I would strongly argue that the trajectory is leading toward a "yes". If there were superb crossing structures on US-101, SR-14, and I-5, one could say the trajectory might be getting better.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2622 (Riley): I'm not convinced that there is "evidence of gene flow and migration" in the Santa Barbara through Ventura area." What is this evidence exactly? One problem may be, as I mentioned before, that it's very hard to see the pie charts in Figure 17 and 18. So it may be worth zooming in on particular areas, to make certain points, more so than is currently the case. I think another problem, again as I said before, is the lack of extensive sampling in this area, of the northern CC-S and southern CC-C. And finally, as I've also said, there needs to be a clear description of the boundaries of the management units, which is not the case currently, that I've seen. Where does CC-C end and CC-S begin? Is the Sierra Pelona in CC-S? I think it should be part of the Western Sierra Nevada, which is what it looks more like is happening in Figure 1, back in the beginning of the document. But overall, in order to be able to evaluate these management units and how discrete they are, we need to know where they begin and end.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2628 (Riley): In terms of connection between the Central Coast and the San Gabriels, we have done work specifically in this area and on this question, and there is no evidence that this is the case, and in fact there is substantial evidence that it is not the case. We have tracked many animals over the years in the Santa Susana Mountains, and never had one cross the 5 Freeway to establish itself in the San Gabriels or Sierra Pelona. And we have had many animals come right up to the freeway, which is clearly a home range boundary. This is evident in a figure in Riley et al. 2014, but we have also seen it regularly in other animals since then, including some animals that we're tracking currently (P105 and P106). We also did a study with Caltrans and LA Metro specifically along Highway 5 in the stretch between the 14 interchange and Santa Clarita, where we monitored 9 different crossing points and natural areas in the vicinity on both sides. We never detected mountain lions at any of the crossing points, or nearby on the East side, although we did detect them in the vicinity on the west side, at multiple sites. Finally, in our regional genetic analysis, we also saw strong evidence of genetic differentiation across Highway 5 (Riley et al. 2014, and subsequent unpublished analyses).

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2630 (Riley): As I said, I don't agree that the Central Coast is not markedly separated from other populations. It is physically separated, by the Central Valley and Highway 5, and that separation is borne out by genetic data, as far as I can tell.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2634 (Riley): Again, we believe that the Santa Monica Mountains, in the Central Coast Group, does indeed represent a unique and unusual ecological setting for the species.

RESPONSE: The Santa Monica Mountains are now in the area recommended for listing.

Line 2641 (Riley): It's hard for me to understand how, if the Central Coast Group has "markedly different genetic characteristics," it is not also markedly separated. This gets back to the point about whether SNP data are also relevant for recent changes, which they definitely can be, even if they also provide information about deeper ancestry (more so than microsats, say).

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2647 (Riley): I agree that the Central Coast overall, specifically because of the presence of the CC-C group, is not imperiled, in the way that the others in the petitioned area are. I think it's worth saying here that that CC-C MU is one of just 4 (along with ESN, WSN, and NC) MUs with an Ne of more than 50 (as opposed to saying "few"). Also, however, as I mentioned in reference to the Table, although it is not as imperiled as the others, Central Coast Central is indeed critical for the long-term survival of the CC-N and CC-S populations, and therefore for the whole Central Coast. If it's important to conserve the species in the petitioned area, it may be worth considering whether it is worth protecting the Central Coast Central unit, because of its critical role as a source for the other areas.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2647 – 2651 (Wilmers): I disagree this population is not imperiled. The effective population size of the Central Coast Group as estimated by Gustafson et al. (2019) is 76, which is less than the Ne ≥ 100 threshold currently recommended by conservation biologists (Comment 10). Additionally, the combined effective population sizes from all three populations calculated by Gustafson et al. (2022) is only 50, a margin of only one effective animal over the older Ne ≥ 50 rule. By either metric the population should be considered imperiled

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2652 – 2653 (Wilmers): Given my analysis for discreteness (comment 12) and imperilment (comment 13) above, the Central Coast group now meets the standards to be designated as a threatened or endangered DPS.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2661 (Riley): Yes, based on Fig. 17, there do seem to be quite a few migrants into the SAs from the southeast. How many are there specifically? It is hard to see, but worth mentioning, I think.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, which makes the gene flow between the individual genetic populations less relevant to the recommendation. This section has been deleted, but the maps and some of the text has been moved to section 2.4

Line 2662 (Riley): Do you means to say that 74 lions in the EPR, or 74 in the EPR and the SAs together? Otherwise, how many were tracked in the SAs? This needs to be clear, I think.

RESPONSE: This section has been deleted, and has been clarified where mentioned in the rest of the document.

Line 2666 (Riley): What is the evidence for the increased traffic and development, and what is meant by "recent years"? Maybe Winston can help with this. Also, the Huffmeyer et al. reference has 2022 as the year, in the Lit Cited. Technically it was accepted and in press in late 2021 I believe, but printed in 2022, so either could in theory be used, but it would be good to be consistent with the Lit Cited.

RESPONSE: This section has been deleted, and the reference has been fixed in the rest of the document.

Line 2668-2672 (Beier): You correctly state: "The conflicting evidence between Vickers et al.'s (2015) telemetry study and Gustafson's et al.'s (2019) genetic work may, in part, be explained by worsening fragmentation from recent land use changes as many of the tissue samples analyzed by Gustafson et al. (2019) were obtained prior to the onset of Vickers et al.'s (2015) study." I agree 100%. But recent (and ongoing) land use changes and time lags in genetic response also affect other groups for which we lack telemetry data, so although Gustafson genetic map is superb, time lags mean it may not reflect the condition today, and certainly not tomorrow.

RESPONSE: Noted.

Line 2671 (Riley): This is confusing - many of the samples in our 2019 Gustafson paper were from before 2000, is that right? That seems surprising, but either way, it needs to be clear. Were they maybe from Paul Beier's work back in the 90's? But also, I think the excellent long-term telemetry data that Winston and others collected is clear evidence of the Santa Anas being discrete, along with the fact that there is a major, busy freeway, I-15, separating the Santa Anas from the EPR. The population genetic data is of course valuable, but the population assignments are an indirect, and not always perfect, measure of immigrants. The telemetry work is directly measuring this movement.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2672 (Vickers): May add: "Telemetry and camera studies have documented two additional mountain lions crossing I-15 west to east from the SA to the EPR, though both stayed for only short periods of weeks to a few months and then returned to the SA before their collars dropped off as planned. No collared mountain lions have been recorded crossing I-15 from east to west, though Gustafson et al. 2018 documented in an extensive pedigree construction for the SA and EPR populations three mountain lions sampled in the SA whose genetics suggested their origin was the EPR. Two of those were deceased when sampled in the SA and no offspring of theirs were detected. One of the three however (M86) appeared to have reproduced extensively and sired eleven offspring that were detected in the SA group at the time. In that same Gustafson et al. 2018 pedigree reconstruction, 3 animals were detected in the EPR whose genetics suggested that their origin was the SA. More recently, over a 3-year camera monitoring period along I-15, no mountain lions have been detected moving from the EPR to the SA, though two individuals were photographed moving from the SA into the EPR under I-15. Efforts are underway with Caltrans and others to increase connectivity through existing passageways like Temecula Creek and to build additional infrastructure for safe passage over or under the highway south of that point. (Vickers unpublished data)"

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2677 (Vickers): See earlier comments re CC-N population - lines 2435-2441

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2688 (Riley): This is true just for demographic stochasticity, but the model's predictions are much more dire when they include inbreeding depression causing declines in survival and reproduction. And as mentioned at the top of the page, there is evidence of this in the region based on poor sperm quality. I think another sentence or clause is needed here to at least mention this potential even more severe danger to the population.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2702 (Vickers): Add: "However, movement across the southern border is becoming more and more restrictive for wildlife including mountain lions due to border security infrastructure expansion and increased border patrol activity over time."

RESPONSE: This section has been deleted.

Line 2729 (Vickers): See earlier comments re appropriateness of use of Ne for population estimation and additional information that is needed here.

RESPONSE: We have reworked the discussion of effective population size and no longer use it to estimate population size. In addition the effective population size of individual genetic populations is no longer particularly relevant to the recommendation,

Line 2736 (Vickers): See earlier comments re discreteness and marked separation of the six populations. In my opinion this answer should be "Yes"

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2736 (Riley): I would argue that the SG-SB is indeed discrete. Both our regional genetic analysis (Riley et al. 2014) and the statewide papers (both Gustafsons) indicate that Highway 5 is a major barrier and that this group is separated from the Central Coast. As I mentioned above, this is also borne out by our mountain lion tracking data in the area. I think figures 3 and 17 actually show that this group is indeed discrete from a genetic point of view, Figure 3a quite compellingly so.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2742 (Riley): As mentioned, we have extensive tracking and camera data, and some genetic data (Riley et al. 2014) about the strength of Highway 5 as a barrier to movement and gene flow for mountain lions.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2759 (Riley): As mentioned, I don't agree that SG-SB is not discrete. Although it's also true that there were relatively few samples available from this area for the statewide papers. I know more recent samples have been acquired by CDFW work in the area, especially at the southern end of the population, so perhaps those could help shed some light on this area.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2759 (Vickers): In my opinion this population should be listed as a threatened DPS.

RESPONSE: Due to reviewer comments, we no longer evaluate whether the individual genetic populations meet the criteria for a DPS, and this section has been deleted.

Line 2795 (Vickers): See earlier comments re appropriateness of use of Ne for population estimation and additional information that is needed here.

RESPONSE: We have reworked the discussion of effective population size and no longer use it to estimate population size. In addition, we evaluate the petitioned area as a whole and the effective population size of individual genetic populations is no longer particularly relevant to our analysis.

Line 2804 (Wilmers): As stated above in comment 2, the department needs to consider whether all six MUs taken together meet the criteria for listing as a single DPS. This would be a good place in the report to do so. For the sake of my review, let's call this single DPS the "Coastal Group", and evaluate them for Discreteness, Significance and Imperilment. Regarding Discreteness, the Coastal Group is markedly separate from other populations in the state using the same genetic arguments I have used above for the other MUs (comment 12) and the department has used for the Southern Coast Group. The Coastal group is also discrete because it has an international border. Regarding significance, the coastal group is significant according to Unique Ecological Setting, Gap in Range and Ecological impact criteria as described by the department and above. Regarding imperilment, the coastal group is imperiled for numerous reasons; 1) It has a combined effective population size of 70.6 (Gustafson et al. 2022) which is less than the Ne = 100 threshold described above, 2) the MU is experiencing signs of inbreeding in the North, Central and Southern parts of its range (as described above and in the status review) and 3) urban, road and/or agricultural development have and continue to fragment populations throughout all of the Coastal group MU.

RESPONSE: Due to reviewer comments, we evaluated the whole petitioned area as a DPS and found it met the criteria.

Line 2807-2817 (Vickers): The proposed ESU area constitutes a "significant" portion of the range in my opinion. Significant should be better defined as a term in this context - i.e. significant as a percentage of all the habitat in the state, or in other ways? As a proportion of the habitat I believe that a common reading of the term would classify the ESU area as significant.

RESPONSE: Noted

Line 2844 (Riley): Yes, we agree with this statement, of course, and think that it provides continued support for considering a Santa Monica Mountains MU.

RESPONSE: The Santa Monica Mountains are now included in the area recommended for listing.

Line 2846 (Riley): I think it's worth naming these groups, the two broad-scale ones, central coast and south coast, and the 6 fine-scale ones, CC-N, CC-C, CC-S, SG-SB, SA, and EPR, so that it's very clear what you're referring to here, and so that readers that aren't intimately familiar with everything won't have to wonder.

RESPONSE: This portion of the sentence has been deleted and text now reads "Long-term maintenance of genetic variation within the genetic populations in the petitioned area is reliant on habitat conservation and connectivity"

Line 2850 (Riley): Yes, this is a very important point, and we agree that connecting the coastal areas to the Sierras, through the Tehachapis, is critical for mountain lion populations across the state, long-term. The Santa Monicas to Los Padres MU that we are suggesting be considered would provide potential connectivity between the Central Coast and the San Gabriels. An important point is that this connection between a potential Santa Monicas to Los Padres MU and the San Gabriels-San Bernardinos MU would connect these two fine-scale MUs, but it would also be essentially the only connection between the broad scale MUs of the Central Coast and the South Coast. So this adds significantly to the importance of this connection. In theory, connection across 5 between the Santa Susanas and the San Gabriels could then also provide connection from the San Gabriels north to the Sierra Pelona and then to the Tehachapis, though that is a bit more indirect. However, the best connection between the coast and the Sierras is directly to the Tehachapis, though the northern part of CC-S, in Los Padres up in the Gorman, Frazier Park, Grapevine area. This area would not be covered in our proposed Santa Monicas to Los Padres MU, so we think it is worth considering whether CC-S is also worthy of listing, because of its significance for connectivity state-wide. If this connection is maintained or enhanced, this would provide another potential place connecting the Central Coast to the South Coast, though again a bit more indirectly, through the Sierra Pelona and to the San Gabriels.

RESPONSE: The area mentioned is now recommended to be listed.

Line 2864 (Riley): I think it's important to make it clear what you're referring to in this last sentence, since the previous one addresses multiple things, including protecting habitat, and the term "crossing infrastructure" is a bit nebulous. You could just say "of crossing structures" at the end of the sentence before "for effectiveness," or something like that.

RESPONSE: Done

Line 2874 (Riley): I think it is definitely worth citing the Benson et al. 2023 statewide survival paper here, when talking about depredation mortality rates (line 2874) and about concern about how depredation mortality could affect the coastal populations (line 2878). As mentioned earlier, this recent publication includes a massive amount of data on survival and mortality causes over decades, over the entire state, and including essentially all of the major researchers on lions, including Dept folks, in the state, and it specifically addresses these survival rates and mortality cause rates in a rigorous way.

RESPONSE: These sections are summaries of the threats more fully explained in Section 4, and do not contain citations. We discuss Benson et al. 2023 in the section on over exploitation 4.3.

Line 2889 (Riley): Yes, and there is no evidence that where wolves and bears coexist with mountain lions, which is essentially all over the west wherever wolves have returned, that this predation matters for lion populations.

RESPONSE: Noted

Line 2895 (Riley): Mark's work on these interactions is certainly interesting, but yes, even when there are wolves across the state again, mountain lions certainly coexisted with wolves and bears for millennia and do so currently in every place that wolves have returned to the west. And as mentioned earlier, lion harvest rates have actually been increasing in states with wolves, so significant, widespread population impacts seem unlikely.

RESPONSE: Noted

Line 2898 (Riley): It would be worth updating this section a bit. We certainly agree that these intraspecific interactions are likely more important in isolated areas such as the Santa Monica Mountains, and it was indeed the case that intraspecific conflict was the leading cause of mortality in the early part of the study, as we reported in Riley et al. 2014, coming especially from adult male P001, who killed a son (P005), a daughter (P007), and a former mate (P002); and also from P001's son, P009, who killed P-B and P008. And we certainly agree, as you say here, that this source of mortality, though it occurs in other populations too, especially unhunted ones, is likely exacerbated by the lack of dispersal out of places like the Santa Monicas. It might also be worth mentioning that when major, habitat altering or destroying events like fire happen in an isolated area, this intraspecific conflict could be further exacerbated. After the Woolsey Fire wiped out about 1/2 of the natural area in the Santa Monicas, there was even more overlap between males (both adults and subadults) in the unburned, eastern half of the Santa Monicas, as we discussed in Blakey et al. 2022. However, as our study has continued, other mortality causes have caught up to and even surpassed intraspecific conflict as sources of mortality. It would be important to cite Benson et al. 2020 (Biol. Conserv. 241:108294) here, where we determined rates of survival and mortality causes for the first almost 20 years of the study, covering 53 deaths, and found that anticoagulant rodenticide poisoning and vehicle mortality were equivalent with intraspecific conflict overall. And in fact, in the few years since this work, vehicles are now the most common cause of mortality.

RESPONSE: This section is a summary of 4.4 on competition where we have included the major points of this comment. The summary sections do not include references or new information.

Line 2902 (Beier): Remove the second period.

RESPONSE: Done

Line 2920-2925 (Riley): By far the best way to evaluate the importance of different mortality causes is through the use of telemetry data, since that gives an unbiased view of survival rates and of the rates of mortality from different causes. Fortunately, as mentioned before, we have a very recent, comprehensive analysis of mountain survival rates and mortality rates for different causes, including vehicles, from across the state and from 100's of collared animals over many years (Benson et al. 2023). Vehicles are indeed an important cause of mortality in the state, and through this analysis we can directly measure its importance against other mortality causes. The telemetry studies have of course not occurred everywhere, or across all years, but they are in more than just the Santa Monica Mountains and Santa Ana Mountains, and overall they give an excellent assessment of the importance of different mortality sources, including vehicles. Counts of vehicle mortalities can give some idea of total numbers, but there are all kinds of well-understood biases associated with such counts, especially if they are not based on systematic surveys for vehicle mortalities, which the Shilling et al 2023 survey is not. These counts are certainly valuable, and they are useful as minimum counts of mortality. But it is important to be aware of the limitations.

RESPONSE: Noted. We have included mention of the results of Benson et al. 2023 in this summary section.

Line 2935 (Riley): Although it may be somewhat true for Highway 17, I don't agree with this statement for the 101 Freeway, and potentially for many future crossings, depending on the specifics of what kind of road they're on. So, we of course believe the wildlife crossing structures specifically, and wildlife connectivity generally, are extremely important for wildlife conservation now and in the future, for all kinds of species, including for mountain lions. However, different crossing structures have different main goals, and different roads have different primary impacts. Major freeways are generally more important in terms of their barrier effects, because few animals even try to cross them, whereas smaller roads such as smaller highways and secondary roads have fewer barrier effects, but they are often more important as potential mortality sources. The main goal of the Wallis Annenberg Wildlife Crossing is not to reduce vehicle mortality, because that is not a major issue for the 101 Freeway, one of the widest and busiest freeways in the world. The main goal is to connect the two natural areas of the Santa Monica Mountains and the Simi Hills, for all species of wildlife, including mountain lions. The crossing will indeed provide safe passage for animals, including mountain lions, but it will not prevent vehicle mortality from continuing in our area, and more of the vehicle mortalities in our region have been on smaller highways or secondary roads than on freeways - of the 41 vehicle mortalities that we know of 25 have been on smaller roads vs. 16 on freeways. So as I said, wildlife crossings are critically important, but depending on where they are and what kind of road they cross, they may not make that much difference in terms of vehicle mortality.

RESPONSE: Have changed 'significantly reduced' to 'may be substantially reduced' so it now reads "If wildlife crossing structures and fencing become widespread within the proposed DPS, mortality from vehicle strikes may be substantially reduced."

Line 2947 (Riley): For the Santa Monica Mountains and surrounding areas, so for a potential Santa Monicas to Los Padres MU, two things are true: 1) toxicants have caused significant mortality in our population; and 2) we have computed cause specific mortality rates associated with it across our overall study area, and it was of similar importance as intraspecific strife, and now just behind vehicles, as the most important causes of mortality. This is all most recently documented in Benson et al. 2020 (needs to be added to the Lit Cited).

RESPONSE: Have added this sentence "In the relatively small population in the Santa Monica Mountains National Recreation Area, AR toxicosis was the third leading cause of death after vehicles strikes and intraspecific strife."

Line 2959, 2963 (Riley): In the Santa Monica Mountains, we have documented both mortality as a result of fire (line 2959), and a major loss of usable habitat after the Woolsey (line 2363) in Blakey et al. 2022, so it would be worth citing that in both of these places, I think.

RESPONSE: These sections are summaries of the threats laid out in Section 4, and do not contain citations.

Line 2998 (Riley): Yes, and as mentioned before, we did detailed viability modeling, based on the best available empirical data and including both demographic and genetic factors, and determined that both the Santa Monica Mountains and Santa Ana Mountains populations are at imminent risk of extinction, especially if connectivity is not improved and inbreeding depression worsens.

RESPONSE: The paragraph has been rewritten to reflect changes in section 4.10 and that sentence has been deleted.

Line 3008 (Riley): This is likely true, that the North Coast, Central Coast overall, specifically Central Coast Central, and Sierras are likely in pretty good shape at this point, and for the foreseeable future. However, the petition is not about those areas, it is specifically about the Central Coast and South Coast, and for all of those areas, except for Central Coast-Central, I think there are significant concerns.

RESPONSE: Have changed 'high potential' to 'potential'

Line 3071-3095 (Vickers): Though the Department spells out the specific reasons that they believe the ESU designation is not appropriate, it is notable that by changing the names of the population segments from ESU's to MU's they can then be potentially listed if determined to be DPS's. Nevertheless, as noted above, in the report, in practical terms, it would seem to be a "distinction without a difference" since the proposed actions for the genetically defined population segments would be the same if listed as threatened under CESA.

RESPONSE: Noted

Line 3096 Figure 19 (Riley): As we have mentioned earlier, we recommend considering adding a new Management Unit to the South Coast Group, to include the Santa Monicas up to Los Padres. There is strong evidence that the Santa Monica Mountains are discrete, based on physical, behavioral/ecological (lack of dispersal), and genetic factors. And we believe that this MU is significant, based on four criteria: 1) it is a unique and unusual ecological setting for the species in and around Los Angeles, a megacity; 2) mountain lions represent the only apex carnivore in the system; 3) the MU maintains critical connectivity to the San Gabriels-San Bernardinos MU, and therefore between the entire rest of this threatened South Coast Group and the Central Coast; and 4) the population is of major cultural significance to the people of southern California and the state. We also think it's worth considering whether the Central Coast South MU overall would be important to list as threatened because of its link to the Tehachapi Mountains and thereby to the Sierra Nevada Mountains. Connecting the Coastal populations overall to the rest of the state, via the Sierras, is critical for the long-term genetic health of the species in the entire state, we believe.

RESPONSE: Due to this and other comments, the suggested area is now included in the area recommended for listing

Line 3104 (Ernest): The CDFW proposal includes a proposal for a Distinct Population Segment (DPS) in the South Coast Ranges. The jagged lines denoting the boundary of the geographic area of this DPS primarily follow roads, curiously bisect the city of Los Angeles immediately adjacent to the Santa Monica Mountains, and are not following ecological/bioregion designations – this is very problematic. Why does the CDFW proposal cut this jagged and apparently arbitrary line in LA around and excluding the Santa Monica Mountains? Makes no sense.

RESPONSE: Due to extensive feedback from reviewers, the area recommend to be listed now includes the Santa Monica Mountains.

Line 3105 Figure 19 (Beier): You did a reasonable job of setting the eastern edge of the DPS. But in the west, why not include CC-S in the DPS? As I said above (comment on Table 7 and lines 2587ff), the evidence for this unit could be interpreted in either direction.

RESPONSE: CC-S is now in the area recommended for listing

Line 3117-3123 (Vickers): The Naidu 2015 PhD thesis is not appropriate to be cited or used to infer anything regarding California mountain lions – the work was not later peer-reviewed, and only used eight samples collected over 30 years ago from California populations. That analysis also used limited numbers of microsatellites (15) and SNP's (25) which is insufficient for inferences. The sweeping conclusions in the report regarding potential connectivity are not appropriate based on this evidence.

RESPONSE: The question of the genetic ancestry of the mountain lions in the Mojave Desert is tricky because there are no genetic studies that include samples from that area. Therefore, we use scientific studies that can help provide context even if they do not examine the question directly. Peer review is not a requirement for information to be used in a status review, and Naidu's sample sizes are small, but not unusually so for work of that time. The text now reads "Another study compared samples from the coastal areas of the SC group (including EPR) and southwest Arizona (Naidu 2015). There was minimal evidence of gene flow between the mountain lions in the coastal area of the SC group and those along the border or in Arizona. In fact, the individuals sampled in south coastal California were found to be more genetically similar to those sampled from the North Rim of the Grand Canyon than those directly across the desert in southwest Arizona (Naidu 2015). However, the study had a small sample size, and did not include samples from the inland desert regions of California. Therefore, the results provide little information regarding the genetic assignment of mountain lions in the desert regions of California. " This discussion has been moved the section 6.2.1

Line 2229 and 3119 and 3120 (Ernest): The CDFW proposal also makes assumptions about mountain lions that may range into the Mojave Desert that are not supported by the best scientific evidence. There are no cited valid and published studies to compare mountain lions sampled in the Mojave Desert and Arizona to the Petitioned Coastal California Populations. The Naidu unpublished PhD 2015 that is cited in the CDFW report lacks peer-review and is not valid for comparing Arizona (and the intervening Mojave Desert) to California Coastal populations. The Naidu PhD 2015 study (and inferences that followed in the CDFW proposal) make invalid conclusions based on the only 8 samples from California, across at least 3 separate populations (meaning at best 2-4 samples per population – insufficient for population genetic analyses), and sampled from a period decade(s) older than the Arizona samples. Naidu 2015 analysis also used insufficient set of microsatellite and SNP DNA markers to make valid inferences with regard to California mountain lions.

RESPONSE: The question of the genetic ancestry of the mountain lions in the Mojave Desert is tricky because there are no genetic studies that include samples from that area. Therefore, we use scientific studies that can help provide context even if they do not examine the question directly. Peer review is not a requirement for information to be used in a status review, and Naidu's sample sizes are small, but not unusually so for work of that time. The text now reads "Another study compared samples from the coastal areas of the SC group (including EPR) and southwest Arizona (Naidu 2015). There was minimal

evidence of gene flow between the mountain lions in the coastal area of the SC group and those along the border or in Arizona. In fact, the individuals sampled in south coastal California were found to be more genetically similar to those sampled from the North Rim of the Grand Canyon than those directly across the desert in southwest Arizona (Naidu 2015). However, the study had a small sample size, and did not include samples from the inland desert regions of California. Therefore, the results provide little information regarding the genetic assignment of mountain lions in the desert regions of California. " This discussion has been moved the section 6.2.1

Line 3156 (Riley): Yes, I totally agree about the importance of the Central Coast Central MU as a source of migrants for the small and imperiled CC-N and CC-S, as I've said in other comments. It might be worth considering whether this area is worthy of protection because of this critical role, even though it is less imperiled than the CC-N and CC-S MUs.

RESPONSE: CC-C is now in the area we recommend for listing.

Line 3167-3169 (Beier): "assisted gene flow" is a slippery slope that can be abused as an excuse not to restore long term connectivity. If you are going to suggest translocations, make a clear demand that the translocation program must monitor gene flow carefully and NOT use the translocations as an excuse to avoid the long-term mgt actions needed. "Deposit $XX million in a particular conservation fund. If you have not made highways permeable and protected key habitat, you lose the $XX million. You cannot use translocation as a cheap way to avoid doing the things that work in perpetuity."

RESPONSE: Noted. Text now includes " While self-sustaining connectivity through a network of corridors, highway wildlife crossings, and habitat patches with functional ecosystem processes would be ideal for long term sustainability, assisted gene flow between populations through targeted translocations should be considered as a short-term management action to augment the genetic variation of the most isolated small populations."

Line 3174-3208 (Vickers): Given that genetic isolation has already been shown to be a substantial extirpation risk for the SMM portion of the CC-S MU, and SA MU (Benson et al.2019), and the SGSB MU and the CC-N MU also have substantial genetics-based risks, it would seem counterintuitive to count on the same processes that have been operating historically to improve the current status without legal interventions to protect those MU's. The Department's recommendation in the report suggest protections be extended only to the SA and SGSB MUs without what would seem to be a commonsense reason why the SMM/CC-S MU and CC-N MU are not in similar enough positions to also warrant protections. A recommendation to make no changes in status or management for those populations and the CC-C MU that can be enforced or written into policy or statute would seem to be a recipe for the genetic status of the populations in the coastal group to continue to decline over time. Single new overcrossings over SR 17 and US 101, though notable, are unlikely to be enough to assure adequate connectivity for those populations. Development threatens to divide the CC-C MU into two segments, and US 101 in the northern Gabilans, I-15 between the SA and EPR MU's, I-10 between the EPR and SGSB MU's, SR 14, I-5, SR 58, and High Speed Rail, along with proposed developments, are all present and increasing threats to connectivity for these MU's that are under consideration. One only has to look at the SA MU and SMM portion of the CC-S MU to observe connectivity occurring now and then through existing infrastructure or simply across highways at grade, but it is not enough to halt continuing genetic decline and advancing extirpation threats.

RESPONSE: The areas mentioned are now included in the area recommended for listing, and if listed would receive the full legal protections of CESA.

Line 3180-3186 (Wilmers): While this list isn't comprehensive, it should surely include I-5 and SR 58 in the Tehachapis as top priorities for restoring and maintaining gene flow for the petitioned populations.

Highway 101 in the coyote valley and near Rocks Ranch should also be top priorities for restoring connectivity into and out of the Santa Cruz Mountains. Finally, crossings along highway152 at Pacheco pass are critical to maintaining connectivity within the CC-North West MU.

RESPONSE: Noted, and this suggestion has been incorporated into section 10.1 with the following text "The following crossing locations have been identified by mountain lion experts and should be among the top priorities for the implementation of crossing infrastructure: 1) Highway 58 near the town of Tehachapi 2) I-5 between the Grapevine and Gorman"

Line 3210 (Riley): I think the Department's recent efforts to better estimate mountain lion population density, and to develop methods to do so, has been really valuable. One other potential research and monitoring goal would be to further evaluate mountain lion populations, using the best available demographic data on survival, reproduction, and census numbers, and using population modeling techniques. Personally, I don't think the number and density of mountain lions across the entire state, particularly given its size and complexity, is of as much importance as determining population abundance and potentially trends in different management units. Maybe something to consider as another Research and Monitoring goal. We had a full-day discussion of this as part of the most recent California Mountain Lion Scientific Working Group meeting in the fall, organized by the Dept.

RESPONSE: Noted. The recommendations include "Determine mountain lion distribution, abundance, resource selection at multiple spatial scales, movements and dispersal patterns, foraging ecology, and landscape genetics in the Sonoran and Mojave deserts, including the lower Colorado River region. Work collaboratively with tribes, adjacent states, Baja California, Mexico, universities, other government entities (e.g., Caltrans, BLM, NPS, State Parks, USGS, Military), IUCN and IUCN Species Survival Commission Cat Specialist Group, and other NGOs." and "Develop rigorous population estimates for the individual genetic populations using available demographic data and/or population modeling techniques."

Line 3301 (Riley): At some point the Lit Cited section needs to be carefully gone over. There are some references that are missing, but are cited in the text; there are some with missing authors, or book editors; and some need more information about the reference, and about how the reader can acquire it. For example, for all of the CDFW reports, how would someone acquire those, so they can evaluate them? A website or more of an address or something should be available whenever possible.

RESPONSE: Noted

The version of the status review sent to external peer reviewers is included below, including line numbers for reference.

STATE OF CALIFORNIA

NATURAL RESOURCES AGENCY

DEPARTMENT OF FISH AND WILDLIFE

DRAFT REPORT TO THE FISH AND GAME COMMISSION

A STATUS REVIEW OF THE PETITIONED SOUTHERN CALIFORNIA/CENTRAL COAST EVOLUTIONARILY SIGNIFICANT UNITS (ESUs) OF MOUNTAIN LION (*Puma concolor*) IN CALIFORNIA

CHARLTON H. BONHAM, DIRECTOR

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

Draft***August 31, 2023***Draft

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

UPDATE FOR FINAL DRAFT

220 Appendix H. California Wildlife Barriers 2020 Report

ACKNOWLEDGMENTS

This report was prepared by Department scientific and technical staff, with substantial contributions from Esther Burkett, Dr. Justin Dellinger, Dr. Michael Buchalski, Dr. Deana Clifford, Dr. Jaime Rudd, Kristi Cripe, Dr. Scott Osborn, Erin Chappell, Dr. Ange Baker, Dr. Anne Hilborn, Julie Horenstein, and Dan Applebee. Terris Kasteen, Dr. Jeff Villepique, Dave Hacker, Bob Stafford, David Mayer, Pete Figura, and Dr. Jason Lombardi provided valuable feedback on a draft version of the report. The Department is extremely grateful for the valuable comments provided on this report by the following peer reviewers: ____________. The conclusions in this report are those of the Department and do not necessarily reflect those of the reviewers.

Cover photograph by Irvine Ranch Conservancy on Orange County Parks Land; used with permission.

EXECUTIVE SUMMARY

To be added following peer review.

1. REGULATORY SETTING

1.1 Petition Evaluation Process

On June 25, 2019, the California Fish and Game Commission (Commission) received a petition that proposed the listing of the mountain lion (*Puma concolor couguar*) as threatened or endangered in a portion of the state identified as the Southern California/Central Coast Evolutionarily Significant Unit (ESU). The petitioners also requested, in the event the Commission determined that the six populations comprising the identified ESU did not collectively comprise a single ESU or otherwise did not warrant listing, that the Commission consider whether any of the populations, singularly or in combination, comprise an ESU and meet the criteria for listing. Commission staff transmitted the petition to the Department of Fish and Wildlife (Department) pursuant to Fish and Game Code section 2073 on July 5, 2019, and published a formal notice of receipt of the petition on July 26, 2019 (Cal. Reg. Notice Register 2019, No. 30-Z, p. 1086). A petition to list or delist a species under the California Endangered Species Act (Fish & G. Code, § 2050 et seq.)(CESA) must include “information regarding the population trend, range, distribution, abundance, and life history of a species, the factors affecting the ability of the population to survive and reproduce, the degree and immediacy of the threat, the impact of existing management efforts, suggestions for future management, and the availability and sources of information. The petition shall also include information regarding the kind of habitat necessary for species survival, a detailed distribution map, and any other factors that the petitioner deems relevant” (Fish & G. Code, § 2072.3).

On January 31, 2020, the Department provided the Commission with its evaluation of the petition, "Evaluation of a Petition from the Center for Biological Diversity and the Mountain Lion Foundation to List the Southern California/Central Coast Evolutionarily Significant Unit (ESU) of Mountain Lions as Threatened under the California Endangered Species Act," to assist the Commission in making a determination as to whether the petitioned action may be warranted based on the sufficiency of scientific information (Fish & G. Code, §§ 2073.5 & 2074.2; Cal. Code Regs., tit. 14, § 670.1, subds. (d) & (e)). Focusing on the information available to the Department relating to each of the relevant categories, the Department recommended to the Commission that the petition be accepted.
At its scheduled teleconference public meeting on April 16, 2020, the Commission considered the petition, the Department's petition evaluation and recommendation, and comments received. The Commission found that sufficient information existed to indicate the petitioned action may be warranted and accepted the petition for consideration. Upon publication of the Commission's notice of its findings, the Southern California/Central Coast ESU of mountain lions became designated a candidate species on May 1, 2020 (Cal. Reg. Notice Register 2020, No. 18-Z, p.692).

Notification, Information Received, and Peer Review

Following the Commission's action to designate mountain lions within the petitioned ESU as a candidate species for threatened or endangered status, the Department notified affected and interested parties and solicited data and comments on the petitioned action pursuant to Fish and Game Code section 2074.4 (see also Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). Comments on the petitioned action were invited via a general notification letter dated May 21, 2020 sent to subscribers to the Fish and Game Commission's CESA email list, via the California Regulatory Notice Register dated May 1, 2020 (Number 18-Z), and through a statewide tribal notification letter dated May 13, 2020 sent via U.S. mail and again via email on May 22, 2020. The same general notification letter was distributed via U.S. mail and via email (when an email address was available) to owners and managers of lands supporting mountain lions primarily within the geographic area of the petitioned ESU, including County Agricultural Commissioners, County Fish and Game Commissions, Caltrans district offices, California Department of Parks and Recreation units, California Department of Pesticide Regulation, military land managers, environmental organizations, the Bureau of Indian Affairs (BIA), California Cattlemen's Association, California Wool Growers Association, Mountain Lion Foundation, Center for Biological Diversity, Audubon California, Natural Resource Defense Council, Endangered Habitats League, Planning and Conservation League, scientists familiar with mountain lions, and other interested individuals and organizations. The Department received 21 comments in response to the general notification and 10 comments in response to the tribal notifications. Supplemental comments were received from the BIA, California Cattlemen's Association, the Center for Biological Diversity, State Parks, lion researchers and some land managers. Comments received are included in Appendix A.

Pursuant to Fish and Game Code section 2074.6, the review process included independent and competent peer review of the draft status review by persons in the scientific/academic community acknowledged to be experts on mountain lions and related topics and possessing the knowledge and expertise to critique the scientific validity of the status review contents. Appendix F contains the specific input provided to the Department by the individual peer reviewers, the Department's written response to the input, and any amendments made to the status review (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)(2)). Independent experts that reviewed the Status Review are listed below.

Table 1. Status Review peer reviewers.

Name	**Affiliation**
Reviewer 1 name	
Reviewer 2 name	
Reviewer 3 name	

This Status Review was prepared by the Department's Wildlife Branch with input from regional biologists.

1.2 Status Review Overview

The Commission's action designating the mountain lion within the boundary of the petitioned Southern California/Central Coast ESU as a candidate species triggered the Department's process for conducting a status review to inform the Commission's decision on whether listing mountain lions within the petitioned ESU is warranted. At its scheduled public meeting on April 14, 2021, the Commission granted the Department a six-month extension to complete the status review and facilitate external peer review.

This status review report is not intended to be an exhaustive review of all published scientific literature relevant to the mountain lion in California; rather, it is intended to summarize key points from the best scientific information available relevant to the status of the species, primarily within the boundary of the petitioned ESU. This final report, based upon the best scientific information available to the Department, is informed by independent peer review of a draft report by scientists with expertise relevant to the mountain lion. This review is intended to provide the Commission with the most current information on the mountain lion and to serve as the basis for the Department's recommendation to the Commission on whether the petitioned action is warranted. The status review report also identifies habitat that may be essential to continued existence of the species and provides management recommendations for recovery of the species (Fish & G. Code, § 2074.6). The receipt of this report is to be placed on the agenda for the next available meeting of the Commission after delivery. At that time, the report will be made available to the public for a 30-day public comment period prior to the Commission taking any action on the petition.

1.3 Administrative Status

In California, mountain lions are designated as a specially protected mammal per Fish and Game Code section 4800. State law prohibits the take, possession, transport, import, or sale of a mountain lion or mountain lion products with limited exceptions. Take of mountain lions is allowed, under specified conditions, for scientific research purposes and to protect public health and safety, listed or fully protected bighorn sheep (*Ovis canadensis* spp.) populations, and livestock or other property.

There are currently two recognized subspecies of mountain lion throughout the Americas (Culver et al. 2000, Kitchener et al. 2017). Lions in North and Central America are classified as *Puma concolor couguar,* while most mountain lions in South America are classified as *Puma concolor concolor.* One formerly recognized subspecies of mountain lion was listed as a California Species of Special Concern until recently. The Department's Species of Special Concern (SSC) designation is similar to the federal Sensitive Species designation. It is administrative, rather than regulatory in nature and intended to focus attention on animals at conservation risk. The designation is used to stimulate needed research on poorly known species and to target the conservation and recovery of these animals before they meet the CESA criteria for listing as threatened or endangered (Thomson 2016). The Yuma puma subspecies of mountain lion (*Puma concolor browni*) was designated by the Department as a subspecies of special concern in 1986 (Williams 1986, Kucera 1998, CDFW 2022a). However, research by McIvor et al. (1995) and Culver et al. (2000) detected little morphological or genetic support for retention of the *P.c. brownii* subspecies. Consequently, the Department no longer considers mountain lions from the valley of the Colorado River and adjacent rocky uplands of the Sonoran Desert to be a distinct taxonomic unit.

1.4 Summary of Petition

The Petitioners propose listing mountain lion populations south of San Francisco Bay in the coastal, Transverse, and Peninsular Mountain ranges, the Sonoran Desert, and part of the Mojave Desert as a single Southern California/Central Coast Evolutionarily Significant Unit (ESU). Alternatively, the Petitioners propose the Commission determine whether one or more of the six populations in the following areas identified by Gustafson et al. (2019) comprise an ESU and meet the criteria for listing as threatened or endangered: 1) Central Coast North (CC-N), which includes the Santa Cruz Mountains and San Francisco Bay Area counties to the east; 2) Central Coast Central (CC-C), generally from southern Monterey Bay to Ventura County; 3) Central Coast South (CC-S), which includes the Santa Monica Mountains, Santa Susana Mountains, Sierra Pelona Mountains, and Simi Hills; 4) San Gabriel and San Bernardino Mountains (SGSB); 5) Santa Ana Mountains (SA); and 6) Eastern Peninsular Ranges (EPR), which includes eastern San Diego County to the Colorado River and the border with Arizona, and is bounded on the south by the border with Mexico. These populations are six of the 10 genetically discernable populations in California as delineated in Gustafson et al. (2019) (Fig. 1). Specifically, the petitioners suggest that the following combinations of populations be considered ESU(s): "Group all three Central Coast populations (CC-N, CC-C and CC-S) into one ESU, with the remaining three populations placed into a second ESU (SA, EPR, and SGSB). Alternatively, the Central Coast populations could be treated as one ESU, SA and EPR as a second ESU, and SGSB separately listed as a third ESU."

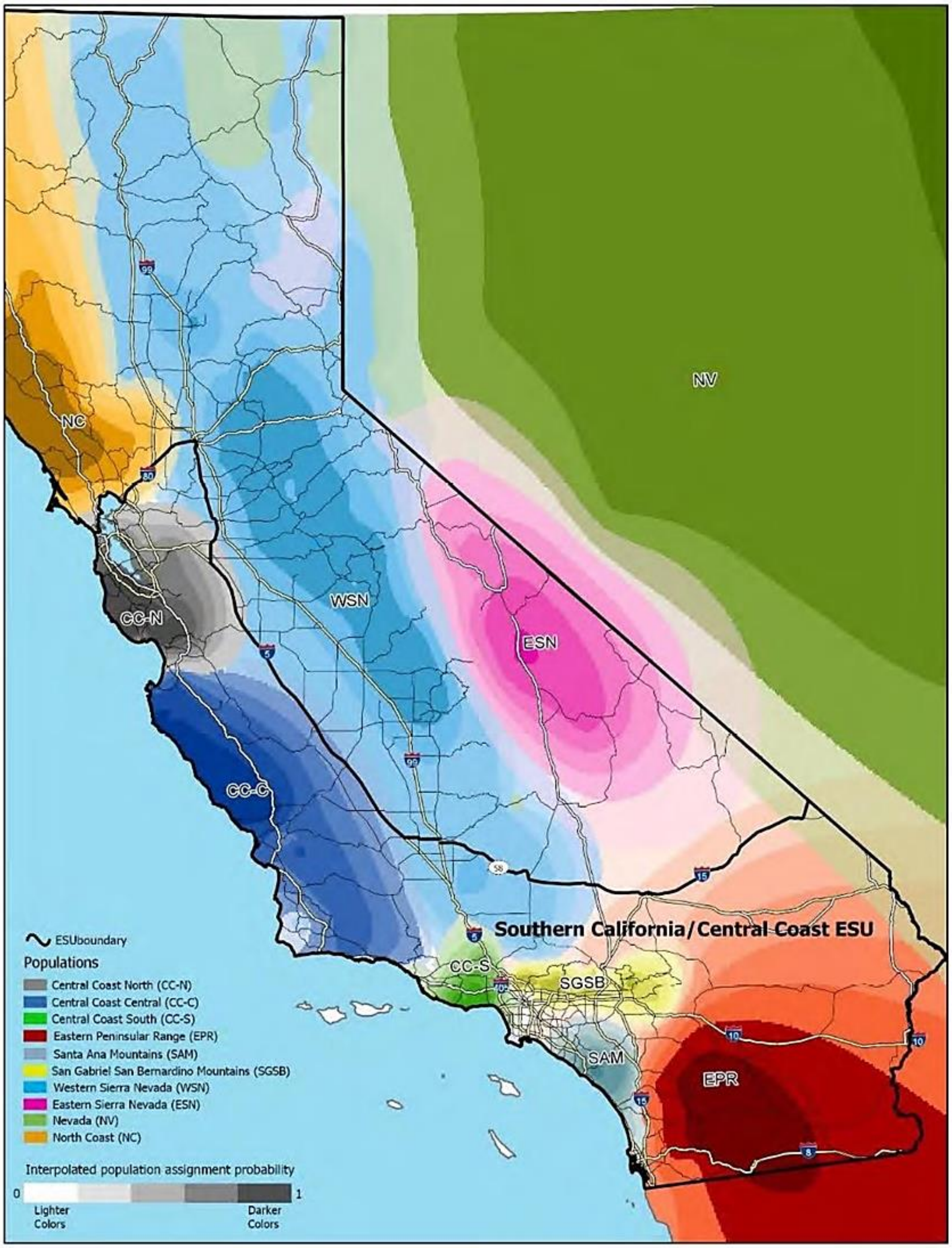


Figure 1. Map of fine-scale genetically discernible mountain lion populations and major roadways in California based on data collected from 1992 to 2016 (genetic information from Gustafson et al. 2019). Black line outlines the petitioned Southern California/Central Coast ESU boundary. This figure is from the Petition, Figure ES 1.

The Evolutionary Significant Unit concept was developed primarily for use in salmonids by the U.S Fish and Wildlife (USFWS) and National Marine Fisheries Service (NMFS) and has been used to list populations of anadromous salmon under the federal Endangered Species Act such as the Columbia River chum salmon ESU (64 Fed. Reg 14508–14517 (March 25, 1999)). The use of ESUs by the Department to evaluate the status of species pursuant to CESA is supported by recent listing determinations by the Commission (e.g., Southern Sierra Nevada Fisher ESU, Coho salmon, central California coast ESU) and by the determination of California's Third District Court of Appeal that the term "species or subspecies" as used in CESA (Fish & G. Code, §§ 2062 and 2067) can include ESUs (*Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156 Cal.App.4th 1535).

To be considered an ESU under federal policy, a population must meet two criteria: 1) it must be substantially reproductively isolated from other conspecific (i.e., same species) population units; and 2) it must represent an important component of the evolutionary legacy of the species that contributes to the genetic diversity of the species as a whole (Waples 1991). The genetic isolation "does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in different population units" (Waples 1991). The Department used these criteria in its evaluation of ESUs for the Pacific fisher and uses them in this status review.

For brevity the term "petitioned ESU" is used throughout this report. When "petitioned ESU" appears, it is intended to encompass the petitioner's proposal to list the petitioned area as a single ESU as well as the petitioner's alternative proposal to evaluate each of the six genetically discernible populations identified by Gustafson et al. (2019) singularly or in combination, within that area as ESUs.

2. BIOLOGY AND ECOLOGY

2.1 Species Description and Life History

Mountain lions belong to the mammalian order Carnivora and are members of the cat family Felidae, subfamily Felinae, and a part of the Puma lineage. Numerous common names include puma, cougar, panther, painter, and catamount (Young and Goldman 1946, Hunter 2015). Mountain lions were once widespread in the Americas, but European settlers extirpated them from most of the U.S. and Canada east of the continental divide by the beginning of the 20th century, with only a small population remaining in Florida and a population of unknown size in Texas; although populations in Mexico do not appear to have suffered similar extirpations (Hall and Kelson 1959, Pierce and Bleich 2003, The Cougar Fund 2023). However, since the late 20th century, breeding populations of mountain lions have returned to North and South Dakota and Nebraska, and those states have instated legal hunting in recent years (Hunter 2015, The Cougar Fund 2023).

Adults are large and slender with muscular limbs and a long, black-tipped tail that is about one third of the animal's total length. Males are typically larger than females. Males generally weigh 55–65 kg (121–143 lbs.) with a length of 2.2–2.3 m (7.2–7.5 ft.) from nose to tail tip, and females generally weigh 35–45 kg (77–99 lbs.) with a length of 2.0–2.1 m (6.6–6.9 ft.) (Currier 1983).

Deer (*Odocoileus* spp.) are the most common prey of mountain lions in the United States, Canada and parts of Mexico, making up about 70% of their diet (Ruth and Murphy 2009). The relationship between mountain lions and deer is so strong that lion distribution throughout the Americas has been described as largely a function of deer distribution (Young and Goldman 1946, Pierce et al. 2000). However, mountain lions are opportunistic predators and known to eat up to 232 different species of mammals, birds and reptiles across their extensive geographic range (Karandikar et al. 2022). This includes but is not limited to elk (*Cervus canadensis*), feral horses (*Equus ferus caballas*), feral burros (*Equus asinus*), guanaco (*Llama guanicoe),* wild pigs (*Sus scrofa)*, pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), brocket deer (*Mazama* sp.), ocelots and related felids (*Leopardus* sp.), greater rhea (*Rhea americana),* coyotes (*Canis latrans*), bobcats (*Lynx rufus*), porcupines (*Erethizon dorsatum*), fishers (*Pekania pennanti*), rodents, wild turkeys (*Meleagris gallopavo*), and livestock (Young and Goldman 1946, Currier 1983, Iriarte et al. 1990, Sweitzer et al. 1997, Wengert et al. 2014, Allen et al. 2015, Vickers and Garcelon 2022).

Mountain lions reach sexual maturity at two to four years, and females care for their young for the first one to two years (Quigley and Hornocker 2009). They have a polygynous social structure, and males do not contribute to rearing young (Logan and Sweanor 2009). Mates locate each other with auditory and olfactory signals including scrapes, made by using their hind feet creating a shallow trough with a small mound of ground debris at the distal end. These forms of communication are also vital for maintaining family cohesion and avoiding competition or direct threats from other mountain lions. Identity, social status, and reproductive condition may all be possible functions of scent markers (Logan and Sweanor 2009). Mountain lion scent marks seem to serve as "bulletin boards," which males and females visit to determine the temporal presence, reproductive status, quality, and possibly even the individual identity of other mountain lions (Currier 1983, Logan and Sweanor 2001, Harmsen et al. 2010, Allen et al. 2014).

Gestation lasts 82–96 days (Young and Goldman 1946, Currier 1983, Hunter 2015). Litter size ranges from one to six, though two to four kittens are typical (Pierce and Bleich 2003, Beier et al. 2010, Riley et al. 2014). Reproductive females seek refuge from human activities. Wilmers et al. (2013) found that mountain lions exhibiting reproductive behaviors (denning and chemical and vocal communication) avoided human disturbances by distances four times greater than non-reproductive mountain lions. At 12–18 months, mothers may come into estrus and become aggressive towards their young, encouraging dispersal (Pierce and Bleich 2003). Intraspecific predation is a known source of mortality in mountain lion populations (Beier and Barrett 1993, Logan and Sweanor 2001, Allen 2014). Survivorship of dispersing mountain lions is low relative to adults with established home ranges, and dispersing young are more likely than resident mountain lions to be involved in depredation incidents or other conflicts with humans as they try to find prey without the advantage of an established home range (Torres et al. 1996).

A study of juvenile lion dispersal was conducted by Beier (1995) in the Santa Ana Mountains of southern California from 1988 to 1992. Juvenile mountain lions dispersed via habitat corridors in a landscape fragmented by urbanization, and some dispersers used corridors containing manmade features such as golf courses and major freeways. Each collared male dispersed over several weeks to months, and as many as four temporary home ranges were occupied sequentially. The mean dispersal distance from a sample of eight males was 63 km (39.1 mi.). Three of the male dispersers died by vehicle strikes, one was shot, one died of disease, and one died of natural cause, leaving only two surviving dispersers. The one monitored female disperser wandered throughout the northern half of the Santa Ana Mountains, changing directions ≥ 5 times upon encountering the urban-wildland interface and covered ≥ 342 km (212.5 mi.) without establishing a temporary home range. Four months after her dispersal date, she returned to the edge of her natal range and bedded near her mother for one day, dying near that location days later of unknown causes. All travel in corridors and habitat peninsulas occurred at night. It was noted that a dispersing lion cannot use a corridor unless its normal travel pattern causes it to encounter the corridor entrance.

Vickers et al. (2015) observed numerous southern California study animals dispersing > 80 km (50 mi.), and one young male moved > 140 km (87 mi.) from California into northern Mexico and back. Mountain lions are known to be capable of dispersing at least 2,450 km (1,522 mi.), and most long-distance dispersers are thought to be young males in search of available mates (Hawley et al. 2016).

Mountain lions are primarily solitary, territorial, and occur in low density. They require large areas of habitat with adequate prey abundance (Quigley and Hornocker 2009). They have large home ranges often comprised of multiple vegetation community types including riparian, chaparral, oak woodlands, coniferous forests, grasslands, and desert environments including rocky desert uplands (Grinnell 1914, Grinnell et al. 1937, Williams 1986, Dickson et al. 2005, McClanahan et al. 2017, Dellinger et al. 2018) and occur from near sea level to high mountain elevations (Grinnell et al. 1937, Young and Goldman 1946, Hunter 2015).

Average home range size in California ranges from 300–350 km^2 (116–135 mi^2) for males and 90–100 km^2 (35–39 mi^2) for females (Grigione et al. 2002, Riley et al. 2021) and varies with prey density. While male home ranges can overlap spatially, male mountain lions are territorial, making temporal overlap between males rare (Logan and Sweanor 2001). However, males attempt to overlap their home ranges with multiple female home ranges to enhance breeding opportunities. Females are less territorial with their home ranges often including significant overlap, and the degree of home range overlap is typically greater where prey densities are higher (Stoner et al. 2018). Subadult males are generally met with aggression from resident adult males and tend to disperse farther from their mothers' home range than subadult females, up to nearly 500 km (310 mi; Pierce and Bleich 2003, Grigione et al. 2002). Due to these behavioral mechanisms, local abundance of male mountain lions is generally limited by available habitat (Maletzke et al. 2014), while female abundance is generally limited by prey availability (Stoner et al. 2018). Given the importance of females to population growth and because one male can breed with multiple females, mountain lion populations are ultimately limited by prey availability (Logan and Sweanor 2001).

2.1.1 Sources of Mortality

From 1974 to 2020, the primary drivers of mountain lion mortality in California were found to be anthropogenic when cause of death could be determined. The leading cause was permitted lethal removal resulting from livestock depredation incidents (17.5% of attributable mortalities), followed by vehicle strikes (14.8%; Benson et al. 2023). Other known mortality factors in order of importance were non strife natural mortality (12.5%), killing by other mountain lions (intraspecific predation or strife; 11.8%), poaching (9.9%), lethal removals to protect endangered bighorn sheep (5.3%), and other human causes (3.4%) (Benson et al. 2023). It should be noted that 76% of Benson et al.'s data was collected since 2000; therefore, the results are indicative of more recent causes of mortality. Other known causes of mortality include disease, catastrophic wildfires (Grinnell et al. 1937, Beier and Barrett 1993, Wilmers et al. 2013, Riley et al. 2014, Vickers et al. 2015) and complications associated with exposure to pesticides and rodenticides (Riley et al. 2007, Rudd and Rogers 2021). However, 24% of tracked mountain lions in Benson et al.'s (2023) study died of unknown causes, which is a greater proportion than those that died of any single known cause.

Dellinger et al. (2021a), using the same dataset (expanded to include 1972 and 1973), derived survival estimates for mountain lions by age, sex, and habitat association. They used data from radio-collared mountain lions across 24 study areas and found of the 629 collared individuals, 246 died while being monitored. Annual survival for all adults (≥3 years old; n = 430) and subadults (≥1 and <3 years old; n = 199) combined across the state was 0.746 (CI 0.719–0.774). Depredation removal was a greater source of mortality for males (n = 36; 0.085 [0.060–0.110]) than females (n = 20; 0.038 [0.024–0.053] Dellinger et al. 2021a). Annual survival estimates by sex and age-class are summarized in Table 2.

Table 2. Survival estimates (with confidence intervals) by sex and age-class for mountain lions in California from 1972–2020 (data from Dellinger et al. (2021b)).

	Males	**Females**
Subadult	0.636 (0.558–0.725)	0.740 (0.631–0.867)
Adult	0.698 (0.649–0.751)	0.806 (0.772–0.843)

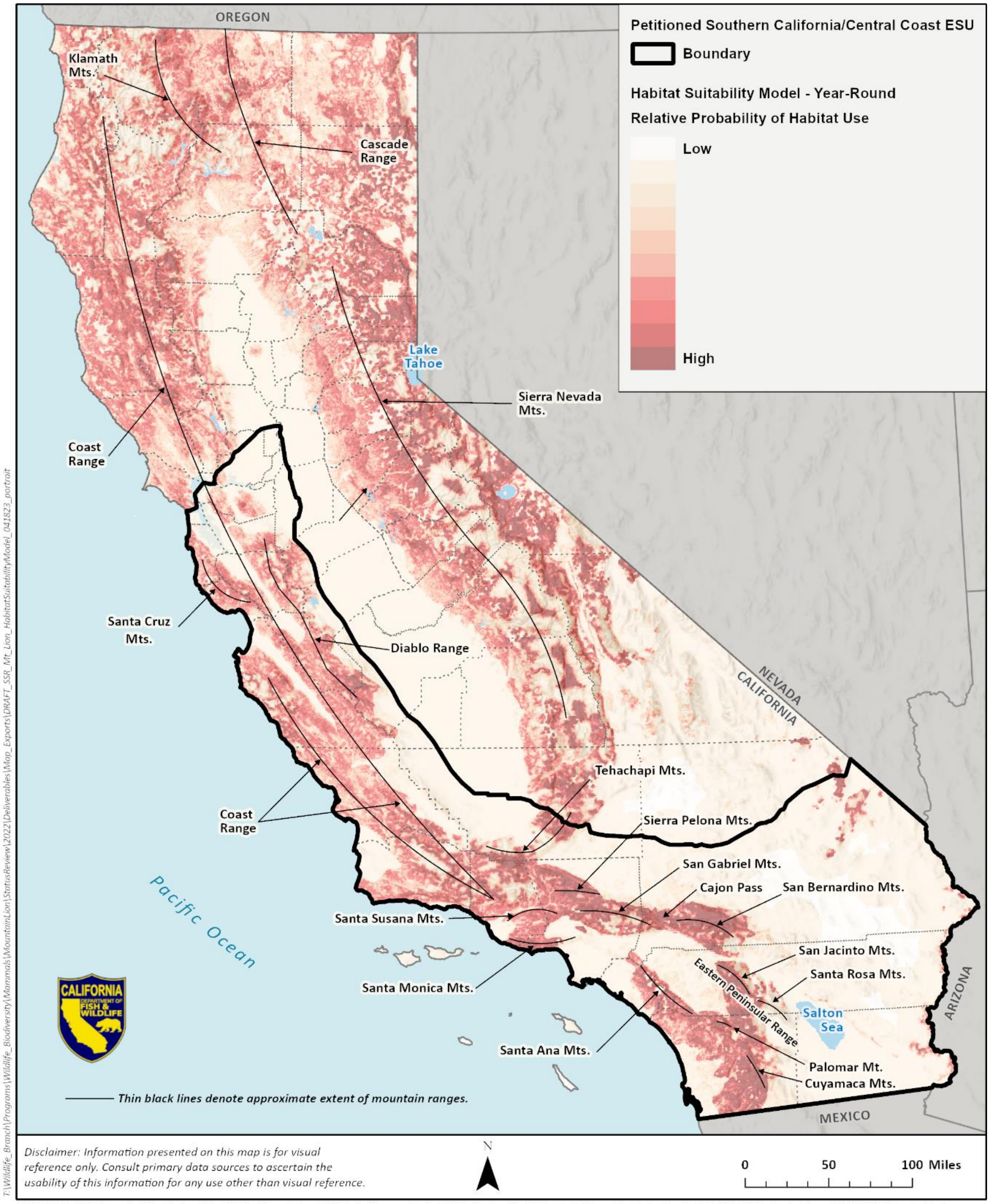
Dellinger et al. (2021a) found survival rates varied by location, clustering into three categories representing animals with home ranges primarily located in urban, rural, or remote/wilderness settings. Animals occurring in remote/wilderness areas (n = 131) had higher annual survival rates (0.794 [0.740–0.853]) than animals in rural areas (n = 92; 0.591 [0.498–0.703]), while survival of animals occurring in urban areas were intermediate and not significantly different from either remote/wilderness or rural areas (n = 156; 0.735 [0.682–0.792].

Mountain lions have few natural predators in California. Mountain lions are subordinate to black bears and gray wolves (*Canis lupus*) across parts of their geographic range including California (Elbroch and Kusler 2018). Black bears occasionally kill mountain lion kittens (Elbroch and Kusler 2018), but mainly affect mountain lions through kleptoparasitism of kill sites in California (Elbroch et al. 2015).

Where gray wolves and mountain lions coexist, wolves are known to affect adult and kitten survival, resource selection, prey selection, bedding locations, and population size (Bartnick et al. 2013, Elbroch et al. 2015, Kusler et al. 2017, Elbroch and Kusler 2018, Elbroch et al. 2020). Currently, no resident wolf packs or individuals are known to exist in the petitioned ESU area.

2.2 Range and Distribution

A species' range is the general geographic area within which a species normally occurs, while its distribution is the set of locations occupied by individuals of a species within its range at a given time. For purposes of CESA and this Status Review, the term range refers to the species' California range (*Cal. Forestry Assn. v. Cal. Fish and Game Com.* (2007) 156 Cal. App. 4th 1535, 1551), though emphasis is on the geographic area of the petitioned ESU. Mountain lions currently range throughout all California ecoregions. Though verified mountain lion sightings and encounters have occurred in all counties in the last decade, they are most commonly reported from the more mountainous and remote areas of the state (Dellinger et al. 2021b; Fig. 2). Mountain lions are most likely to establish home ranges in areas with sufficient forest and shrub habitat which promote presence of their primary prey, mule deer (*Odocoileus hemionus)* (Dellinger et al. 2020*a*). In California, these areas include the coastal mountain ranges from southern California north to the Oregon border, the southern Cascade Range, and the Sierra Nevada (Fig. 2). The areas with the least suitable habitat, and thus lowest densities of both mule deer and mountain lions, include intensively farmed areas of the Central Valley and lowlands of the inland desert regions of the state. However, recent survey work has found resident breeding populations of mountain lions near the Sutter Buttes in the Sacramento Valley and in the Mojave Desert (McClanahan et al. 2017, Dellinger et al. 2018). The distribution of mountain lions in California has changed little from what Grinnell et al. (1937) described, with a few notable exceptions: the large, high density urban areas of the San Francisco Bay Area and the Los Angeles–San Diego coastal plain and inland valleys, and intensively farmed agricultural areas such as the Salinas Valley and the Central Valley where historical reports noted mountain lions were not uncommon in riparian areas (Newberry 1857). Central Valley riparian corridors likely played an important role in connecting mountain lion populations in the Sierra Nevada with populations in coastal mountain ranges.



CDFW Wildlife Branch, GIS-LS, Apr 18, 2023 - Map Data: CDFW, Dellinger et al., 2020, Center for Biological Diversity, Esri - Scale: 1:4,900,000 - Projection: NAD83 California Teale Albers (m)

Figure 2. Range and distribution of mountain lions in California based upon a habitat selection model (Dellinger et al. 2020*a*). Darker red indicates a higher probability of mountain lion occupancy. Mountain lions may occur in

areas outside of this distribution, though such animals may include breeding and/or dispersing individuals. Major mountain ranges in the petitioned ESU are labeled.

2.3 Habitat That May Be Essential to the Continued Existence of the Species

Dellinger et al. (2021b) described general patterns of mountain lion habitat use in California:

> "Mountain lions are among the most widely distributed carnivore species (Logan and Sweanor 2001). This wide distribution is a product of their ability to persist in almost any habitat provided adequate prey is available. When establishing a home range, mountain lions select habitat with adequate prey and stalking cover to aid in meeting energetic demands. After establishing a home range, many things, including human activity, can influence habitat use patterns (Wilmers et al. 2013).
>
> In California, mountain lion habitat use patterns were found to be seasonal in the more temperate areas of the state (Dellinger et al. 2018) while, in the more Mediterranean areas, mountain lion habitat use patterns are more stable between seasons (Wilmers et al. 2013)."

Studies of mountain lions in North America have noted patterns of associations with vegetative and topographic cover, steep slopes, and higher elevations, and avoidance of open agricultural lands, sagebrush (*Artemesia tridentata*) dominated habitats, open meadows, and pastures (Murphy 1983, Logan and Irwin 1985, Laing 1988, Lindzey et al. 1994, Pierce and Bleich 2003). .

Zeller et al. (2017) found that in southern California, mountain lions preferred to establish home ranges that contained chaparral, scrub, and grasslands, but within those home ranges, spent their time in slightly more rugged terrain, riparian areas, and woodland. Dickson and Beier (2002) noted riparian areas were selected for in all seasons by mountain lions in southern California and suggested the preference is related to the presence of stalking cover and prey. Use of chaparral stands may be dependent on stand age. Burdett et al. (2010) speculated that dense, mature late seral chaparral may be avoided because mule deer prey cannot easily move through such stands. Other noted associations include strong preference for rugged areas and a strong avoidance of human development in the form of agricultural areas, urban areas, and roads (Burdett et al. 2010).

2.4 Population Structure

There are currently two recognized subspecies of mountain lion throughout the Americas (Culver et al. 2000, Kitchener et al. 2017). Lions in North and Central America are classified as *Puma concolor couguar,* while most mountain lions in South America are classified as *Puma concolor concolor* (the subspecific identity of some mountain lions west of the Andes in South America remains uncertain). This taxonomy is partly based on the finding that the entire North American population is genetically homogenous at three mitochondrial loci (Culver et al. 2000), which was further supported in an analysis by Caragiulo et al. (2014) which analyzed three different mitochondrial genes and used a larger number of modern mountain lion samples. Genetic diversity is greater in Central and South American mountain lions, and it is hypothesized that the North American population derived from a recent (i.e., late Pleistocene circa 10,000 years ago) recolonization by a small number of founders whose ancestors originated in eastern South America 200,000–300,000 years ago (Culver et al. 2000, Caragiulo et al. 2014).

Several studies have demonstrated that the complex geography and land use patterns in California have influenced patterns of gene flow and genetic exchange among mountain lions in different areas of the state (Ernest et al. 2003, Gustafson et al. 2019, 2022). Two studies are especially relevant to understanding the genetic structure of mountain lions within the petitioned ESU. The first is Gustafson et al. (2019), which the petitioners referenced extensively. Gustafson et al. (2019) collected samples from 992 mountain lions around California and Nevada and used microsatellite markers—which undergo mutations at a relatively rapid rate and are appropriate for examining differences between populations at short timescales (on the order of hundreds of years). The authors identified nine clusters of similar genetics, which they referred to as genetic populations, in California and one cluster in Nevada. Though these populations show significant genetic differentiation, they are not fully isolated (Fig. 3). There is gene flow among many of the populations with the WSN population providing important recent connectivity between the Central Coast populations and populations to the north and east, and the SGSB population linking the EPR and SA populations with the WSN and the Central Coast populations.

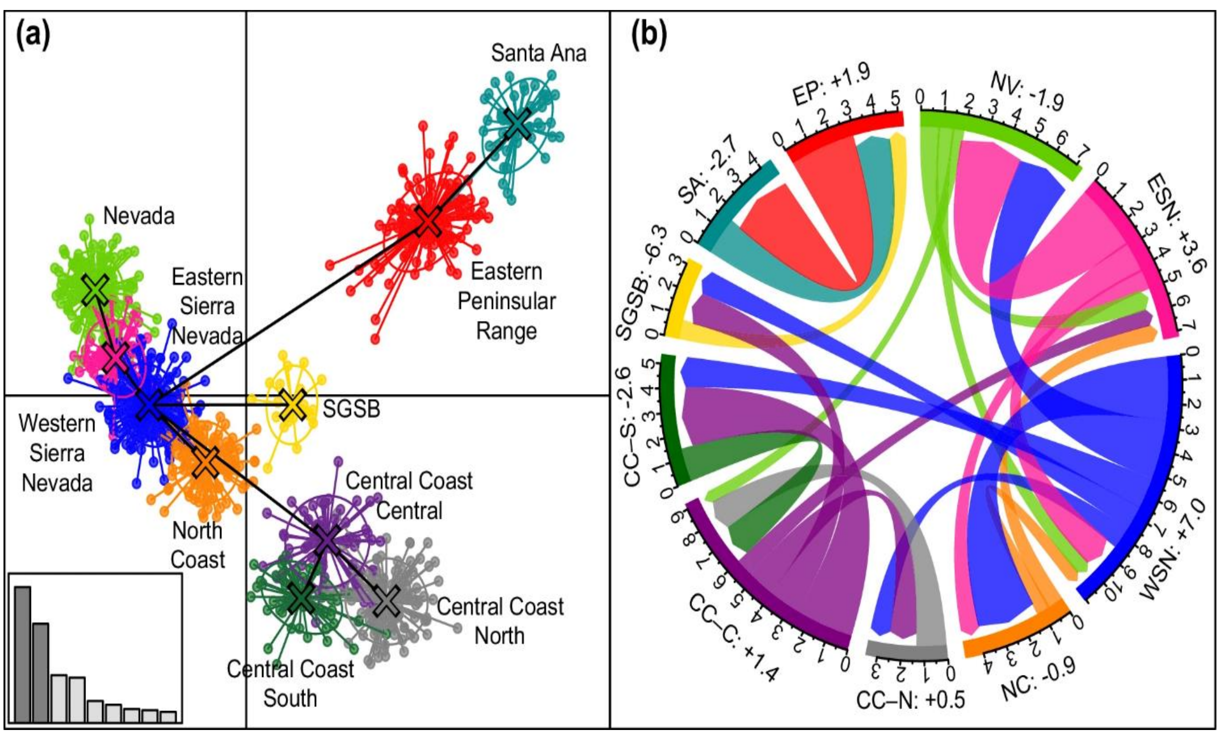
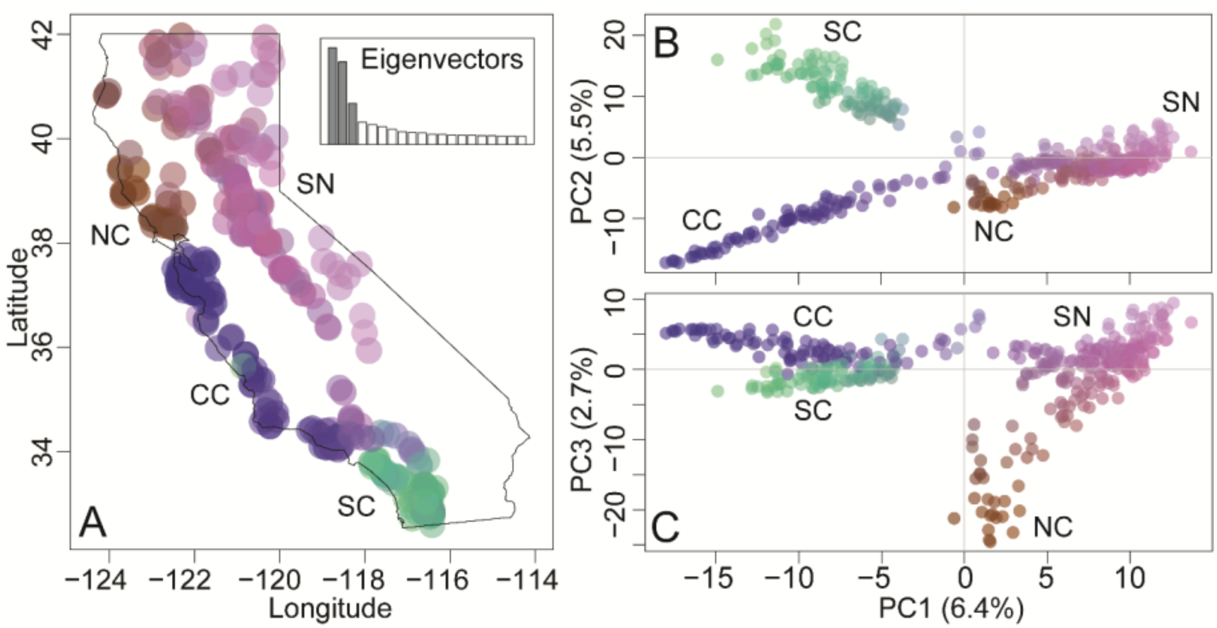


Figure 3. Functional connectedness of puma populations, based on (**a**) discriminant analysis of principal components and (**b**) bi-directional migration rate estimates (multiplied by 100 for visualization). Each dot represents an individual (**a**). Each color (**a,b**) represents a population. Black lines (**a**) indicate the most closely

related population based on genetic dissimilarities. The inset barplot (**a**) shows which axes are being displayed (i.e., discriminate functions 1 and 2) and the relative proportion of variation explained by each of the 9 discriminant functions. Two-thirds of the individuals in each population are contained within the corresponding ellipsoid. For a biologically meaningful interpretation, only estimates of interpopulation migration rates with 95% confidence intervals that do not cross 0 are presented (**b**). Net genetic source-sink migration rates are presented next to population names with positive values indicating net genetic source and negative values indicating net genetic sink (e.g., WSN exported 9% of migrants and received 2% so its net rate is +7%). *NV* Nevada, *ESN* Eastern Sierra Nevada, *WSN* Western Sierra Nevada, *NC* North Coast, *CC-N* Northern section of the Central Coast, *CC-C* Central section of the Central Coast, *CC-S* Southern section of the Central Coast, *SGSB* San Gabriel San Bernardino, *SA* Santa Ana, *EP* Eastern Peninsular Range. Reproduced from Gustafson et al. (2019).

The second study relevant to understanding the genetic structure of mountain lions within the petitioned ESU is Gustafson et al. (2022), which analyzed 16,285 genome-wide single-nucleotide polymorphisms[1] (SNPs) from 401 pumas sampled broadly across the state. SNPs can be used to understand the differences among populations at evolutionary timescales relevant to the discussion of ESUs (i.e., thousands to tens of thousands of years). SNPs are known to resolve population genetic structure with higher resolution and greater statistical power than the microsatellites that were used in the 2019 study (Narum et al. 2013, Vendrami et al. 2017, Hohenlohe et al. 2018). Using SNPs, Gustafson et al.'s (2022) best supported model identified four broad-scale genetic clusters concordant with California's geography: North Coast (NC); Sierra Nevada (SN); Central Coast (CC), which includes Gustafson et al.'s (2019) CC-N, CC-C, and CC-S genetic populations; and Southern Coast (SC), which includes Gustafson et al.'s (2019) SA, SGSB, and EPR (Fig. 4).



[1] Random substitutions of the nucleotides at identified positions on DNA which typically do not code for physiological or behavioral traits.

Figure 4. Principal component analysis (PCA) of 401 pumas at 16,285 SNPs reveals four broad-scale genetically discernable populations (NC = North Coast, CC = Central Coast, SC = Southern Coast, SN = Sierra Nevada). (A) The colorplot (R package *adegenet*) of the PCA represents colors corresponding to a combination of the first 3 eigenvectors. The inset plot shows the proportion of the variance explained by shaded PC eigenvectors 1–3 compared to other eigenvectors. The color values are plotted at sample locations to demonstrate geographic structure. Colorplots of (B) PC1 and PC2 and (C) PC1 and PC3 resolved the 4 broad-scale genetically discernable populations. Reproduced from Gustafson et al. (2022).

On a finer scale, both cluster analyses and genetic differentiation tests by Gustafson et al. (2022) also support the presence of nested substructure within the four well-supported, broad-scale populations. The authors found evidence of 10 fine-scale genetically discernable populations roughly approximate to the genetic populations identified by Gustafson et al. (2019). Consistent with the 2019 study, there is evidence these fine-scale populations are not fully genetically isolated. Evidence of historic genetic exchange among the fine-scale populations with the WSN population providing important connectivity between the Central Coast populations and populations to the north and east, and the SGSB population linking the EPR and SA populations with the WSN and the Central Coast populations from Gustafson et al.'s (2019) microsatellite analysis (Fig. 3) is further supported by the SNP analysis (Gustafson et al. 2022). Additionally, the CC-S genetic population is of critical importance to sustaining statewide gene flow because of the intersection of dispersal corridors connecting the SN, CC, and SC broad scale genetic populations. Both publications suggest a pattern of population structure consistent with both natural landscape features (e.g., Central Valley, San Francisco Bay, Sierra Nevada Crest) and anthropogenic development (e.g., roads and highways, housing developments) impeding gene flow at various temporal and spatial scales resulting in gene flow among mountain lion populations in California following a "horseshoe" network around the Central Valley. San Francisco Bay acts as the open end of the horseshoe, with NC, WSN, ESN, CC-C, and CC-N comprising the body of the horseshoe (Ernest et al. 2003, Gustafson et al. 2019, 2022). Notably, the Santa Monica Mountains, SGSB, SA, and EPR are not part of the horseshoe.

2.4.1 Management Units

Although populations are linked, natural topography and anthropogenic development of the California landscape has resulted in local populations experiencing different demographic rates, levels of connectivity, and genetic variation—even over short geographic distances. We propose an alternate conceptual framework, the Management Unit (MU) (outlined below), to understand and conserve contemporary California mountain lion populations. We propose that the existing population genetic data of Gustafson et al. (2019) can be used to delineate the boundaries of six MUs within the petitioned area.

The management unit concept represents an important tool for the conservation and management of discrete populations in relation to contemporary landscape change. Management units have been defined as demographically independent populations whose growth rate depends primarily on local births and deaths rather than immigration (Moritz 1994). Therefore, there is a requirement of limited connectivity among MUs that emphasizes the notion of demographic independence and thus the need for separate management (Taylor and Dizon 1999). The MU concept becomes particularly useful for delineating groups for purposes such as monitoring the effects of human activity on population abundance and regulating those activities (Palsbøll et al. 2007, Schwartz et al. 2007). The identification of MUs is therefore central to the near-term management and conservation of mountain lions in California. The populations and the areas of habitat they occupy are important for maintaining genetic variation and contributing to the long-term adaptability and persistence of the species. Substantial threats to portions of the statewide population exist—habitat loss and fragmentation, mortalities from vehicle strikes and depredation take, habitat degradation from climate change and wildfires, and exposure to and mortality from toxic rodenticides—which necessitates long-term planning and management to ensure their persistence.

The delineation of MUs requires a threshold of dispersal rates among populations, in this case dispersal meaning the movement of individuals from the birth population into another. Work by Hasting (1993) suggests that population growth rates within occupied patches of habitat become correlated at dispersal rates above 10%, effectively resulting in a single demographic unit (i.e., population) among patches (or in this context, a management unit). By this threshold, populations warrant assignment to different MUs if the rate of dispersal among populations is < 10% (Palsbøll et al. 2007). However, movement data based on direct observations are not always available for natural populations, and the use of population genetic analyses has been proposed as an indirect means of inferring levels of connectivity. Estimates of population genetic divergence, which is a function of migration rate, are increasingly being used to delineate the boundaries of MUs (Funk et al. 2012).

We are defining MUs based on a genetic differentiation of 10%, which is a conservative estimate. Use of the Gustafson et al. (2019) dataset is appropriate for this purpose as it is based on microsatellite markers which have a faster mutation rate and should reflect patterns of connectivity over shorter timescales (Funk et al. 2012). Gustafson et al. (2019) present bi-directional estimates of the migration rate between local populations in their manuscript. None of the six genetic populations within the petitioned area have a net bi-directional migration rate estimate of 10% or greater. These results provide conservative evidence suggesting the genetic populations within the petitioned area(s) are demographically independent and warrant management as separate MUs.

The SNP data presented in Gustafson et al. (2022) would be less suitable for this purpose. Those populations relevant to the petitioned area include CC-N, CC-C, CC-S, SGSB, EPR, and SA as identified in Gustafson et al. (2019). We will refer to these Management Units going forward and assess them under various criteria for listing under CESA in Section 6.

3. STATUS AND TRENDS IN CALIFORNIA

3.1 Trends in Distribution and Abundance

Significant changes in mountain lion distribution have occurred within the petitioned ESU due to habitat loss and fragmentation from land use changes as early as the late 1700s and continuing to the present from ongoing development and the associated transportation and infrastructure networks. Many areas within the historical range of mountain lions have been modified by urban and agricultural development, primarily in the San Francisco Bay Area, southern California, and the Central Valley, making them mostly unsuitable for mountain lions. The highly urbanized zone spreading out from Los Angeles as well as coastal development between Los Angeles and San Diego to the border with Mexico has supplanted large areas of lion habitat in the coastal valleys and plains between isolated patches of remaining habitat in the Santa Monica, San Gabriel, San Bernardino, and Santa Ana mountains (Fig. 5; Vickers et al. 2015, Benson et al. 2016, 2019, Gustafson et al. 2019). The Eastern Peninsular Mountains are also affected by human development and road networks but to a lesser degree than the aforementioned four mountain ranges. Likewise, remaining habitat in the Santa Cruz Mountains and southern San Francisco Bay Area is increasingly constricted by development and busy highways (Wilmers 2014, Wang et al. 2017). However, establishing temporal trends in distribution is difficult due to the paucity of reliable historical data.

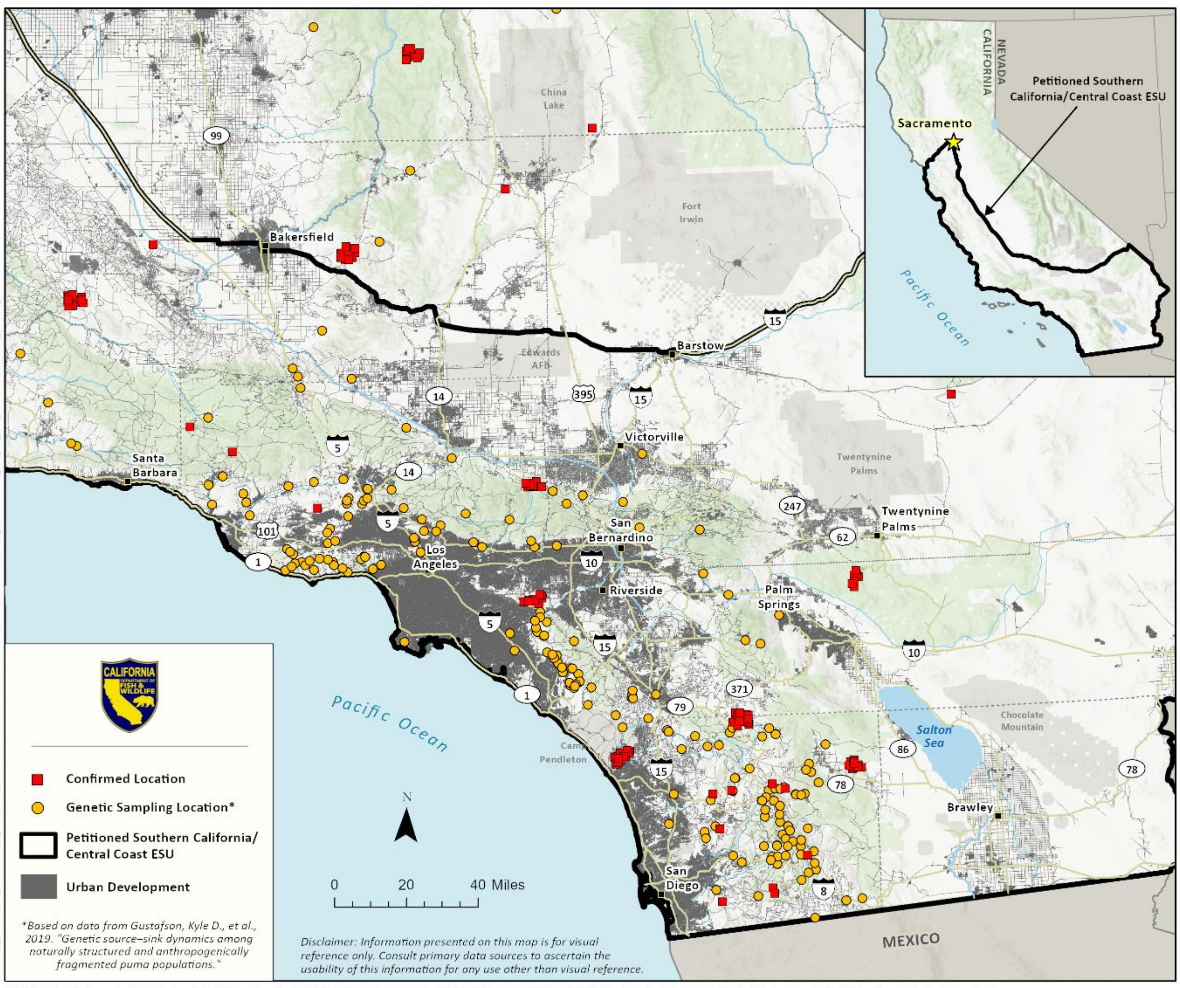


Figure 5. Map of extent of human development in southern California. Included on the map are genetic sample locations from Gustafson et al. 2019 (orange circles, samples collected 1992-2016) and confirmed locations of

mountain lions from CDFW camera traps (red squares, images captured 2009-2022). Note: does not show agricultural development.

There are no rigorous or systematic early California mountain lion population estimates available. The first data-driven estimate was made during years that a trapping bounty was in effect in California, when biologists estimated there were 600 mountain lions in California, 10 years prior to the end of the bounty period in 1953 (McLean 1954, Dellinger and Torres 2020). L. W. Sitton (1977), nearly 10 years after the conclusion of the bounty period, estimated that there were approximately 2,400 mountain lions in California. A 1989 study estimated 4,100–5,700 mountain lions in the state, based on the amount of suitable habitat and adult density estimates from prior studies (Mansfield and Weaver 1989).

Two long-term survival studies on radio-collared mountain lions in the SA provide some insight into population trend for mountain lions in rural enclaves in southern California (Beier 1993, Vickers et al. 2015). Studying 32 radio-collared mountain lions from 1988–1993, researchers found a 75% adult survival rate (Beier and Barrett 1993), which is similar to adult survival rates in other populations, e.g., the CC-S Management Unit (Riley et al. 2014). However, in a more recent SA study, 31 mountain lions marked from 2001 to 2013 had a survival rate of 56.5% across all sexes and age groups (Vickers et al. 2015). These results, combined with genetic information compiled in Gustafson et al. (2019), suggest that semi-rural areas such as the SA are population sinks for mountain lions, while remote, undeveloped areas (e.g., the Sierra Nevada) act as source populations (Dellinger et al. 2021a,b; Benson et al. 2023).

3.2 Population Size

The Department recently used fecal DNA data from 336 individual mountain lions collected from 13 study sites widely distributed throughout the state to estimate the statewide mountain lion population size using a spatial capture recapture model. The result is a statewide estimate of 3,242 (95% CI 2,826-3,742) mountain lions. It is important to note that this population estimate includes all age classes of mountain lions, including dependent young. More modeling work is required to provide an accurate assessment of how lion density varies in different habitats of the state in order to derive population estimates for specific management units (CDFW unpublished data).

Using the effective population sizes presented in Gustafson et al. 2019, an estimate of adult population can be created for the management units within the petitioned ESU (Table 3). Mountain lion population estimates in the table are derived from the estimated ratio of effective population size (N_e) to total adult population size (N). Effective population size essentially estimates the number of breeding adults in a population that successfully pass their genes on to future generations, recognizing that only a portion of adult animals in a population breed (see section 4.9.3 for more information on N_e).

Table 3. Effective population size and estimated total adult population of central coast and southern California mountain lion Management Units (derived from Gustafson et al. 2019).

Population	**Effective Population Size (N_e)**	**Estimated Total Adult Population (N)**[a]
Central Coast North (CC-N)	16.6	33–66
Central Coast Central (CC-C)	56.6	113–226
Central Coast South (CC-S)	2.7[b]	5–10
Santa Ana Mountains (SA)	15.6[c]	31–62
San Gabriel/San Bernardino Mountains (SGSB)	5	10–20
Eastern Peninsular Range (EPR)	31.6	63–126
Total Petitioned ESU	**128.1**	**255–510**

[a] Calculations are based on the estimated ratio of effective to total adult population size (N_e/N) of Florida panthers being 0.25–0.5 (Ballou et al. 1989). This ratio was used in the Florida Panther Recovery Plan (USFWS 2008) and is inclusive of estimates derived for other wild felids including ocelots (*Leoparuds pardalis;* Janečka et al. 2008) and tigers (*Panthera tigris*; Smith and McDougal 1991). It is recognized that these derived population estimates, while informative, are not definitive and may be superseded by new population estimates being developed by the Department.

[b] Benson et al. (2019) calculated an N_e of 4 for the Santa Monica Mountains population within the CC-S. Applying the Ballou et al. (1989) factors would lead to an estimate of 8–16 mountain lions in this area, which is roughly consistent with current estimates of this well-monitored population.

[c] Several studies provide N_e calculation for the SA population. Ernest et al. (2014) calculated an N_e of 5.1 and Benson et al. (2019) calculated an N_e of 6. Applying the Ballou et al. (1989) factors to the most recent calculation would lead to an estimate of 12–24 mountain lions in the SA, which is roughly consistent with current estimates.

The N_e/N method is one method of generating population estimates for mountain lions that are informative, but not definitive. However, the best currently available data agree that most of the Management Units within the petitioned ESU have small population sizes and low genetic variation (see Section 4.9), which could put them at increased risk of local extirpation (Beier 1993, 1995, Dickson et al. 2005, Ernest et al. 2014, Riley et al. 2014, Vickers et al. 2015, Benson et al. 2016, 2019, Gustafson et al. 2019).

4. FACTORS AFFECTING ABILITY TO SURVIVE AND REPRODUCE

4.1 Past and Threatened Modification and Destruction of Habitat

4.1.1 Urbanization

Anthropogenic habitat loss and fragmentation has been occurring in California since the arrival of Spanish settlers in the 18th century and increased dramatically with expansion of mining and agriculture in the mid-19th century. Early 20th century naturalists catalogued the flora and fauna throughout the state and noted the loss of formerly abundant prey species of the mountain lion, including elk, mule deer, pronghorn, and beaver (Stephens 1906, Grinnell 1914, Merriam 1919, Leopold 1966). Successive waves of agricultural and other development, including roads and highways, resulted in the conversion of natural vegetation, and led to further loss and fragmentation of mountain lion habitat. Development impacts have been extensive in the greater San Francisco Bay area, Los Angeles Basin and adjacent mountain ranges, Sacramento, and San Joaquin valleys (water diversions, agricultural development, and residential development), and the South Coast Province (residential, commercial, agricultural, and industrial uses).

The California State Wildlife Action Plan (SWAP) summarizes existing stressors on wildlife populations and ecosystems in the state and describes recent and ongoing habitat loss, fragmentation, and degradation in California (CDFW 2015). The SWAP reports significant habitat loss among many important ecosystems throughout the state. For example, over 195,000 ha (480,000 acres) of rangeland habitats were converted in California between 1984 and 2008 (approximately 3% of available rangelands) primarily due to residential and commercial development and agricultural intensification (Cameron et al. 2014). Additionally, habitat degradation—resulting from pollution, invasive species, livestock grazing, intensive recreation, soil erosion, drought, flooding, or wildfire—is a widespread stressor to wildlife populations in California (CDFW 2015).

Habitat fragmentation occurs when portions of habitat are lost or degraded such that natural areas are divided into small and isolated remnants (CDFW 2015). This fragmentation can have numerous negative impacts on wildlife including declining biodiversity and impairment of ecosystem functions; isolation of species into small subpopulations susceptible to extinction; and inhibition of movement between populations that leads to reduced genetic variation and inbreeding (Ibid.). Species with large home ranges, like mountain lions, require large contiguous areas of habitat or connectivity between multiple diffuse patches of habitat as resources are dispersed across a broader area, habitat fragmentation may lead to a loss of the habitat necessary for survival (e.g., sufficient breeding or foraging habitat) (Ibid.). In California, examples of habitat fragmentation include the conversion of native grasslands to agriculture in the Central Valley, which fragmented once continuous habitat into small patches, and in southern California, urbanization of historic habitat and movement corridors between mountain ranges (Ibid.).

In southern California in particular, human populations are especially dense, and land conversion is extensive. The significant amount of urban, suburban, and rural development in this area—resulting from population pressures of the region's 24 million residents—has led to substantial habitat loss and fragmentation (CDFW 2015). Currently, nearly 40% of the land area in southern coastal California is in urban and suburban use (CAL FIRE 2010). Beyond the immediate footprint of the development, urban, suburban, and rural growth patterns have fragmented the landscape (CDFW 2015). Land-use planning and zoning laws have allowed sprawling development with residential housing located far from existing urban centers, requiring new roads and infrastructure, as well as communities designed with large lot sizes and little or no preserved open space (Ibid.). These development patterns not only reduce the amount of habitat available but also degrade the quality of adjacent habitat making the remaining natural habitats more vulnerable to the incursion of invasive species, air, and water pollution, and altered fire regimes (Ibid.). In addition, the developed areas, roads, and utility corridors fragment the landscape leaving few or no corridors between natural areas (Ibid.).

The habitat loss and fragmentation described in the SWAP have caused reductions in the geographic distribution of mountain lions in the central and south coast regions of California. Moreover, in the absence of adequate habitat conservation efforts, including connectivity measures, such reductions are expected to continue. A study of mountain lion habitat in the CC-S and EPR MUs showed that nearly half of lion habitat in the study area is on private land, and approximately one-third of the lands that were available habitat in 1970 will be developed by 2030. Additionally, some habitat that is currently adjacent to development may become fragmented, with potential loss of connectivity and increased risk to mountain lions from vehicle strikes and depredation take (Burdett et al. 2010).

Additionally, limited habitat connectivity has resulted in highly restricted gene flow in many areas of central and southern California. For example, between the EPR and the SA MUs, connectivity is limited due to the barrier effect of Interstate 15 in the Temecula region. Similar connectivity challenges occur between the CC and WSN MUs. Recently published information on reproductive and morphological abnormalities in mountain lions indicate inbreeding in the CC-S (Huffmeyer et al. 2022). This study provides new evidence of inadequate habitat connectivity and highly impeded gene flow for these populations (see section 4.9 for more information).

Residential and industrial development is projected to continue throughout the petitioned ESU, even in the areas that are already highly urbanized (United States Environmental Protection Agency (USEPA) 2017). Projections of increased housing density through the year 2050 demonstrate that continued development will exacerbate existing barriers to mountain lion movement, effectively rendering existing pathways less permeable, and in some areas may lead to complete isolation of portions of MUs (Ibid.). Areas that are projected become substantially more isolated by the year 2050 due to residential development include the Santa Cruz Mountains of the CC-N, the SGSB MU, the Santa Monica and Santa Susanna mountains in the CC-S MU; and the Sierra Palona and Tehachapi Mountains near the nexus of the WSN, CC-S, SGSB and EPR MUs (Ibid.).

The cumulative effects of approximately 200 years of major habitat loss and fragmentation due to development and road construction, loss of riparian habitat and vital water sources due to water diversions and dams, and the associated reduction and shifting of prey species appear to have contributed to the separation of mountain lions into smaller population units in the central and southern regions of California. In the Santa Monica Mountains, researchers have documented an unusually high number of mortalities from intraspecific aggression, presumably at least partially attributable to mountain lions being confined to remaining patches of suitable habitat and unable to disperse across anthropogenic barriers (Riley et al. 2014). The impact is most pronounced near large human population centers such as those in southern coastal California and the San Francisco Bay area.

4.1.2 Agriculture and Forestry

The conversion of native lands to intensively farmed crops and pasture has large swaths of land that no longer provide foraging and reproductive habitat for mountain lions. This conversion began as early as the 1700s in coastal California and accelerated rapidly in the 19th and 20th centuries as water storage and delivery systems were developed enabling the irrigation of crops. Approximately 43% of California's land area is used for agricultural production (California Department of Food and Agriculture (CDFA) 2009). In recent years 3.6 million hectares (9,000,000 ac.) of land has been in intensively farmed irrigated agricultural production on average (California Department of Water Resources (DWR) 2023). Although the same pattern of conversion of native vegetation communities to agricultural uses occurred wherever suitable soils and adequate water existed, it is in California's 47,000 km^2 (18,000 mi^2) Central Valley, by far the largest contiguous region of intensively farmed land in the state, that the change has been most dramatic. The Central Valley appears to form a semi-permeable barrier between coastal mountain ranges from the Sierra Nevada and Cascade mountains. Historically the Central Valley contained extensive riparian forests along the Sacramento and San Joquin rivers, their tributaries, and in the delta which likely provided corridors of suitable cover for mountain lions living in and traveling through the valley. In places, riparian forest and scrub along tributary rivers descending to the Sacramento and San Joaquin rivers from the Sierra Nevada in the east and the Coast Ranges in the west likely facilitated genetic connection between the Western Sierra Nevada genetic group and the Central Coast MUs. However, an estimated that 92-97% of such forests have been lost through channelization, altered hydrology, and conversion to agricultural and urban uses, and much of the remaining riparian forest has been modified (CDFW 2014). Loss of Central Valley riparian forests and riparian scrub is likely a major driver of contemporary mountain lion population structure.

Although the impacts are less intense and less permanent, commercial timber harvesting may adversely modify mountain lion habitat at the northern extreme of the petitioned ESU. A study of mountain lion home ranges in the redwood forest of northwest California found mountain lions used forest areas with a greater proportion fragmentation and edge more frequently than areas of more contiguous forest; however, lions generally avoided areas of active timber harvest operations (Meinke 2004). Mountain lion home ranges included different stages of forest succession from freshly harvested stands to late seral forests, perhaps indicating commercial timber management, as regulated by CAL FIRE, does not fragment mountain lion habitat or isolate populations. Conversely, Smallwood(1994) found mountain lion use of forest stands of the central coast, north coast, and Sierra Nevada Mountains sharply declined within 6 years following clear cut harvest. Mountain lions generally prefer heterogeneous habitat, and redwood growth rates are fast compared to the conifer species of the Sierra Nevada, so it is possible that even recently harvested commercial timberland in the redwood forest of central California could continue to provide important mountain lion habitat.

4.2 Vehicle Strikes, Roads, and Rail Lines

As mentioned in the section on mortality sources (2.1.1), vehicle strikes are the second most common cause of known mortalities of mountain lions in California (Benson et al. 2023). The Road Ecology

Center at the University of California, Davis (UC Davis) has records of 535 mountain lions killed on state highways between 2015–2022 (Shilling et al. 2023). However, these records only include reported mountain lion mortalities, so the true number is likely higher. Figure 6 displays documented mountain lion mortality events caused by vehicle strikes from 2000 to 2021. The incidents were mapped from a collection of roadkill reports from Department records and from Dr. Fraser Shilling at the Road Ecology Center. Though the data were not collected systematically as part of any statewide scientific investigation, reported collisions are most common in or near the urban areas of the central and south coasts.

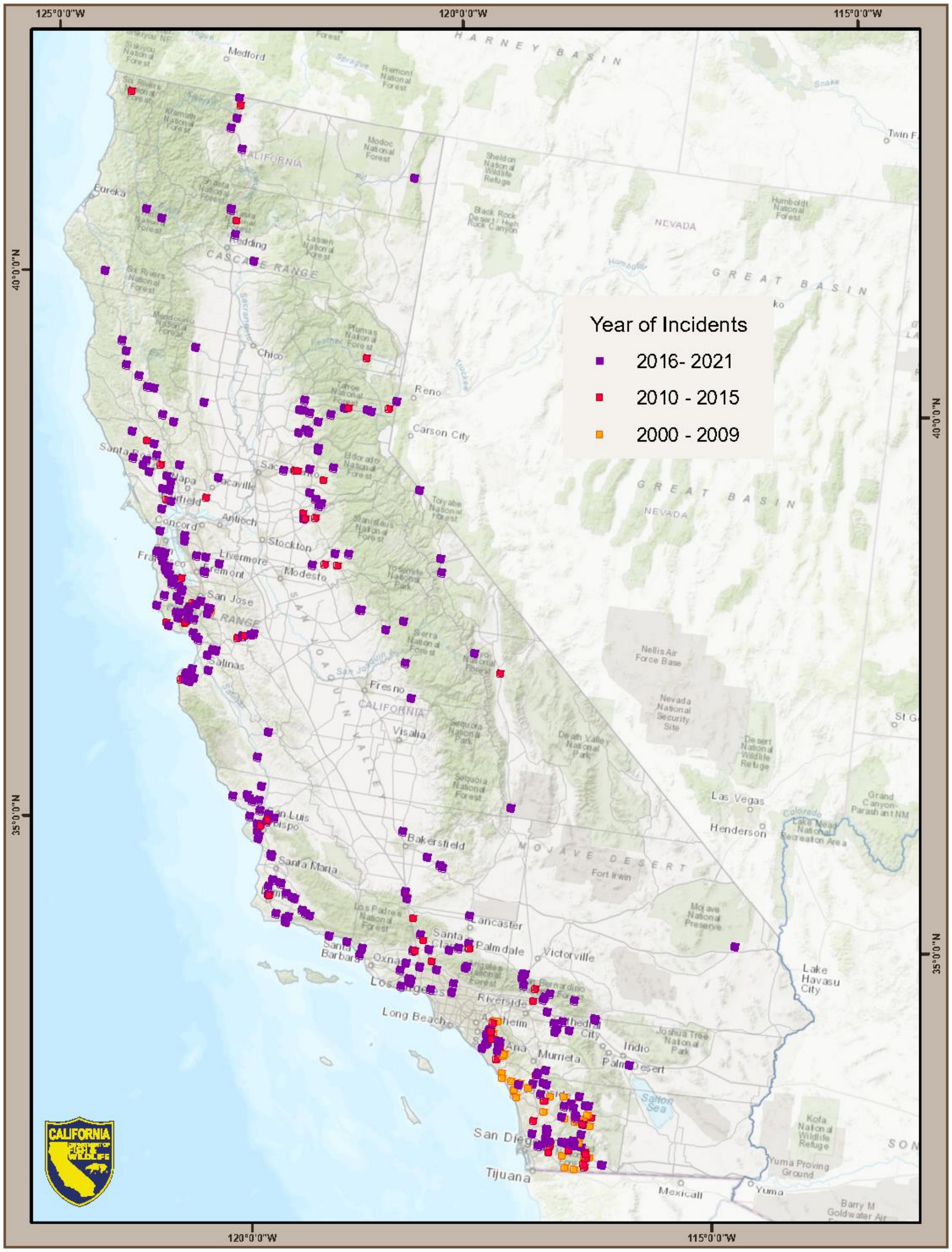


Figure 6. Mountain lion vehicle strike mortality incidents from 2000–2021 from a collection of roadkill reports from Department records and Dr. Fraser Shilling at the University of California, Davis, Road Ecology Center.

In southern California (SA and EPR), the Los Angeles and San Diego regions are major areas of road mortalities (Shilling et al. 2023). From 1981 to 2013, reported vehicle strikes accounted for 53% (50/94) of known mountain lion deaths in the SA MU (which includes the greater Los Angeles metropolitan area) and 30% (46/154) in the EPR MU (which includes the greater San Diego metropolitan area) (Vickers et al. 2015). Vehicle strikes remain the main mortality factor for mountain lions in the SA MU, and a tertiary mortality factor in the EPR MU (Ibid.). Due to the high levels of vehicle-related mortalities in the SA and EPR lion MUs, land protection alone may not be sufficient to ensure mountain lion persistence in the region (Ibid.).

In the Bay Area (CC-N), vehicle strikes are also a significant source of mortality. California State Route (SR)-12, SR-17, SR-1, and especially Interstate-280 have high numbers of mountain lion mortalities (Shilling et al. 2023). Shilling and Vickers (2023) identify the stretch of I-280 northwest of San Jose as the deadliest highway in California for mountain lions with 20 deaths along a 32 km (20 mi.) stretch from 2015–2022. At least six mountain lions were killed by vehicle strikes on Highway 17 in the Santa Cruz Mountains between 2008–2018 (Midpeninsula Regional Open Space 2017, Slade 2018), and news outlets reported at least three vehicle strikes killing mountain lions on I-280 in San Mateo County between 2014 and 2016. Unpublished Department records indicate ≥ 15 mountain lions killed by vehicle strikes on Highway 17 and ≥ 15 mountain lions killed by vehicles on I-280 from 2014 to 2020, and an additional 10 road killed mountain lions from the CC-N MU in 2021 alone (Terris Kasteen, pers. comm.).

Vehicle strikes also may also cause indirect mortality of dependent young mountain lions. When a female with dependent young is struck by a vehicle, the kittens likely starve to death or become easy prey for predators, including other mountain lions. If the kittens are larger and more mobile, they may approach areas where they are more likely to encounter humans as they search for food. This was seen in November 2017, when a mother mountain lion was killed by a vehicle strike in the SA and two of her kittens were found roaming near human development—one in a backyard and the other along a road (Veklerov 2018). Both kittens, too young to survive on their own, were removed from the wild and placed in the Oakland Zoo.

In addition to direct mortality from vehicle strikes, roads also pose a threat to mountain lions in terms of restricted movement. Radio and satellite-tracking data have revealed that mountain lions will sometimes approach a busy freeway, hesitate to cross, linger in the area, or sometimes pace back and forth parallel to the freeway before turning back (Stoner et al. 2008). Dr. Winston Vickers observed this behavior recently in a female lion that originated from the SA. The satellite-collared lion was heading easterly toward the EPR, but when she encountered I-15, she ranged up and down along the freeway before turning around, ultimately returning to the SA (W. Vickers, pers. comm.).

The threat of vehicle strikes is not limited to roads and highways. Trains also kill wildlife (Gangadharan et al. 2017), and railways often parallel highways and roads (e.g., an existing railway runs roughly parallel to Interstate-15 in the Cajon Pass area between the San Gabriel and San Bernardino Mountains). A high-speed rail line (HSR) is planned to run roughly parallel to I-15, and a HSR line is planned from the Victorville area to Las Vegas in the median of I-15, with a barrier wall at the base of the HSR line. Other areas for HSR are the Central Valley and the route from San Jose through Pacheco Pass.

Planning for safe wildlife crossings in southern California has been underway for nearly two decades. In 2008, the South Coast Missing Linkages Project identified areas of the state where linkages are needed (Fig. 7). The County of Ventura has incorporated these linkages into their General Plan land use zones to help ensure these important wildlife movement corridors remain passable (Ventura County 2019). The Department and the California Department of Transportation (Caltrans) have announced there will be three wildlife overcrossings along I-15 and the HSR line in San Bernardino County which should facilitate the movement of mountain lions and other species (CDFW 2023a). In addition, current undercrossings and culverts will be maintained and improved along the corridor.

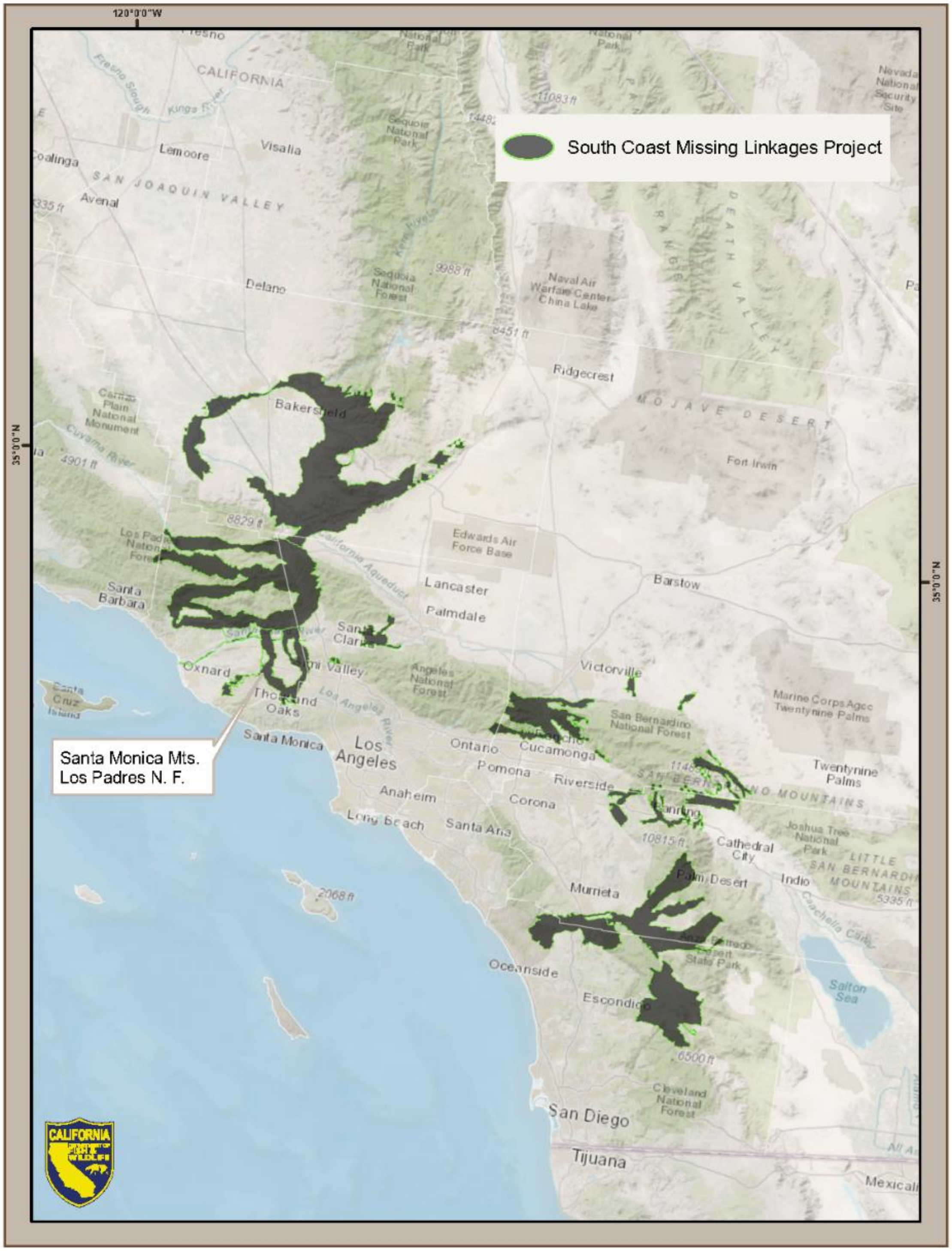


Figure 7. Important wildlife corridors identified in the South Coast Missing Linkages Report (SC Wildlands 2008).

The Department has identified and prioritized selected wildlife barriers statewide, and 10 out of 12 high priority barriers were associated with mountain lions (CDFW 2022b). However, funding to implement wildlife crossing projects, including land acquisition to make the crossing more natural and acceptable to wildlife, has been limited to date. The lack of wildlife crossings, particularly in highly urbanized areas or across major transportation corridors, contributes to the current mortality rates associated with vehicle strikes. There has been some recent movement on this issue; construction for the Wallis Annenberg Wildlife Crossing in the Liberty Canyon area of the CC-S MU (Fig. 8) broke ground in 2022. The overpass will facilitate mountain lion movement between the Santa Monica Mountains and the Simi Hills and could ultimately facilitate genetic exchange between the CC-S and the rest of the CC and/or SN. It may also minimize local vehicle-related mortality. And a wildlife undercrossing with associated fencing and habitat conservation was constructed under Highway 17 in the Santa Cruz Mountains in February of 2023. Another wildlife crossing over Highway 101 in San Benito County is in the planning and fundraising phase. Together, these crossings will facilitate the movement of mountain lions between the Santa Cruz Mountains in the CC-N MU and the Gabilan Mountains of the CC-C MU.

Figure 8. Rendering of Wallis Annenberg Liberty Canyon Wildlife Crossing. Source: Santa Monica Mountains Conservancy.

4.3 Predator Control and Overexploitation

4.3.1 Historical Overexploitation

The management of mountain lions in California has varied widely in the last century. In the early to mid-20th century, mountain lions were a bountied predator in California, like other western states (Young and Goldman 1946, Dellinger and Torres 2020). When the bounties ended in 1964, mountain lions were classified as a nuisance or vermin species—an unlimited number of mountain lions could be killed year-round without a hunting license, but there was no longer paid incentive for removal (Dellinger et al. 2021b). From 1969–1972, mountain lions were considered a game species and could be hunted with a proper hunting license; their status as a game species was reinstated from 1986–1990, but no mountain lions were harvested during this period (Ibid.). Between 1972–1986 and again 1990 to present, mountain lions were classified as a specially protected species preventing hunting (Dellinger and Torres 2020).

During the bounty period (pre-1964), paid incentives encouraged people to hunt and kill mountain lions resulting in approximately 12,580 mountain lions killed across California (Dellinger et al. 2021b). Nearly one-third of the bounties paid in the first few decades were in northern California in Humboldt, Trinity, Mendocino, and Lake counties (Dellinger and Torres 2020). Additionally, the Department employed 1–5 lion hunters whose only job was to remove mountain lions throughout the state (McLean 1954; Dellinger and Torres 2020).

After the bounty period, mountain lions become classified as a game species by the Department, and two hunting seasons took place (1970–1971) during which 118 animals were harvested from 4,953 permits issued (Dellinger et al. 2021b). Following the second hunting season, a legislative moratorium on mountain lion hunting was put into effect(Fitzhugh and Gorenzel 1986). However, this moratorium did allow mountain lions to be killed for injuring or killing pets and livestock under state issued depredation permits (Dellinger et al. 2021b). The moratorium expired in 1986 causing mountain lions to revert to their previous status as game animals (Ibid.). The Department then began to establish hunting zones and harvest quotas—a process that was near completion in 1990 when hunting tags had been issued for the newly established mountain lion zones (Ibid.). However, a voter ballot initiative (Proposition 117) was made law by California voters which classified mountain lions as a "specially protected mammal species" (FGC 2019). Mountain lions have retained this designation with the only allowable take occurring via depredation permits when mountain lions are encountered attacking or threatening livestock, after causing property damage, to protect public safety, or targeted removal for animals negatively impacting federally listed bighorn sheep populations (FGC 2019).

4.3.2 Livestock Depredation and Human Safety

The interactions between humans and mountain lions in California have profound impacts on the conservation and management of the species. Human-wildlife conflicts are interactions that result in perceived, potential, or actual negative impacts to one or more species. As the state's trustee agency for fish and wildlife resources (Fish & G. Code, § 1802), the Department's responsibilities include serving as the primary state agency charged with helping to resolve human-wildlife conflict, public safety, and depredation issues (CDFW 2015).

In some cases, mountain lions that are a threat to domesticated animals can be taken, both lethally and nonlethally. Mountain lions encountered in the act of pursuing, inflicting injury to, or killing livestock or domestic animals may be killed by landowners and their agents without prior authorization (Fish and G. Code, § 4807). The Department is also required to be responsive to depredation permit requests when mountain lions injure or are thought to have injured property such as livestock and pets (Fish & G. Code, § 4802 et seq.). Lethal removals are carried out under the authority of Department-issued depredation permits to the property owner experiencing the damage. The property owner can then designate a third party (e.g., local trapper) to carry out the depredation permit. Additionally, the Department may take or authorize local public safety agencies to take mountain lions perceived to be an imminent threat to public health and safety through nonlethal techniques or, when nonlethal techniques prove ineffective, through lethal take (Fish & G. Code, §§ 4801, 4801.5).

In 2013, the Department developed a situation-specific approach for responding to human-mountain lion conflict including: 1) mountain lions in areas of human habitation, 2) mountain lions depredating pets/livestock, and 3) mountain lion public safety situations. The most noteworthy change in management action reflected in this approach was specifying that only one mountain lion could be taken under a single depredation permit. In 2017, the Department again revised its approach, consistent with Fish and Game Code section 4801.5, to prioritize non-lethal measures for dealing with mountain lion depredation in the Santa Monica and Santa Ana mountains where research indicated that local mountain lion populations constrained by anthropogenic barriers lacked genetic variation (CDFW 2017). In 2020, the Department amended its mountain lion management policy to expand the area where non-lethal measures would be prioritized, consistent with Fish and Game Code section 4801.5 (CDFW 2020). Specifically, the Department has implemented a 3-step process across the central coast and southern parts of California to guide its case-specific response to mountain lion depredations. In this 3-step process, non-lethal measures (e.g., hazing and improvements to animal husbandry) are used to try and resolve depredations during the first two instances of a depredation event at a given property. If a third depredation event occurs at a property despite the implementation of non-lethal measures the Department considers authorizing lethal removal of the offending animal. It should be noted that this process is based on the individual property and not the individual mountain lion. Elsewhere across the state, the Department uses a 2-step process in response to depredation events, such that non-lethal measures are used after the first event. A lethal permit may potentially be issued if another depredation occurs at the same property.

From January 2010 through 2020, the Department recorded 3,637 reported mountain lion incidents. These include public safety concerns and depredations as well as sightings and complaints of nuisance animals. Of the incidents, 2,202 were reported depredations (predation on pets or livestock by mountain lions), 1,327 were classified as potential human conflict cases, and 108 were general nuisance. For incidents of any type, El Dorado County had the most reports (261 reports) followed by Shasta County (176) and Los Angeles County (168). Many reported mountain lion incidents involve observations that cannot be confirmed, due largely to the transitory nature of wildlife sightings and incidents. For potential human conflict incidents, Los Angeles County had the most cases (108) followed by San Diego County (85), and Mendocino County (65). From 1986 to 2020, there were 19 reported mountain lion attacks on humans, 3 of them fatal, in California. Prior to the 2020 amendment to the Department's mountain lion management policy, 8.6% of all reported mountain lion depredations resulted in the lethal removal of one or more mountain lions from within the petitioned ESU. Following the amendment, the percentage declined to just 0.2% (CDFW Wildlife Incident Reporting System accessed 5/16/2023). The Department prioritizes human safety and lethally removes mountain lions that represent an immediate threat to public safety.

Depredation, wherein mountain lions attack pets and livestock, account for most reported mountain lion-human incidents. Conflicts related to depredation are increasing (Dellinger et al. 2021a) in part due to population growth and development in rural communities and natural areas and expansion of agricultural activities. From 1972 to 2020, at least 3,694 mountain lions were removed in depredation incidents (Dellinger et al. 2021b), and it was the leading cause of attributable mortality of collared mountain lions (Benson et al. 2023). Over the last 20 years, an average of approximately 92 mountain lions have been removed on depredation permits per year across California (Dellinger et al. 2021b). Over this same period, an average of 2.55 mountain lions were removed annually in the SC genetic group identified by Gustafson et al. (2022) (composed of the SGSB, SA, and EPR MUs), 1.4–2.7% of the estimated population size (as estimated by Gustafson et al. (2019)), and approximately 11.7 mountain lions were removed annually from the CC genetic group (composed of the CC-N, CC-C, and CC-S MUs), equating to an annual removal of 3.9–7.7% of the estimated population size (Dellinger et al. 2021b).

Of the mountain lions killed because of depredation, 66% are male (CDFW 2019), and approximately 33% involving dispersing subadult males (Torres et al. 1996). From 1981 to 2013 in the SA and EPR MUs, the number of male mountain lions taken for depredation exceeded the number of females removed by 340% (Vickers et al. 2015). Not only do mountain lions killed pursuant to depredation permits diminish the total abundance of mountain lions in these populations, but because they consist predominantly of males, the number of primary gene dispersers is also greatly reduced, which further inhibits adequate gene flow between lion populations in California (Vickers et al. 2017).

Most reported depredation incidents from 1972–2019 were of sheep and goats on small scale operations (Dellinger et al. 2021a). Interestingly, researchers have noted that at the county level, mountain lion depredation rates increase by 9% for every lion removed through a depredation permit the prior year (Dellinger et al. 2021a). The authors suggested this was likely a result of subadults moving to given areas when resident adults were removed. Those subadults are more likely to use areas closer to people and have less well-developed hunting skills and are likely to favor targeting easily killed domestic animals (Dellinger et al. 2021a). This suggests non-lethal measures instead of lethal removal in response to mountain lion depredation incidents could benefit both mountain lions and livestock owners.

Dellinger et al. (2021a) found that the number of reported depredation events involving pets trended upward from 1972 to 2019. Given that most depredation incidents involve pets and non-commercial livestock, it seems unlikely that the number of conflicts will decline in the future, particularly in the urban southern coast region. Nisi et al. (2022) found that although mountain lions in the Santa Cruz Mountains avoided the areas where they were most likely to come into conflict with humans during the day, they were more likely to be in those areas at night when lethal responses are more likely to occur. Nisi et al. (2022) suggested that ways in which mountain lions interpret human cues and risk levels do not lead to changes in behavior that are sufficient to reduce conflict with humans. Therefore, improving livestock husbandry to minimize the risk of depredation is vital to further reduce the lethal take of mountain lions.

Mountain lions are occasionally removed when predating upon state and federally endangered Sierra Nevada bighorn sheep (*O. canadensis sierrae*) or state threatened and federally threatened Peninsular bighorn sheep (*O. canadensis nelson*). The Department is authorized to take such actions via Fish and Game Code section 4801, and such actions are identified in each species' federal recovery plan (USFWS 2000, 2007). Historically, this action has primarily affected the SN genetic cluster in the ESN outside the petitioned ESU boundary and where mountain lion populations are relatively large and well connected (CDFW 2021).

In addition to reported depredation take, poaching and other unpermitted take is rarely reported but has been observed in the CC-S, SA, and EPR (Beier and Barrett 1993, Riley et al. 2014, Vickers et al. 2015) as well as in the CC-N (Yap et al. 2019). Benson et al. (2023) reported 26 out of 263 known California mountain lion mortalities from 1974–2020 were due to poaching, accounting for 2%-3% of annual mortalities, a less frequent source of mortality than depredation take (6%), vehicle collisions (4%), natural mortality (3%), and being killed by another mountain lion (3%); although it is possible that collared study animals are illegally taken less frequently than unmarked animals. .

Benson et al. (2023) found that the annual rate mortality from killing for management purposes (0.06 [0.05–0.08]), was roughly equal to all types of natural mortality (0.06 [0.05–0.08]) and is additive to natural mortality. Collectively, all forms of permitted take are unlikely to negatively influence mountain lion populations and trends when viewed at the statewide level, nor in the large and well-connected NC and SN populations. However, the additive mortality resulting from depredations and human conflicts in areas where lion populations are already small and isolated such as California's central and south coasts may result in local population declines (Benson et al. 2023). Importantly, the authors noted the risk of mortality from management killing declined from 2001 to 2020, and raised the possibility that the decline may be related to the recent changes in CDFW's management policies.

4.4 Competition

Mountain lions compete with other large carnivores in most areas of their range. Black bears are known to occasionally displace mountain lions from their kills which deprives them of calories, potentially forcing them to expend additional energy hunting to procure more prey (Allen et al. 2021). In a study in Mendocino County, mountain lions did not seek bear-free areas to mitigate competition with black bears; rather, they increased their predation rates to compensate for the kills stolen by bears (Elbroch et al. 2015). It is unknown whether displacement by black bears occurs frequently enough to affect mountain lion survival and reproductive rates (Elbroch and Kusler 2018). Mountain lions and bears overlap in space in almost all mountain lion habitats in California except for the Santa Cruz Mountains, and until recently the Santa Monica Mountains. In western North America gray wolves affect adult and kitten survival, directly kill individual mountain lions, and affect habitat and prey selection, bedding locations, and population size (Bartnick et al. 2013, Elbroch et al. 2015, Kusler et al. 2017, Elbroch and Kusler 2018, Elbroch et al. 2020)). Given the small size and limited distribution of California's current gray wolf population, competition between wolves and mountain lions has not been a significant threat to the persistence of mountain lions to date, and as wolves are currently absent from the petitioned ESU, wolf competition is not considered a current threat. Finally, smaller predators and scavengers such as coyotes are known to opportunistically feed from mountain lions kills (Brunet et al. 2022), although the degree this loss of food resources impacts lions is difficult to quantify.

Intraspecific conflict and aggression appear to be a significant mortality factor in areas where mountain lions occupy small patches of suitable habitat (Vickers et al. 2015). Intraspecific aggression has been identified as the leading cause of mortality for the nearly isolated mountain lions in the Santa Monica Mountains (a portion of the CC-S; Riley et al. 2014). Although intraspecific aggression is a common source of mortality in mountain lion populations (Beier and Barrett 1993, Logan and Sweanor 2001, Allen 2014), unusually high levels have been observed in the CC-S MU (Riley et al. 2014). About 41% of deaths of radio and satellite-collared mountain lions being tracked from 2002 to 2018 in the Santa Monica Mountains were from intraspecific aggression, with multiple cases of adult males killing their siblings, offspring sired by other males (i.e., infanticide), and previous mates (Riley et al. 2014). These high levels of intraspecific aggression/predation are likely due to limited available habitat in the Santa Monica Mountains, which are largely surrounded by urban and agricultural development and other dispersal barriers (Riley et al. 2014, Benson et al. 2019). Additionally, in the SA MU, intraspecific predation was documented on two occasions in recent years (W. Vickers, unpublished data). Therefore, this form of competition should be considered a potential threat to lion populations in small, isolated MUs such as the CC-S, SA, and the SGSB. However, the effect of competition on the entire petitioned ESU is unknown and is simply one potential piece of the cumulative impacts on mountain lions in California—not likely a significant threat on its own.

4.5 Toxicants

Mountain lions throughout California are exposed to toxic chemicals in their environment which can be lethal or debilitating depending on the extent of exposure. Some ingested toxicants can be transferred in utero to fetuses, and debilitated lions may be more susceptible to other forms of mortality such as starvation and traumatic injuries.

4.5.1 Pesticide Exposure

Anticoagulant rodenticide (AR) baits are commonly used to control rodent pests in urban, suburban, and agricultural areas (Litovitz et al. 1998, Maroni et al. 2000). As summarized in Serieys et al. (2015), ARs interrupt the production of vitamin K-dependent blood clotting proteins, leading to the depletion of these proteins over a period of days and inducing mortality by internal hemorrhage. Comprised of two classes of compounds, ARs are the primary chemical method used worldwide for the control of rats and mice. First-generation ARs, including warfarin, diphacinone, and chlorophacinone, are more readily metabolized, have a shorter half-life in liver tissue (two weeks to several months), and must be consumed in multiple feedings to reach a lethal dose. Second-generation ARs include brodifacoum, bromadiolone, difenacoum, and difethialone, and were developed to target rodents with genetic resistance to warfarin. Due to increased toxicity and persistence in animal tissues, with half-lives ranging from 6–12 months, second-generation ARs may persist in liver tissue for more than a year in some species. Both classes of compounds have a delayed onset of action, and death from AR consumption can occur up to 10 days after ingestion. Individual rodents may continue to accumulate the compounds over a period of days, increasing their likelihood of capture by predators as they become weakened by the toxicant. For these reasons, ARs have the potential of creating primary and secondary poisoning risks to non-target wildlife; this is especially the case for predatory mammals as they consume targeted prey that have ingested ARs. AR exposure has been positively associated with proximity to urban areas, raising concerns about long-term conservation impacts of AR exposure on non-target wildlife populations on the fringe of urban areas (Hosea 2000, Riley et al. 2007, McMillin et al. 2008, Gabriel et al. 2012, Serieys et al. 2015, 2018)

Mountain lions use diverse habitats—including residential, periurban, suburban, and urban—where their diet may include native, exotic, invasive and domestic prey (Moss et al. 2016, Smith et al. 2016), exposing them to ARs otherwise used to control vertebrate pests. Further, mountain lions may also utilize public and private agricultural, industrial, and forested areas throughout the state, including remote locations on public lands where prohibited rodenticides are often used to protect illicit cannabis plantations (Gabriel et al. 2012). Previous and ongoing work by the Department's Wildlife Health Lab detected AR exposure in 96% (237/247) of tested mountain lion livers submitted between 2016 and 2018 (Fig. 9; Rudd and Rogers 2021). Second-generation ARs are more commonly detected than first-generation ARs, despite a 2014 California regulatory change restricting second-generation AR use to certified pesticide applicators (Rudd et al. 2018, Rudd and Rogers 2021). Seventy percent of the mountain lion livers (174/247) tested had three or more different ARs present at the time of death (Fig. 10). To date, there is no observable pathological condition consistent with AR exposure in necropsied mountain lions (Rudd et al. 2018).

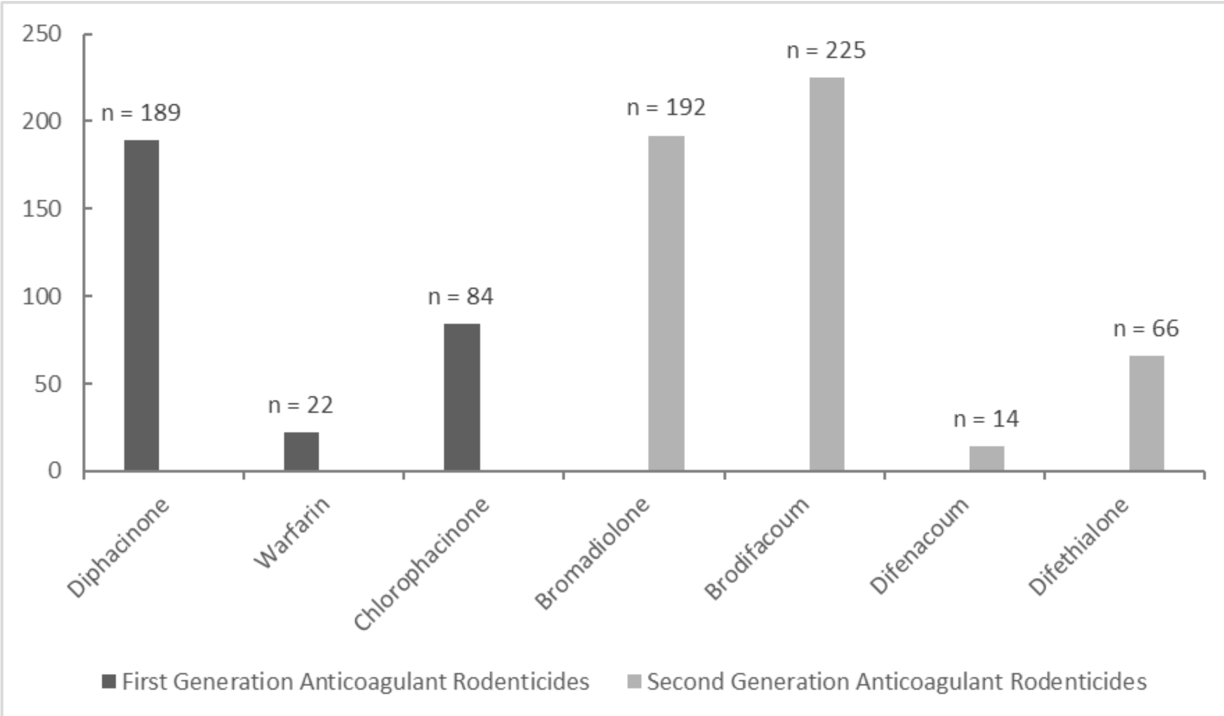


Figure 9. Anticoagulant rodenticide residues detected in 247 livers of mountain lions submitted to the Wildlife Health Laboratory for postmortem examination 2016–2018 (Rudd and Rogers 2021)

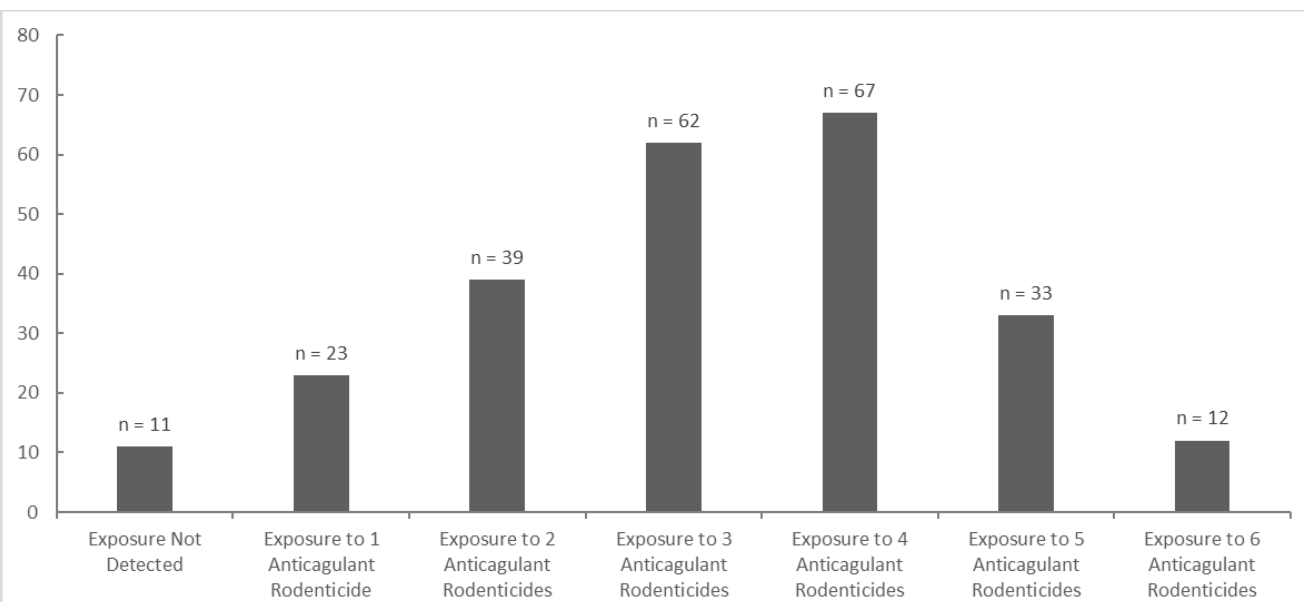


Figure 10. Number of different anticoagulant rodenticides analytes detected in 247 individual mountain lion livers analyzed from January 1, 2016–March 31, 2018 (Rudd and Rodgers 2021).

There is a high degree of variability among species and individuals in their vulnerability to AR exposure. Felids are relatively resistant to the coagulopathic effects of ARs (Kopanke et al. 2018). In the absence of a universal threshold value that could be indicative of AR toxicosis (i.e., poisoning), the diagnosis of AR-related toxicosis and coagulopathy (i.e., impaired clot formation leading to excessive bleeding) requires both the presence of one or more AR in the appropriate sample (e.g., liver or serum) and antemortem or postmortem evidence of a coagulopathy unrelated to another identifiable cause of hemorrhage (e.g., trauma, disease, or infection). It is important to note that exposure in the absence of toxicosis should not be ignored (van den Brink et al. 2018). The uncertainties about the magnitude and drivers of chronic exposure and/or sub-lethal levels of rodenticide exposure demonstrate the need for continued monitoring.

In the Santa Monica Mountains National Recreation Area (CC-S MU), the National Park Service has concluded the deaths of seven mountain lions since 2004 were associated with AR exposure and toxicosis (Riley et al. 2007, NPS 2021). Two mountain lions that died from AR toxicosis in 2004 also had infestations of notoedric mange (Riley et al. 2007, Uzal et al. 2007). Notoedric mange in felids, typically caused by the parasitic mite *Notoedres cati*, is assumed to be non-fatal in bobcats and mountain lions; however, AR exposure may make felids more susceptible to advanced mange disease (Riley et al. 2007).

Of particular interest, AR exposure was detected in the liver of a pregnant female mountain lion from Santa Barbara County and in the livers of her two fetuses (Table 4; Rudd et al. 2020). Many toxic substances, including ARs, can adversely affect fetal development and survival at doses that may not produce toxic effects in the mother (Gupta 2012). Fetuses are also typically more susceptible to AR toxicity because the placenta is the only source of vitamin K for the fetus (Gupta 2012). AR-related coagulopathy and toxicity was not observed in the two fetuses with exposure to brodifacoum and diphacinone (Rudd et al. 2020).

Table 4. Anticoagulant rodenticide detection in maternal and fetal mountain lion livers. BRD: brodifacoum, BRM: bromadiolone, CHL: chlorophacinone, COU: coumachlor, DIF: difethialone, DIPH: diphacinone, WAR: warfarin, DFN: difenacoum. An asterisk (*) indicates that the samples were pooled together for qualitative and quantitative analyses (i.e., samples too small to be evaluated individually).

ID	Mortality by cause	County	ARs detected in pregnant adult (ppb)	# of fetuses	ARs detected in fetal tissue (ppb)
Z16-1126	Depredation	Tuolumne	BRD (230), BRM (trace)	4*	Not detected
Z17-0199	HBC	Santa Barbara	BRD (71), BRM (130), CHL (trace), DIF (trace), DIPH (830)	2	1. BRD (trace), DIPH (150) 2. BRD (trace), DIPH (160)
Z17-0281	Depredation	Trinity	BRD, BRM, DIF, DIPH (all trace)	4*	Not detected
Z17-0328	Depredation	Yuba	BRD (trace), BRM (120), DIPH (trace)	3*	Not detected
Z19-0793	Depredation	Amador	BRD, BRM, DIPH (all trace)	3*	Not detected

Additionally, exposure to ARs may predispose animals to excessive hemorrhage following an otherwise non-lethal traumatic injury or increase sensitivity to additional exposure (van den Brink et al. 2018).

The Petition cited Rudd et al. (2019) to state that mountain lions in California are exposed to dangerously high levels of illegal pesticides, such as carbofuran. However, this citation is incorrect; the Department has not documented any cases of carbofuran toxicity to date. Further research is needed to investigate the lethal and sub-lethal effects of anticoagulants and other toxicants on wildlife in terrestrial environments (Riley et al. 2007, Gabriel et al. 2015, Rudd et al. 2018).

4.5.2 Mercury

Mercury is hypothesized to contribute to reproductive, endocrine, and immunosuppression issues documented in Florida panthers (Roelke 1991, Facemire et al. 1995). While morbidity and mortality resulting from mercury toxicity have not been documented in mountain lions in California, elevated mercury concentrations have been found in the fur and whiskers of mountain lions from the coastal region of the Santa Cruz Mountains (Weiss-Penzias et al. 2019).

4.6 Infectious Diseases

Mountain lions are afflicted by various viral, bacterial, and parasitic pathogens. It is not known if these pathogens and their respective diseases alone could imperil the species in California. However, small, isolated mountain lion populations are at greater risk from a catastrophic disease outbreak which could reduce their ability to persist into the future, especially when combined with other threats. Following is a list of the most common pathogens that could potentially affect mountain lion populations.

4.6.1 Viral Diseases

Feline leukemia virus (FeLV). FeLV is a common immunosuppressive viral pathogen in domestic cats known to cause morbidity and mortality. While infection is seemingly rare in non-domestic felids, FeLV is considered a disease of potential epidemic concern for small populations. Researchers have found infection prevalence in mountain lions to be low, ranging from 0–5.4% (Paul-Murphy et al. 1994, Foley et al. 2013). More recently, the Department, in collaboration with Colorado State University, documented a similar FeLV infection prevalence of 2.4% in lymph nodes collected from 130 necropsied CA mountain lions tested from 2016–2018 (J. Rudd, CDFW, pers. comm.). To date, the Department has documented only two mountain lion mortalities due to suspected FeLV-related infections (e.g., opportunistic bacterial and fungal infections and anemia)—one in 1993 (Jessup et al. 1993) and another in 2020 (J. Rudd and Q. Martins, unpublished data).

Puma lentivirus (PLV). PLV is a genus of immunosuppressive lentivirus that infects domestic and wild felids with some degree of species specificity (Lee et al. 2014) and includes feline immunodeficiency virus (FIV). PLV (type B) infection was recently detected in 46 necropsied mountain lion carcasses from California (35.4%; J. Rudd, CDFW, unpublished data) and is thought to be the cause of death for a 16-month-old male mountain lion that died in April 2018 in Modoc County (J. Rudd and D. Garcelon, unpublished data). However, the remainder of necropsied animals in which PLV infection was detected were aclinical and did not exhibit signs of pathology (J. Rudd, CDFW, unpublished data).

Rabies virus. Striped skunks (*Mephitis mephitis*) are the primary terrestrial wildlife reservoir for rabies in California, but other mesocarnivores, including raccoons, gray foxes (*Urocyon cinereoargenteus*), bobcats, and coyotes, can become infected and transmit the disease. Despite these species serving as potential sources of prey for mountain lions, there have been only two known cases of rabies in mountain lions in California—in 1909 in Santa Clara County (Storer 1923) and in 1994 in Mendocino County (CDFW 2000).

Pseudorabies virus (PrV). PrV is a highly transmissible porcine alphaherpesvirus whose natural hosts are members of the pig family Suidae (Pomeranz et al. 2005). The virus can cause respiratory, reproductive, and neurological symptoms in young piglets, while adult pigs show little to no clinical illness (Pomeranz et al. 2005, Müller et al. 2011). Infection of PrV into non-native hosts is typically fatal with mortalities documented in several carnivore species after consuming wild and domestic pigs, including bears *(Ursus arctos)* (Zanin et al. 1997), wolves (Verpoest et al. 2014), coyotes (Raymond et al. 1997), foxes (Bitsch et al. 1969), lynx (Lynx sp.; Masot et al. 2017), and Florida panther (Glass et al. 1994). In California, pseudorabies has been detected in wild pigs from 13 counties (McDougle 2017). Although PrV has not been detected in California mountain lions to date (Wisely et al. 2018), the high prevalence of the virus and overlapping distribution of wild pigs and mountain lions in significant parts of California suggest that PrV could be a hazard to lions in California.

Feline Panleukopenia Virus (FPV). FPV belongs to a family of parvoviruses that are closely related to canine parvovirus and mink enteritis virus (Truyen and Parrish 2013). FPV primarily infects felids and has a high mortality rate, although individuals that do survive infection generally have life-long immunity. In natural domestic cat populations, FPV has the potential to regulate population sizes due to its high mortality rate, especially in young animals. In California, FPV was the most common pathogen detected in wild mountain lions from California, with an antibody prevalence of 36% in tested blood samples from 1991–2008 (Foley et al. 2013). Infection with FPV resulted in the morbidity and death of two six-week-old mountain lion siblings from Ventura County in 2021, and was the cause of morbidity in an ataxic, emaciated 11-month-old mountain lion from Nevada County that was euthanized in July 2022 (J. Rudd, CDFW, pers. comm.). Pathological findings for all three mountain lions demonstrated viral-associated encephalitis.

Highly Pathogenic Avian Influenza (HPAI). Since October 2021, outbreaks of H5N1 HPAI belonging to Eurasian lineage, clade 2.3.4.4 have been detected in wild birds and domestic poultry throughout Europe and North America. The majority of H5 HPAI virus detections in both wild and domestic birds have overlapped with annual fall migration and large aggregations of overwintering waterbirds (Verhagen et al. 2021). In addition to causing disease outbreaks in domestic poultry, currently circulating H5N1 HPAI appears to be persisting in wild bird reservoirs with multiple reports of spillover causing illness (e.g., lethargy, inappetence, neurologic signs) and death in a higher diversity of wild bird species than during previous avian influenza outbreaks, affecting raptors and avian scavengers such as turkey vultures and ravens (APHIS 2023). In the United States, similar illness and death have also been reported in mammals, primarily carnivores, including seals, red foxes (*Vulpes vulpes*), raccoons, striped skunks, coyotes, bears, bobcats, and mountain lions (CDFW 2023b). In California, five mountain lions have been documented to have died from the virus: two from Mono County in December 2022 and January 2023 and three from Modoc County in March 2023 (J. Rudd, CDFW, pers. comm.). Occasionally, wild birds, including waterfowl, can make up a component of the natural diet for mountain lions, and at least three of the mountain lions that died had a history of hunting wild Canada geese (J. Rudd, CDFW, pers. comm.). While infection with H5N1 HPAI is considered uncommon in mammals, there is evidence suggesting that certain mutations in the H5N1 virus may lead to mammal-to-mammal transmission (Foley et al. 2013). Given the five documented H5N1 HPAI-related mortalities in California mountain lions over a four-month period and infections in mammals in general, this is an emerging infectious disease that should be closely monitored so that these mutations can be detected as they may increase the zoonotic potential of H5N1 HPAI viruses.

Other viral diseases. The recent emergence of another coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-II), which causes COVID-19 in humans, is of notable concern to wildlife, including free-ranging and captive felids (Martínez-Hernández et al. 2020, McAloose et al. 2020, Delahay et al. 2021, Giraldo-Ramirez et al. 2021). In 2021, the virus was reported in a captive mountain lion from a Texas zoo with signs of mild upper respiratory infection (e.g., coughing, wheezing);

however, to date, no mountain lions in California have tested positive for SARS-COV-II (J. Rudd and D. Clifford, CDFW, unpublished data).

In 2010, a feline coronavirus (FCV) was implicated as the cause of mortality in an emaciated young adult mountain lion that developed feline infectious peritonitis, a common disease associated with FCV infection (Stephenson et al. 2013).

Detection of other viral diseases in the mountain lion population also includes canine distemper virus (Foley et al. 2013), feline herpesvirus (Foley et al. 2013), gammaherpesvirus (Troyer et al. 2014), J. Rudd, CDFW, unpublished data), feline foamy virus (Kehl et al. 2013, Kechejian et al. 2019), and feline calicivirus (Foley et al. 2013). These pathogens and their associated diseases are not believed to cause significant population level morbidity or mortality.

4.6.2 Bacterial Diseases

Yersinia pestis. *Y. pestis* is the bacterial pathogen that causes plague. Plague exposure, either by flea bites or consumption of infected prey, is common in carnivores, and most species exhibit antibodies in areas where plague is endemic (Salkeld and Stapp 2006). Human plague infection can be acquired from animals, including mountain lions (Wong et al. 2009). The California Department of Public Health and the Department surveyed 92 mountain lion carcasses collected from 2016–2017 and detected *Y. pestis* antibodies in four mountain lions from plague endemic areas of the state—an overall antibody prevalence of 4.3%. The presence of antibodies demonstrates exposure to the pathogen at some time in the past. All four mountain lions, taken under depredation permits, were otherwise healthy on postmortem and histological examination with no evidence of active infection (J. Rudd, CDFW, unpublished data).

Leptospirosis. Leptospirosis is a potentially fatal zoonotic disease. Though there have been reports of exposure to, and infection by, *Leptospira* spp. in domestic cats (Ferris and Andrews 1965, Fenimore et al. 2012, Lapointe et al. 2013, Chan et al. 2014, Weis et al. 2017), there have been few studies of leptospirosis in wild felids. A study of necropsied mountain lions from California showed that 46% (63/136) of tested mountain lions were positive for *Leptospira* spp*.* exposure or infection (Straub et al. 2021). Nephritis (swelling of the nephrons in the kidneys) was a common comorbidity of necropsied mountain lions that had evidence of *Leptospira* spp. exposure or infection; however, nephritis alone was not a significant source of morbidity or mortality.

Other bacterial diseases. Other bacterial parasites that have been detected in the mountain lions include *Bartonella* sp. (Bevins et al. 2012) and *Erlichia equi* (Foley et al. 1999).

4.6.3 Parasitic Diseases

Mange. Notoedric and sarcoptic mange are skin diseases caused by highly contagious parasitic mites. Severe and sometimes fatal mange epidemics from these mites have been described worldwide, and wild felids in California have been infested with the mite *Notoedres cati* (Riley et al. 2007, Serieys et al. 2013). In wildlife, mange causes considerable suffering, predisposing the individual to secondary bacterial infections through open wounds, changes in behavior, emaciation, and death (Maehr et al.

1995, Bornstein et al. 2001, Serieys et al. 2013, Niedringhaus et al. 2019). Mange poses a considerable threat to wildlife species that are more social or have high spatial overlap, which can promote transmission (Rudd et al. 2020). Given mountain lions' largely solitary nature, the potential for disease spread is presumably low.

Other parasitic diseases. Other parasites have been detected in mountain lions including dermatophytosis (A. Herman, pers. comm.), *Toxoplasma gondii (*Bevins et al. 2012*), Trichonella sp.* (Reichard et al. 2016), J. Rudd, CDFW, unpublished data)*, Sarcosystis sp.* (Greiner et al. 1989), and *Clicospirura sp*. (Ferguson et al. 2011). Mortalities associated with these parasites have not been reported in California.

4.7 Wildland Fire and Fire Management

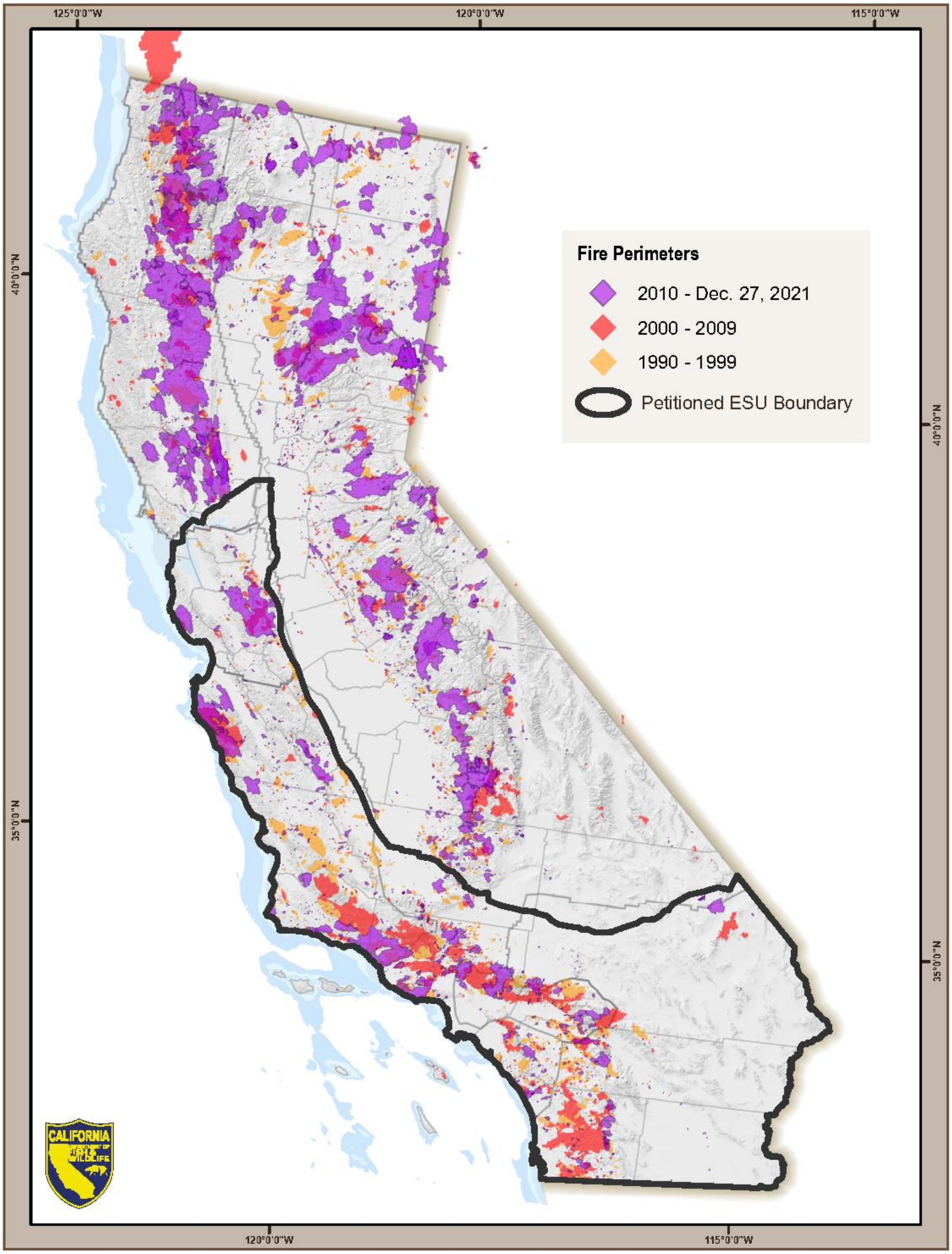
Fire is a natural disturbance in California ecosystems that historically benefitted many native wildlife species by encouraging the regeneration and growth of many plant species and creating landscape heterogeneity (Jennings et al. 2016). However, intense, high-severity burns can significantly disrupt natural ecosystems by changing vegetative and animal species compositions temporarily or long term (Williams et al. 2023). Wildfires in California may cause direct mortality to mountain lions in extreme conditions and result in temporary adverse modification of their habitats, however, deer populations typically respond favorably the resulting regeneration of vegetation.

In California's wildland-urban interface and in many habitats prone to fire, changes in temperature, humidity, and wind patterns attributable to climate change have led to more frequent wildfires that burn larger areas (Syphard et al. 2007, 2009, Jennings et al. 2016). Dennison et al. (2014), reviewing western U.S. fire data from 1984–2011, and Williams et al. (2019), reviewing California data from 1972–2018, reported an eight-fold increase in forest area burned in summer wildfires in the Sierra Nevada, Cascade, and North Coast ecoregions, but did not find significant trends in other ecoregions such as coastal chaparral in southern and central California. However, Jennings et al. (2016) found that fires have become more frequent in the shrubland ecosystems of southern California. Wildfires can also accelerate the impacts of climate change through the emission of short-lived climate pollutants like black carbon (soot) and methane that are tens to thousands of times greater than carbon dioxide (the focus of many greenhouse gas reduction efforts) in terms of warming effect and are responsible for 40% or more of global warming to date (CNRA 2016).

Keeley and Syphard (2021) distinguished fuel-dominated and wind-dominated fires and considered the latter type more dominant in the grasslands, shrublands, and woodlands of California's central and southern coast. They pointed out that wind-dominated fires rely on both an extreme wind event and an (usually human-caused) ignition source. The authors considered the major driver of wind-dominated fire impacts to be more frequent ignitions associated with human population growth and the expansion of residential developments into the wildland-urban interface (Keeley and Syphard 2021). Shifting weather patterns resulting from climate changes have further altered fire regimes in southern California. Climate models predict increasing temperatures and decreasing humidity under future climates (Miller and Schlegel 2006), and strong, dry easterly winds (i.e., Santa Ana winds) may become more frequent and extend into the late fall and early winter when fuel loads are highest and fuel moistures lowest—suggesting extreme fire events will become more frequent in the future (Jennings et al. 2016).

Since 2000, a substantial proportion of the mountains in southwestern California where undeveloped mountain lion habitat remains have burned in wildfires (Fig. 11). Fire-return intervals (the number of years between successive fires in the same location) in southern California shrublands historically ranged from 30–100 years but are now 33% more frequent (Keeley et al. 1999, Lombardo et al. 2009, Safford et al. 2011, Jennings et al. 2016). This shortened interval between fires can interrupt vegetative community successional cycles, reduce plant diversity, favor the establishment of non-native species, and shift shrublands to grass-dominated landscapes (Keeley 2005, Jennings et al. 2016). Jennings et al. (2016) found that fire return frequencies in parts of southern California have increased to the point that the ecosystem is no longer resilient. They warn that if trends continue, mountain lion habitat may be lost as dominant vegetation communities convert to homogenous non-native annual grasslands, which are typically avoided by mountain lions.

The central coast of California has similarly experienced a succession of large, severe wildfires in the last two decades. Major fires in the year 2020 alone included the 160,508 ha (396,624 acres) SCU Complex Fire in the interior of the CC-N MU, the 35,009 ha (86,509 acres) CZU Lightning Complex Fire in the Santa Cruz Mountains, the 50,555 ha (124,924 acres) Dolan Fire in Big Sur, and the 19,461 ha (48,088 acres) River Fire on the eastern slopes of the Santa Lucia Mountains in Monterey County (https://www.fire.ca.gov/incidents/2020). In the central coast region, the annual distribution of fire sizes has trended toward larger fires in the last 75 years, although trends in the frequency of large fires in the same region over the same period are less clear (Keeley and Syphard 2021). Trends in annual area burned differ by responsibility area, with U.S. Forest Service (USFS)-managed areas experiencing an approximately ten-fold increase between 1940–2000, from 5,000 ha/million ha to nearly 50,000 ha/million ha. By contrast, within the California Department of Forestry and Fire Protection (CAL FIRE) responsibility area (largely private lands and state lands), the annual area burned decreased from approximately 15,000 ha/million ha in 1920 to less than 2,000 ha/million ha in 2010 (Keeley and Syphard 2017). Making predictions about future trends in this region is complicated by the interplay between precipitation levels and fuel accumulation. Within the Central Coast zone, projections indicate precipitation levels may increase in the north in coming decades, resulting in less frequent, but high severity fires; while in the south, precipitation is project to decrease, potentially limiting fuel accumulation thereby limiting fire severity, although fires may become more frequent due to prolonged dry periods (Langridge 2018). In the redwood (*Sequoia sempervirens*) forests of the Santa Cruz Mountains, burned areas likely continue to be used by mountain lions as redwoods are adapted to wildfire and trees commonly survive most wildfires and trees that succumb remain standing for decades. Additionally, redwood sprouts and seedlings are prolific following fires, numbering in the tens of thousands per hectare, and canopies develop rapidly (Lazzeri-Aerts and Russell 2014). Consequently, dense cover favored by mountain lions for hunting and travel develops within a few years following severe wildfire. In more xeric forests and shrublands of the CC-N and CC-S, fire effects on mountain lion habitat are similar to those described for southern California.



1494
1495 **Figure 11.** Wildfire perimeters in California by fire year.

While highly mobile mountain lions are likely able to escape most wildfires, quickly moving wind-driven catastrophic wildfires described by Keeley and Syphard (2021) are capable of overtaking fleeing mountain lions. When large fires with multiple heads develop, fleeing wildlife may become trapped between fire fronts (Fig. 12). Vickers et al. (2015) documented one death of a collared mountain lion in the SA and one in the EPR due to human-caused wildfires. The death of a collared mountain lion in the CC-S population found severely emaciated with burned feet following the 2018 Woolsey Fire can reasonably be attributed to wildfire-related injuries. A young lion found with burned paw pads following the 2018 Tomas Fire in the CC-C was treated and placed into captivity. An adult lion found unable to walk due to burned paw pads found in the 2020 Bobcat Fire in the San Gabriel Mountains was cared for and released to live another 10 months before dying of unknown causes. In northern California, one three-month-old male kitten suffering burn injuries to the feet and face from the 2020 Zogg Fire in Shasta County was treated and placed into captivity. The same year, the August Complex Fire in Colusa, Glenn, Mendocino, Tehama, Trinity, and Humboldt counties was likely responsible for the death of one adult female lion and the orphaning of her two kittens which were rescued and placed in captivity (D. Clifford, CDFW, pers. comm.).

Figure 12. Left: Burned paw of female lion F121 (L) with phalanges showing, found deceased following the Bond Fire in Orange County, California. (Phot Credit: Nick Molsberry, CDFW). Right: F121 prior to the fire (Photo Credit: UC Davis Wildlife Health Center).

Additionally, wildfires temporarily displace mountain lions, increasing the distances they move and amount of area they use (Blakey et al. 2022). Their increased movement leads them to cross over roads more often exposing them to vehicle strikes, and brings them in contact with other mountain lions, increasing the chance of intraspecific aggression (Jennings et al. 2016, Blakey et al. 2022). Benson et al. (2019) noted that additional mortalities associated with catastrophic events such as wildfires, disease, or other unpredictable events could substantially increase extinction probabilities for small mountain lion populations.

Research on mountain lions occupying shrub-dominated habitat south of Los Angeles documented that mountain lions can respond opportunistically to burned areas, suggesting that they may benefit in the short-term from fire disturbance (i.e., within 9 years after a fire; Jennings et al. 2016). The overall pattern was greater use of burned areas by mountain lions than would be expected by their availability on the landscape (Ibid.). Additionally, of the 9,598 kill or cache sites analyzed by Jennings et al. (2016), far more than expected were in or near recent burns (≤ 6 years old), likely reflecting intensive use of recent burned areas by mule deer taking advantage of quickly growing fresh forage. Some researchers have speculated that dense, mature chaparral stands may be avoided by mountain lions because they are too dense for their main prey (mule deer) to navigate (Burdett et al. 2010), suggesting periodic disturbance from wildfires may be necessary to sustain lion populations. However, a study in the Santa Monica Mountains and Simi Hills after the 2018 Woolsey fire showed that, in general, mountain lions avoided the burn areas up to 15 months post fire (Blakey et al. 2022). These apparently contradictory results may be attributable to differences in the dominant vegetation communities and differences in burn frequency and severity between study sites.

Traditional fire suppression is evolving into fire management with a greater understanding of its importance in ecosystem health (Keeley and Syphard 2016). Several strategies are employed including prescribed burns and mechanical fuels reduction. Like wildfires themselves, fire management strategies have the potential to benefit or harm mountain lions and their prey. Prescribed fires and mechanical fuels removal lessen the likelihood of catastrophic wildfires, but they can also result in the temporary loss of riparian vegetation and the shrub and tree cover favored by mountain lions.

4.8 Climate Change

Climate change resulting from human-caused impacts (Bedsworth et al. 2018) threatens biodiversity through both direct effects and interrelated indirect threats (Garcia et al. 2014, González-Orozco et al. 2016). A species' vulnerability to the direct effects of climate change is a function of its level of exposure and its sensitivity to such effects mediated by its ability to adapt physiologically or behaviorally (Dawson et al. 2011). Indirect effects of climate change are ecosystem changes that affect organisms—including increased frequency and severity of drought, wildfires, flooding, and landslides—which in turn can lead to shifts in vegetation patterns, changes in habitat quality, and modified predator-prey relationships (Williams et al. 2008, Keeley and Syphard 2016). North America has already experienced climatic effects from increases in greenhouse gas emissions (U.S. Global Change Research Program 2017).

There has been a consistent trend in recent decades of warming temperatures in California. Average state temperatures have increased by about 1.67°C (3°F) (Frankson et al. 2022); four of the warmest years on record occurred in the last decade (OEHHA 2018), and 2021 was the warmest summer on record in the state (Frankson et al. 2022). Climate model projections for annual temperature in California in the 21st century range from 1.5–4.8°C (2.7–8.8°F) greater than the 1960–2005 mean (Bedsworth et al. 2018).

Rises in temperature have not been consistent across California. Rapacciuolo et al. (2014) found that while temperatures generally warmed in California between the historical period (1900–1939) and modern period (1970–2009), increases in mean annual temperature were greatest in southern California, an area roughly corresponding to the extent of the SC genetic group in Gustafson et al. (2022). The mean annual maximum temperature also increased in southern California, while decreasing in much of central and northern California (Rapacciuolo et al. 2014). Projections of future temperature conditions at specific locations in California are available from the State of California's Cal-Adapt program (https://cal-adapt.org/). Table 5 presents results for a representative location in each of the four broad mountain lion genetic cluster areas described in Gustafson et al. (2022) from Cal-Adapt's Local Climate Change Snapshot (https://cal-adapt.org/tools/local-climate-change-snapshot/). Three measures of change in environmental temperature are presented: Annual Average Maximum Air Temperature (AAT_{MAX}), Annual Average Minimum Temperature (AAT_{MIN}), and Number of Extreme Heat Days per Year (EHD)[2]. For each measure, a baseline value modeled from measurements recorded from 1961–1990 is presented, along with modeled future values for the end of the 21st century (2070–2099). Averaged modeled values for the High Emissions scenario (known as Representative Concentration Pathway 8.5)—which most closely tracks current emissions trends—are presented, along with the range of averages from all the model runs. The sites chosen as representative of the broad-scale genetically discernable populations are Willits, CA (NC), Placerville, CA (SN), Atascadero, CA (CC), and Fallbrook, CA (SC). Models for all temperature metrics of the four representative sites suggest substantial warming will occur at the sites during the 21st century.

Table 5. Baseline and projected changes in Annual Average Maximum Temperature (AAT_{MAX}), Annual Average Minimum Temperature (AAT_{MIN}), and Number of Extreme Heat Days (EHD) per Year for four representative sites in the North Coast (NC), Sierra Nevada (SN), Central Coast (CC), and Southern Coast (SC) mountain lion genetic cluster areas identified by Gustafson et al. (2022). Model data are derived from Cal-Adapt's Local Climate Change Snapshot tool, accessed November 2021. The CC cluster incorporates CC-N, CC-C, and CC-S, and the SC cluster is made up of SA, EPR, and SGSB. (For more detail, see Fig. 1.)

[2] AATMAX is calculated as the average of the maximum daily air temperatures recorded at a site over the entire year. AATMIN is likewise calculated as the average of all minimum daily temperatures for the year. The number of extreme heat days per year (EHD) is the modeled number of days when the daily maximum temperature is above a location-specific threshold temperature for the site. The threshold for a site is defined as the 98th percentile value of historical daily maximum temperatures (from 1961–1990, between April and October) observed at the location.

Metric	**Model/Projection Years**	**NC**	**SN**	**CC**	**SC**
AAT_{MAX} (°F)	Modeled Average (1961–1990)	68.4	71.6	71.7	74.6
AAT_{MAX} (°F)	Projected Average (2070–2099)	75.8	80.3	79.3	82.4
AAT_{MAX} (°F)	Projected Range	70.8–78.3	76.8–83.9	76.6–82.7	79.3–85.7
AAT_{MIN} (°F)	Modeled Average (1961–1990)	38.9	47.7	41.9	50.5
AAT_{MIN} (°F)	Projected Average (2070–2099)	46.1	55.7	49.1	58.1
AAT_{MIN} (°F)	Projected Range	42.2–48.7	52.5–58.9	46.4–51.6	55.4–60.5
EHD (Days/Yr)	Modeled Average (1961–1990)	3	3	5	4
EHD (Days/Yr)	Projected Average (2070–2099)	27	53	42	45
EHD (Days/Yr)	Projected Range	2–48	29–79	22–73	24–94

Precipitation change projections are less consistent than those for temperature, but recent studies indicate increasing variability in precipitation in California, with a greater number of "atmospheric river" storms in the valleys and leeward side of mountain ranges and an increased likelihood of extreme drought in other regions of the state primarily due to rising temperatures (Cayan et al. 2005, Williams et al. 2015, OEHHA 2018, Huang et al. 2020). Similar to temperature rises, changes in precipitation and water availability have also not been distributed equally across California. In the past century, southern California experienced a decline in total annual precipitation, while much of central and northern California had an increase in precipitation (Rapacciulo et al. 2014). With increased temperatures and decreased precipitation in southern California, the southern third of the state, including the southern Sierra Nevada, experienced a severe increase in mean climatic water deficit—the amount of water plants would use if it were available in the soil (Ibid.).

Increasing severity and frequency of drought is another consequence of climate change in California. The state recently (2011–2017) experienced the longest drought since the U.S. Drought Monitor began reporting in 2000 (NIDIS 2022*a*) and went through another serious drought from 2020–2022 (Fig. 13; NIDIS 2022b). A recent modeling effort using data on historical droughts indicates the mean state of drought from 2050–2099 in the southwestern U.S., inclusive of California, will likely exceed the Medieval-era megadrought between 1100–1300 CE, under both moderate and high greenhouse gas emissions models (Cook et al. 2015). The probability of a multidecadal (35-year) drought occurring during the late 21st century is greater than 80% in all models (Ibid.). This would represent a climatic shift that not only falls outside of contemporary variability in aridity but also be unprecedented in the past millennium (Ibid.).

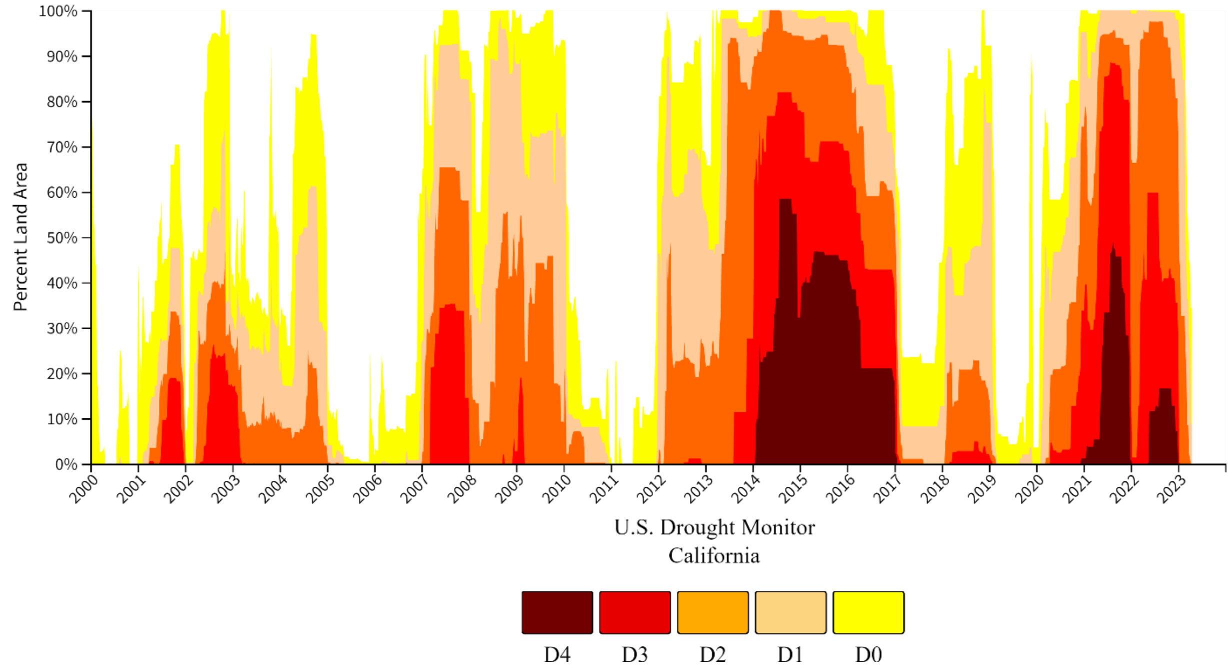


Figure 13. Percent of California land area in each Palmer Drought Index category, Jan 2000–April 2023. DO = Moderately Dry, D1 = Moderate Drought, D2 = Severe Drought, D3 = Extreme Drought, D4 = Exceptional Drought. (Source: NIDIS 2022)

Drought can also exacerbate the effects of other environmental stressors. During the recent severe drought, tree mortality increased dramatically; approximately 129 million trees died in California from 2012–2017 (OEHHA 2018). Multiple years of high temperatures and low precipitation left them weakened and more susceptible to pathogens and parasites (Ibid.). Vast areas of dead and dying trees are also more prone to severe wildfires (CNRA 2016)).

The frequency and extent of wildfire is influenced by temperature, fuel loads, and fuel moisture (Climate Change Science Program 2008). Increasing periods of drought combined with extreme heat and low humidity that stress or kill trees and other vegetation create ideal conditions for wildland fires (Ibid). As temperatures have warmed and snow melts earlier, large-wildfire frequency and duration has increased, and wildfire seasons lengthened (Westerling et al. 2006, OEHHA 2018). The years 2018, 2020, and 2021 were California's biggest recorded fire years, and the 7 largest fires ever recorded in California also occurred during those years (Wikipedia 2023). For more discussion of the impacts of fire on mountain lions, see section 4.7.

Climate change and its impacts on temperature, precipitation, and fire can also result in habitat modifications for wildlife species. Research suggests that most suitable mountain lion habitat in California is moderately vulnerable to climate change (Thorne et al. 2016, Dellinger et al. 2020*a*). Suitable mountain lion habitat could be lost in portions of southern California due to increased frequency and intensity of wildfires that would result in conversion to grasslands, which, as previously stated, are generally avoided by mountain lions (Jennings et al. 2016). Further, aspects of climate change, such as changing drought and wildfire regimes, may impact mountain lions via influences on prey populations.

For example, low rainfall has been found to negatively influence mule deer doe and fawn survival in desert regions of the western U.S., likely because there is less food available (Marshal et al. 2002, Bender et al. 2007, Monteith et al. 2014). With precipitation levels expected to become increasingly variable as the climate continues to change, mountain lion populations could be adversely impacted if there is a reduction in the amount and/or carrying capacity of suitable habitat available to them. Reductions in the area and quality of suitable habitat and carrying capacity could negatively influence gene flow and population sizes.

As large-bodied mammals, both mountain lions and deer may be sufficiently large to not be strongly affected directly by moderate increases in environmental temperature, which more drastically affect small-bodied mammals (Naya et al. 2018, Fuller et al. 2016). The generally nocturnal habits of mountain lions and their prey may mitigate impacts from warmer environments. As mountain lions in California currently occur across a variety of ecoregions and climatic conditions ranging from deserts to montane and coastal forests, broad near-term shifts in their distribution from the direct effects of a warming climate seem unlikely.

4.9 Risks to Small, Isolated Populations

Small, isolated mountain lion populations—such as the CC-N, CC-S, SA, and SGSB, which are each estimated to number ≤ 66 individuals (Table 3)—are inherently vulnerable to extinction due to multiple factors. These factors may include demographic stochasticity[3], genetic drift[4], or inbreeding, which can eventually lead to inbreeding depression[5]. Genetic drift and inbreeding both reduce genetic variation which can diminish the ability of a population to respond to changes in the environment (Primack 1993, Reed and Frankham 2003).

4.9.1 Demographic and Environmental Stochasticity

Reproduction and survival rates vary among individuals and between years in wildlife populations. This variation leads to demographic stochasticity, which tends to average out in large populations but has a much greater effect on the rate of growth or decline in small populations. If a small population declines, subsequent generations become even more susceptible to demographic stochasticity. Unpredictable changes in the natural environment can cause the size of small populations to vary dramatically while larger, more widely distributed populations would remain more stable because these changes normally occur only in localized areas of the entire population’s geographic range (Primack 1993). For example, changes in the vegetation community, abundance of resources, or disease and parasite exposure can

[3] Population changes resulting from random variation in birth and death.

[4] The variation in the relative frequency of different genotypes (allele frequencies) in a small population, resulting from the chance disappearance of particular genes as individuals die or do not reproduce.

[5] Reduced biological fitness (health and fertility) resulting from the concentration of deleterious alleles in the population from the mating of closely related individuals.

cause the size of small, isolated populations to fluctuate wildly, possibly leading to local extinction (Primack 1993). Additionally, natural disasters such as droughts, fires, and severe storms can lead to dramatic population changes such that the disaster impacts most or all individuals in small populations. As populations get smaller, they become more vulnerable to demographic variation, environmental variation, genetic drift, and inbreeding depression. Each of these effects can amplify the impact of the other effects, further reducing population size and accelerating local extinction in what has been termed an extinction vortex (Primack 1993).

While the statewide population of mountain lions is large enough that demographic and environmental stochasticity is unlikely to be an issue, the smaller and more isolated populations (CC-N, CC-S, SA and SGSB) are potentially vulnerable to its impacts. Of specific concern are the increasingly large and severe fires leading to direct death or injury (see section 4.7). For example, the Woolsey Fire in 2018 burnt about 36,800 ha (91,000 acres) in the center and west of the Santa Monica Mountains Recreation Area (in the CC-S). According to the National Park Service, two of the 13 mountain lions with working radio-collars in and around the Santa Monica Mountains at the time of the Woolsey Fire succumbed to the fire or its impacts (NPS 2023). In such a small population (Table 3), the impact of just one event like the Woolsey Fire on the population could be strong, especially if the dead animals were breeding adults.

4.9.2 Inbreeding and Genetic Drift

Inbreeding and genetic drift can both result in decreased genetic variation in wildlife populations. Deleterious alleles (maladaptive genes) can be present at low frequency in even large, healthy populations. As populations become small, these maladaptive genes can increase in frequency, and populations may suffer the effects of inbreeding depression, resulting in offspring with a reduced ability to survive and reproduce (Frankham 2005, Harding et al. 2016). Genetic drift may also lead to the loss of beneficial alleles or the fixation of detrimental alleles in a small population due to a limited breeding pool (Hedrick and Kalinowski 2000). Detrimental fixed alleles can result in decreased fitness for all individuals and lead to population declines (Hedrick and Kalinowski 2000, Frankham 2005)

Multiple genetic studies have shown that certain mountain lion populations along the southern coast of California have particularly low genetic variation (Ernest et al. 2003, Gustafson et al. 2019, 2022) which may be the result of habitat fragmentation and genetic isolation. Analysis at the fine scale (10 genetic clusters) conducted by Gustafson et al. (2022) (called linkage decay analysis) showed evidence of inbreeding between closely related[6] individuals in at least four of the populations (see details in section 4.9.4 below). Saremi et al. (2019) investigated mountain lion genomes and found additional evidence of recent inbreeding among closely related individuals (i.e., runs of homozygosity) in some central and southern California populations.

However, the results of Gustafson et al. (2022) suggest the problems of inbreeding and homozygosity are not universal throughout California. Several California populations (e.g., Sierra Nevada) display little

[6] "A common ancestor less than three generations ago" (Saremi et al. 2019) i.e., first-cousins or closer

evidence of inbreeding (see section 4.9.4 below for details). Additionally, the analysis of genetic variation in the broad-scale groups suggests there is potential for the genetic variation remaining in the broad-scale groups to reduce the impacts of inbreeding depression in many of the fine-scale groups to negligible levels if gene flow can be enhanced. This finding also aligns with the results of Saremi et al. (2019) that indicated even though inbreeding had reduced variation in a considerable proportion of the genomes of individual mountain lions, these low-heterozygosity genome regions were generally not shared between populations. This suggests genetic restoration is possible even among genetically depauperate populations. When considering that genetic variation is high in multiple California populations when compared to a limited number of populations along the central and southern coasts, there is potential for long-term persistence of mountain lions throughout much of the state if adequate habitat can be protected and if habitat connectivity can be restored and/or enhanced in key locations.

4.9.3 Loss of Genetic Variation

The genetic variation of wildlife populations is fundamental to their risk of extinction—high levels of genetic variation have been shown to be positively correlated with survival and reproduction rates and decreased extinction risk (Hedrick and Kalinowski 2000, Reed and Frankham 2003). The concept of effective population size[7] (N_e) is fundamental to conservation genetics as it impacts the rate at which a population will lose genetic variation through genetic drift or inbreeding. Though N_e is determined by several factors, it is generally significantly less than the census population (i.e., the number of animals actually breeding in a population is usually significantly fewer than the total number of animals in the population; Palstra and Ruzzante 2008). The estimated statewide census mountain lion population size is 3,242 (95% CI 2,826-3,742) animals (CDFW Unpublished data), however, the estimated N_e of the 10 genetic clusters is approximately 483 (427.9–549.1) animals, which includes mountain lions from parts of Nevada (Gustafson et al. 2019) making the estimated N_e at least 8–12 times smaller than the census population. Furthermore, the population estimates of all but one of the fine-scale genetic clusters identified by Gustafson et al. (2019) are far below the several hundred reproductive individuals experts theorize are required to ensure long-term population viability (Traill et al. 2007, 2010, Flather et al. 2011), with several thousand individuals being the goal (Primack 1993). Observations of wild populations indicate that it is possible for small populations to persist, at least in the short term, in the face of low genetic variation; however, this does not imply that small populations will ultimately maintain long-term viability (Harding et al. 2016).

Gustafson et al. (2022) found that among the 10 fine-scale genetic populations, only the WSN had an estimated $N_e \geq 50$. An N_e above 50 is a long-standing, though controversial, threshold for whether a population is at risk of extinction via the harmful effects of inbreeding depression on demography (Franklin 1980). Yet, true extinction risk is often the result of the complicated interaction of both genetic and demographic factors. Recent analyses reveal that anywhere from 792,300–1,59,100 ha (1,957,816–

[7] The number of individuals in a population that are contributing to the next generation (i.e., reproducing and passing on their genes).

3,605,515 acres) of well-connected suitable habitat might be necessary to allow mountain lions to maintain an $N_e \geq 50$ (Dellinger et al. 2020*b*). Currently, five of the six Management Units in the petitioned ESU occupy areas with less suitable habitat than the thresholds mentioned above, suggesting long-term viability of mountain lions in these areas may be reduced unless management actions increase connectivity and/or habitat availability.

An important metric of genetic variation is heterozygosity (H_E)[8]. Adequate genetic variation is important for maintaining evolutionary potential, as this variation is the raw material that allows populations to adapt to changing conditions over generations. The amount of heterozygosity in California lion populations is highly variable (Gustafson et al. 2019; range of H_E = 0.33–0.53; based on microsatellite loci) but lower on average than other western states, including Wyoming, Nevada, Arizona, Utah, Colorado, and New Mexico (range of H_E = 0.49–0.59; (Anderson et al. 2004, McRae et al. 2005, Andreasen et al. 2012) Unlike California, these other states show less population genetic structure due to higher rates of gene flow, which in turn counteracts the effect of genetic drift in reducing heterozygosity (Anderson et al. 2004, McRae et al. 2005). The lower overall heterozygosity, as well as the large variance in heterozygosity among local populations, observed in California is most likely driven by the state's unique landscape and compounded by contemporary patterns of urban and transportation development (Ernest et al. 2003, Gustafson et al. 2019, 2022).

Gustafson et al. (2022) found that among the four broad-scale populations, California mountain lions have retained substantial heterozygosity, particularly in the Sierra Nevada region with its large stretches of undeveloped contiguous habitat (Dellinger et al. 2020*b*). Multiple genetic investigations have now demonstrated the importance of the Sierra Nevada region as a reservoir of genetic variation (Ernest et al. 2003, Gustafson et al. 2019). Bi-directional migration rate models based on genetic data indicated the WSN population serves as a significant source of migrants into other regions of California, importantly the EPR, CC-N, and SGSB (Fig. 1; Gustafson et al. 2019).

A population bottleneck is an event that greatly reduces the size of a population, and these events can have significant impacts on genetic variation as the resulting reduction in N_e increases both the strength of genetic drift and the probability of inbreeding among closely related individuals. Gustafson et al. (2019) found all of the fine-scale genetic populations appear to have gone through genetic bottlenecks within the last $2N_e$–$4N_e$ generations, except for the Modoc Plateau and North Coast. Assuming a mountain lion generation time of 5 years (Saremi et al. 2019), this suggests that the genetic populations with smaller N_e could have experienced bottlenecks within the last few decades, a timeframe consistent with anthropogenic effects. However, for some of the larger, more genetically diverse populations, interpretation of the potential cause of the genetic bottleneck event becomes more challenging (e.g., WSN bottleneck within the past 1,560–3,120 years). Large variance in the estimates of time-since-bottleneck suggest demographic declines of mountain lions in California cannot be associated with any one event or period, and the biological meaning of these findings should be interpreted cautiously.

[8] Heterozygosity refers to having inherited two different alleles for a particular trait compared to homozygosity, in which the inherited alleles are identical at a given location of the genome.

Gustafson et al. (2022) found no evidence for local adaptive differences among the four broad-scale geographic mountain lion populations (i.e., best-supported model of population structure). Though the appropriateness of using reduced representation genome sequencing data (in this case, restriction site-associated DNA sequencing data) to detect local adaptation has been questioned within the scientific literature (Lowry et al. 2017), this approach has been employed successfully in other studies (Catchen et al. 2017). Mountain lions are long-distance dispersers and inhabit all major mountain ranges in California (Dellinger et al. 2020*b*) suggesting local adaptation may be unlikely. The results of Gustafson et al. (2022) provide no evidence for locally adapted ecotypes warranting specific conservation status, nor risk of outbreeding depression resulting from the mixing of genetic populations as a result of active management (e.g. translocations) (Frankham et al. 2011). However, some unique alleles were identified in the SC genetic group which should be conserved to help preserve statewide genetic variation (Gustafson et al. 2022).

While genetic risks may significantly increase a small population's risk of extinction, it is important to note that a small population size alone is not necessarily predictive of reduced population viability. Implementation of a well-planned conservation strategy can substantially mitigate risks associated with small populations. A comprehensive plan for long term viability should include the principles of representation, resiliency, and redundancy (Shaffer and Stein 2000, Wolf et al. 2015).

4.9.4 Genetic Impacts on the Petitioned ESU and Related Management Units

Genetic variation within the petitioned ESU is highly variable. The analysis of genome-wide single-nucleotide polymorphisms conducted by Gustafson et al. (2022) elucidates evidence of retained genetic variation within California mountain lion genetic groups. Some of the four broad-scale genetic populations identified by the authors (figure 4) have relatively low genetic variation, while others have retained sufficient variation to be capable of serving as sources of genetic rescue under various management scenarios (i.e., assisted gene flow). Maintaining and enhancing connectivity within and among broad-scale groups, particularly with the SN and the CC, has the potential to counteract the effects of genetic drift and inbreeding to at-risk coastal populations. Gustafson et al. (2022) also found the broad-scale SC population shares little gene flow with other regions and yet has higher genetic variation and more unique alleles than the CC or NC broad-scale populations. Whether this variation is adaptive is unknown, but as a principle of biological conservation, genetic variation should be conserved to maximize genetic diversity in populations.

Sierra Nevada Group. This population is of critical importance to sustaining statewide gene flow as it is located at the intersection of dispersal corridors connecting the SN, CC, and SC groups. Enhancing connectivity through the Transverse Ranges including the Tehachapi, Sierra Pelona, San Gabriel, and San Bernardino mountains, represents a critical conservation priority.

Central Coast Group. The three management units of the CC group vary significantly in their levels of genetic variation. The CC-N and CC-S Management Units have low estimated N_e (CC-N: 15.1–18.2; CC-S: 2.5–2.9), limited habitat to retain a self-sustaining population of mountain lions (Gustafson et al. 2019, Dellinger et al. 2020b), and represent areas of genetic management concern. The analysis conducted by

Gustafson et al. (2022) in the CC-S and CC-N showed evidence of close inbreeding (note: the genetic clusters identified in Gustafson et al.'s 2022 report are not precisely analogous to the 10 genetic clusters identified in Gustafson et al. 2019). This finding is consistent with the whole genome sequencing results of Saremi et al. (2019) from the Santa Cruz and Santa Monica mountains which suggested close and recent inbreeding led to runs of homozygosity in the lion genomes.

The CC-S MU especially appears to have very low genetic variation and is exhibiting both genetic and phenotypic evidence of inbreeding (Ernest et al. 2014, Riley et al. 2014, Benson et al. 2019, Gustafson et al. 2019). This MU is one of two (see SA MU below) to have the lowest genetic variation observed for the species globally, apart from the endangered Florida panther (Riley et al. 2014). Phenotypic evidence of inbreeding depression in the form of kinked tails, failed descension of the testes, and abnormal sperm morphology have been observed, similar to Florida panthers (Huffmeyer et al. 2022, Ernest et al. 2014, Roelke et al. 1993). Freeway traffic is isolating the CC-S mountain lions (Ernest et al. 2014, Riley et al. 2014, Vickers et al. 2015), and contemporary gene flow has been severely limited. Projection models predict the extirpation of the CC-S population in 50 years without enhanced demographic dispersal and gene flow (Benson et al. 2016, 2019).

Conversely, the CC-C MU has ample habitat for maintaining a breeding population, a relatively large, estimated population size and exhibits little evidence of inbreeding (Dellinger et al. 2020b, 2021a, Gustafson et al. 2022). Bi-directional migration rate models indicate the CC-C serves as a significant source of migrants for the adjacent and more isolated areas of coastal California, including the Santa Cruz and Santa Monica mountains (Gustafson et al. 2019). This indicates that the CC-C will likely play a key role in efforts to increase connectivity and gene flow within the CC group in the petitioned ESU (Figs. 1,3). Given the apparent absence of gene flow across the Central Valley, this MU may be the only consistent source of migrants for CC-N and CC- S. Thus, maintaining connectivity to and within the CC-C MU is essential for the long-term viability of both adjacent MUs.

South Coast Group. The South Coast Group is comprised of 3 MUs: Santa Ana Mountains (SA), Eastern Peninsular Range (EPR), and the San Gabriel/San Bernardino ranges (SGSB). The SGSB Management Unit, in the South Coast group, has low observed genetic variation, a very small, estimated N_e (3.3–6.4 mountain lions), and exhibits evidence of inbreeding (Gustafson et al. 2019, 2022). Additionally, the SGSB mountain lions occupy small, isolated mountain ranges separated by urbanized areas and desert containing little shrub or tree cover which increases their risk for inbreeding depression (Gustafson et al. 2019). The area has a small amount of available suitable habitat and thus cannot support a large lion population (Dellinger et al. 2020b).

The SA MU has concerningly low genetic variation (Gustafson et al. 2019) and habitat availability (Dellinger et al. 2020b). The SA is the other MU to have the lowest genetic variation of any mountain lion population other than Florida panthers (Riley et al. 2014). Like the CC-S MU, genetic and phenotypic evidence of inbreeding depression in the form of kinked tails has been observed in the SA MU (Roelke et al. 1993, Ernest et al. 2014, Gustafson et al. 2022). Also, as with CC-S, the main isolation factor appears to be the freeways, which have limited gene flow in recent decades (Ernest et al. 2014, Riley et al. 2014, Vickers et al. 2015), and models similarly predict this population will be extinct in 50 years without intervention (Benson et al. 2016, 2019).

The EPR MU, on the other hand, shows little evidence of inbreeding and appears to have retained sufficient variation as to be capable of serving as a source of genetic rescue (Gustafson et al. 2019, 2022). Like the CC-C in the CC group, the EPR could perform an important role in increasing connectivity and gene flow in the SC group if connectivity is improved (Figs. 1,3). The EPR is the only MU known to exchange migrants with the SA MU, and management actions which enhance gene flow between these areas remain critical to the viability of the mountain lion population in the Santa Ana Mountains. Gene flow between EPR and the adjacent SGSB MUs appears limited. Further, the degree of dispersal from Arizona, Nevada, Mexico remains unknown (Gustafson et al. 2019). Connectivity between these MUs and adjacent populations in Mexico and Arizona may be curtailed by border barriers and the damming and major channelization of the Colorado River. Immigration and emigration patterns of mountain lions in the eastern area of the EPR have not been studied, and mountain lion density may be low in that area. Some gene flow may occur across the Colorado River from the Kofa National Wildlife Refuge into California, and some movement of mountain lions has been documented between the EPR and Mexico (Vickers et al. 2015; W. Vickers, unpublished data).

In summary, the recent results of Gustafson et al. (2022) demonstrate that genetically at-risk populations are nested within a broader-scale group of interconnected populations that collectively retain high genetic variation. This suggests that if connectivity can be maintained and enhanced at the broader scale, genetic variation within smaller MUs can be restored.

5. EXISTING MANAGEMENT

5.1 Land Ownership within the Petitioned Central Coast/Southern California ESU

Based on a GIS analysis of the petitioned ESU boundary, the total area is 15,273,700 ha (37,742,134 acres) (Table 6). Approximately 52% of that amount is public land and 48% is private. The Bureau of Land Management (BLM) owns the largest amount of land at 21%, followed by the U.S. Forest Service (9%), the National Park Service (6%), the Department of Defense (5%), and the California Department of Parks and Recreation (3%). Local (city or county) and Nonprofit Special Districts combined are 4% of the government agencies, while tribal lands total 167,700 ha (414,396 acres), which is 1% of the non-private land within the petitioned ESU (Table 6, Fig. 14).

Public (and private) lands are managed for many different purposes including recreation, extractive uses (timber harvest and mining), grazing, and wildlife habitat. Thus, a property's management would not necessarily benefit mountain lions, and many lands—particularly BLM lands in desert regions—likely support low densities of mountain lions.

Table 6. Land ownership within the petitioned Southern California/Central Coast ESU and the percentage of total land and public land in the petitioned ESU.

Land Ownership within Petitioned Evolutionarily Significant Unit	**Hectares**	**Acres**	**% of total land**	**% of public land**
Total Public Land	7,905,421	19,534,644	51.8%	—
Total Private Land	7,368,327	18,207,458	48.2%	—
[redacted]				
U.S. Bureau of Land Management	3,183,887	7,867,525	20.8%	40.3%
U.S. Forest Service	1,430,387	3,534,548	9.4%	18.1%
U.S. National Park Service	928,264	2,293,781	6.1%	11.7%
U.S. Department of Defense and Camp Roberts	781,100	1,930,132	5.1%	9.9%
California Department of Parks and Recreation	435,636	1,076,476	2.9%	5.5%
Nonprofit, Special District, and Joint	383,076	946,597	2.5%	4.8%
Local (City or County)	231,070	570,984	1.5%	2.9%
Tribal Land	168,135	415,469	1.1%	2.1%
California Department of Fish and Wildlife	111,462	275,428	0.7%	1.4%
California State Lands Commission	97,683	241,379	0.6%	1.2%
U.S. Bureau of Reclamation	57,731	142,656	0.4%	0.7%
U.S. Fish and Wildlife Service	39,090	96,594	0.3%	0.5%
Other State	32,864	81,207	0.2%	0.4%
California Department of Water Resources	15,183	37,518	0.1%	0.2%
Other Federal	9,853	24,348	0.06%	0.1%

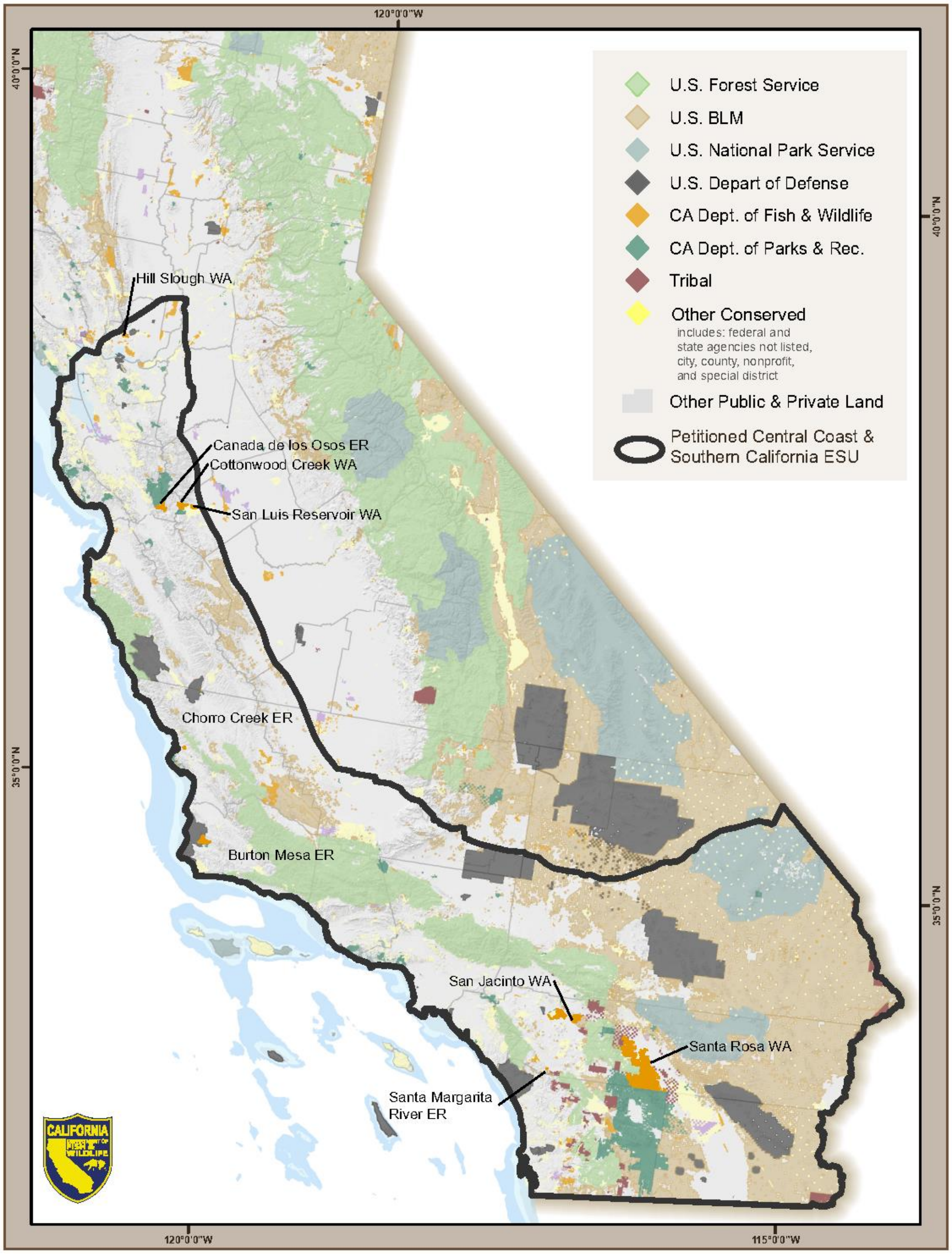


Figure 14. Public and tribal lands within the petitioned Southern California/Central Coast ESU for mountain lions with larger Department Wildlife Areas and Ecological Reserves labeled.

5.2 California Wildlife Protection Act

California voters through Proposition 117 adopted the California Wildlife Protection Act (CWPA) of 1990. Among other things, the CWPA specifically called out the loss of deer, mountain lion, and other wildlife habitat within California's mountain ranges and foothills, including the Simi Hills, and the Santa Lucia, Santa Susana, Santa Monica, San Gabriel, San Bernardino, San Jacinto, and Santa Ana mountains in southern California as well as the need to preserve habitat corridors to maintain the genetic integrity of California's wildlife. The CWPA, through the establishment of the Habitat Conservation Fund, included an ongoing annual appropriation of $14,500,000 for the acquisitions of deer and lion habitat in those areas. More generally, the CWPA emphasized the use of funds to acquire habitat needed to maintain connectivity between isolated or fragmented habitats to promote the genetic integrity of wildlife populations. The act also designated mountain lions as specially protected mammals and prohibited their taking, injury, possession or sale, except for instances where a lion represents an imminent threat to public safety or has damaged livestock or other property damage.

5.3 State, Federal, and Local Land Planning and Land Use Laws

The laws and regulations governing actions within the mountain lion's range vary by ownership. Several state and federal environmental laws apply to activities undertaken in California, and while they may not specifically address mountain lions, may indirectly provide some level of protection for the species and its habitat. The primary environmental laws are summarized below.

5.3.1 California Environmental Quality Act (CEQA)

The California Environmental Quality Act (CEQA) requires state and local agencies to identify, analyze, and consider alternatives to, and to publicly disclose environmental impacts from, projects over which they have discretionary authority (Pub. Resources Code § 21000 et seq.). CEQA requires an agency find that projects may have a significant adverse effect on the environment if they have the potential to substantially reduce the habitat, decrease the number, or restrict the range of any rare, threatened, or endangered species (Cal. Code Regs., tit. 14, §§ 15065(a)(1), 15380). CEQA establishes a duty for public agencies to avoid or minimize such potentially significant adverse effects where feasible (Cal. Code Regs., tit. 14, § 15021), and it differs substantially from NEPA in requiring potentially significant adverse effects be mitigated to a less than significant level unless overriding considerations are documented. In practice, implementation of CEQA by state and local governing bodies typically results in projects incorporating impact avoidance, minimization, and mitigation measures into project design and construction. A lead agency is not required to make a mandatory finding of significance conclusion for a project unless it determines on a project-specific basis that 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*;* or substantially reduce the number or restrict the range of an endangered, rare or threatened species. Under CEQA, a lead agency should identify and evaluate potential impacts to mountain lions, and if the impacts are found to be significant, mitigate or justify them under the Biological Resources section of an environmental document prepared pursuant to CEQA.

Another important component of CEQA is the requirement that governing bodies disclose and consider project-related impacts that when considered alone may not be significant, but when viewed in concert with other past, present, and foreseeable related projects cumulatively results in a significant impact to the environment (i.e., cumulative impacts; Cal. Code Regs., tit. 14, § 15355). This requirement often results in the incorporation of wildlife movement corridors in local development and infrastructure projects (e.g., open space setbacks along stream corridors and property lines) which can provide opportunities for mountain lions to pass through urban and suburban landscape, although such corridors not always wide enough or vegetated with adequate shrub and tree cover to encourage use by mountain lions.

Section 21080.5 of the Public Resources Code provides that a regulatory program of a state agency shall be certified by the Secretary for Resources as being exempt from the requirements for preparing EIRs, negative declarations, and initial studies if the Secretary finds that the program meets the criteria of CEQA. A certified regulatory program (CRP) remains subject to other provisions in CEQA such as the policy of avoiding significant adverse effects on the environment where feasible. These CRPs include the regulation of timber harvest by CAL FIRE and the State Board of Forestry through the Forest Practice Act; the regulation of coastal development permits by the California Coastal Commission through the California Coastal Act of 1976, Division 20 (commencing with Section 30000) of the Public Resources Code and the preparation, approval, and certification of local coastal programs as provided in Sections 30500 through 30522 of the Public Resources Code; and the pesticide regulatory program administered by the Department of Pesticide Regulation and county agricultural commissioners. While these CRPs are exempt from some of the procedural requirements of CEQA, courts have consistently held that they remain subject to the broad policy goals and substantive standards of CEQA, including requirements to consider feasible alternatives and cumulative impacts and to recirculate environmental review documents in certain circumstances.

5.3.2 Z'Berg–Nejedley Forest Practice Act

The Z'Berg–Nejedley Forest Practice Act was originally enacted in 1973 to ensure that forest practices, including timber harvesting, are undertaken in a manner that will also preserve and protect California's fish, wildlife, forests, and streams. CAL FIRE disseminates regulations, known as the Forest Practice Rules, that support the statutes of the Forest Practice Act. The Forest Practice Rules implement the provisions of the Act in a manner consistent with other laws, including CEQA, Porter-Cologne, CESA, and the Timberland Productivity Act of 1982. CAL FIRE enforces these laws and regulations governing logging on private land. The only area within the petitioned ESU where commercial timber harvest commonly occurs is the redwood forest zone of Santa Cruz County and nearby minor areas of San Mateo and Santa Clara counties (CDTFA 2021).

5.3.3 Natural Community Conservation Plans and Habitat Conservation Plans

Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs) are federally and state authorized conservation plans that permit incidental take of species listed under the federal Endangered Species Act (ESA) or CESA, respectively. Take authorization may be applied to species not currently listed but which may become listed as threatened or endangered over the term of the plan, which is often 25–75 years. Non-federal entities can obtain authorization for federally threatened and endangered species incidental to otherwise lawful activities through development and implementation of an HCP pursuant to Section 10 of the ESA. California's companion law, the Natural Community Conservation Planning Act of 1991, takes a broader approach than either CESA or ESA. An NCCP identifies and provides for the protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. There are currently four HCPs in California that include mountain lions as a covered species; all four are also NCCPs, but only three include mountain lion as a covered species.

The 1998 San Diego Multiple Species Conservation Program (MSCP) is a 50-year NCCP/HCP that covers 233,099 ha (576,000 acres) in the southwestern portion of San Diego County and includes mountain lion as a covered species. The Program includes coverage for mountain lions as 81% of the core areas (± 42,492 ha, ± 105,000 acres) that will be conserved contain lion habitat, and the core areas have multiple connections to help maintain ecosystem balance. While the MSCP generally notes linkage areas were designed to accommodate "large animal movement," it does not identify linkages designed for mountain lions or contain specific measures designed to protect them. While the MSCP addresses specific design criteria for linkages and road crossings/under crossings are included in subarea plans, not all subarea plans are complete.

The San Diego Water Authority NCCP/HCP also includes mountain lion as a covered species. The Plan Area encompasses 401,448 ha (992,000 acres) in western San Diego and southwestern Riverside counties. The plan estimates that approximately 139 ha (344 acres) of potential mountain lion habitat could be impacted over the 55-year permit term with approximately 284 ha (702 acres) of potentially suitable habitat provided within the existing Preserve Area. The plan includes general conditions to avoid and minimize impacts to habitat linkages and wildlife movement corridors and includes habitat-based mitigation for unavoidable impacts.

The Orange County Transportation Authority NCCP/HCP (OCTA Plan) lists the mountain lion as a covered species for purposes of the federal HCP, but not for purposes of the NCCP permit. The OCTA Plan contains four "Species Goals" intended to offset impacts to mountain lions, including (1) acquiring 410 ha (1,013 acres) of suitable habitat; (2) realigning fencing near the Highway 241 toll road; (3) funding of the North Coal Canyon Restoration Project; and (4) a "wildlife crossing policy" requiring pre-construction surveys to ensure existing crossings "maintain or improve functionality" if modified by new freeway projects. However, the OCTA Plan does not require the construction of specific wildlife crossings.

A Western Riverside County Multiple Species HCP/NCCP, which covers approximately 510,227 ha (1,260,800 acres) in western Riverside County and proposes to set aside 202,343 ha (500,000 acres) for habitat, also lists the mountain lion as a covered species. Plan implementation is expected to result in the loss of 53,418 ha (132,000 acres) of suitable mountain lion habitat and includes three biological objectives to mitigate these impacts related to the Conservation Area, Conservation Area Linkages, and maintaining or improving dispersal route functionality.

5.3.4 National Environmental Policy Act

Most federal land management actions must undergo National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. § 4321, et seq.) analysis. NEPA requires federal agencies to document, consider alternatives, and disclose to the public the impacts of major federal actions and decisions that may significantly impact the environment. The Department is not aware that the mountain lion is afforded any federal special status, and as such, impacts on the species are not required to be considered during NEPA analysis. The law directs federal agencies to adopt all practical means to minimize or mitigate adverse effects when selecting preferred alternatives or justify not doing so.

There are three local ordinances within the petitioned ESU that are relevant to mountain lions.

5.3.5 Ventura County Habitat Connectivity and Wildlife Movement Ordinances

A Ventura County Wildlife Connectivity Ordinance was adopted by the Ventura County Board of Supervisors in 2019 (the "Connectivity Ordinance") to facilitate wildlife connectivity and minimize habitat fragmentation for mountain lions, mule deer, California gnatcatchers (*Polioptila californica)*, bobcats, least Bell's vireos (*Vireo bellii pusillus)*, California red-legged frogs (*Rana draytonii)*, and other species. Two of the linkages targeted in the Connectivity Ordinance are the Santa Monica Mountains—Sierra Madre Mountains connection and the Sierra Madre Mountains—Castaic Connection, which connect wildlife habitat in the Santa Monica Mountains, Santa Susana Mountains, Simi Hills, and Los Padres National Forest. While implementation of the Connectivity Ordinance should help allow wildlife to move more easily through private lands between core habitat areas, it would not address connectivity across major roads and highways which is outside its jurisdiction (https://vcrma.org/habitat-connectivity-and-wildlife-movement-corridors).

5.3.6 Los Angeles County Significant Ecological Areas Plan

The Los Angeles County Significant Ecological Areas Program is currently in the process of updating its Significant Ecological Areas (SEAs) Ordinance. The draft ordinance is intended to protect biodiversity in SEAs from incompatible development and ensure that projects reduce habitat fragmentation and edge effects by providing technical review of impacts and requiring mitigation. Like the Ventura County ordinance, the SEAs designations can lead to compact development and allow wildlife to move across private lands more easily between core habitat areas. However, the SEA ordinance is not specifically designed to protect mountain lions (https://planning.lacounty.gov/long-range-planning/significant-ecological-areas-program/).

5.3.7 City of Los Angeles Draft Wildlife Ordinance

The City of Los Angeles Department of City Planning has developed draft regulations for the protection of wildlife within the city limits, including the promotion of wildlife movement corridors. One stated goal of the draft regulations is to improve wildlife mobility and connectivity opportunities along waterways, ridgelines, and natural open spaces. The Wildlife Pilot Study is intended to result in regulations that will help to preserve wildlife and promote habitat connectivity on small to medium size residential developments in a pilot study area in the Santa Monica Mountains between the 405 and 101 freeways (LACP 2023).

5.4 Management on Federal Lands

5.4.1 National Forest and Bureau of Land Management Resource Management Plans

The U.S. Department of Agriculture's Forest Service is responsible for developing forest management plans consistent with the National Forest Management Act requirements. These plans guide land use and development within national forests and grasslands in a way that balances use and protection of natural resources to support ecological, social, and economic sustainability. Within the petitioned Southern California/Central Coast ESU, the USFS has adopted Forest Management Plans for the Los Padres, Angeles, San Bernardino, and Cleveland National Forests. These plans identify conservation strategies for mountain lion related to land acquisition, preventing habitat fragmentation, monitoring, and fire management.

The U.S. Department of Interior's Bureau of Land Management prepares Resource Management Plans to provide broad-scale direction for managing public lands in accordance with the principles of multiple use and sustained yield, as mandated by the Federal Land Policy and Management Act. These plans establish goals, objectives, and decisions for air quality, biological resources, cultural resources, lands with wilderness characteristics, paleontological resources, visual resources, water resources, fire ecology and management, trail and travel management, lands and realty, land use authorizations, livestock grazing, minerals management, recreation and visitor services, and areas of critical environmental concern. Within the petitioned Southern California/Central Coast ESU, adopted BLM plans include the Southern Diablo Mountain Range, the central coast of California, the Carrizo Plain National Monument RMP, the Clear Creek RMP, the South Coast RMP, the West Mojave RMP, the Eastern San Diego County RMP, the Santa Rosa and San Jacinto Mountains National Monument RMP, the Northern and Eastern Colorado Desert Coordinated Management Plan, and the Desert Renewable Energy Conservation Plan. While these plans may not specifically address mountain lions, they aim to balance resource conservation and ecosystem health with commodity production and public use of the land and may indirectly provide some level of protection for mountain lions and their habitat.

5.4.2 Military Bases

The Sikes Act was established in 1960 to ensure conservation and protection of natural resources used by the Department of Defense. The U.S. Congress amended the Sikes Act in 1997 requiring the Department of Defense to develop and implement Integrated Natural Resources Management Plans. These plans outline how each military installation will manage its significant natural resources holistically while maintaining military readiness. Since these lands are often protected from access and use by the public, they may contain some of the more significant remaining large tracts of undeveloped land and thus be an important tool for species conservation and habitat connectivity. Military bases within the petitioned Southern California/Central Coast ESU include Fort Hunter Liggett, Camp Roberts, Camp San Luis Obispo, Vandenberg Space Force Base, Marine Corps Base Camp Pendleton, Naval Weapons Station Seal Beach, March Air Reserve Base, Marine Corps Air Station Miramar, Naval Air Facility El Centro, Chocolate Mountain Aerial Gunnery Range, and other installations.

5.4.3 National Recreation Areas, National Monuments, and National Preserves

The guiding principles for managing biological resources on the U.S. Department of the Interior's National Park Service lands include maintenance of animal populations native to park ecosystems (NPS 2006). The NPS also commits to work with other land managers on regional scientific and planning efforts. NPS management plans provide direction and guidance on a variety of issues including resource preservation, visitor use, development, and boundary management. These plans generally specify management objectives and may vary in the type of plan, ranging from a general management plan to wilderness plans to strategic facility investment plans. For example, the Santa Monica Mountains National Recreation Area General Management Plan (GMP) provides a framework for the area's management, administered by the National Park Service, California State Parks, and the Santa Monica Mountains Conservancy. The GMP includes mountain lions as a "park species of concern" and includes construction best management practices, facility siting, fire management, vegetation, and habitat connectivity strategies intended to mitigate project impacts. However, the GMP does not include specific actions for mountain lions.

Other federally managed lands such as Carrizo Plains National Monument, Fort Ord National Monument, Pinnacles National Park, Mojave National Preserve, Death Valley National Park, and the Golden Gate National Recreational Area, Muir Woods National Monument, provide habitat and important habitat corridors for mountain lions.

5.5 Management on State Lands

5.5.1 California Department of Fish and Wildlife

The Department is responsible for over 445,000 ha (1,100,000 acres) of fish and wildlife habitat, managed through 749 properties throughout the state, including 111,462 ha (275,428 acres) within the petitioned ESU. These properties provide habitat for a rich diversity of fish, wildlife, and plant species and include representatives of most major ecosystem in the state. In addition, several private land conservation programs assist landowners with the management of wetlands, riparian habitats, native grasslands, and wildlife-friendly farmlands.

Most Department lands are classified as either Wildlife Areas or Ecological Reserves. Wildlife Areas are acquired for the conservation of wildlife and the habitats on which they depend, and to provide opportunities for recreational uses that are compatible with those conservation goals (Fish & G. Code §§ 1525 -1530, 1745). Ecological Reserves are acquired primarily for the purpose of protecting rare and endangered native species and specialized habitat types (Fish & G. Code § 1580). Certain public uses, deemed compatible with those goals, are authorized for ecological reserves—typically this includes hiking on established trails to observe native plants and wildlife (Fish & G. Code, § 1584). The Department prepares land management plans for Wildlife Areas and Ecological Reserves which are subject to public review under CEQA prior to being finalized.

The 167 Department properties within the petitioned Southern California/Central Coast ESU range from a fishing access property of less than 1 acre to the 117,197-acre Santa Rosa Wildlife Area in Riverside County. Of particular interest are Department properties in the coastal mountains of San Diego County, including Rancho Jamul Ecological, Sycuan Peak, Crestridge Ecological Reserve, and Hollenbeck Canyon Wildlife Area. Mountain lion densities appear to be high in these areas as indicated by the large number of vehicle strikes. The Santa Margarita River Ecological Reserve was rated as the best potential site for a wildlife crossing over Hwy 15 within the habitat linkage from the Santa Ana Mountains to the Palomar Mountains in the Eastern Peninsular Range (Riley et al. 2018). Other significant Department properties within the petitioned ESU include the Hill Slough Wildlife Area in Solano County; the Cottonwood Creek, Cañada de Los Osos and San Luis Reservoir Wildlife Areas in Merced and Santa Clara counties; the Chorro Creek Ecological Reserve in San Luis Obispo County; the Burton Mesa Ecological Reserve in Santa Barbara County; and San Jacinto Wildlife Area in Riverside County.

5.5.2 California State Parks

California's State Park System encompasses more than 607,000 ha (1.5 million acres) in approximately 280 parks. These parks are managed for public use and enjoyment and species and habitat protection through an integrated program of planning, restoration projects and evaluation, ongoing maintenance, and long-term monitoring. California Public Resource Code section 5019.53 declares:

> "The purpose of state parks shall be to preserve outstanding natural, scenic, and cultural values, indigenous aquatic and terrestrial fauna and flora and the most significant examples of ecological regions of California, such as the Sierra Nevada, northeast volcanic, great valley, coastal strip, Klamath-Siskiyou Mountains, southwest mountains and valleys, redwoods, foothills and low coastal mountains, and desert and desert mountains. Each state park shall be managed as a composite whole in order to restore, protect, and maintain its native environmental complexes to the extent compatible with the primary purpose for which the park was established."

A state park must have an approved general plan before major park facilities can be developed. These general plans direct the long-term management of the park. Some parks may also develop a more specific resource management plan. Big Basin Redwoods State Park in Santa Cruz County designates mountain lions as a species of special management concern, and the Park's Management Guidelines call for the Protection of known wildlife habitat linkages to permit movement of wildlife, increase species abundance and diversity, and monitor the functionality of core wildlife habitat areas and wildlife linkages (CA Parks 2013). Big Basin Redwoods State Park and surrounding parks including The Forest of Nisene Marks, Año Nuevo, Henry Cowell Redwoods, Wilder Ranch, Portola Redwoods, and Castle Rock State Park encompass over 22,250 ha (55,000 acres) of the Santa Cruz Mountains in the CC-N. Anza-Borrego Desert State Park in the EPR is the largest park in the state system at over 240,000 ha (600,000 acres) and contains over 161,000 ha (400,000 acres) of land managed as wilderness. Park-wide management goals include being proactive in biological conservation and managing for subspecies, evolutionary units, ecologically functional units, populations, or other levels of biological organization to conserve biodiversity; and management that encourages natural ecological process such as hydrologic processes, wildfire, and biotic community interactions to continue. Other wildlife-related goals and guidelines include species inventory and monitoring programs, protection of special status plants and animals, control of non-native plants and animals, and the protection of habitat buffers and movement corridors (CA Parks 2005). Other notable parks within the petitioned Southern California/Central Coast ESU boundary include Butano, Garapata, Andrew Molera, Julia Pfeifer Burns, Portola, Henry W. Coe, Henry Cowell, Castle Rock complex, Montaña de Oro, Point Magu, Malibu Creek, Topanga, Chino Hills, Lake Perris, and Cuyamaca Rancho.

5.5.3 Management on County and City Lands

Although generally smaller in size than conserved state and federal land units, city and county owned and managed lands conserve many key linkage areas or expand and buffer adjacent conservation lands. For example, a series of properties owned by the City of Los Angeles—including Runyun Canyon Park, Franklin Canyon Park and Stone Canyon and Encino Reservoirs—conserve the easternmost extant of the CC-S and provide partial linkage to Griffith Park (also owned by the City of Los Angeles). And Ventura County's Happy Camp Canyon Regional Park conserves an important part of the southern Santa Susanna Mountains that may serve as a key piece of future linkages between the Santa Monica Mountains/Simi Hills and the Santa Susannas. In the SA MU, parks and preserves owned and managed by Orange County serve as linkages and buffers to larger conserved areas in the Sana Ana Mountains. Important units include Whiting Ranch and Irvine Ranch Open Space Preserves and the Ronald Casper Wilderness Park. In the coastal EPR of San Diego County, the county's open space preserves in the Otay area and mitigation bank in Marron Valley complement the Department's Rancho Jamul Ecological Reserve and the BLM's Otay Wildlife Management Area to create a large block of contiguous conserved lands in the San Ysidro Mountains adjacent to the Mexican border.

5.6 Management in Neighboring States and Nations

5.6.1 Arizona

Mountain lions are found throughout Arizona in desert and forested mountain habitat. They are not considered endangered or threatened in Arizona and are classified as a big game species by the Arizona Game and Fish Department with regulated hunting zones throughout the state (AGFD). The population was recently estimated at 1,166 to 1,175 (95% CI = 622-2,558) adults and subadults statewide exclusive of tribal lands (Howard et al. 2020). Mountain lions have recently expanded into previously unoccupied areas in western Arizona near the California border where they were previously thought to be transient including the Kofa, Castle Dome, New Water, Palomas, and Eagle Tail mountains, where no evidence of mountain lions was detected during surveys in 1987 (Thompson, R. et al. 2008, Naidu et al. 2011).

The AGFD collects age and sex information and genetic material from harvested mountain lions to monitor populations and to evaluate metapopulations, connectivity and dispersal. Mountain lions are regulated by several statutes and Arizona Game and Fish Commission Order. It is unlawful to harvest a female lion with kittens or to harvest a spotted kitten. AGFD has established several mountain lion management zones in the state with harvest thresholds that require closing the season when the threshold is reached. Five different zones exist on the western border of Arizona abutting the California boundary, with a total of eight separate harvest units within those zones. For the 2022–2023 harvest season, the threshold quota for these units ranges from 3–17 mountain lions. The harvest data suggests that the mountain lion population is stable to increasing in many parts of Arizona. The current population estimate is 2,000–2,700 mountain lions statewide, with their annual average population estimate from 2004 to 2020 equal to 2,876 animals (AZGFD 2022).

5.6.2 Nevada

Mountain lions are classified as a game mammal in Nevada and both sexes can be hunted under special regulations. A tag is required to hunt mountain lions, and a resident or nonresident can obtain up to two tags a year. Hunting is allowed statewide, except for on the Sheldon National Antelope Refuge and a few hunt zones in the Las Vegas area. Andreasen et al. (2012) found that mountain lion populations in western Nevada commonly interbreed with individuals in the Sierra Nevada of California, and those populations are somewhat isolated from other Nevada populations by inhospitable playas in the Lahontan Basin. The authors also found that the Sierra Nevada population appears to receive more mountain lions from central and eastern Nevada than it contributes. In contrast, Gustafson et al. (2019) found more lions emigrate from the Western Sierra Nevada and Eastern Sierra Nevada genetic groups to Nevada than from Nevada to the Sierra Nevada groups.

5.6.3 Mexico

Mountain lions are distributed throughout Mexico along both coasts, in mountainous areas, deserts, sub-tropical and tropical forests, and deciduous dry, conifer, and oak forests (Valdez and Ortega-Santos 2019). Populations are found in most states except in areas with large human populations, including central Mexico and much of the Mexican Altiplano (Chávez and Ceballos 2014). Although, individuals can live near human settlements and have been seen near large cities including Guadalajara, Mexico City, and Monterrey (del Castillo 2009). The great plasticity of this species, specifically in its diet (Núñez et al. 2000, Rosas-Rosas et al. 2003, 2008, Monroy-Vilchis et al. 2009) has facilitated its survival in almost all habitat types in Mexico. However, it is being extirpated regionally, mainly in those areas that have been transformed by agricultural development and urbanization (Valdez and Ortega-Santos 2019).

Threats to mountain lion survival in Mexico include habitat fragmentation, prey depletion, and illegal hunting(Valdez 1999, Rosas-Rosas et al. 2003, 2008). Additionally, widespread cattle ranching, agriculture expansion, and unlawful human settlement in protected natural areas threaten their survival in the long term (Galindo et al. 2016). The extensive past and present expansion of human-dominated landscapes and the concomitant habitat conversion are the major threats. Mountain lions are a major management concern where there are conflicts with livestock interests and where UMAs (Unidades para la Conservacion, Manejo y Aprovechamiento Sustentable de la Vida Silvestre or units for the conservation, management, and sustainable use of wildlife) have fenced in prey species for sport hunting (Rosas-Rosas et al. 2008, Ávila-Nájera et al. 2011). Because cattle ranching is the main economic activity in areas where mountain lions and jaguars (*Panthera onca*) occur, livestock losses from predation by these felid species are one of the most important economic factors affecting ranch owners (Rosas-Rosas and Valdez 2010). In most regions where trophy hunting is practiced on game ranches, owners believe mountain lions to be a threat to their investments in raising and maintaining game species (Rosas-Rosas et al. 2003), and predator control is considered necessary. However, trapping and poisoning large cats has not been common, even in areas with large livestock enterprises, at least in the last decade, but poisoning does occur (Rosas-Rosas, personal observation; Zarco-González et al. 2012, Rodríguez-Soto et al. 2013).

The status of the mountain lion in Mexico is tenuous because persistent predator control programs are indiscriminately removing individuals (Chávez and Ceballos 2014). In most states where predation on livestock is severe, ranchers resort to predator control without following a scientific management plan because there is a lack of federal and state conservation intervention programs (Rosas-Rosas et al. 2008, Rosas-Rosas and Valdez 2010). In addition to the mismanagement of livestock enterprises, increased narco-violence throughout the country may hamper conservation efforts. Despite this, larger-sized jaguar populations throughout Mexico have bounced back over the last 10 years indicating a growing population(Ceballos et al. 2021, 2022) which may impact co-occurring mountain lions in areas they co-occur. While some contemporary connectivity appears to exist between Californian and Mexican EPR lion populations where there is not a US Border Fence, gene flow has never been examined in close detail, and future studies are warranted to better understand this. While mountain lion conservation efforts are tenuous in northern Mexico, continued genetic contributions from Mexico in the absence of concerted mountain lion conservation efforts in northern Mexico are not assured. Cooperative international wildlife conservation efforts should be explored to ensure the persistence of this important linkage.

6. ASSESSMENT OF LISTABLE MANAGEMENT UNITS

6.1 Assessment of Evolutionary Significant Units

The petitioners propose listing the petitioned area, consisting of six identified genetic populations, as a single ESU. Alternatively, they request the Commission consider whether any of the six populations, individually or in combination, comprise one or more ESUs and meet the criteria for listing under CESA (see Fig. 1).

To determine whether a population could be considered an ESU under CESA, the Department has previously followed the approach used by the federal government for ESA (Waples 1991) which consists of two main criteria:

1) The population must be substantially reproductively isolated from other conspecific population units.
2) It must represent an important component in the evolutionary legacy of the species.

For criterion 1, isolation does not have to be absolute, but it must be strong enough to permit evolutionarily important differences to accrue in the different population units., it must also be of substantial ecological/genetic importance to the species as a whole (criterion 2). To make the determination for criterion 2, the following questions are relevant:

a) Is the population genetically distinct from other conspecific populations?
b) Does the population occupy unusual or distinctive habitat?
c) Does the population show evidence of unusual or distinctive adaptation to its environment?

Waples (1991) highlights the following types of information as useful for answering the above questions (Note: his examples are written to be specifically relevant to Pacific Salmon, so we have altered the language to make them more applicable to terrestrial organisms):

1) Genetic traits. Examples include presumably neutral characters detected by protein electrophoresis or DNA analyses as well as other genetically based traits that are more difficult to quantify.
2) Phenotypic traits. Examples include morphological and meristic characters, occurrence of parasites, and disease and parasite resistance.
3) Life-history traits. Examples include time, size, and age at reproduction; reproductive behavior; fecundity; migration patterns; and timing of emergence and outmigration.
4) Habitat characteristics. This category includes such physical characteristics of habitat encountered during the entire life cycle.

Waples (1991) notes:

> "The existence of substantial genetic differences from other conspecific populations based on protein electrophoresis or DNA analyses would strongly suggest that evolutionarily important, adaptive differences also exist. The failure to find such differences (or the absence of genetic data) would not rule out the possibility that such adaptive differences exist, but it would place a greater burden of proof on data for other characters. Data for habitat characteristics should be interpreted in a similar fashion: habitat differences suggest (but do

> not prove) the possibility of adaptive differences, whereas the inability to detect habitat differences constrains the scope of possible local adaptations but does not prove they do not exist. In evaluating data for phenotypic and life-history traits, every effort should be made to account for environmental effects that are manifested in periods shorter than one generation (and therefore do not reflect adaptations)."

When evaluating the petition, CDFW's first consideration was whether the petitioned ESU(s) meet the criteria for being considered an ESU. The second consideration was whether any of the populations within the petitioned ESU area meet the definition of an ESU, singly or in combination. We used several lines of genetic and ecological evidence to evaluate these potential ESUs.

As discussed in section 2.4, genetic evidence at the broadest geographic scale shows that there is only one recognized subspecies of mountain lion in North America (*Puma concolor cougar*; Culver et al. 2000, Caragiulo et al. 2014, Kitchener et al. 2017), indicating insufficient adaptive localized genetic, physiological, or behavioral variation has been found within North American mountain lion populations for taxonomists to recognize local subspecies.

It is important to understand the adaptive differences described in the ESU criteria are unlikely to develop when populations are isolated over short time scales (i.e., decades, or even hundreds of years). To explore potential adaptive differences among California populations, Gustafson et al. (2022) used several methods to evaluate genetic evidence of local adaptation among the genetic clusters. They found no outlier loci, which, when present, suggest local adaptation (Ibid.). Though detection of outlier loci can be limited when used in conjunction with a reduced representation of the genome, it has often been shown to be an effective approach (Catchen et al. 2017).

Mountain lions occupy much of California, except for heavily urbanized areas, intensively farmed areas of the Central Valley, and low elevation areas of the southern deserts. As noted earlier, when the landscape is permeable, they can disperse over long-distances (Sweanor et al. 2000, Hawley et al. 2016) and inhabit all major mountain ranges in California (Dellinger et al. 2020*b*). This widespread distribution and dispersal potential suggest local adaptation is unlikely and there is little evidence of morphological, mitochondrial, or adaptive genomic differences between mountain lions within the petitioned ESU or any of the petitioned populations and the broader statewide lion population to suggest the presence of distinct evolutionary lineages (Gustafson et al. 2022). While gene flow between the petitioned ESU and the NC and SN populations is limited, it does still occur (Gustafson et al. 2019, 2022).

The Management Units identified at a regional scale do have boundaries that in many areas correspond to anthropogenic barriers to dispersal (Gustafson et al. 2019), suggesting they have developed in recent decades or perhaps 100–200 years as land use has changed significantly within the petitioned ESU. Some of these Management Units represent small and somewhat isolated populations in areas where connectivity to the statewide population has been drastically reduced in the last 50–100 years due to expanding human development. However, there are no populations of mountain lions within the petitioned ESU boundary that have been isolated for much longer periods and, based on current scientific information, represent important portions of the evolutionary legacy of the mountain lion species.

Taken as a whole, the genetic evidence does not support applying the ESU concept to the overall petitioned area or any of the Management Units individually, as a subspecies or ESU for the following reasons:

1. There is only one recognized subspecies of mountain lion in North America (Puma concolor cougar) based on mitochondrial DNA data (Culver et al. 2000, Caragiulo et al. 2014, Kitchener et al. 2017), suggesting little potential for adaptive localized genetic variation among North American mountain lion populations. This would in turn make adaptive genetic variation among mountain lion populations within California even less likely.
2. Genetic investigations conducted by Gustafson et al. (2022) failed to detect distinct ecotypes or local adaptation, suggesting that the identified California genetic populations and Management Units do not represent an important component of the evolutionary legacy of the species.
3. Genetic data indicate habitat fragmentation and dispersal barriers have recently limited the ability of mountain lions to move freely between certain geographic areas and local populations in southern California and the central coast area (Gustafson et al. 2019). However, this fragmentation has mostly occurred within the last 200 years and has not yet resulted in genetic differentiation sufficient to represent an important component of the evolutionary legacy of the species. The most recent genetic study, which used SNPs to characterize variation across more of the genome, suggests many of these local populations separated by barriers have considerable shared ancestry and are more genetically similar than previously thought (Gustafson et al. 2022).

However, the Department recognizes that several of the populations/Management Units in the petitioned ESU are imperiled due to small populations sizes and isolation, and that populations considered distinct based on reproductive isolation and genetic differences may warrant specific conservation measures. In the sections below we further evaluate whether the six populations/Management Units, singly or in combination, warrant potential listing under CESA.

6.2 Assessment of Distinct Population Segments

While the petition is focused on ESUs and the Department has recommended listing ESUs in the past, its assessment of what may constitute a listable entity is not limited by federal ESU policy. The USFWS and NMFS (the Services) have also identified and listed Distinct Population Segments (DPS) pursuant to the ESA and have developed a policy for evaluating DPSs pursuant to the ESA. A DPS is a vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species. DPSs have been used 137 times by USFWS to list imperiled populations rather than listing a species across its full range. Examples from California include the Southern Sierra Nevada fisher (85 Fed. Reg. 29532-29589 (May 15, 2020)), the Peninsular bighorn sheep (63 Fed. Reg. 13134-13150 (March 18, 1998)), and the Sierra Nevada bighorn sheep (64 Fed. Reg. 19300-19309 (April 20, 1999)). While the ESU designation and supporting policy has primarily been applied to fish populations, the DPS designation has been more widely applied to, and policy is more relevant to terrestrial species.

To guide its evaluation of whether a possible DPS might warrant listing as threatened or endangered, the Services first evaluate two elements to determine if the population segment should be considered a DPS:

1) Discreteness of the population segment in relation to the remainder of the species.
2) Significance of the population segment in relation to the remainder of the species.

If the population segment being considered is a DPS, then the Services evaluate its conservation status (i.e., is the population segment, if treated as if it were a species, endangered or threatened?) (61 Fed. Reg. 4722-4725 (February 7, 1996)).

The elements are interpreted as follows:

Discreteness: a population segment may be considered discrete if it meets either of two conditions:

a) It is markedly separated from other populations of the same taxon because of physical, physiological, ecological, or behavioral factors. Quantitative measures of genetic or morphological discontinuity may provide evidence of this separation.
b) It is delimited by an international government boundary, and there are significant differences between the countries in control of exploitation, management of habitat, conservation status, or regulatory mechanisms.

Significance: If a population segment is found to be discrete under one or more of the above conditions, its biological and ecological significance will then be considered. This consideration may include, but is not limited to, the following:

a) Persistence of the discrete population segment in an ecological setting unusual or unique for the taxon.
b) Evidence that loss of the discrete population segment would result in a significant gap in the range of a taxon.
c) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historic range.
d) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics.

Imperiled Status: If a population segment is found to be both Discrete and Significant, and if treated as a species, could it be found to be threatened or endangered based on the listing factors established in the ESA?

Using this approach, we evaluated the following Management Units and groups to determine if they should be considered DPSs and if any of those DPSs meet the standards for listing presented in the federal policy:

1. Central Coast North (CC-N) Management Unit
2. Central Coast Central (CC-C) Management Unit

3. Central Coast South (CC-S) Management Unit
4. The Central Coast Group. Consists of three Management Units—CC-N, CC-C, and CC-S and is identified as a broad scale genetic cluster in Gustafson et al. (2022) within the petitioned ESU.
5. Santa Ana (SA) Management Unit
6. Eastern Peninsular Range (EPR) Management Unit
7. San Gabriel/San Bernardino (SGSB) Management Unit
8. Southern Coast Group. Identified as a broad scale genetic cluster in Gustafson et al. (2022) that is within the petitioned ESU. It is significantly isolated from the other Management Units in California. Consists of three Management Units—SA, EPR, and SGSB.

Table 7 summarizes our evaluation and decision process. For each Management Unit and Group considered for potential listing, its discreteness, significance, and impereled status are evaluated (consistent with federal DPS policy, for details of criteria, see above). Additional information about each MU and Group is presented in text below.

Table 7. Decision matrix summarizing evaluations of whether Management Units may be considered a Distinct Population Segment (DPS) and potentially warrant listing under CESA (based on federal DPS policy). For a unit to be considered a DPS, at least one "yes" is needed from each of the orange and green columns. To be potentially listed under CESA, that DPS must be imperiled.

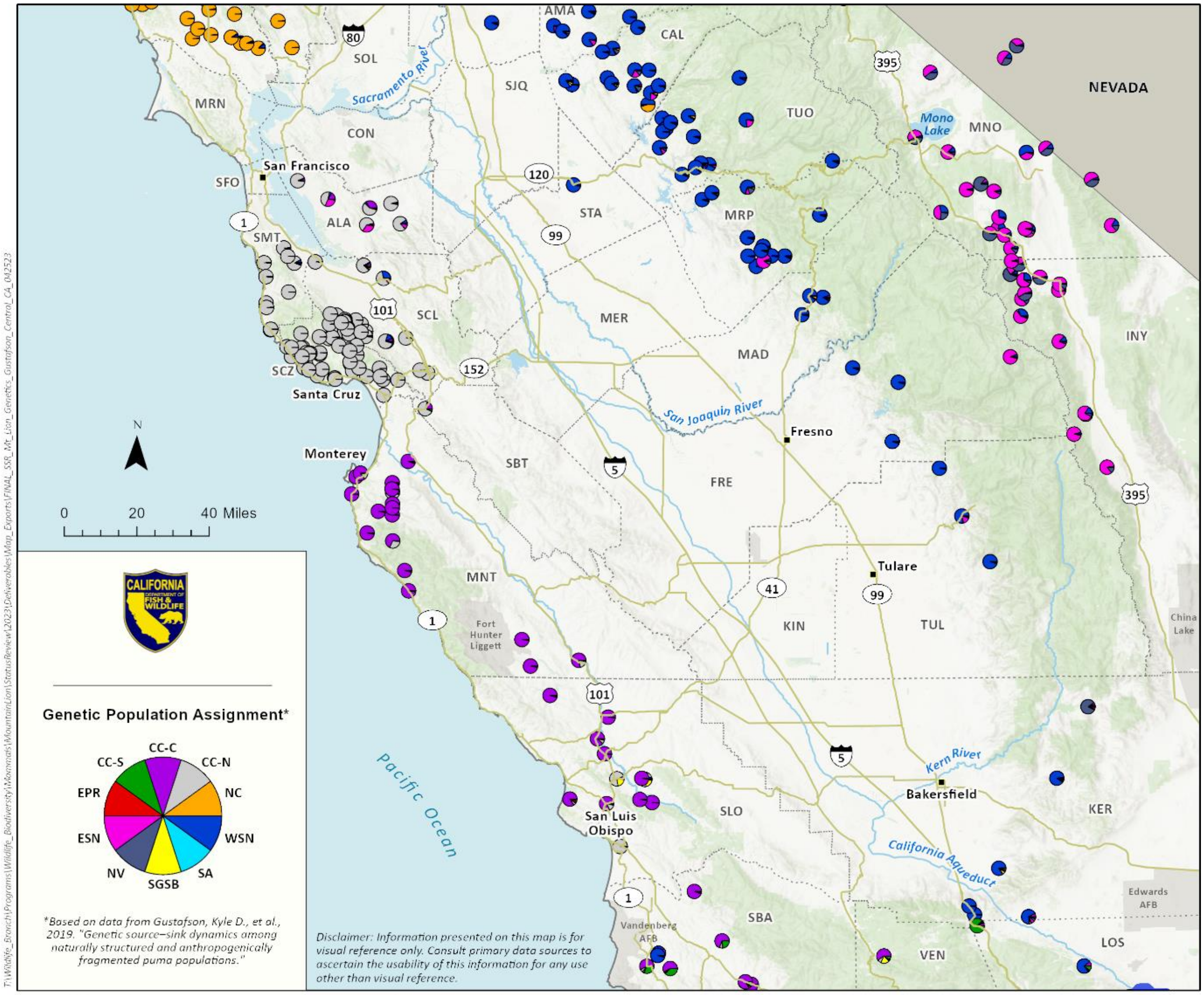
Management Unit(s)	**Discreteness**		**Significance**				**Qualifying DPS?**	**Imperiled?**	**Recommendation**
	Markedly Separated	International Border	Unique Ecological Setting	Gap in Range	Only surviving natural occurrence	Markedly different genetic characteristics	Does the MU or Group Constitute a DPS?	May be Threatened or Endangered?	Could the DPS Warrant Listing as a Threatened or Endangered DPS?
CC-N (Includes Santa Cruz Mountains)	Yes	No	No	No	No	No	No	Yes	No
CC-C	No	No	No	Yes	No	No	No	No	No
CC-S (Includes Santa Monica Mountains)	No	No	No	No	No	No	No	Yes	No
Central Coast Group (CC-S, CC-C, CC-N)	No	No	No	Yes	No	Yes	No	No	No
SA	Yes	No	No	No	No	No	No	Yes	No
EPR	No	Yes	Yes	Yes	No	No	Yes	Yes	**Yes**
SGSB	No	No	No	Yes	No	No	No	Yes	No
South Coast Group (SA, EPR, SGSB)	Yes	Yes	No	Yes	No	Yes	Yes	Yes	**Yes**

6.2.1 Details of Assessment

To determine whether a mountain lion MU (or group of several MUs) is "markedly separate" from other MUs we relied upon genetic data from Gustafson et al. (2019, 2022), and when available, information from mountain lion movement studies. The federal DPS policy lists a variety of factors that can cause separateness (i.e., physical, physiological, ecological, or behavioral factors). For mountain lions, we considered that physical separateness was likely the strongest factor due to limits on connectivity caused by recent human development. We have genetic data that can shed some light on the extent of separateness, though there are several important limitations to the data that we discuss below.

Using microsatellite data from Gustafson et al. 2019, each sample from a mountain lion can tell us some information about the relatively recent ancestry of that animal, which can be represented as a pie chart. The different colors show what percentage of their ancestry has been assigned to different MUs. The SNP data from Gustafson et al. 2022 represent more of the genome and reveal ancestry further back in time. The 2022 study informs questions about the amount of genetic material historically shared between MUs and retained genetic variation within individuals and extant MUs. However, the effects of relatively recent (i.e. within the last few centuries) land use changes that restrict connectivity between MUs is not revealed by such data.

How to read the maps: Each pie chart represents the location where a genetic sample was obtained from an individual mountain lion and the genetic affinities of the lion. A pie chart that is fully or almost fully one color is good evidence that both parents were from the same MU. If the pie chart of a sampled lion is in the same MU as its parents (e.g., a fully gray sample in the Santa Cruz Mountains in Fig. 15), it means the sampled lion is unlikely to have moved from the MU of its parents. If it is found outside of the population of its parents (i.e., the fully gray sample near San Luis Obispo in Fig. 15), that is strong evidence that it is a first-generation migrant that moved to a new population during its lifetime. These individuals may have died without breeding or may have had offspring in the new location. A pie chart that is a 50/50 split is good evidence of a hybrid offspring among parents from two different MUs (i.e. likely the offspring of a migrant). As the pie pieces get smaller, MU hybridization occurred further and further back among more distant ancestors. Very small pie segments may represent statistical 'noise' in the ancestry calculation.



CDFW Wildlife Branch, GIS-LS, Apr 25, 2023 - Map Data: CDFW, Gustafson et al., 2019, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 15. Assignment of individual mountain lions to genetic populations identified by Gustafson et al. 2019 using microsatellite DNA markers.

A solid pie chart outside of its parents' MU indicates the sampled animal was sampled outside its birth MU, but whether that animal was able to breed and have any lasting effect on the gene pool of the MU where it was sampled is unknown.

A mixed pie chart tells us gene flow (movement with breeding) occurred in the past; we do not know if it is still occurring. These mixed pie charts are an example of what is referred to as introgression (the transfer of genetic information from one population to another because of hybridization between them and repeated backcrossing).

Genetics can assess connectivity over longer time frames indicative of introgression and gene flow (mixed pie charts). However, it does not provide information about the extent of current connectivity.

In our discussion of markedly separate, we use the Gustafson et al. (2019) pie charts as part of the evidence to evaluate if there has been "recent" gene flow between populations (i.e., are they connected or are they 'markedly' separate from each other). To assess recent connectivity more adequately, we also consider anthropogenic barriers such as major roads and development. The pie charts from Gustafson et al. (2022) give additional information about gene flow further in the past, which provides historical context for the amount of gene flow seen in the Gustafson et al (2019) pie charts.

Central Coast-North

<u>Discreteness</u>

Markedly Separate: Yes. This MU is physically isolated from the NC cluster by the San Francisco Bay and Sacramento-San Joaquin Delta and heavily urbanized areas and future development is projected to exacerbate existing isolation. There is very little evidence of gene flow between the NC and CC-N in the 2019 ancestry assignment data. Most of the mountain lion pie charts in the Santa Cruz Mountains are almost fully gray, indicating little gene flow from outside CC-N into the mountains (Fig. 15). The samples collected from east of the San Francisco Bay show hybridization mainly with ESN, WSN, and CC-C. Ancestry from CC-N shows up in a few samples in CC-C, providing more evidence of some recent connectivity between CC-N and CC-C. However, the more solid grey and purple samples at the border of CC-N and CC-C in Fig. 15 (more recent ancestry) compared to more mixed samples at the same place in Fig. 16 (more historical ancestry) suggests the exchange of individuals between the CC-N and CC-C populations appears to be infrequent in recent times as compared to further in the past.

International Border: No.

<u>Significance</u>

Unique Ecological Setting: No. The coastal redwood and mixed conifer and hardwood forests that make up the Santa Cruz Mountains are also found in coastal mountains north of San Francisco Bay.

Gap in Range: No. The CC-N MU is effectively cut off to the north by San Francisco Bay and largely bounded on the east by development and agriculture in the Central Valley. The only major connection is south to CC-C. Losing this population would shrink the range but not create a new gap in the distribution of mountain lions in California.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. CC-N is a fine scale genetic cluster, and the SNP data analyzed by Gustafson et al. (2022) suggest there is shared ancestry with the other CC populations. There is no evidence of local adaptive genetics.

<u>Imperiled?</u>

Threatened or Endangered: Yes. This is a small, isolated population with an effective population size of 16.6 and an estimated 33–66 adult animals.

Conclusion: Evidence does not support a designation as a threatened or endangered DPS.

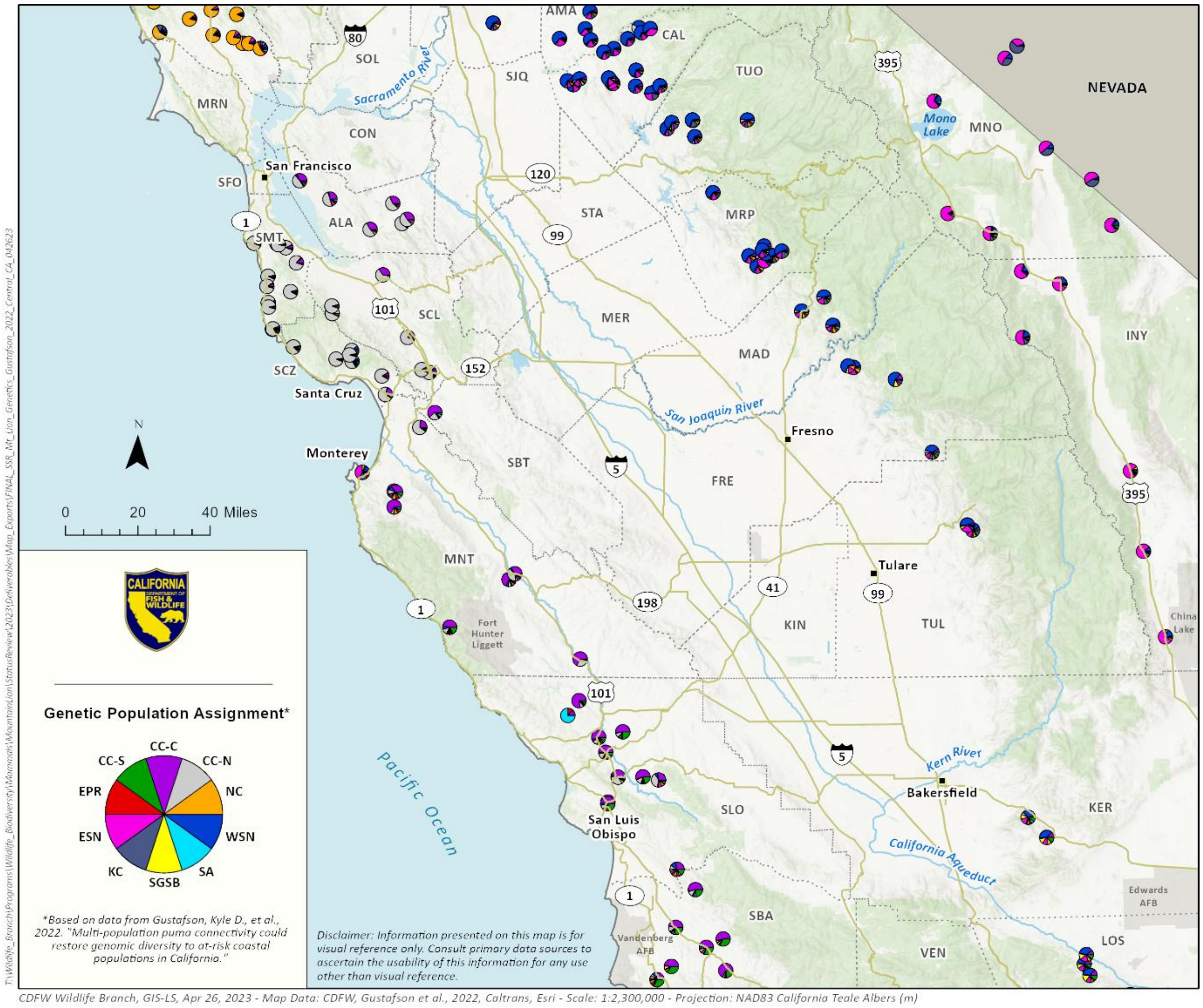


Figure 16. Assignment of individual mountain lions to genetic populations identified by Gustafson et al. 2022 using Single Nucleotide Polymorphisms.

Central Coast-Central

<u>Discreteness</u>

Markedly Separate: No. This MU is not delineated by major areas of human development. In consequence, there is some gene flow in from CC-N, and, especially in the south around Santa Barbara, samples show that there has been hybridization between CC-C and multiple other MUs. There is good representation of CC-C ancestry in CC-S, especially outside of the Santa Monica mountains, as would be expected if there were not major barriers to movement (Figs. 15–17).

International Border: No.

<u>Significance</u>

Unique Ecological Setting: No. The natural communities in CC-C are not unique.

Gap in Range: Yes. CC-C links the CC-N to the rest of the coastal populations. Losing CC-C would completely isolate the Santa Cruz Mountains, creating a gap in the range.

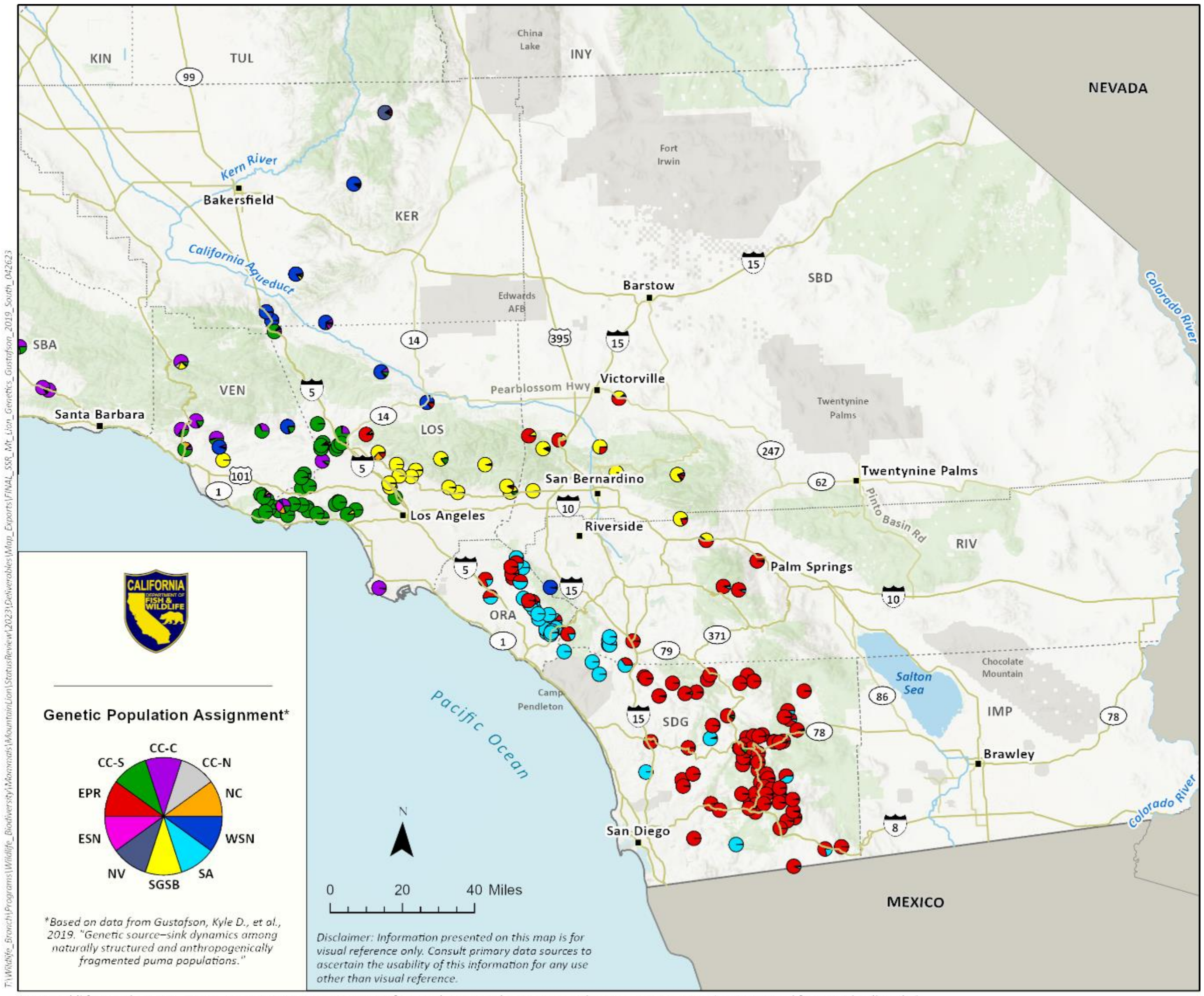
Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. The SNP data suggest there is shared ancestry with the other two Central Coast populations (Gustafson et al. 2022). There is no evidence of local genetic adaptation.

<u>Imperiled?</u>

Threatened or Endangered: No. The CC-C is a relatively large contiguous MU with an effective population size of 56.6 and an estimated 113–226 adult animals. CC-C serves as a source for many surrounding populations.

Conclusion: Evidence does not support designation as a threatened or endangered DPS.



CDFW Wildlife Branch, GIS-LS, Apr 26, 2023 - Map Data: CDFW, Gustafson et al., 2019, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 17. Assignment of individual mountain lions from southern Management Units to genetic populations identified by Gustafson et al. 2019 using microsatellite DNA markers.

Central Coast South

<u>Discreteness</u>

Markedly Separate: No. Although the Santa Monica Mountains have limited gene flow in and out and are bounded by heavy urbanization to the south and southeast, the larger MU still has connectivity to the central coast, the Sierra Nevada, and, to a much lesser extent, the southern California populations (Figs. 15–17). Most of the samples taken from northern CC-S show migration and hybridization in ways that suggest that area has connectivity to several MUs including CC-C and WSN.

International Border: No.

<u>Significance</u>

Unique Ecological Setting: No. The CC-S is composed of coastal plain, agricultural areas, chapparal, and montane woodlands and forests, all of which are represented elsewhere in the range of mountain lions in California.

Gap in Range: No. There is genetic evidence that this MU has some contemporary connectivity to the CC-C and WSN; however, if the CC-S MU were to become extirpated, the CC-C and WSN MUs would retain some connectivity via the Tehachapi Mountains and points west to the Santa Barbara area (Fig. 17). Connectivity to the SGSB is already very limited; therefore, loss of this MU would not create an additional gap between the South Coast group and MUs farther north. Connectivity across highway 101 linking the Santa Monica Mountains to the Simi Hills will be significantly improved following the completion of the Wallis Annenberg wildlife overpass, which will promote gene flow within the southern portion of this MU.

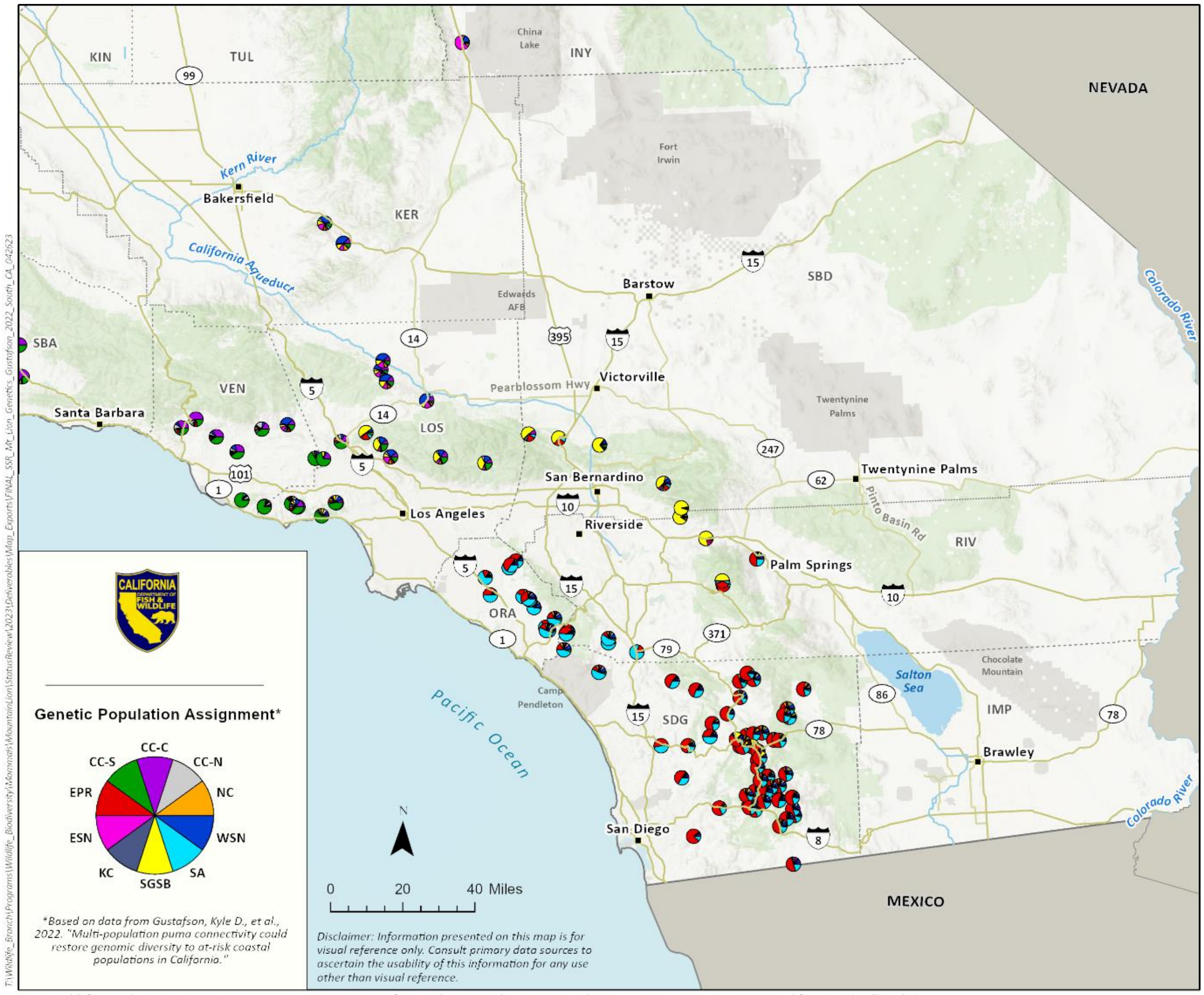
Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. Gustafson et al.'s (2022) SNP data suggest there is shared ancestry between CC-S and the other CC populations (Fig. 18). There is no evidence of locally adaptive genetics.

<u>Imperiled?</u>

Threatened or Endangered: Yes. This is a small, mostly isolated population of 5–10 adult animals and an effective population size of 2.7 (Gustafson et al. 2019) and projected future development will likely further isolate the population.

Conclusion: Evidence does not support designation as an imperiled DPS, because it is neither discrete nor biologically significant.



CDFW Wildlife Branch, GIS-LS, Apr 26, 2023 - Map Data: CDFW, Gustafson et al., 2022, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 18. Assignment of individual mountain lions from southern Management Units to genetic populations identified by Gustafson et al. 2022 using Single Nucleotide Polymorphisms.

Central Coast Group

<u>Discreteness</u>

Markedly Separate: No. Genetic evidence shows that CC group is a distinct genetic group, distinct from the other three groups Gustafson et al. (2022) identified in California. However, there is evidence of gene flow and migration in the area from Santa Barbara through Ventura and towards the Tehachapi Mountains (Fig. 17), and it appears that there has been some genetic connectivity between the CC group and the SN group. There are areas of intense urbanization at the northern and southern edges (San Francisco and Los Angeles), and the intensive agriculture of the Central Valley forms a substantial barrier to the east. However, the Los Padres National Forest in the CC group is a large patch of public land that borders or approaches other large areas of public land in the SGSB and WSN, presenting broad interfaces that likely allow some mountain lions to move between neighboring groups and MUs (Fig. 16).

Therefore, the Central Coast Group does not appear to be markedly separated from other populations in California.

International Border: No.

Significance

Unique Ecological Setting: No. The Central Coast Group encompasses a wide range of vegetative types and ecological settings; however, no major ecosystems within its bounds are unique to the Central Coast Group, and though unique vegetative communities exist (e.g., Santa Lucia fir forest), their geographic scale is not large nor isolated enough to support uniquely adapted mountain lion populations.

Gap in Range: Yes. Loss of the Central Coast Group would considerably diminish the range of the mountain lion in California.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: Yes. The SNP data suggests the Central Coast Group has experienced some degree of restricted genetic exchange with the larger California population for some time and it is one of four broad scale genetic clusters in California and is genetically distinct from the SC group and the SN group (Gustafson et al. 2022; Fig. 4), suggesting unique genomic variation may be present within the group.

Imperiled?

Threatened or Endangered: No. The Central Coast Group contains the CC-C MU which is one of the few MUs in California with an effective population size of ≥ 50. Although the Santa Cruz Mountains and Santa Monica Mountains populations within this group are small and isolated, the group encompasses a relatively large area of contiguous habitat, and collectively the estimated effective population size is 76 with an estimated 151–306 animals.

Conclusion: As the Central Coast Group is not discrete nor threatened with extinction, there is no support for designation as a threatened or endangered DPS.

Santa Ana

Discreteness

Markedly Separate: Yes. This population is classified as a fine-scale genetic group by Gustafson et al. (2019), and the Santa Ana MU is surrounded by human development to the north and east with I-15 running along much of its eastern and southern boundary. There is evidence that individual mountain lions from the EPR have been able to move into the population and breed (full red and half red pie charts in Fig. 17). However, that connectivity may no longer be present. A thirteen-year study (2001–2013) that collared 74 mountain lions in the EPR observed only one mountain lion move in the opposite direction from the SA to the EPR, and that individual was killed for depredating sheep before it could breed and introduce genetic material to the population (Vickers et al. 2015). Vickers et al. (2015) points out the strength of I-15 as a barrier between SA and EPR as traffic and nearby development have increased in recent years. Additionally, Huffmeyer et al. (2021) documented physiological evidence of inbreeding depression in the population. Interestingly, Gustafson et al. (2019) found relatively robust connectivity between the SA genetic group and the EPR genetic group by examining microsatellite loci. The conflicting evidence between Vickers et al.'s (2015) telemetry study and Gustafson's et al.'s (2019) genetic work may, in part, be explained by worsening fragmentation from recent land use changes as many of the tissue samples analyzed by Gustafson et al. (2019) were obtained prior to the onset of Vickers et al.'s (2015) study.

International Border: No.

Significance

Unique Ecological Setting: No. The SA MU is comprised of coastal mountains that provide habitats similar to those found in in the EPR and CC-S MUs.

Gap in Range: No. This is a very small population that is connected only to EPR, and recent studies suggest the current strength of that connection is weak. Its loss would slightly reduce the range of, but not create a significant gap in, California's lion distribution.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. The SA MU is a fine-scale genetic group, and SNP data suggest there is shared ancestry with the rest of the SC populations (Gustafson et al. 2022; Fig. 18). There is evidence of inbreeding in this population, but there is no evidence of adaptive genetic differentiation.

Imperiled?

Threatened or Endangered: Yes. This is a small, largely isolated population with an effective population size of 16 and an estimated 31–62 adult animals. Benson et al.'s (2019) demographic model of the SA population predicted a 15–17% chance of extirpation over a 50-year period with observed levels of immigration.

Conclusion: Although this MU is threatened with extinction and is discrete, it does not meet the criteria for significance; therefore, it does not meet the criteria for a listable DPS.

Eastern Peninsular Range

Discreteness

Markedly Separate: No. This population is classified as a fine-scale genetic group by Gustafson et al. (2019, 2022). Genetic evidence suggests historically there has been relatively robust connectivity between the EPR and SA MUs (Figs. 17 & 18), but Vickers et al. (2015) suggests that contemporary movement between these MUs is extremely limited. Historically there has been gene flow from the EPR to the SGSB MU, but the most recent genetic evidence suggests essentially no movement of mountain lions from the SGSB to EPR (Fig. 17). I-10 separates EPR from SGSB and is a busy interstate that likely creates a strong contemporary barrier. However, there are still potential areas where mountain lions can move in and out of the MU along its southern and eastern borders. Connectivity between mountain lions in the EPR and those in Baja California, Mexico and Arizona is poorly understood. Mountain lions have been observed on the California–Baja California border in an unfenced/walled area suggesting the opportunity for the exchange of individuals (Vickers, UC Davis, unpub. data). And records suggest sporadic individuals in the mountainous regions of the Mojave (Dellinger et al. 2019) and Sonoran deserts which suggests some potential genetic exchange between mountain lions in the EPR and those living along the Colorado River in California and Arizona.

International Border: Yes. The EPR borders Baja California, Mexico. The international border is marked by walls and fences that attempt to manage human migration; although some significant sections of the border, including a large section of the Eastern Peninsular Mountains, remain open. However, the status of the mountain lion population in Baja California, Mexico and the frequency of lion movement across the border is unknown. Management of mountain lions is different in Baja California, Mexico compared to California; for example, trophy hunting is legal in Mexico. (See section 5.8.3 for details on differences between how California and Mexico manage mountain lions.)

<u>Significance</u>

Unique Ecological Setting: Yes. While the EPR is primarily characterized by coastal chapparal, woodland, and forest types which are represented elsewhere within the range of mountain lions in California, the habitat transitions in the east to more xeric creosote bush (*Larrea tridentata*) scrub, alluvial basins, and western Sonoran woodlands, basins, and scrub. These latter ecoregions are not represented elsewhere within the California range (Griffith et al. 2016).

Gap in Range: Yes. Loss of the EPR MU would isolate the SA MU and eliminate connections to lion populations in the peninsular ranges of Baja California, Mexico.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. The EPR MU is a fine-scale genetic group with genetic evidence of historic connection to other SC populations (Gustafson et al. 2019, 2022; Fig. 18).

<u>Imperiled?</u>

Threatened or Endangered: Yes. The EPR MU is the largest population within the SC group; however, the effective population size is 32, with an estimated 63–126 adults. While there is some evidence of remaining connection with mountain lion populations in Baja California, Mexico, the EPR MU population is likely too small to ensure its long-term persistence.

Conclusion: The EPR MU is appropriately considered a Distinct Population Segment and it is imperiled.

San Gabriel/San Bernardino

<u>Discreteness</u>

Markedly Separate: No. This population is classified as a fine-scale genetic group by Gustafson et al. (2019, 2022). There is significant urban development along most of its southern boundary in the San Fernando Valley and the Inland Empire. To the north is less dense development and desert, although residential development in this area is projected to increase significantly by 2050. Despite the barriers of I-15 and I-10, there is evidence of moderate gene flow from EPR into SGSB (Figs. 3 & 17). There has been very limited historical gene flow out of SGSB into CC-S and CC-C. However, it is likely that Highway 14 and I-5 are fairly strong contemporary barriers to movement (Fig. 17).

International Border: No.

<u>Significance</u>

Unique Ecological Setting: No. The southern California montane shrub, woodland, and forest ecoregion types composing the SGSB are also represented in the CC-C, CC-S, and EPR MUs (Griffith et al. 2016).

Gap in Range: Yes. Genetic evidence suggests the SGSB historically received infrequent migrants from CC-S, although few mountain lions appear to have moved from the SGSB to neighboring MUs (Figs. 17 & 18). Although limited, the connectivity between SGSB and the EPR may be the only mechanism through which the EPR and SA are connected to other California lion populations, and loss of SGSB would potentially fully isolate the SA and EPR MUs creating a significant gap in the California range.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: No. SNP data suggest there is shared ancestry with the rest of the SC populations (Gustafson et al. 2022; Fig. 18).

<u>Imperiled?</u>

Threatened or Endangered: Yes. The SGSB MU is the smallest population within the South Coast Group with an effective population size of 5 and an estimated 10–20 adults.

Conclusion: While SGSB plays a significant role in facilitating genetic exchange between other MUs, it does not meet the criteria for discreteness, so the evidence does not support a designation as a DPS.

Southern Coast Group

<u>Discreteness</u>

Markedly Separate: Yes. Genetic evidence from Gustafson et al. (2022) shows that the SC group is a distinct genetic population, separate from other significant populations in California (Gustafson et al. 2019, 2022). Human development and roadways create significant barriers to movement and increase physical separation to the point where the San Gabriel and San Bernardino mountains are likely the only pathway of connectedness between the SC group and other California populations, and what connectivity there is, is likely tenuous. Consequently, the SC group is physically separated from other California populations.

International Border: Yes. The SC group borders Mexico. The international border is marked by walls and fences that attempt to manage human migration; although some significant sections of the border, including a large section of the Eastern Peninsular Mountains, remain open. However, the status of the mountain lion population in Baja California and the frequency of mountain lion movement across the border is unknown. Management of mountain lions in Mexico differs from management in California; for example, trophy hunting is legal in Mexico. (See section 5.8.3 for details on differences between how California and Mexico manage mountain lions.)

Significance

Unique Ecological Setting: Yes. The SC group encompasses desert and chaparral habitat on the eastern side of coastal mountain ranges that is unlike mountain lion-occupied habitat elsewhere in the state.

Gap in Range: Yes. While loss of the SC group would not bisect or isolate portions of the range of mountain lions within California, it could eliminate mountain lions from the entire southern fifth of the state (as mentioned elsewhere, the relationship of mountain lions in the EPR genetic group identified by Gustafson et al. (2019) to mountain lions in the eastern deserts and Colorado River corridor is poorly understood). Additionally, loss of the SC group would isolate coastal lion populations in California from those in Mexico.

Only Surviving Natural Occurrence: No.

Markedly Different Genetic Characteristics: Yes. Available SNP data from Gustafson et al. (2022) which are more reflective of longer-term separation of populations than the microsatellite analyses conducted by Gustafson et al. (2019) supports the South Coast group being a broad scale genetic group separated from other groups in California (Fig. 4), with higher genetic diversity and more private alleles than the Central Coast or North Coast broad scale genetic groups, suggesting the group retains unique genomic variations.

Imperiled?

Threatened or Endangered: Yes. Although the combined effective population size of the South Coast Group is about 53 with 101–208 adult animals (Gustafson et al. 2019), available habitat is limited in the Santa Ana, San Gabriel, and San Bernardino mountains. Also, those areas have limited connection with the Eastern Peninsular Mountains where most of the habitat lies. Three substantially disconnected populations exist in this group. Therefore, it is not meaningful to combine the effective population size estimates of the constituent MUs, and the group should be considered threatened. Additionally, projected future residential development will likely make movement of mountain lions between this group and the WSN and CC-S less frequent.

Conclusion: There is evidence supporting designation of the South Coast Group as a potentially threatened or endangered DPS.

6.3 Assessment of Significant Portion of Range

CESA requires that the Commission, in making its determination, consider whether mountain lions in California are in serious danger of becoming extinct throughout all or a significant portion of their range. While what comprises a "significant portion" of a species' range is not further defined in CESA, our analysis in the Assessment of Distinct Population Segments section above addressed whether the MUs, singly or in combination, could be considered discrete "significant portions" of the species' statewide range based upon whether those units are discrete from other populations, and whether they are ecologically or genetically significant. Only the EPR MU and the South Coast Group (composed of the SGSB, EPR, and SA MUs) were found to meet those criteria (they occupy discrete portions of the range *and* are significant in terms of genetics, ecological setting, or range connectivity). Therefore, the Department considers the South Coast Group (and the EPR MU within) a significant portion of the mountain lion's range. The lion population in these areas is also imperiled.

7. SUMMARY OF LISTING FACTORS

CESA's implementing regulations identify key factors relevant to the Department's analysis and the Commission's decision on whether listing a species as threatened or endangered is warranted. A species will be listed as endangered or threatened if the Commission determines that the species' continued existence is in serious danger or is threatened by any one or any combination of the following factors: (1) present or threatened modification or destruction of its habitat; (2) overexploitation; (3) predation; (4) competition; (5) disease; or (6) other natural occurrences or human-related activities (Cal. Code Regs., tit. 14, § 670.1, subd. (i)).

This section provides summaries of information from the foregoing sections of this status review, arranged under each of the factors to be considered by the Commission in determining whether listing is warranted.

7.1 Present or Threatened Modification or Destruction of Habitat

The main threats affecting mountain lions in the petitioned ESU and MUs evaluated in this review are habitat loss and fragmentation from historical and ongoing transportation infrastructure expansion and development (including residential and commercial structures, intensive agriculture, HSR lines, canals, and reservoirs), and lack of sufficient connectivity between remaining habitat patches which has resulted in reduced genetic exchange between populations. The amount of suitable habitat available to mountain lion populations has been significantly reduced in and adjacent to areas such as the Central Valley, San Francisco Bay area, and the greater Los Angeles and San Diego urban areas. Over time significant barriers have developed which impede mountain lion movement and isolate populations and ongoing residential and commercial development is projected to exacerbate isolation. The lack of sufficient gene flow between isolated populations has resulted in inbreeding in some smaller populations which may reduce survival and reproductive fitness, as evidenced by physical abnormalities in some mountain lions in the small and isolated Santa Ana and Santa Monica populations.

Long-term maintenance of genetic variation within the two broad-scale genetic populations identified by Gustafson et al. (2022) and the six fine-scale genetic populations identified by Gustafason et al. (2019, 2022) in the petitioned area is reliant on habitat conservation and connectivity. Maintenance and enhancement of gene flow between the petitioned ESU and the larger, more genetically diverse mountain lion populations in the Sierra Nevada and through the Tehachapi Mountains, and the San Gabriel, and San Bernardino mountains is required to maintain viable populations in the petitioned area.

After evaluating the threat posed by the present and future modification and destruction of habitat to the statewide mountain lion population, the Department concludes that the remaining, relatively large populations in the NC, SN, and portions of the CC are sufficient to preclude the threat of extinctions statewide, or in any of the four large-scale genetically discernable populations identified by Gustafson et al. (2022), presently and in the foreseeable future. As noted earlier in this report, some smaller fine-scale populations have well-documented significant risk factors at this time. In the most isolated habitat patches (e.g., Santa Monica Mountains, Santa Ana Mountains), it is conceivable that local extirpations may occur in the absence of efforts to improve habitat connectivity and remove barriers to movement. Management intervention to develop a broad wildlife crossing infrastructure, including the protection and enhancement of large blocks of suitable habitat on each side of crossing facilities, to link MUs would increase connectivity and potentially alleviate the genetic and stochastic risks associated with small populations. Such an effort will require adequate funding and concerted and sustained commitment by many parties to ensure proper design, placement, maintenance, and monitoring for effectiveness.

7.2 Overexploitation

Existing state laws and recent changes to the Department’s approach to issuing mountain lion depredation permits have significantly reduced the risk of overexploitation in the petitioned ESU and statewide. Under current management, occasional take of individual mountain lions due to repeated depredations on a single property or for public safety in the petitioned ESU is foreseeable and may exacerbate the detrimental effects associated with small population size and limited genetic exchange in isolated mountain lion populations such as the Santa Monica Mountains (CC-S), SA, and EPR. Depredation take has been the leading cause of known mortality across the petitioned ESU and a major identified source of mortality in the EPR. Unauthorized take via shooting or trapping (i.e., poaching) is known to occur but is difficult to quantify. Overexploitation likely poses little threat to the statewide population nor to any of the four large-scale genetically discernable populations; however, for the MUs with small population sizes (SA, CC-N, CC-S, SGSB), the additive mortality from permitted take is a concern.

7.3 Predation

As large-bodied predators, adult mountain lions in California are subject to little predation pressure. Gray wolves sometimes kill both adult and juvenile mountain lions, and black bears are known to occasionally kill mountain lion kittens but rarely adults (Elbroch and Kusler 2018). However, predation by wolves and black bears is not known to be a significant cause of California mountain lion mortality or known to threaten the persistence of lion populations. Therefore, and given the current absence of gray wolves within the petitioned area, predation is not currently considered to present a significant threat to California mountain lion populations.

7.4 Competition

Black bears and gray wolves are known to displace mountain lions from their kills which potentially forces mountain lions to expend additional energy hunting to procure more prey (Elbroch et al. 2015, Elbroch and Kusler 2018). Given the absence of wolves in the petitioned area, wolf competition would have no effect on central or southern coast lion populations. The potential impact of black bears in these areas remains unknown and warrants further study. Intraspecific conflict has been identified as the leading cause of mortality for the nearly isolated mountain lions in the Santa Monica Mountains within the CC-S (Riley et al. 2014). Intraspecific aggression appears to be a significant mortality factor where individual mountain lions occupy small patches of suitable habitat within habitat-limited landscapes, and therefore, this form of competition should be considered a significant threat to lion populations in the Santa Monica and Santa Ana mountains, and possibly within the SGSB MU. .

7.5 Disease

Mountain lions are susceptible to various viral, bacterial, and parasitic pathogens. Lions living near urban areas where the threat of domestic animals could play a role in disease transmission appear to be especially vulnerable. To the best of our knowledge, pathogens alone have not threatened large mountain lion populations (e.g., on the level of a state), and thus we do not think they represent a significant threat to the species in California. However, pathogens may be harmful to individuals and small populations, and, when combined with the serious threats of habitat loss and fragmentation, climate change, wildfires, and other threats, the possibility of a catastrophic disease outbreak further reduces the certainty that smaller, isolated, highly dense mountain lion populations will persist into the future.

7.6 Other Natural Occurrences or Human-related Activities

7.6.1 Vehicle-Related Mortality

Vehicle-related mortality is a major mortality factor for mountain lions in California. It is difficult to accurately assess the magnitude of the problem due to lack of systematic data collection. One estimate is that 100 mountain lions are killed every year by vehicle strikes (Pollard 2016), while a more recent report puts that number at 70 per year during the period from 2015 to 2022 (Shilling et al. 2023). Outside of the extensively studied populations of the CC-N and CC-S, it is difficult to quantify the impact of this threat on populations. Researchers have found that reported vehicle collisions are densest in the urban areas of the Bay Area, the central and south coasts, and the northern Sierra Nevada foothills. Dense clusters of reported vehicle strike mortalities also exist in more rural areas such as the I-5 corridor near the Oregon border and US 50, I-80, and SR-20 in the Sierra Nevada foothills (Shilling et al. 2023). Well-designed wildlife crossing structures and associated fencing to funnel animals to the crossing can reduce vehicle-related mortalities (Grilo et al. 2015, Villalobos-Hoffman et al. 2022). While such structures are extremely costly and require careful planning to be effective, there has been progress on the is front with the completion of the Highway 17 undercrossing in the Santa Cruz Mountains, construction of the Wallis Annenberg Wildlife Crossing underway in the CC-S, and several other structures in the planning stage. When such wildlife crossing structures and fencing become widespread, lion mortality from vehicle strikes in the petitioned ESU and elsewhere in the state will likely be significantly reduced.

7.6.2 Toxicants

Mountain lions throughout California are exposed to toxic chemicals in their environment which can be lethal or debilitating, depending on the quantities ingested. Lions with toxicant-impaired functions may be more susceptible to other forms of mortality such as starvation and vehicle strikes. Lions can encounter ARs used to control vertebrate pests throughout the state, including remote locations where legal and prohibited rodenticides are used to protect illicit cannabis plantations. Necropsies have verified that nearly all tested mountain lions in California have been exposed to ARs. While toxicants are not known to directly cause significant mortality statewide, their effects may be additive to other sources of mortality. The population effects of toxicant exposure within smaller MUs is unknown.

7.6.3 Wildland Fire and Fire Management

The effect of wildfire on mountain lions is complex and understudied throughout their geographic range. Fire is a regular ecological process in many California vegetative communities, and many native plant species display adaptations to fire such as thick fire-resistant bark, post-fire crown-sprouting, and smoke-induced seed germination which can create better forage for deer, the main prey of mountain lions. Mountain lions have been documented using burned landscapes more frequently than expected based on availability during the first nine years post-fire. However, some areas of suitable shrub habitat have been converted to less suitable annual grasslands due to unnaturally frequent repeated burns in the same area resulting from increased human ignitions and the effects of climate change. Wildfires also cause mountain lion injury and direct mortality, which is likely additive to other sources of mortality. Fires are projected to become more frequent with climate change, resulting in the conversion of some preferred mountain lion woodland and shrubland habitat to grasslands, which are documented to be mostly avoided by lions. The impact of wildfire on the statewide mountain lion population, genetic groups or MUs is difficult to predict; however, some small patches of habitat such as the Santa Monica Mountains (CC-S) and Santa Ana Mountains (SA) may be vulnerable to large, severe fires (e.g., the Woolsey Fire Los Angeles and Ventura counties in 2018) that could modify most extant lion habitat in one or a few events, potentially threatening or even extirpating local populations.

7.6.4 Climate Change

Projections indicate the California climate will continue to warm, and precipitation events will become less predictable and droughts more frequent. These changes will influence the condition and distribution of vegetative communities and the animal communities that depend upon them. The Department is not aware of any study using bioclimatic modeling to project changes in the geographic range of the mountain lion or their main prey species (mule deer) based on climate variables. As large-bodied mammals, it may be that both mountain lions and mule deer are sufficiently large not to be affected directly by moderate increases or decreases in environmental temperature, which more drastically affect small-bodied mammals with higher surface area to volume ratios. The generally nocturnal habits of mountain lions and their prey also help alleviate impacts from warmer environments. Mountain lions are known to occur across a wide variety of ecoregions ranging from deserts to temperate and coastal rainforests in California. The mountain lion's body size, foraging habits, and breadth of climates in the wide range of ecosystems the species occupies suggests the direct or indirect effects of climate change are unlikely to lead to near-term shifts in distribution of the species or population declines.

7.6.5 Risks to Small, Isolated Populations

Small, isolated populations are inherently vulnerable to extinction due to demographic stochasticity, inbreeding depression, and genetic drift which result in a loss of genetic variability and a reduced genetic capacity to respond to changes in the environment. A lack of immigration can also prevent isolated populations from recovering from stochastic extinctions or population declines, independent of genetic effects. In wildlife populations, genetic variation has been shown to be strongly correlated with high survival and reproduction rates, as well as decreased extinction risk. Genetic effects can amplify the impact of the other threats and random environmental effects to further reduce population sizes and accelerate populations towards extirpation in what has been termed an extinction vortex.

The estimated statewide mountain lion population estimate 3,242 (95% CI 2,826-3,742) animals is relatively robust for a large carnivore. In addition, there are the four major genetic population clusters in the state that contain high levels of genetic variation and exhibit little evidence of inbreeding depression (Gustafson et al. 2022). However, certain isolated populations, including the CC-N (Santa Cruz Mountains), CC-S (Santa Monica Mountains), SA, and SGSB (as delineated by Gustafson et al. 2022) are small enough that there are concerns about inbreeding and effective population size.

Certain small populations in southern California have particularly low genetic variation and the SA and CC-S populations exhibit high levels of inbreeding (Ernest et al. 2014, Riley et al. 2014, Benson et al. 2019, Gustafson et al. 2019). The SGSB and CC-N similarly have low observed genetic variation and effective population sizes. In contrast, the Klamath–Cascades, WSN, ESN, CC-C, and EPR populations show little evidence of inbreeding (Gustafson et al. 2019, 2022) and some level of genetic exchange between certain MUs appears to exist. As genetic variation is relatively high in multiple California populations compared to variation in several smaller central and southern coastal populations, there is high potential for long-term persistence of mountain lions throughout most of the state and all four broad-scale populations identified by Gustafson et al. (2022) if adequate habitat and connectivity can be protected.

8. PROTECTION AFFORDED BY LISTING

It is the policy of California to conserve, protect, restore, and enhance any endangered or threatened species and its habitat (Fish & G. Code, § 2052). If the Commission votes to list mountain lion populations under CESA, the act would prohibit take[9] except under certain circumstances: 1) when authorized by the Department for scientific, education, or management purposes through research and management MOUs (Fish & G. Code, § 2081, subd. (a)); 2) when authorized by the Department through incidental take permits (ITPs) when take is incidental to otherwise lawful purposes and the impacts have been minimized and fully mitigated (Fish & G. Code, § 2081, subd. (b)); 3) under authority of Fish & Game Code section 2087 when take accidentally results from otherwise lawful routine and ongoing agricultural activities; 4) when take occurs on land covered by Voluntary Local Programs, NCCPs, or Safe Harbor Agreements (Fish & G. Code, §§ 2086, 2835, 2089.2, respectively); or 5) authorized take pursuant to the Wildlife Protection Act of 1990 (Fish & G. Code, § 4800, et seq.).

If mountain lion populations are listed under CESA, the impacts of any take caused by activities authorized through ITPs must be minimized and fully mitigated (Fish & G. Code, § 2081, subd. (b)). These conditions often include protection of habitat in perpetuity, development and implementation of a species-specific adaptive management plan, and funding through an endowment to pay for long-term monitoring and maintenance to ensure the mitigation land meets performance criteria. Obtaining an incidental take permit is voluntary. The Department cannot force compliance; however, any person violating the take prohibition may be criminally and civilly liable under state law.

Additional protection of mountain lions following listing would be expected to occur through state and local agency environmental review under CEQA. CEQA requires affected public agencies to analyze and disclose project-related environmental effects, including potentially significant impacts on wildlife species. The CEQA Guidelines require a mandatory finding of significant impact, thus requiring preparation of an Environmental Impact Report, when a project has the potential to substantially reduce the number or restrict the range of a threatened or endangered species (Cal. Code Regs. 14, §15065(a)(1)). In common practice, potential impacts to listed species are examined more closely in CEQA documents than potential impacts to unlisted species. Where significant impacts are identified under CEQA, the lead agencies must typically adopt project-specific avoidance, minimization, and mitigation measures to limit impacts to the species. State listing, in this respect, and consultation with the Department during state and local agency environmental review under CEQA would be expected to benefit mountain lions in the petitioned ESU in terms of reducing impacts from individual projects. Absent listing, such protection measures or mitigations might not occur.

CESA listing may also result in increased priority for limited conservation funds such as Wildlife Conservation Board, Local Assistance, and State Wildlife Grants, along with land acquisition assistance from non-governmental organizations (NGOs) such as The Nature Conservancy.

9. LISTING RECOMMENDATION

[9] "Take" is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill (Fish & G. Code, § 86).

CESA directs the Department to prepare this report regarding the status of the mountain lion in the petitioned Southern California/Central Coast ESU based upon the best scientific information available (Fish & G. Code, § 2074.6). CESA also directs the Department based on its analysis to indicate in the status report whether the petitioned action (i.e., listing as threatened) is warranted (Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

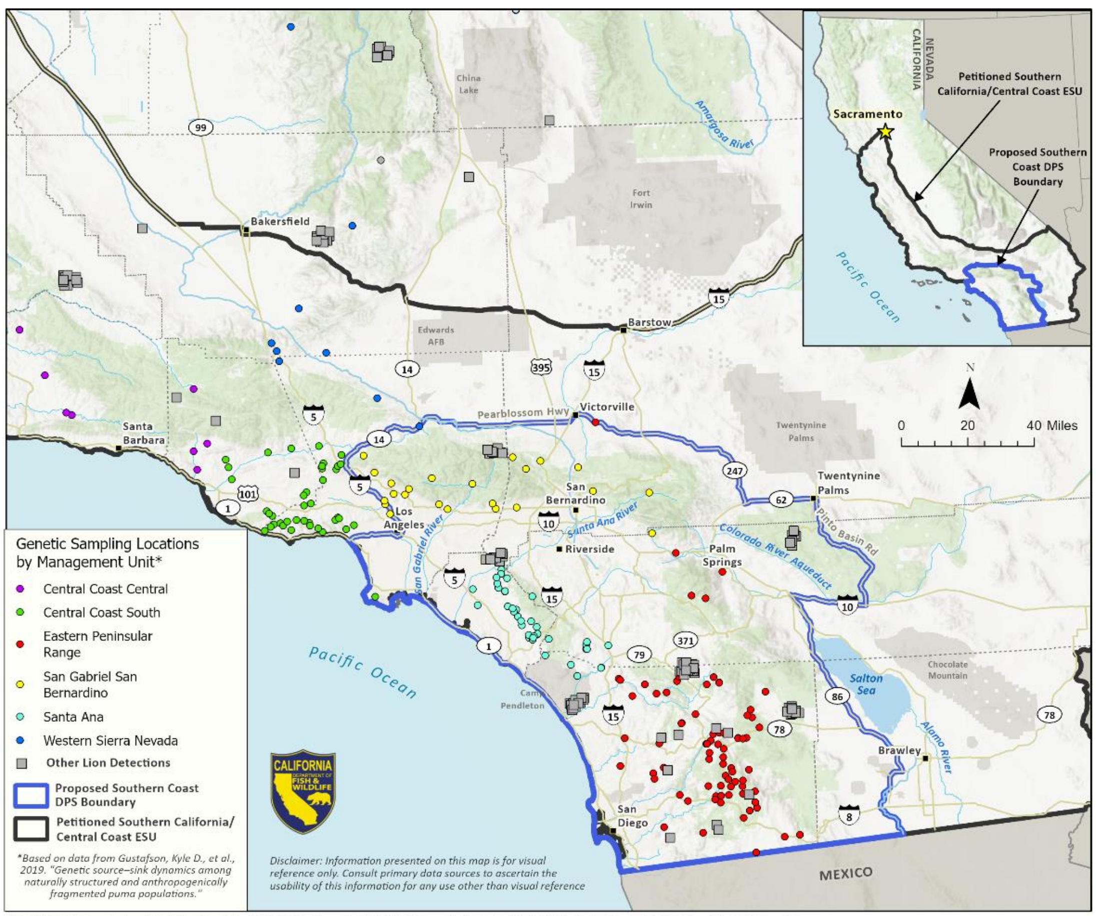
Under CESA, an endangered species is defined as "a native species or subspecies…which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish & G. Code, § 2062). A threatened species is defined as "a native species or subspecies…that, although not presently threatened with extinction, is likely to become an endangered species in the foreseeable future in the absence of the special protection and management efforts required by [CESA]" (Fish and G. Code, § 2067).

The Legislature left to the Department and the Commission, which are responsible for providing the best scientific information and for making listing decisions, respectively, the interpretation of what constitutes a "species or subspecies" under CESA. (*Cal. Forestry Assn. v. Cal. Fish and G. Com.* (2007) 156 Cal.App.4th 1535, 1548-49). Courts should give a "great deal of deference" to Commission listing determinations supported by Department scientific expertise (*Central Coast Forest Assn. v. Fish & G. Com.* (2018) 18 Cal. App. 5th 1191, 1198-99). The Commission's authority to list necessarily includes discretion to determine what constitutes a species or subspecies (*Id*. at p. 1237). The Commission's determination of which populations to list under CESA goes beyond genetics to questions of policy (Ibid.).

The Department evaluated the petitioned ESU as well as those populations within the petitioned ESU to determine if they singly or in combination should be considered threatened or endangered pursuant to CESA. The Department has determined, based upon the best available scientific evidence, that there is currently insufficient evidence that the mountain lions within the petitioned ESU and the populations within the petitioned ESU boundary meet the criteria to be listed as threatened or endangered ESUs. The petitioned ESU, or any combination of its populations, do not meet the criteria to be considered as ESUs—they are not both substantially isolated from other populations *and* important components of the evolutionary legacy of the mountain lion species. Although movement of individuals is increasingly restricted, there is limited gene flow between the petitioned ESU and other mountain lion populations, and neither the petitioned ESU nor the Management Units within it are totally reproductively isolated. Nor is the petitioned ESU sufficiently genetically or morphologically differentiated from the larger California population to suggest the presence of distinct evolutionary lineages or evolutionarily important differences. Therefore, there is insufficient scientific evidence to classify the portions of the California mountain lion population petitioned for listing as one or several ESUs as defined by Waples (1991).

The Department has also examined populations within the petitioned ESU through the lens of federal Distinct Population Segment policy in recognition of the Petitioner's intent to examine the viability of major genetic or otherwise significant groupings of mountain lions in California. The South Coast Group (as defined by Gustafson et al. 2022) consists of three MUs (EPR, SA, and SGSB) and meets the federal criteria to be considered a Distinct Population Segment, as the best available scientific evidence shows that it is discrete and biologically significant. Further, scientific evidence indicates the South Coast Group DPS is not in imminent danger of extinction, but it is likely imperiled if management actions are not taken to conserve and restore habitat connectivity between MUs to allow the exchange of individuals and facilitate genetic connections to the larger statewide population. Therefore, the Department recommends that the South Coast Group DPS be listed as Threatened under California law.

The Department recommends the boundary for the threatened South Coast Group be as delineated in Figure 19. Unlike the boundary of the proposed ESU, we do not include the desert regions in eastern San Bernardino, Riverside, and Imperial counties in the South Coast Group DPS. The EPR genetic cluster depicted in Gustafson et al. 2019 has ambiguous boundaries and Figure 2 in Gustafson et al. 2019 clearly shows there are no sample points within the desert regions in question. No tissue from mountain lions in this region were included in Gustafson et al.'s (2019, 2022) genetic analyses. Thus, the spatial interpolation of genetic clusters in this area cannot be considered reliable and population membership of mountain lions occupying these eastern regions cannot be determined.



CDFW Wildlife Branch, Aug 07, 2023 - Map Data: CDFW, Gustafson et al., 2019, Caltrans, Esri - Scale: 1:2,300,000 - Projection: NAD83 California Teale Albers (m)

Figure 19. Proposed boundary of South Coast DPS recommended for threatened status. Points represent genetic sampling locations color coded by the Management Unit they lie within. Grey squares are confirmed locations of mountain lions from camera trap data (CDFW unpublished).

Mountain lions are known to occur in the desert regions of California and in Death Valley National Park (Lundgren et al. 2022), but camera trap data suggest they may exist at low densities (Dellinger et al. 2019). Genetic material from the eastern deserts has not been systematically collected, and, consequently, mountain lions in those areas have not been assigned to a genetic population nor has local gene flow been characterized. The nearest location for which genetic samples have been analyzed is the Mojave Desert region of Nevada (Andreasen et al. 2012). In a statewide genetic study of mountain lion population structure, Andreasen et al. (2012) found that animals from southern Nevada were genetically similar to individuals from the Great Basin and the Sierra Nevada region of California (Fig. 2, therein). Further, a doctoral dissertation found minimal evidence for gene flow between mountain lions from southwest Arizona and those from south coastal California and individuals sampled from the North Rim of the Grand Canyon were found to be more genetically similar to those from south coastal California (Naidu 2015). The results of these two studies suggest mountain lions from the desert regions of California may share more recent genetic ancestry with animals to the northeast—namely the Great Basin and Colorado Plateau—as compared to animals immediately across the lower Colorado River in southwest Arizona. A fuller understanding of the genetics of mountain lions from southeastern California would require additional study with a focus on sampling new locations of collecting scat or capture of individual mountain lions. This would be complicated by the fact that individuals in this region may occur at low density and likely have larger home ranges coupled with the hot arid conditions making samples difficult to obtain.

For the reasons stated above, we suggest it currently is not possible to assign population membership to mountain lions occupying the California deserts east of the samples examined by Gustafson et al. (2019, 2022) or to assess their current level of conservation risk. We therefore do not find it appropriate to include large portions of the Mojave and Sonoran deserts in the DPS area. Instead, we suggest the South Coast DPS be bounded by the foot of the eastern slope of the Peninsular Ranges (Fig. 19). We created a boundary that encompasses the areas where the genetic samples were found, as well as connected areas of suitable habitat with verifiable sightings of mountain lions via camera traps (GBIF 2023, CDFW, unpublished data).

10. MANAGEMENT AND RECOVERY ACTION RECOMMENDATIONS

California's statewide mountain lion population is complex and diverse. Large areas of the state appear to have robust, genetically diverse, and well-connected lion populations (e.g., NC and SN groups) while other populations show evidence of inbreeding depression and genetic isolation (e.g., SA, Santa Monica Mountains of the CC-S). Multiple genetic investigations have now demonstrated the importance of the Sierra Nevada region as a reservoir of genetic variation (Ernest et al. 2003, Gustafson et al. 2019). Bi-directional migration rate models based on genetic data indicated the western Sierra Nevada serves as a significant source of migrants into other regions of California (Gustafson et al. 2019). The overarching goals of mountain lion management in the state should be maintaining and enhancing landscape connectivity between robust core populations and smaller, more isolated MUs within the CC and SC regions as well as enhancing and expanding remaining habitat patches and reducing mortality rates in those populations. Increased connectivity would help offset the risks to small populations that result from demographic and genetic factors. Benson et al. (2019) found that conserving mountain lions in isolated mountain ranges in greater Los Angeles (Santa Monica and Santa Ana mountains) is feasible with relatively modest increases in landscape connectivity.

Two MUs which may have significant relevance for restoring regional gene flow are the CC-C and EPR (Fig. 1). The CC-C MU has ample habitat for maintaining a breeding population (Dellinger et al. 2020*b*). Given the data indicating minimal gene flow across the Central Valley, this population may be the only consistent source of migrants for the CC-N and CC-S. Thus, maintaining connectivity to the CC-C MU may be essential for the long-term viability of both adjacent populations. Concurrently, maintaining connectivity and habitat quality within the CC-C population as the human population increases will be essential for that population to remain robust and a viable source for the CC-N and CC-S populations. The EPR is the only population known to exchange migrants with the SA population, and management actions which enhance gene flow between these areas will be critical to the sustainability and recovery of mountain lions in the SA. Dispersal in and out of the EPR is limited and the degree of dispersal across the border between the U.S. and Mexico remains unknown (Gustafson et al. 2019). While self-sustaining connectivity through a network of corridors and habitat patches with functional ecosystem processes would be ideal for long term sustainability, assisted gene flow between populations through targeted translocations should be considered as a short-term management action to augment the genetic variation of the most isolated small populations.

The specific recommendations below are compiled from sources including the Petitioners, mountain lion researchers, Gustafson et al. (2022), the Department, and others, and are designed to facilitate the above goals.

10.1 Connectivity

- Identify the most strategic locations for wildlife crossing structures, and design and build crossing infrastructure to improve wildlife connectivity and permeability at existing roads and highways, combined with protections of adjacent habitat to ensure perpetual wildlife access to the crossing structures and connections to the core protected habitat areas such as National Forests (South Coast Wildlands 2008). Crossing infrastructure should include, but is not limited to, overcrossings, underpasses, culverts, and exclusionary fencing that guides animals to safer crossing areas (Vickers et al. 2015). The following crossing locations have been identified by mountain lion experts and should be among the top priorities for the implementation of crossing infrastructure: (1) I-15 Freeway at Temecula Creek Bridge to enhance the Palomar Linkage and connect the Santa Ana and Eastern Peninsular Mountain Ranges (Ernest et al. 2014, Gustafson et al. 2017, Zeller et al. 2017, Riley et al. 2018) (2) I-15 Freeway at “Site 5” as described in Riley et al. (2018) (3) I-280 between San Bruno and Cupertino, which is the "deadliest highway for mountain lions in California" according to Shilling and Vickers (2023).

- In recognition of the importance of the Sierra Nevada region as a reservoir of genetic variation and significant source of migrants into other regions of California (Ernest et al. 2003, Gustafson et al. 2019, 2022), acquire, maintain, and enhance corridors and patches of suitable habitat linking the SN, CC-S, SGSB, SA, and EPR populations, emphasizing the retention and expansion of protected habitat in the Santa Ana, Santa Monica, and San Gabriel mountains.
- Encourage land use and planning agencies at federal, state, county, and local levels of government to require analysis of regional wildlife connectivity in all new development proposals in primary travel corridors and habitat linkages, such as those in the Tehachapi and Sierra Pelona mountains (Gustafson et al. 2019) and between the SA and EPR (Vickers et al. 2015).
- Explore periodic assisted translocations of outbred animals (i.e., genetic rescues) to quickly increase genetic variation in small, isolated mountain lion populations such as the Santa Monica Mountains (CC-S) and SA (Johnson et al. 2010).
- Fund monitoring programs to evaluate the success of wildlife crossing structures, including monitoring the genetic variation and movements of mountain lion populations on either side.
- Dedicate sufficient funding from the Wildlife Conservation Board, Habitat Conservation Fund, and other state funding sources towards acquiring key mountain lion and wildlife habitat and for establishment of highway crossing infrastructure.
- Encourage the maintenance and restoration of riparian vegetation communities in the CC and SC regions to provide prey habitat, resting and feeding cover, and viable movement corridors between remaining patches of mountain lion habitat. This could include limiting water diversions in these areas.

10.2 Research and Monitoring

While the recommendations below apply statewide, priority should be given to projects that enhance understanding of mountain lion populations and behaviors in petitioned ESU area.

- Periodically replicate genetic analyses similar to Gustafson et al.'s (2019) work to monitor genetic variation within MUs and signals of mountain lion immigration and emigration.
- Investigate whether the wide range of environmental conditions (e.g., precipitation, temperature) across California, and/or localized areas of restricted gene flow, are associated with local adaptations or drift. Such information will be vital to choosing which populations to reconnect through the establishment of wildlife corridors or by translocation actions (i.e., assisted migration and genetic rescue).
- Determine mountain lion distribution, abundance, resource selection at multiple spatial scales, movements and dispersal patterns, foraging ecology, and to study landscape genetics in the Sonoran and Mojave deserts, and along the lower Colorado River region of the state. Work collaboratively with tribes, adjacent states, Baja California, Mexico, universities, other

government entities (e.g., Caltrans, BLM, NPS, State Parks, USGS, Military), IUCN and IUCN Species Survival Commission Cat Specialist Group, and other NGOs.

- Monitor responses to increasing fire frequency to assess how mountain lions, other carnivores, and their prey will be affected by large-scale changes that may pose a threat to landscape integrity and persistence of mountain lion populations in southern California ((Jennings et al. 2016).
- Evaluate trans-highway movements, resource selection, home range placement, and vehicle-related mortality of adult and subadult mountain lions (Cougar Management Guidelines Working Group 2005, McKinney 2011). Focus on interstates in the South Coast Group (i.e., I-5, I-10, I-15, 101, 405), and roadways throughout the state that contain priority barriers or history of mountain lion vehicle-inducted mortality (i.e., I-5 near Oregon border, I-80 and SH 50, 70, 49, 396, 89 in the Sierra Nevada.
- Investigate the influence of variation in black bear seasonal presence and density on mountain lion kill rates and prey selection, habitat use, and kitten and adult survival. Also investigate areas where bears and mountain lions overlap with gray wolves to understand interactions.
- Investigate the influence of gray wolf distribution and density on mountain lion abundance, habitat selection, prey selection and kill rates, kitten and adult survival, and movements at multiple spatial scales.
- Rapidly detect, diagnose, and determine the significance of disease outbreaks and emerging diseases such as avian influenza.
- Continue AR screening of livers from mountain lion carcasses to further enhance our understanding about the locations and effects that AR exposure has on mountain lion health and mortality. Continued monitoring should also measure the effectiveness of regulatory changes intended to reduce exposure of non-target wildlife to rodenticides (Rudd et al. 2018).
- Investigate potential correlations between habitat, genetics, and prevalence of health and disease issues.
- Determine conditions associated with human-mountain lion conflict hotspots.
- Assess efficacy of non-lethal measures for mitigating/deterring mountain lions from depredating domestic animals. Assess whether co-occuring carnivores and native ungulate populations impact the efficacy of non-lethal measures for mitigating human-mountain lion conflict.

10.3 Regulations and Policy

- Work with the California Department of Pesticide Regulation to improve the management of second-generation ARs such as brodifacoum, bromadiolone, difenacoum, and difethialone to reduce mountain lion exposure, with an emphasis on southern California and central coast mountain lion habitat areas and linkages and explore outreach efforts on this issue.
- Improve law enforcement for areas where use of second-generation ARs is restricted to ensure compliance with the state’s regulations.

10.4 Partnerships and Coordination

- Continue to collaborate with Caltrans and others to analyze how projects in the State Highway Operation Protection Program and State Transportation Improvement Program can be designed to facilitate wildlife connectivity through wildlife passage features such as culverts, under crossings, overcrossings, bridges, directional fencing, scuppers, barrier breaks, roadside animal detection systems, signage, etc.
- Continue to collaborate with Caltrans and the Road Ecology Center at UC Davis to help collect and analyze roadkill data to identify hotspots where mountain lions, deer, and other animals are killed. Investigate funding channels for creating an open access statewide roadkill database for data download and analysis as needed by multiple interested parties. Encourage Caltrans to implement wildlife passage features to the greatest extent feasible and as expeditiously as possible.
- Continue to collaborate with external researchers, tribal members, agencies, universities, and NGOs to help solve habitat conservation, landscape connectivity, and vehicle-related and other mortality incidents in southern and central California.
- Encourage local governments to place conditions on new developments to minimize negative impacts on riparian systems and native vegetation by buffering the riparian areas to allow use by mountain lions and their prey. Promote efforts to restore riparian ecosystems and protected lands in the vicinity of wildlife crossing structures.

10.5 Public Education

- Continue to promote awareness and education regarding mountain lions, human safety, pet and livestock conflict prevention, pesticide exposure, and conservation messaging throughout southern California.
- Develop and implement outreach and education activities to promote use of predator-proof enclosures for domestic animals (Vickers et al. 2015).

11. ECONOMIC CONSIDERATIONS

The Department is charged in an advisory capacity to provide a written report and a related recommendation to the Commission based on the best scientific information available regarding the status of mountain lion in the petitioned Southern California/Central Coast ESU. The Department is not required to prepare an analysis of economic impacts (See Fish & G. Code, § 2074.6; Cal. Code Regs., tit. 14, § 670.1, subd. (f)).

LITERATURE CITED

Allen, M. L. 2014. The ecology and behaviour of pumas (*Puma concolor*) in northern California, U.S.A. Doctoral Dissertation, Victoria University of Wellington, Wellington.

Allen, M. L., L. M. Elbroch, and H. U. Wittmer. 2021. Can't bear the competition: Energetic losses from kleptoparasitism by a dominant scavenger may alter foraging behaviors of an apex predator. Basic and Applied Ecology 51:1–10.

Allen, M. L., L. Mark, D. S. Casady, and H. U. Wittmer. 2015. Feeding and spatial ecology of mountain lions in the Mendocino National Forest, California. California Fish and Game. Volume 101.

Allen, M. L., H. U. Wittmer, and C. C. Wilmers. 2014. Puma communication behaviours: Understanding functional use and variation among sex and age classes. Behaviour 151:819–840.

Anderson, C. R., F. G. Lindzey, and D. B. McDonald. 2004. Genetic structure of cougar populations across the Wyoming Basin: Metapopulation or megapopulation. Journal of Mammology 85:1207–1214.

Andreasen, A. M., K. M. Stewart, W. S. Longland, J. P. Beckmann, and M. L. Forister. 2012. Identification of source-sink dynamics in mountain lions of the Great Basin. Molecular Ecology 21:5689–5701.

APHIS. 2023. 2022-2023 Detections of Highly Pathogenic Avian Influenza in Mammals. <https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-mammals>.

Ávila-Nájera, D. M., O. Rosas, L. Tarango, J. Martínez, and E. Santoyo. 2011. Conocimiento, uso y valor cultural de seis presas del jaguar (Panthera onca) y su relación con éste, en San Nicolas de los Montes, San Luis Potosí, Mexico. Revista Mexicana de Biodiversidad 82:1020–1028.

AZGFD. 2022. Frequently asked questions about mountain lion management in Arizona. <https://azgfd-portal-wordpress-pantheon.s3.us-west-2.amazonaws.com/wp-content/uploads/archive/MountainLionMgtFAQ_May2022.pdf>.

Ballou, J. D., T. J. Foose, R. C. Lacy, and U. S. Seal. 1989. Florida panther (*Felis concolor coyi*) population viability analysis and recommendations. Gland, Switzerland.

Bartnick, T. D., T. R. van Deelen, H. B. Quigley, and D. Craighead. 2013. Variation in cougar (*Puma concolor*) predation habits during wolf (*Canis lupus*) recovery in the southern Greater Yellowstone Ecosystem. Canadian Journal of Zoology 91:82–93.

Beier, P. 1993. Determining minimum habitat areas and habitat corridors for cougars. Conservation Biology 7:94–108.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. The Journal of Wildlife Management 59:228–237.

Beier, P., and R. H. Barrett. 1993. The cougar in the Santa Ana Mountain Range, California.

Beier, P., S. P. D. Riley, and R. M. Sauvajot. 2010. Mountain lions (*Puma concolor*). Pages 141–155 *in*. Urban carnivores: ecology, conflict, and conservation. Johns Hopkins University Press.

Bender, L. C., L. A. Lomas, and J. Browning. 2007. Condition, survival, and cause-specific mortality of adult female mule deer in north-central New Mexico. Journal of Wildlife Management 71:1118–1124.

Benson, J. F., K. D. Dougherty, P. Beier, W. M. Boyce, B. Cristescu, D. J. Gammons, D. K. Garcelon, J. M. Higley, Q. E. Martins, A. C. Nisi, and S. P. Riley. 2023. The ecology of human-caused mortality for a protected large carnivore. Proceedings of the National Academy of Sciences 120.

Benson, J. F., P. J. Mahoney, J. A. Sikich, L. E. K. Serieys, J. P. Pollinger, H. B. Ernest, and S. P. D. Riley. 2016. Interactions between demography, genetics, and landscape connectivity increase extinction probability for a small population of large carnivores in a major metropolitan area. Proceedings of the Royal Society B: Biological Sciences 283.

Benson, J. F., P. J. Mahoney, T. W. Vickers, J. A. Sikich, P. Beier, S. P. D. Riley, H. B. Ernest, and W. M. Boyce. 2019. Extinction vortex dynamics of top predators isolated by urbanization. Ecological Applications 29.

Bevins, S. N., S. Carver, E. E. Boydston, L. M. Lyren, M. Alldredge, K. A. Logan, S. P. D. Riley, R. N. Fisher, T. W. Vickers, W. Boyce, M. Salman, M. R. Lappin, K. R. Crooks, and S. VandeWoude. 2012. Three pathogens in sympatric populations of pumas, bobcats, and domestic cats: Implications for infectious disease transmission. PLoS ONE 7.

Bitsch, V., B. Knox, and B. Munch. 1969. Cases of Pseudorabies in free-living red foxes (*Vulpes vulpes*) and in captive blue foxes (*Alopex lagopus*) in Denmark. Acta Veterinaria Scandinavica 10:195–196.

Blakey, R. v, J. A. Sikich, D. T. Blumstein, and S. P. D. Riley. 2022. Mountain lions avoid burned areas and increase risky behavior after wildfire in a fragmented urban landscape. Current Biology 32:4762-4768.e5.

Bornstein, S., T. Mörner, and W. M. Samuel. 2001. *Sarcoptes scabiei* and sarcoptic mange. Pages 107–119 *in*. Parasitic diseases of wild mammals. Volume 2.

van den Brink, N. W., J. E. Elliott, R. F. Shore, and B. A. (eds) Rattner. 2018. Anticoagulant rodenticides and wildlife. Volume V. Springer International Publishing, New York.

Brunet, M. J., K. L. Monteith, K. S. Huggler, J. G. Clapp, D. J. Thompson, P. W. Burke, M. Zornes, P. Lionberger, M. Valdez, and J. D. Holbrook. 2022. Cats and dogs: A mesopredator navigating risk and reward provisioned by an apex predator. Ecology and Evolution 12:1–15.

Burdett, C. L., K. R. Crooks, D. M. Theobald, K. R. Wilson, E. E. Boydston, L. M. Lyren, R. N. Fisher, T. W. Vickers, S. A. Morrison, and W. M. Boyce. 2010. Interfacing models of wildlife habitat and human development to predict the future distribution of puma habitat. Ecosphere 1.

CA Parks. 2005. Anza-Borrego Desert State Park Final General Plan and EIR. Sacramento, CA.

CA Parks. 2013. General Plan and Final Environmental Impact Report for Big Basin Redwoods State Park.

California Department of Fish and Wildlife (CDFW). 2000. Mountain lion attacks on humans. Outdoor California 1–31.

Cameron, D. R., J. Marty, and R. F. Holland. 2014. Whither the rangeland?: Protection and conversion in California's rangeland ecosystems. PLoS ONE 9.

Caragiulo, A., I. Dias-Freedman, J. A. Clark, S. Rabinowitz, and G. Amato. 2014. Mitochondrial DNA sequence variation and phylogeography of Neotropic pumas (Puma concolor). Mitochondrial DNA 25:304–312.

del Castillo, A. 2009. No Title. Milenio. <https://www.milenio.com/node/317738>. Accessed 14 Dec 2010.

Catchen, J. M., P. A. Hohenlohe, L. Bernatchez, W. C. Funk, K. R. Andrews, and F. W. Allendorf. 2017. Unbroken: RADseq remains a powerful tool for understanding the genetics of adaptation in natural populations. Molecular Ecology Resources 17:362–365.

Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent changes toward earlier springs---Early signs of climate warming in western North America. Watershed Management Council Networker 3–7.

Cayan, D. R., E. P. Maurer, M. D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climatic Change 87:S21–S42.

California Department of Food and Agriculture (CDFA). 2009. AgVision 2030: Agricultural Land Loss & Conversion. <https://www.cdfa.ca.gov/agvision/docs/Agricultural_Loss_and_Conservation.pdf>.

California Department of Fish and Wildlife (CDFW). 2014. Ecosystem Restoration Program Conservation Strategy for Restoration of the Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions.

California Department of Fish and Wildlife (CDFW). 2015. California State Wildlife Action Plan 2015 Update.

California Department of Fish and Wildlife (CDFW). 2017. Human/Wildlife Interactions in California: mountain lion depredation, public safety, and animal welfare. Amendment to Department Bulletin 2013-02.

California Department of Fish and Wildlife (CDFW). 2019. Report to the Fish and Game Commission regarding findings of necropsies on mountain lions taken under depredation permits in 2018.

California Department of Fish and Wildlife (CDFW). 2020. Amendment to DB2017-17 boundaries and regional guidance team requirements.

California Department of Fish and Wildlife (CDFW). 2021. Report to the Fish and Game Commission Five year species review of Sierra Nevada Bighorn Sheep (Ovis canadensis sierrae).

California Department of Fish and Wildlife (CDFW). 2022*a*. California Natural Diversity Database (CNDDB), Special Animals List.

California Department of Fish and Wildlife (CDFW). 2022*b*. Restoring California’s Wildlife Connectivity 2022.

California Department of Fish and Wildlife (CDFW). 2023*a*. Caltrans, California Department of Fish and Wildlife and Brightline Agree to Build Wildlife Overcrossings for Rail Project. NEWS. <https://wildlife.ca.gov/News/caltrans-california-department-of-fish-and-wildlife-and-brightline-agree-to-build-wildlife-overcrossings-for-rail-project#gsc.tab=0>.

California Department of Fish and Wildlife (CDFW). 2023*b*. Highly Pathogenic Avian Influenza. <https://wildlife.ca.gov/Conservation/Laboratories/Wildlife-Health/Monitoring/HPAI>.

CDTFA. 2021. Timber Production Figures (Table 16b). <https://www.cdtfa.ca.gov/dataportal/charts.htm?url=PropTaxTimberProductionStats>. Accessed 1 Feb 2022.

California Department of Water Resources (DWR). 2023. Agriculture. <https://water.ca.gov/Water-Basics/Agriculture>. Accessed 9 Aug 2023.

Ceballos, G., C. C. González, V. Urios, D. Medellin, and ... 2022. Spatial ecology of jaguars in Mexico: implications for conservation. <https://www.researchsquare.com/article/rs-1617784/latest.pdf>.

Ceballos, G., H. Zarza, J. F. González-Maya, J. A. de la Torre, A. Arias-Alzate, C. Alcerreca, H. V. Barcenas, G. Carreón-Arroyo, C. Chávez, C. Cruz, D. Medellín, A. García, M. Antonio-García, M. A. Lazcano-Barrero, R. A. Medellín, O. Moctezuma-Orozco, F. Ruiz, Y. Rubio, V. H. Luja, and E. J. Torres-Romero. 2021. Beyond words: From jaguar population trends to conservation and public policy in Mexico. PLoS ONE 16:1–22.

Chan, K. W., Y. H. Hsu, W. L. Hu, M. J. Pan, J. M. Lai, K. C. Huang, and S. J. Chou. 2014. Serological and PCR detection of feline *Leptospira* in Southern Taiwan. Vector-Borne and Zoonotic Diseases 14:118–123.

Chávez, C., and G. Ceballos. 2014. Puma (*Puma concolor*). G. Ceballos, editor. Mammals of Mexico. John Hopkins University Press.

Climate Change Science Program. 2008. Weather and climate extremes in a changing climate, regions of focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. T. R. Karl, G. A. Meehl, C. D. Miller, S. J. Hassol, A. M. Waple, and W. L. Murray, editors. Department of Commerce, NOAA's National Climate Data Center, Washington DC.

California Natural Resources Agency (CNRA). 2016. Safeguarding California: Implementation Action Plan.

Cook, B. I., T. R. Ault, and J. E. Smerdon. 2015. Unprecedented 21st century drought risk in the American Southwest and Central Plains. Science Advances 1.

Cougar Management Guidelines Working Group. 2005. Cougar management guidelines. 1st edition. Wild Futures, Bainbridge Island, WA.

Culver, M., W. E. Johnson, J. Pecon-Slattery, and S. J. O'Brien. 2000. Genomic ancestry of the American puma (*Puma concolor*). Journal of Heredity 91:186–197.

Currier, M. J. P. 1983. *Felis concolor*. Mammalian Species 1–7.

Dawson, T. P., S. T. Jackson, J. I. House, I. C. Prentice, and G. M. Mace. 2011. Beyond predictions: biodiversity conservation in a changing climate. Science 332:53–58.

Delahay, R. J., J. de la Fuente, G. C. Smith, K. Sharun, E. L. Snary, L. Flores Girón, J. Nziza, A. R. Fooks, S. M. Brookes, F. Z. X. Lean, A. C. Breed, and C. Gortazar. 2021. Assessing the risks of SARS-CoV-2 in wildlife. One Health Outlook 3.

Dellinger, J. A., B. Cristescu, J. Ewanyk, D. J. Gammons, D. Garcelon, P. Johnston, Q. Martins, C. Thompson, T. W. Vickers, C. C. Wilmers, H. U. Wittmer, and S. G. Torres. 2020*a*. Using mountain lion habitat selection in management. Journal of Wildlife Management 84:359–371.

Dellinger, J. A., K. D. Gustafson, D. J. Gammons, H. B. Ernest, and S. G. Torres. 2020*b*. Minimum habitat thresholds required for conserving mountain lion genetic diversity. Ecology and Evolution 10:10687–10696.

Dellinger, J. A., D. K. Macon, J. L. Rudd, D. L. Clifford, and S. G. Torres. 2021*a*. Temporal trends and drivers of mountain lion depredation in California, USA. Human-Wildlife Interactions 15:162–177.

Dellinger, J. A., J. L. Rudd, B. Furnas, M. Buchalski, A. Heeren, V. Monroe, and D. L. Clifford. 2021*b*. Interim mountain lion conservation assessment – Full Report. Sacramento, CA.

Dellinger, J., N. Darby, and S. G. Torres. 2018. Factors influencing occupancy and detection rates of mountain lions in the Mojave Desert of California. Southwestern Naturalist 63:248–255.

Dennison, P. E., S. C. Brewer, J. D. Arnold, and M. A. Moritz. 2014. Large wildfire trends in the western United States, 1984-2011. Geophysical Research Letters 41:2928–2933.

Dickson, B. G., and P. Beier. 2002. Home-Range and Habitat Selection by Adult Cougars in Southern California. The Journal of Wildlife Management 66:1235.

Dickson, B. G., J. S. Jenness, and P. Beier. 2005. Influence of vegetation, topography, and roads on cougar movement in Southern California. Journal Of Wildlife Management 69:264–276.

Elbroch, L., and A. Kusler. 2018. Are pumas subordinate carnivores, and does it matter? PeerJ 6.

Elbroch, L. M., J. M. Ferguson, H. Quigley, D. Craighead, D. J. Thompson, and H. U. Wittmer. 2020. Reintroduced wolves and hunting limit the abundance of a subordinate apex predator in a multi-use landscape. Proceedings of the Royal Society B: Biological Sciences 287.

Elbroch, L. M., P. E. Lendrum, M. L. Allen, and H. U. Wittmer. 2015. Nowhere to hide: Pumas, black bears, and competition refuges. Behavioral Ecology 26:247–254.

Elbroch, M. L., P. E. Lendrum, J. Newby, H. Quigley, and D. J. Thompson. 2015. Recolonizing wolves influence the realized niche of resident cougars. Zoological Studies 54:1–11.

Ernest, H. B., W. M. Boyce, V. C. Bleich, B. May, S. J. Stiver, and S. G. Torres. 2003. Genetic structure of mountain lion (*Puma concolor*) populations in California. Conservation Genetics 4:353–366.

Ernest, H. B., T. W. Vickers, S. A. Morrison, M. R. Buchalski, and W. M. Boyce. 2014. Fractured genetic connectivity threatens a Southern California puma (*Puma concolor*) population. PLoS ONE 9.

Facemire, C. F., T. S. Gross, and L. J. Guillette. 1995. Reproductive impairment in the Florida panther: Nature or nurture? Environmental Health Perspectives 4:79–86.

Fenimore, A., K. Carter, and K. Lunn. 2012. Detection of *Leptospiruria* in shelter cats in Colorado. Journal of Veterinary Internal Medicine 26:94.

Ferguson, J., K. Woodberry, and C. M. Gillin. 2011. Cylicospirura species (Nematoda: Spirocercidae) and stomach nodules in cougars (*Puma concolor*) and bobcats (*Lynx rufus*) in Oregon. Journal of Wildlife Diseases 47:140–153.

Ferris, D. H., and R. D. Andrews. 1965. *Leptospira pomona* in feral cat. American Journal of Veterinary Research 26:373–376.

Fitzhugh, E. L., and W. P. Gorenzel. 1986. Biological status of mountain lions in California. Proceedings of the Twelfth Vertebrate Pest Conference.

Flather, C. H., G. D. Hayward, S. R. Beissinger, and P. A. Stephens. 2011. Minimum viable populations: Is there a “magic number” for conservation practitioners? Trends in Ecology and Evolution. Volume 26.

Foley, J. E., P. Swift, K. A. Fleer, S. Torres, Y. A. Girard, and C. K. Johnson. 2013. Risk factors for exposure to feline pathogens in California mountain lions (*Puma concolor*). Journal of Wildlife Diseases 49:279–293.

Foley, J., P. Foley, and M. Jecker. 1999. *Granulocytic ehrlichiosis* and tick infestation in mountain lions in California. Journal of Wildlife Diseases 35:703–709.

Frankham, R. 2005. Genetics and extinction. Biological Conservation 126:131–140.

Frankham, R., J. Ballou, and Eldridge M. D. B. 2011. Predicting the probability of outbreeding depression. Conservation Biology 25:465–475.

Franklin, I. R. 1980. Evolutionary change in small populations. Pages 135–149 *in*. Conservation Biology - An evolutionary-ecological perspective. Sinauer Associates, U.S.A., Sunderland, Massachusetts.

Frankson, R., L. E. Stevens, K. E. Kunkel, S. M. Champion, D. R. Easterling, W. Sweet, and M. Anderson. 2022. California State Climate Summary 2022. NOAA Technical Report NESDIS 150-CA. Silver Springs, Maryland.

Funk, W. C., J. K. McKay, P. A. Hohenlohe, and F. W. Allendorf. 2012. Harnessing genomics for delineating conservation units. Trends in Ecology and Evolution. Volume 27. Elsevier Current Trends.

Gabriel, M. W., L. W. Woods, R. Poppenga, R. A. Sweitzer, C. Thompson, S. M. Matthews, J. M. Higley, S. M. Keller, K. Purcell, R. H. Barrett, G. M. Wengert, B. N. Sacks, and de ana L. Clifford. 2012. Anticoagulant rodenticides on our public and community lands: Spatial distribution of exposure and poisoning of a rare forest carnivore. PLoS ONE 7:e0140640.

Gabriel, M. W., L. W. Woods, G. M. Wengert, N. Stephenson, J. M. Higley, C. Thompson, S. M. Matthews, R. A. Sweitzer, K. Purcell, R. H. Barrett, S. M. Keller, P. Gaffney, M. Jones, R. Poppenga, J. E. Foley, R. N. Brown, D. L. Clifford, and B. N. Sacks. 2015. Patterns of natural and human-caused mortality factors of a rare forest carnivore, the fisher (*Pekania pennanti*) in California. PLoS ONE 10.

Galindo, F., D. Williams, D. González-Rebeles, C. Zarza, H. Ávila-Flores, R. Olea-Perez, and G. Suzán. 2016. Conservation and Livestock Production in Tropical Mexico. A. A. Aguirre and R. Sukumar, editors. Tropical Conservation: Perspectives on Local and Global Priorities. Oxford University Press.

Gangadharan, A., S. Pollock, P. Gilhooly, A. Friesen, B. Dorsey, and C. C. St. Clair. 2017. Grain spilled from moving trains create a substantial wildlife attractant in protected areas. Animal Conservation 20:391–400.

Garcia, R. A., M. Cabeza, C. Rahbek, and M. B. Araújo. 2014. Multiple dimensions of climate change and their implications for biodiversity. Science 344.

Giraldo-Ramirez, S., S. Rendon-Marin, J. A. Jaimes, M. Martinez-Gutierrez, and J. Ruiz-Saenz. 2021. Sars-Cov-2 clinical outcome in domestic and wild cats: A systematic review. Animals 11.

Glass, C. M., R. G. McLean, J. B. Katz, D. S. Maehr, C. B. Cropp, L. J. Kirk, A. J. McKeirnan, and J. F. Evermann. 1994. Isolation of pseudorabies (Aujeszky's disease) virus from a Florida panther. Journal of wildlife diseases 30:180–184.

González-Orozco, C. E., L. J. Pollock, A. H. Thornhill, B. D. Mishler, N. Knerr, S. W. Laffan, J. T. Miller, D. F. Rosauer, D. P. Faith, D. A. Nipperess, H. Kujala, S. Linke, N. Butt, C. Külheim, M. D. Crisp, and B. Gruber. 2016. Phylogenetic approaches reveal biodiversity threats under climate change. Nature Climate Change 6:1110–1114.

Greiner, E. C., M. E. Roelke, C. T. Atkinson, J. P. Dubey, and S. D. Wright. 1989. *Sarcocystis sp.* in muscles of free-ranging Florida panthers and cougars (*Felis concolor*). Journal of Wildlife Diseases 25:623–628.

Grigione, M. M., P. Beier, R. A. Hopkins, D. Neal, W. D. Padley, C. M. Schonewald, and M. L. Johnson. 2002. Ecological and allometric determinants of home-range size for mountain lions (*Puma concolor*). Animal Conservation 5:317–324.

Grilo, C., D. J. Smith, and N. Klar. 2015. Carnivores: Struggling for survival in roaded landscapes. Pages 300–312 *in* R. van der Ree, D. J. Smith, and C. Grilo, editors. Handbook of Road Ecology. John Wiley & Sons, Ltd. <https://onlinelibrary.wiley.com/doi/full/10.1002/9781118568170.ch35>. Accessed 25 Apr 2023.

Grinnell, J. 1914. Yuma cougar (Felis oregonensis browni, Merriam). Pages 251–253 *in*. An account of the mammals and birds of the lower Colorado Valley with especial reference to the distributional problems presented. Volume 12. University of California Publications in Zoology.

Grinnell, J., J. Dixon, and J. Linsdale. 1937. California Mountain Lion. Pages 533–589 *in*. Fur-bearing mammals of California, Their Natural History, Systematic Status, and Relations to Man. Volume II. University of California Press, Berkeley, California, USA.

Gupta, R. 2012. Veterinary toxicology: basic and clinical principles. Academic Press.

Gustafson, K. D., R. B. Gagne, M. R. Buchalski, T. W. Vickers, S. P. D. Riley, J. A. Sikich, J. L. Rudd, J. A. Dellinger, M. E. F. LaCava, and H. B. Ernest. 2022. Multi-population puma connectivity could restore genomic diversity to at-risk coastal populations in California. Evolutionary Applications.

Gustafson, K. D., R. B. Gagne, T. W. Vickers, S. P. D. Riley, C. C. Wilmers, V. C. Bleich, B. M. Pierce, M. Kenyon, T. L. Drazenovich, J. A. Sikich, W. M. Boyce, and H. B. Ernest. 2019. Genetic source–sink dynamics among naturally structured and anthropogenically fragmented puma populations. Conservation Genetics 20:215–227.

Gustafson, K. D., T. W. Vickers, W. M. Boyce, and H. B. Ernest. 2017. A single migrant enhances the genetic diversity of an inbred puma population. Royal Society Open Science 4.

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. Volume II. The Ronald Press Company, New York.

Harding, L. E., J. Heffelfinger, D. Paetkau, E. Rubin, J. Dolphin, and A. Aoude. 2016. Genetic management and setting recovery goals for Mexican wolves (*Canis lupus baileyi*) in the wild. Biological Conservation 203:151–159.

Harmsen, B. J., R. J. Foster, S. M. Gutierrez, S. Y. Marin, and C. P. Doncaster. 2010. Scrape-marking behavior of jaguars (*Panthera onca*) and pumas (*Puma concolor*). Journal of Mammalogy 91:1225–1234.

Hasting, A. 1993. Complex interactions between dispersal and dynamics: lessons from coupled logistic equations. Ecology 74:1362–1372.

Hawley, J., P. Rego, A. P. Wydeven, M. K. Schwartz, T. C. Viner, R. Kays, K. L. Pilgrim, and J. A. Jenks. 2016. Long-distance dispersal of a subadult male cougar from South Dakota to Connecticut documented with DNA evidence. Journal of Mammalogy 97:1435–1440.

Hedrick, P. W., and S. T. Kalinowski. 2000. Inbreeding Depression in Conservation Biology. Annual Review of Ecology and Systematics 31:139–162.

Hohenlohe, P. A., B. K. Hand, K. R. Andrews, and G. Luikart. 2018. Population genomics provides key insights in ecology and evolution. Pages 483–510 *in* Rajora OP, editor. Population Genomics: Concepts, Approaches and Applications. Springer International Publishing: Cham.

Hosea, R. C. 2000. Exposure of non-target wildlife to anticoagulant rodenticides in California. Proceedings of the Vertebrate Pest Conference 19.

Howard, A. L., M. J. Clement, F. R. Peck, and E. S. Rubin. 2020. Estimating Mountain Lion Abundance in Arizona Using Statistical Population Reconstruction. Journal of Wildlife Management 84:85–95. <http://dx.doi.org/10.1002/jwmg.21769>.

Huang, X., D. L. Swain, and A. D. Hall. 2020. Future precipitation increase from very high resolution ensemble downscaling of extreme atmospheric river storms in California. Science Advances 6:1–14.

Huffmeyer, A. A., J. A. Sikich, T. W. Vickers, S. P. D. Riley, and R. K. Wayne. 2022. First reproductive signs of inbreeding depression in Southern California male mountain lions (*Puma concolor*): Signs of inbreeding depression in California mountain lions. Theriogenology 177:157–164.

Hunter, L. 2015. Wild cats of the world. Bloomsbury Publishing.

Iriarte, J. A., W. L. Franklin, and W. E. Johnson. 1990. Biogeographic variation of food habits and body size of the America puma. Oecologia 85:185–190.

Janečka, J. E., M. E. Tewes, L. L. Laack, L. I. Grassman, A. M. Haines, and R. L. Honeycutt. 2008. Small effective population sizes of two remnant ocelot populations (Leopardus pardalis albescens) in the United States. Conservation Genetics 9:869–878.

Jennings, M. K., R. L. Lewison, T. W. Vickers, and W. M. Boyce. 2016. Puma response to the effects of fire and urbanization. Journal of Wildlife Management 80:221–234.

Jessup, D. A., K. C. Pettan, L. J. Lowenstine, and N. C. Pedersen. 1993. Feline Leukemia-Virus Infection and Renal Spirochetosis in a Free-Ranging Cougar (Felis-Concolor). Journal of Zoo and Wildlife Medicine 24:73–79.

Johnson, W., D. Onorato, M. Roelke, and E. D. Land. 2010. Genetic restoration of the Florida panther. Science 329:1641–1645.

Karandikar, H., M. W. Serota, W. C. Sherman, J. R. Green, G. Verta, C. Kremen, and A. D. Middleton. 2022. Dietary patterns of a versatile large carnivore, the puma (*Puma concolor*). Ecology and Evolution 12:1–11.

Kechejian, S. R., N. Dannemiller, S. Kraberger, C. Ledesma-Feliciano, J. Malmberg, M. R. Parker, M. Cunningham, R. McBride, S. P. D. Riley, W. T. Vickers, K. Logan, M. Alldredge, K. Crooks, M. Löchelt, S. Carver, and S. Vandewoude. 2019. Feline foamy virus is highly prevalent in free-ranging *Puma concolor* from Colorado, Florida and southern California. Viruses 11.

Keeley, J. E. 2005. Fire as a threat to biodiversity in fire-type shrublands. Pages 97–106 *in* B. E. Kus and J. L. Beyers, editors. Planning for biodiversity: bringing research and management together. U.S. Forest Service General Technical Report, Albany, California, USA.

Keeley, J. E., C. J. Fotheringham, and M. Morais. 1999. Reexamining fire suppression impacts on brushland fire regimes. Science 284:1829–1832.

Keeley, J. E., and A. D. Syphard. 2016. Climate change and future fire regimes: Examples from California. Geosciences (Switzerland) 6.

Keeley, J. E., and A. D. Syphard. 2017. Different historical fire-climate patterns in California. International Journal of Wildland Fire 26:253–268.

Keeley, J. E., and A. D. Syphard. 2021. Large California wildfires: 2020 fires in historical context. Fire Ecology 17.

Kehl, T., A. Bleiholder, F. Roßmann, S. Rupp, J. Lei, J. Lee, W. Boyce, W. Vickers, K. Crooks, S. VandeWoude, and M. Löchelt. 2013. Complete genome sequences of two novel Puma concolor foamy viruses from California. Genome Announcements 1.

Kitchener, A., Breitenmoser-Würsten, E. Eizirik, A. Gentry, L. Werdelin, A. Wilting, N. Yamaguchi, A. v. Abramov, P. Christiansen, C. Driscoll, and Duckworth JW. 2017. A revised taxonomy of the Felidae: the final report of the Cat Classification Task Force of the IUCN Cat Specialist Group. Cat News.

Kopanke, J. H., K. E. Horak, E. Musselman, C. A. Miller, K. Bennett, C. S. Olver, S. F. Volker, S. Vandewoude, and S. N. Bevins. 2018. Effects of Low-level Brodifacoum Exposure on the Feline Immune Response. Scientific Reports 8:1–13.

Kucera, T. E. 1998. Yuma mountain lion (*Felis concolor browni*). Pages 135–138 *in* B. C. Bolster, editor. Terrestrial Mammal Species of Special Concern in California. California Department of Fish and Game, Sacramento, CA, USA.

Kusler, A., L. M. Elbroch, H. Quigley, and M. Grigione. 2017. Bed site selection by a subordinate predator: an example with the cougar (*Puma concolor*) in the Greater Yellowstone Ecosystem. PeerJ e4010.

LACP. 2023. Wildlife Ordinance. <https://planning.lacity.org/plans-policies/wildlife-pilot-study>.

Laing, S. 1988. Cougar habitat selection and spatial use patterns in southern Utah. University of Wyoming, Laramie, Wyoming, USA.

Langridge, R. 2018. Central Coast Summary Report.

Lapointe, C., I. Plamondon, and M. Dunn. 2013. Feline leptospirosis serosurvey from a Quebec referral hospital. Canadian Veterinary Journal 54:497–499.

Lazzeri-Aerts, R., and W. Russell. 2014. Survival and recovery following wildfire in the southern range of the coast redwood forest. Fire Ecology 10:43–55.

Lee, J. S., S. N. Bevins, L. E. K. Serieys, W. Vickers, K. A. Logan, M. Aldredge, E. E. Boydston, L. M. Lyren, R. McBride, M. Roelke-Parker, J. Pecon-Slattery, J. L. Troyer, S. P. Riley, W. M. Boyce, K. R. Crooks, and S. VandeWoude. 2014. Evolution of Puma lentivirus in bobcats (*Lynx rufus*) and mountain lions (*Puma concolor*) in North America. Journal of Virology 88:7727–7737.

Leopold, A. 1966. A Sand County Almanac. Oxford University Press Inc.

Lindzey, F. G., W. D. van Sickle, B. B. Ackerman, D. Barnhurst, T. P. Hemker, and S. P. Laing. 1994. Cougar population dynamics in southern Utah. The Journal of Wildlife Management 58:619–624.

Litovitz, T., W. Klein-Schwartz, and K. S. Dyer. 1998. 1997 annual report of the American Association of Poison Control Centers toxic exposure surveillance system. The American Journal of Emergency Medicine 16:443–497.

Logan, K. A., and L. L. Irwin. 1985. Mountain lion habitats in the Big Horn Mountains, Wyoming. Wildlife Society Bulletin 13:257–262.

Logan, K., and L. Sweanor. 2001. Desert puma: evolutionary ecology and conservation of an enduring carnivore. Island Press.

Logan, K., and L. L. Sweanor. 2009. Behavior and social organization of a solitary carnivore. Pages 105–117 *in*. Cougar. University of Chicago Press.

Lombardo, K. J., T. W. Swetnam, C. H. Baisan, and M. I. Borchert. 2009. Using bigcone douglas-fir fire scars and tree rings to reconstruct interior chaparral fire history. Fire Ecology 5:35–56.

Lowry, D. B., S. Hoban, J. Kelley, K. E. Lotterhos, L. K. Reed, M. C. F. Antolin, and A. Torfer. 2017. Breaking RAD: an evaluation of the utility of restriction site-associated DNA sequencing for genome scans of adaptation. Molecular Ecology Resources 17:142–152.

Lundgren, E. J., D. Ramp, O. S. Middleton, E. I. F. Wooster, E. Kusch, M. Balisi, W. J. Ripple, C. D. Hasselerharm, J. N. Sanchez, M. Mills, and A. D. Wallach. 2022. A novel trophic cascade between cougars and feral donkeys shapes desert wetlands. Journal of Animal Ecology 1–10.

Maehr, D. S., E. C. Greiner, J. E. Lanier, and D. Murphy. 1995. Notoedric mange in the Florida panther (*Felis concolor coryi*). Journal of wildlife Disease 31:251–254.

Maletzke, B. T., R. Wielgus, G. M. Koehler, M. Swanson, H. Cooley, and J. R. Alldredge. 2014. Effects of hunting on cougar spatial organization. Ecology and Evolution 4:2178–2185.

Mansfield, T. M., and R. A. Weaver. 1989. The status of mountain lions in California. Transactions of the Western Section of the Wildlife 25:72–76.

Maroni, M., C. Colosio, A. Ferioli, and A. Fait. 2000. Biological monitoring of pesticide exposure: a review. Toxicology 143:1–118.

Marshal, J. P., P. R. Krausman, V. C. Bleich, W. B. Ballard, and J. S. Mckeever. 2002. Rainfall, El Niño, and dynamics of mule deer in the Sonoran Desert, California. The Journal of Wildlife Management 66:1283–1289.

Martínez-Hernández, A. B. Isaak-Delgado, J. A. Alfonso-Toledo, C. I. Muñoz-García, G. Villalobos, N. Aréchiga-Ceballos, and E. Rendón-Franco. 2020. Assessing the SARS-CoV-2 threat to wildlife: Potential risk to a broad range of mammals. Perspectives in ecology and conservation.

Masot, A. J., M. Gil, D. Risco, O. M. Jiménez, J. I. Núñez, and E. Redondo. 2017. Pseudorabies virus infection (Aujeszky's disease) in an Iberian lynx (*Lynx pardinus*) in Spain: A case report. BMC Veterinary Research 13:4–11. <http://dx.doi.org/10.1186/s12917-016-0938-7>.

McAloose, D., M. Laverack, L. Wang, M. L. Killian, L. C. Caserta, F. Yuan, P. K. Mitchell, K. Queen, M. R. Mauldin, B. D. Cronk, S. L. Bartlett, J. M. Sykes, S. Zec, T. Stokol, K. Ingerman, M. A. Delaney, R. Fredrickson, M. Ivančić, M. Jenkins-Moore, K. Mozingo, K. Franzen, N. H. Bergeson, L. Goodman, H. Wang, Y. Fang, C. Olmstead, C. McCann, P. Thomas, E. Goodrich, F. Elvinger, D. C. Smith, S. Tong, S. Slavinski, P. P. Calle, K. Terio, M. K. Torchetti, and D. G. Diel. 2020. From people to *Panthera*: Natural Sars-Cov-2 infection in tigers and lions at the Bronx Zoo. mBio 11:1–13.

McClanahan, K. A., B. N. Duplisea, J. A. Dellinger, and M. W. Kenyon. 2017. Documentation of mountain lion occurrence and reproduction in the Sacramento Valley of California. California Fish and Game 103:7–14.

McDougle, J. 2017. Pseudorabies in California feral swine.

McIvor, D. E., J. A. Bissonette, and G. S. Drew. 1995. Taxonomic and conservation status of the Yuma mountain lion. Conservation Biology 9:1033–1040.

McKinney, T. D. 2011. Cougar Research and Management Needs. J. A. Jenks, editor. Managing cougars in North America. Utah State University, Logan, Utah.

McLean, D. D. 1954. Mountain lions in California. California Fish and Game 40:146–166.

McMillin, S. C., R. C. Hosea, B. F. Finlayson, B. L. Cypher, and A. Mekebri. 2008. Anticoagulant rodenticide exposure in an urban population of the San Joaquin kit fox. Proceedings of the Vertebrate Pest Conference 23:163–165.

McRae, B. H., P. Beier, L. E. Dewald, L. Y. Huynh, and P. Keim. 2005. Habitat barriers limit gene flow and illuminate historical events in a wide-ranging carnivore, the American puma. Molecular Ecology 14:1965–1977.

Meinke, C. W. 2004. Mountain lion habitat use relative to human activities in and around Redwood National and State Parks of northwest California.

Merriam, C. H. 1919. Is the jaguar entitled to a place in the California fauna. Journal of Mammalogy 1:38–40.

Midpeninsula Regional Open Space. 2017. Highway 17 Wildlife Passage and Bay Area Ridge Trail Crossing, Lexington Study Area; Fact Sheet. <https://www.openspace.org/sites/default/files/Hwy17_FactSheet.pdf>. Accessed 1 Feb 2022.

Miller, N. L., and N. J. Schlegel. 2006. Climate change projected fire weather sensitivity: California Santa Ana wind occurrence. Geophysical Research Letters 33:1–5.

Monroy-Vilchis, O., Y. Gomez, M. Janczur, and V. Urios. 2009. Food niche of Puma concolor in central Mexico. Wildlife Biology 15:97–105.

Monteith, K. L., V. C. Bleich, T. R. Stephenson, B. M. Pierce, M. M. Conner, J. G. Kie, and R. T. Bowyer. 2014. Life-history characteristics of mule deer: Effects of nutrition in a variable environment. Wildlife Monographs 1–62.

Moss, W. E., M. W. Alldredge, K. A. Logan, and J. N. Pauli. 2016. Human expansion precipitates niche expansion for an opportunistic apex predator (*Puma concolor*). Scientific Reports 6. <https://www.nature.com/articles/srep39639>. Accessed 23 Apr 2023.

Müller, T., E. Hahn, F. Tottewitz, M. Kramer, B. G. Klupp, T. C. Mettenleiter, and C. Freuling. 2011. Pseudorabies virus in wild swine: a global perspective. Archives of virology 156:1691–1705.

Murphy, K. M. 1983. Relationships between a mountain lion population and hunting Relationships between a mountain lion population and hunting pressure in western Montana pressure in western Montana. University of Montana.

Naidu, A. 2015. Where mountain lions traverse: Insights from landscape genetics in southwestern United States and northwestern Mexico. The University of Arizona.

Naidu, A., L. A. Smythe, R. W. Thompson, and M. Culver. 2011. Genetic analysis of scats reveals minimum number and sex of recently documented mountain lions. Journal of Fish and Wildlife Management 2:106–111.

Narum, S., C. Buerkle, J. Davey, and M. R. Miller. 2013. Genotyping-by-sequencing in ecological and conservation genomics. Molecular Ecology 22:2841–2847.

Naya, D. E., H. Naya, and C. R. White. 2018. On the interplay among ambient temperature, basal metabolic rate, and body mass. American Naturalist 192:518–524.

Newberry, J. S. 1857. Reports on the geology, botany, and zoology of Northern California and Oregon. Washington D.C.

NIDIS. 2022a. Drought.gov: California. <https://www.drought.gov/states/california>. Accessed 3 Feb 2022.

NIDIS. 2022b. California-Nevada Drought Status Update. <https://www.drought.gov/drought-status-updates/california-nevada-drought-status-update-2>. Accessed 3 Feb 2022.

Niedringhaus, K. D., J. D. Brown, Sweeley. K. M., and M. J. Yabsley. 2019. A review of sarcoptic mange in North American wildlife. International Journal for Parasitology: Parasites and Wildlife 9:285–297.

Nisi, A. C., J. F. Benson, and C. C. Wilmers. 2022. Puma responses to unreliable human cues suggest an ecological trap in a fragmented landscape. Oikos.

National Park Service (NPS). 2006. Management of National Park Service Programs.

National Park Service (NPS). 2021. Puma Profiles: Notable Deaths. Santa Monica Mountains National Monument website. <https://www.nps.gov/samo/learn/nature/puma-profiles-notable-deaths.htm>. Accessed 31 Jan 2022.

National Park Service (NPS). 2023. 2018 Woolsey Fire. Santa Monica Mountains National Recreation Area California. <https://www.nps.gov/samo/learn/management/2018-woolsey-fire.htm#:~:text=The Woolsey Fire burned more acres,Peter Strauss Ranch post Woolsey Fire.&text=The Woolsey Fire burned,Ranch post Woolsey Fire.&text=Fire burned more acres,Peter Strauss Ranch post>.

Núñez, R., B. Miller, and F. Lindzey. 2000. Food habits of jaguars and pumas in Jalisco, Mexico. Journal of Zoology 252:373–379.

OEHHA. 2018. Indicators of Climate Change in California.

Palsbøll, P. J., M. Bérubé, and F. W. Allendorf. 2007. Identification of management units using population genetic data. Trends in Ecology and Evolution 22:11–16.

Palstra, F. P., and D. E. Ruzzante. 2008. Genetic estimates of contemporary effective population size: What can they tell us about the importance of genetic stochasticity for wild population persistence? Molecular Ecology 17:3428–3447.

Paul-Murphy, J., T. Work, D. Hunter, E. McFie, and D. Fjelline. 1994. Serologic survey and serum biochemical reference ranges of the free-ranging mountain lion (*Felis concolor*) in California. Journal of Wildlife Diseases 30:205–215.

Pierce, B. M., and V. C. Bleich. 2003. Mountain Lion (*Puma concolor*). Pages 744–757 *in* G. A. Feldhamer, J. A. Chapman, and B. C. Thompson, editors. Wild Mammals of North America Biology, Management, and Economics. 2nd ed. The Johns Hopkins University Press., Baltimore, Maryland.

Pollard, L. 2016. 100 Calif Mountain Lions a Year Killed by Motor Vehicles / Public News Service. Public News Service - CA. <https://www.publicnewsservice.org/2016-12-27/endangered-species-and-wildlife/100-calif-mountain-lions-a-year-killed-by-motor-vehicles/a55466-1>. Accessed 31 Jan 2022.

Pomeranz, L. E., A. E. Reynolds, and C. J. Hengartner. 2005. Molecular Biology of Pseudorabies Virus: Impact on Neurovirology and Veterinary Medicine. Microbiology and Molecular Biology Reviews 69:462–500.

Primack, R. 1993. Essentials of conservation biology. Sinauer Associates Inc., Sunderland, Massachusetts, USA.

Quigley, H., and M. Hornocker. 2009. Cougar population dynamics. Pages 59–75 *in*. Cougar. University of Chicago Press.

Rapacciuolo, G., S. P. Maher, A. C. Schneider, T. T. Hammond, M. D. Jabis, R. E. Walsh, K. J. Iknayan, G. K. Walden, M. F. Oldfather, D. D. Ackerly, and S. R. Beissinger. 2014. Beyond a warming fingerprint: Individualistic biogeographic responses to heterogeneous climate change in California. Global Change Biology 20:2841–2855.

Raymond, J. T., R. G. Gillespie, M. Woodruff, and E. B. Janovitz. 1997. Pseudorabies in captive coyotes. Journal of wildlife diseases 33:916–918.

Reed, D. H., and R. Frankham. 2003. Correlation between fitness and genetic diversity. Conservation Biology 17:230–237.

Reichard, M. v, K. Logan, M. Criffield, J. E. Thomas, J. M. Paritte, D. M. Messerly, M. Interisano, G. Marucci, and E. Pozio. 2016. The occurrence of *Trichinella* species in the cougar *Puma concolor* couguar from the state of Colorado and other regions of North and South America. Journal of Helminthology 91:320–325.

Riley, S. P. D., C. Bromely, R. H. Poppenga, F. A. Uzal, L. Whited, and R. M. Sauvajot. 2007. Anticoagulant exposure and notoedric mange in bobcats and mountain lions in urban southern California. Journal of Wildlife Management 71:1874–1884.

Riley, S. P. D., T. Smith, and T. W. Vickers. 2018. Assessment of wildlife crossing sites for the Interstate 15 and Highway 101 freeways in southern California.

Riley, S., L. Serieys, J. Pollinger, and J. A. Sikich. 2014. Individual behaviors dominate the dynamics of an urban mountain lion population isolated by roads. Current Biology 24:1989-1994.

Rodríguez-Soto, C., O. Monroy-Vilchis, and M. M. Zarco-González. 2013. Corridors for jaguar (*Panthera onca*) in Mexico: Conservation strategies. Journal for Nature Conservation 21:438–443.

Roelke, M. E. 1991. Mercury contamination in the free-ranging endangered Florida panther (*Felis conclor coryi*). Proceedings American Association of Zoo Veterinarians 277–283.

Rosas-Rosas, O. C., L. C. Bender, and R. Valdez. 2008. Jaguar and puma predation on cattle calves in northeastern Sonora, Mexico. Rangeland Ecology and Management 61:554–560.

Rosas-Rosas, O. C., and R. Valdez. 2010. The role of landowners in jaguar conservation in Sonora, Mexico. Conservation Biology 24:366–371.

Rosas-Rosas, O. C., R. Valdez, L. C. Bender, and D. Daniel. 2003. Food habits of pumas in northwestern Sonora, Mexico. Wildlife Society Bulletin 31.

Rudd, J., D. Clifford, B. Cypher, and Hull J. M. 2020. Use of flumethrin-impregnated collars to manage an epidemic of sarcoptic mange in an urban population of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*). Journal of Zoo and Wildlife Medicine 51:631–642.

Rudd, J. L., S. C. McMillin, M. W. Kenyon, D. L. Clifford, and R. H. Poppenga. 2018. Prevalence of first and second-generation anticoagulant rodenticide exposure in California mountain lions (*Puma concolor*). Proceedings of the Vertebrate Pest Conference 28:240–243.

Rudd, J. L., and K. Rogers. 2021. Anticoagulant rodenticide exposure in non-target wildlife. Presented at The Wildlife Society's San Francisco Bay Area Chapter special speaker series event (virtual).

Ruth, T. K., and K. Murphy. 2009. Diet and prey selection of a perfect predator. M. Hornocker and S. Negri, editors. Cougar Ecology and Conservation. University of Chicago Press, Chicago.

Safford, H. D., K. van de Water, and D. Schmidt. 2011. California Fire Return Interval Departure (FRID) map, 2010 version. USDA Forest Service, Pacific Southwest Region and The Nature Conservancy-California. <http://www.fs.fed.us/r5/rsl/clearinghouse/r5gis/frid/>. Accessed 2 Feb 2022.

Salkeld, D. J., and P. Stapp. 2006. Seroprevalence rates and transmission of plague (*Yersinia pestis*) in mammalian carnivores. Vector-Borne and Zoonotic Diseases 6:231–239.

Saremi, N., M. Supple, A. Byrne, and J. A. Cahill. 2019. Puma genomes from North and South America provide insights into the genomic consequences of inbreeding. Nature 10:1–10.

SC Wildlands. 2008. South Coast Missing Linkages: A Wildland Network for the South Coast Ecoregion. <http://www.scwildlands.org.>.

Schwartz, M. K., G. Luikart, and R. S. Waples. 2007. Genetic monitoring as a promising tool for conservation and management. Trends in Ecology and Evolution 22:25–33.

Serieys, L. E. K., T. C. Armenta, J. G. Moriarty, E. E. Boydston, L. M. Lyren, R. H. Poppenga, K. R. Crooks, R. K. Wayne, and S. P. D. Riley. 2015. Anticoagulant rodenticides in urban bobcats: exposure, risk factors and potential effects based on a 16-year study. Ecotoxicology 24:844–862.

Serieys, L. E. K., J. Foley, S. Owens, L. Woods, E. E. Boydston, L. M. Lyren, R. H. Poppenga, D. L. Clifford, N. Stephenson, J. Rudd, and S. P. D. Riley. 2013. Serum chemistry, hematologic, and post-mortem findings in free-ranging bobcats (*Lynx rufus*) with notoedric mange. Journal of Parasitology 99:989–996.

Serieys, L. E. K., A. J. Lea, M. Epeldegui, T. C. Armenta, J. Moriarty, S. Vandewoude, S. Carver, J. Foley, R. K. Wayne, S. P. D. Riley, and C. H. Uittenbogaart. 2018. Urbanization and anticoagulant poisons promote immune dysfunction in bobcats. Proceedings of the Royal Society B: Biological Sciences 285.

Shaffer, M., and B. A. Stein. 2000. Safeguarding our precious heritage. B. Stein, L. S. Kutner, and J. S. Adams, editors. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press.

Shilling, F., D. Waetjen, and W. T. Vickers. 2023. California Wildlife-Vehicle Conflict Report P-22 Edition.

Sitton, L. W. 1977. California mountain lion investigations with recommendations for management.

Slade, S. 2018. Another Mountain Lion Killed on 17. Land Trust of Santa Cruz County. <https://www.landtrustsantacruz.org/another-mountain-lion-killed-17/>. Accessed 1 Feb 2022.

Smallwood, K. S. 1994. Trends in California mountain lion populations. Southwestern Naturalist 39:67–72.

Smith, J. A., Y. Wang, and C. C. Wilmers. 2016. Spatial characteristics of residential development shift large carnivore prey habits. Journal of Wildlife Management 80:1040–1048.

Smith, J. L. D., and C. McDougal. 1991. The contribution of variance in lifetime reproduction to effective population size in tigers. Conservation Biology 5:484–490.

Stephens, F. 1906. California Mammals. The West Coast Publishing Company, San Diego, CA.

Stephenson, N., P. Swift, and R. B. Moeller. 2013. Feline infectious peritonitis in a mountain lion (*Puma concolor*), California, USA. Journal of Wildlife Diseases 49:408–412.

Stoner, D. C., W. R. Rieth, M. L. Wolfe, M. B. Mecham, and A. Neville. 2008. Long-distance dispersal of a female cougar in a Basin and Range landscape. Journal of Wildlife Management 72:933–939.

Stoner, D. C., J. O. Sexton, D. M. Choate, J. Nagol, H. H. Bernales, S. A. Sims, K. E. Ironside, K. M. Longshore, and T. C. Edwards. 2018. Climatically driven changes in primary production propagate through trophic levels. Global Change Biology 24:4453–4463.

Storer, T. I. 1923. Rabies in a mountain lion. California Fish and Game 9:45–48.

Straub, M., J. Rudd, and L. Woods. 2021. Leptospira prevalence and its association with renal pathology in mountain lions (Puma concolor) and bobcats (Lynx rufus) in California, USA. Journal of Wildlife Diseases 57:27–39.

Sweanor, L. L., K. A. Logan, and M. G. Hornocker. 2000. Cougar dispersal patterns, metapopulation dynamics, and conservation. Conservation Biology. Volume 14.

Sweitzer, R. A., S. H. Jenkins, and J. Berger. 1997. Near-extinction of porcupines by mountain lions and consequences of ecosystem change in the Great Basin Desert. Conservation Biology 11:1407–1417.

Syphard, A. D., V. C. Radeloff, T. J. Hawbaker, and S. I. Stewart. 2009. Conservation threats due to human-caused increases in fire frequency in mediterranean-climate ecosystems. Conservation Biology 23:758–769.

Syphard, A. D., V. C. Radeloff, J. E. Keeley, T. J. Hawbaker, M. K. Clayton, S. I. Stewart, and R. B. Hammer. 2007. Human influence on California fire regimes. Ecological Applications 17:1388–1402.

Taylor, B. L., and A. E. Dizon. 1999. First policy then science: Why a management unit based solely on genetic criteria cannot work. Molecular Ecology 8:11–16.

The Cougar Fund. 2023. The Cougar Fund- State by State. <https://cougarfund.org/our-work/advocacy/state-by-state/#:~:text=Today viable%2C breeding cougar populations are found in,Mexico%2C South Dakota%2C North Dakota%2C Texas%2C and Florida.>.

Thompson, R., A., J. O. Munig, C. Laberge, and S. Poppenberger. 2008. Proceedings of the Ninth Mountain Lion Workshop. Pages 85–90 *in*. Arizona Game and Fish Department; Proceedings of the Ninth Mountain Lion Workshop.

Thomson, R. 2016. California amphibian and reptile species of special concern. University of California Press, Berkeley, CA.

Thorne, J. H., R. M. Boynton, A. J. Holguin, J. A. E. Stewart, and J. Bjorkman. 2016. A climate change vulnerability assessment of California’s terrestrial vegetation. Sacramento, CA, USA.

Torres, S. G., T. M. Mansfield, J. E. Foley, T. Lupo, and A. Brinkhaus. 1996. Mountain lion and human activity in California: testing speculations. Wildlife Society Bulletin 24:451–460.

Traill, L., C. Bradshaw, and B. Brook. 2007. Minimum viable population size: a meta-analysis of 30 years of published estimates. Biological Conservation 139:159–166.

Traill, L. W., B. W. Brook, R. R. Frankham, and C. J. A. Bradshaw. 2010. Pragmatic population viability targets in a rapidly changing world. Biological Conservation 143:28–34.

Troyer, R. M., J. A. Beatty, K. R. Stutzman-Rodriguez, S. Carver, C. C. Lozano, J. S. Lee, M. R. Lappin, S. P. D. Riley, L. E. K. Serieys, K. A. Logan, L. L. Sweanor, W. M. Boyce, T. W. Vickers, R. McBride, K. R. Crooks, J. S. Lewis, M. W. Cunningham, J. Rovnak, S. L. Quackenbush, and S. VandeWoude. 2014. Novel *Gammaherpesviruses* in North American domestic cats, bobcats, and pumas: identification, prevalence, and risk factors. Journal of Virology 88:3914–3924.

Truyen, U., and C. R. Parrish. 2013. Feline panleukopenia virus: Its interesting evolution and current problems in immunoprophylaxis against a serious pathogen. Veterinary Microbiology 165:29–32.

U.S. Global Change Research Program. 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I. Pages 1–440 *in* D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, editors. Washington DC.

United States Environmental Protection Agency (USEPA). 2017. Updates to the Demographic and Spatial Allocation Models to Produce Integrated Climate and Land Use Scenarios (ICLUS) Version 2.

U.S. Fish and Wildlife Service (USFWS). 2000. Recovery plan for Bighorn sheep Peninsular Ranges, California.

U.S. Fish and Wildlife Service (USFWS). 2007. Recovery plan for the Sierra Nevada Bighorn sheep.

U.S. Fish and Wildlife Service (USFWS). 2008. Florida Panther Recover Plan, 3rd Revision.

Uzal, F. A., R. S. Houston, S. P. D. Riley, R. Poppenga, J. Odani, and W. Boyce. 2007. Notoedric mange in two free-ranging mountain lions (*Puma concolor*). Journal of Wildlife Diseases 43:274–278.

Valdez, R. 1999. Jaguar. S. Demarais and P. R. Krausman, editors. Ecology and Management of Large Mammals in North America.

Valdez, R., and J. A. Ortega-Santos. 2019. Wildlife ecology and management in Mexico. Texas A&M University Press.

Veklerov, K. 2018. Orphaned mountain lion cubs at Oakland Zoo part of trend in California. San Francisco Chronicle7 January 2018.

Vendrami, D. L. J., L. Telesca, H. Weigand, M. Weiss, K. Fawcett, K. Lehman, M. S. Clark, F. Leese, C. McMinn, H. Moore, and J. I. Hoffman. 2017. RAD sequencing resolves fine-scale population structure in a benthic invertebrate: Implications for understanding phenotypic plasticity. Royal Society Open Science 4:160548–160548.

Ventura County. 2019. Ordinances 4537 and 4539. <https://vcrma.org/habitat-connectivity-and-wildlife-movement-corridors>. Accessed 1 Feb 2022.

Verhagen, J. H., R. A. M. Fouchier, and N. Lewis. 2021. Highly pathogenic avian influenza viruses at the wild–domestic bird interface in europe: Future directions for research and surveillance. Viruses 13.

Verpoest, S., A. B. Cay, O. Bertrand, M. Saulmont, and N. De Regge. 2014. Isolation and characterization of pseudorabies virus from a wolf (*Canis lupus*) from Belgium. European Journal of Wildlife Research 60:149–153.

Vickers, T. W., J. N. Sanchez, C. K. Johnson, S. A. Morrison, R. Botta, T. Smith, B. S. Cohen, P. R. Huber, H. B. Ernest, and W. M. Boyce. 2015. Survival and mortality of pumas (*Puma concolor*) in a fragmented, urbanizing landscape. PLoS ONE 10.

Vickers, T. W., T. Smith, and B. Cohen. 2017. Mountain lion (*Puma concolor*) connectivity in the north San Diego county multi-species conservation plan area.

Vickers, W., and D. Garcelon. 2022. U.C. Davis – Southern and northeastern California cougar projects - 2021 annual report.

Villalobos-Hoffman, R., J. E. Ewing, and M. S. Mooring. 2022. Do wildlife crossings mitigate the roadkill mortality of tropical mammals? A case study from Costa Rica. Diversity 14.

Wang, Y., J. A. Smith, and C. C. Wilmers. 2017. Residential development alters behavior, movement, and energetics in an apex predator, the puma. PLoS ONE 12.

Waples, R. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of "Species" under the Endangered Species Act. Marine Fisheries Review 53:11–22.

Weis, S., A. Rettinger, M. Bergmann, J. R. Llewellyn, N. Pantchev, R. K. Straubinger, and K. Hartmann. 2017. Detection of *Leptospira* DNA in urine and presence of specific antibodies in outdoor cats in Germany. Journal of Feline Medicine and Surgery 19:470–476.

Weiss-Penzias, P. S., M. S. Bank, D. L. Clifford, A. Torregrosa, B. Zheng, W. Lin, and C. C. Wilmers. 2019. Marine fog inputs appear to increase methylmercury bioaccumulation in a coastal terrestrial food web. Scientific Reports 9:1–11.

Wengert, G. M., M. W. Gabriel, S. M. Matthews, J. M. Higley, R. A. Sweitzer, C. M. Thompson, K. L. Purcell, R. H. Barrett, L. W. Woods, R. E. Green, S. M. Keller, P. M. Gaffney, M. Jones, and B. N. Sacks. 2014. Using DNA to describe and quantify interspecific killing of fishers in California. Journal of Wildlife Management 78:603–611.

Westerling, A. L., H. G. Hidalgo, D. R. Cayan, and T. W. Swetnam. 2006. Warming and earlier spring increase western U.S. forest wildfire activity. Science 313:940–943.

Wikipedia. 2023. List of California wildfires. <https://en.wikipedia.org/wiki/List_of_California_wildfires>.

Williams, A. P., J. T. Abatzoglou, A. Gershunov, J. Guzman-Morales, D. A. Bishop, J. K. Balch, and D. P. Lettenmaier. 2019. Observed impacts of anthropogenic climate change on wildfire in California. Earth's Future 7:892–910.

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.

Williams, D. F. 1986. Yuma mountain lion (*Felis concolor browni*). In: Mammal Species of Special Concern in California.

Williams, S. E., L. P. Shoo, J. L. Isaac, A. A. Hoffmann, and G. Langham. 2008. Towards an integrated framework for assessing the vulnerability of species to climate change. PLoS biology 6.

Wilmers, C. C. 2014. Mountain view puma (46m) killed on Highway 280. Santa Cruz Puma Project Blog.

Wilmers, C. C., Y. Wang, B. Nickel, P. Houghtaling, Y. Shakeri, M. L. Allen, J. Kermish-Wells, V. Yovovich, and T. Williams. 2013. Scale dependent behavioral responses to human development by a large predator, the puma. PLoS ONE 8.

Wisely, S. W., B. Parker, J. Rudd, and D. Clifford. 2018. Investigating Pseudorabies virus as a mortality factor for California mountain lions. Proceedings of the Vertebrate Pest Conference 28:115–117.

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

Wong, D., M. Wild, M. A. Walburger, C. L. Higgins, M. Callahan, L. A. Czarnecki, E. W. Lawaczeck, C. E. Levy, J. G. Patterson, R. Sunenshine, and P. Adem. 2009. Primary pneumonic plague contracted from a mountain lion carcass. Clinical Infectious Diseases 49:33–38.

Yap, T., B. Cummings, and J. P. Rose. 2019. A petition to list the southern California/Central Coast Evolutionarily Significant Unit (ESU) of mountain lions as threatened under the California Endangered Species Act (CESA).

Young, S., and E. Goldman. 1946. Puma, mysterious American cat. The American Wildlife Institute, Washington, D.C.

Zanin, E., I. Capua, C. Casaccia, A. Zuin, and A. Moresco. 1997. Isolation and characterization of Aujeszky's disease virus in captive brown bears from Italy. Journal of wildlife diseases 33:632–634.

Zarco-González, M. M., O. Monroy-Vilchis, C. Rodríguez-Soto, and V. Urios. 2012. Spatial Factors and Management Associated with Livestock Predations by *Puma concolor* in Central Mexico. Human Ecology 40:631–638.

Zeller, K. A., T. W. Vickers, H. B. Ernest, and W. M. Boyce. 2017. Multi-level, multi-scale resource selection functions and resistance surfaces for conservation planning: Pumas as a case study. PLoS ONE 12.

APPENDIX A – Acronyms, Abbreviations and Definitions

CDFW - California Department of Fish and Wildlife

Central Coast (CC), one of four genetic populations presented in Gustafson et al. 2022 based on Single Nucleotide Polymorphism data. Includes coastal mountains south of San Francisco Bay to and including the Santa Monica Mountains.

CEQA – California Environmental Quality Act

CESA - California Endangered Species Act

Commission - Fish and Game Commission

DPS - Distinct Population Segment

Department - California Department of Fish and Wildlife

Distinct Population Segment (DPS) - A vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species.

Effective Population Size (Ne) - The number of individuals in a population that effectively participate in producing the next generation.

Evolutionary Significant Unit (ESU) - A term related to the federal Endangered Species Act originally applied to anadromous fish populations that designates a population that is substantially reproductively isolated from conspecific populations *and* represents an important component of the evolutionary legacy of the species.

Genetic Groups / Broad-Scale Genetic Groups – The four genetic groups for which Gustafson et al. (2022) found the strongest support through SNP analysis. These groups include:

Central Coast Group – Lions from the San Francisco Bay and Sacramento-San Joaquin Delta south through the Santa Monica Mountains inclusive of Gustafson et al.'s (2019) Central Coast-North, Central Coast-Central, and Central Coast-South genetic populations.

North Coast Group – Lions north of San Francisco Bay through the Coast Ranges to border with Oregon. Largely coincident with Gustafson et al.'s (2019) North Coast genetic population.

Sierra Nevada Group – Lions from the Klamath, Cascades, and Sierra Nevada mountains from the Oregon border south through the Tehachapi Mountains inclusive of Gustafson et al.'s (2019) Western Sierra Nevada and Eastern Sierra Nevada genetic populations.

Southern Coast Group – Lions in the San Gabriel and San Bernardino, Santa Ana, and Eastern Peninsular mountains inclusive of Gustafson et al.'s (2019) San Gabriel-San Bernardino, Santa Ana, and Eastern Peninsular Range genetic populations.

Management Unit (MU) - Demographically independent populations of conspecifics whose growth rate depends predominantly on local births and deaths rather than immigration.

Management Units identified in this report:

- **Central Coast North (CC-N**) - A geographic area based upon the CC-N genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes the Santa Cruz Mountains and east bay hills, extending south to approximately the Monterey County line.

- **Central Coast Central (CC-C)** - A geographic area based upon the CC-C genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which generally includes coastal mountain ranges from southern Monterey Bay to Ventura County.
- **Central Coast South (CC-S)** - A geographic area based upon the CC-S genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes the Santa Monica Mountains, Santa Susana Mountains, Sierra Pelona Mountains, and Simi Hills.
- **Eastern Peninsular Ranges (EPR)** - A geographic area based upon the EPR genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which includes eastern San Diego County to the Colorado River and the border with Arizona and is bounded on the south by the border with Mexico.
- **Eastern Sierra Nevada (ESN)** - A geographic area based upon the Eastern Sierra Nevada genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which extends from the east side of the Sierra Nevada crest to the Nevada border from northern Mono County south to northern San Bernardino County.
- **Nevada (NV)** - A geographic area based upon the Nevada genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses which encompasses most of the state of Nevada.
- **San Gabriel and San Bernardino Mountains (SGSB)** - A geographic area based upon the SGSB genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses and includes the San Gabriel and San Bernardino mountain ranges.
- **Santa Ana Mountains (SA)** - A geographic area based upon the SA genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses that encompasses the Santa Ana Mountains.
- **Western Sierra Nevada (WSN)** - A geographic area based upon the Western Sierra Nevada genetic population identified by Gustafson et al.'s (2019) microsatellite marker analyses that extends from the Oregon border through the Cascades and Sierra Nevada Mountains to the Tehachapi Mountains and includes the Sierra Nevada foothills and much of the Central Valley.

Microsatellite Markers - Repetitive segments of DNA scattered throughout the genome in noncoding regions between genes or within genes.

Principal Component Analysis (PCA) - A statistical multivariate technique which transforms a large number of correlated of variables into few uncorrelated variables which represents the whole data set.

Single Nucleotide Polymorphism (SNP) - a variation in nucleotides at a single position in a DNA sequence among individuals.

State Wildlife Action Plan (SWAP) – California's comprehensive plan for examining the health of wildlife populations and prescribing actions to conserve wildlife and vital habitat before they become more rare and more costly to protect.

USFS – U.S.D.A. Forest Service.

USFWS - United States Fish and Wildlife Service

APPENDIX C – Solicitations for Information

Tribal notice via email and hard copy mailing, statewide.

Fish and Game Commission's CESA Interested Parties list (Confidential list).

San Diego area USFWS biologist emailed solicitation letter to southern California biologists/land conservation planning group.

Heather Pert (CDFW) emailed a contacts group of biologists/land conservation planners.

Hard copy mailed to local Fish and Game Commissions and Board of Supervisors within and adjacent to the petitioned ESU counties.

State Parks, Caltrans, USFS, NPS, BLM notified via email.

Cattlemen's, BIA, Woolgrowers notified via email.

Additional contacts not yet listed; in process.

APPENDIX D – Public and Tribal Comments

CBD (also sent another set of comments later)

Vickers

Mountain Lion Foundation

Tribes, including Charley Dirk and his Tribe, from phone conversation.

Carmel area land manager (who sent pictures).

Escondido Conservancy

State Parks

Caltrans

Etc.

APPENDIX E – External Peer Review Invitation Letters

APPENDIX F – External Peer Review Comments

APPENDIX G - California Department of Fish and Wildlife Human-Wildlife Conflict and Depredation Policies