# The Conservation and Management Plan for Bighorn Sheep in California

## 2025

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Front Cover Photograph: Two ewes and two rams in the San Gorgonio Mountains.
Photo by Josh Schulgen.

## STATEMENT FROM THE DIRECTOR

Bighorn sheep are an inspiring symbol of California's rugged wilderness, inhabiting some of the most extreme landscapes in the state — from the snow-capped peaks of the Sierra Nevada to the arid Mojave and Sonoran deserts. These resilient and resourceful animals have played an important ecological, cultural and historical role in California, yet their populations have faced significant challenges due to disease, habitat fragmentation, loss of connectivity, extreme weather events, and other environmental stressors.

The California Department of Fish and Wildlife is proud to present the *Conservation and Management Plan for Bighorn Sheep in California*, a comprehensive blueprint for conserving and managing this species. This plan represents a significant update to previous management efforts, incorporating the best available science and traditional ecological knowledge through extensive collaboration with partners.

Given the varying statuses of wild sheep populations across California, bighorn sheep management is a complex challenge. The Sierra Nevada bighorn and Peninsular bighorn are federally endangered and require targeted recovery efforts and their own recovery plans. Other desert bighorn populations allow for hunting opportunities. This plan focuses on the non-endangered desert bighorn sheep populations and establishes a comprehensive framework for monitoring populations, mitigating threats, and ensuring the species' long-term survival.

The plan establishes a strong foundation for future efforts by:

- Ensuring the persistence of ecologically functional, genetically diverse and disease-resilient bighorn populations;
- Conserving and enhancing habitat and water availability to support sustainable populations;
- Providing opportunities for hunting, viewing and public engagement;
- Strengthening collaboration with California Native American Tribes, governmental agencies, partners and the public to achieve shared management goals.

The California Department of Fish and Wildlife remains committed to conservation and responsible management and ensuring the long-term sustainability of this magnificent species. We invite you to join us in this important effort — whether as outdoor enthusiasts, conservationists, hunters, or as neighbors to populations of bighorn sheep. Your support is vital to the success of bighorn sheep conservation in California.

Charlton H. Bonham
Director, California Department of Fish and Wildlife

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# EXECUTIVE SUMMARY

*Photo by Josh Schulgen*

# EXECUTIVE SUMMARY

This conservation and management plan provides guidance and direction to help set priorities for bighorn sheep management in California. The statewide vision is to have healthy bighorn sheep populations that benefit from management efforts that aim to conserve bighorn sheep for their intrinsic, ecological, and utilitarian values. To accomplish this, the plan establishes general policies, goals, and objectives on a statewide scale. Although the California Department of Fish and Wildlife (Department) has statutory authority and primary responsibility for wildlife management in California, partnerships with Tribes, stakeholders, and agencies have assisted with bighorn sheep management in the past and will be increasingly important in the future.

Bighorn sheep inhabit California's most rugged mountains, spanning the lowest and hottest deserts to the highest and snowiest peaks. Two subspecies of bighorn sheep are native to California; the Sierra Nevada bighorn sheep, endemic to Sierra Nevada Range and federally and state listed as endangered, and the desert bighorn sheep, distributed across mountain ranges in southeastern California and across the wider desert southwest of the United States and Mexico. Desert bighorn include larger populations, some of which provide coveted once-in-a-lifetime hunting opportunities. The Peninsular bighorn sheep, classified as a federally endangered and state threatened Distinct Population Segment of desert bighorn, inhabit their namesake mountain range from Palm Springs to the border with Mexico and beyond.

As of 2025, it is estimated that California supports 5,400 bighorn sheep, including some 400 Sierra Nevada bighorn, 750 Peninsular bighorn, and 4,250 desert bighorn outside of the Peninsular Ranges. Those distinctions between the smaller endangered populations and the more abundant non-endangered desert bighorn call for distinct approaches to conservation and management. This management plan addresses broad concerns affecting all bighorn sheep in California, however, specific management prescriptions for desert bighorn sheep are addressed through Bighorn Conservation Units (BCU) management plans, whereas management of endangered Sierra Nevada bighorn and Peninsular bighorn sheep populations are specified by their respective Recovery Plan.

Since the 1980s, the Department has developed specific recovery plans for the federally endangered Sierra Nevada and Peninsular populations, in collaboration with federal agencies such as the U.S. Fish and Wildlife Service and the National Park Service. These plans are comprehensive in their goals, objectives, and actions for recovering these populations. The Department also developed management unit plans for each hunt zone for desert bighorn but was lacking a comprehensive desert bighorn-wide approach to conservation and management. This plan aims to fill that gap while also providing a statewide update to the Department's 1983 plan for bighorn sheep management in California.

Section I of this plan is a statewide overview of bighorn distribution, life history, habitat use, disease and pathogens, predation, and conservation and management actions. The remaining two sections focus specifically on the non-endangered populations of desert bighorn in California. Section II provides an overview of desert bighorn natural history, conservation concerns, and recreational hunting opportunities. Section III provides a comprehensive desert-wide approach to conservation and management through the development of statewide goals, objectives, and actions.

Over 60 subpopulations of desert bighorn inhabit a variety of habitat types. The goals and objectives identified in this plan provide an important framework for managing desert bighorn in California; however, to have effective adaptive management it is critical to identify regional and population specific conservation management goals and objectives. As such, the Department identified six Bighorn Conservation Units (BCUs): Northern California, Northern Deserts, North-Central Deserts, South-Central Deserts, Southern Deserts, and Transverse Ranges. The Department will develop a BCU plan for each region in accordance with the Fish and Game Code section 4901 et seq.. Individual BCU plans will be focused on priority actions within a geographic area and establish objectives and future management direction. They will be routinely updated by the Department as additional information is gathered.

Achieving the goals and objectives identified in this Plan will help the Department maintain, enhance, and restore desert bighorn populations and their habitats throughout the state while allowing for traditional-cultural, recreational, and aesthetic use and enabling coordination with governmental agencies, California Native American Tribes, non-governmental organizations (NGOs), and the public.

*Two ewes with two lambs in the Mojave National Preserve. Photo by George Kerr.*

# I. NATURAL HISTORY OF BIGHORN SHEEP IN CALIFORNIA

# INTRODUCTION

Prior to non-Indigenous settlement, bighorn sheep (*Ovis canadensis*) ranged across the rugged mountains and desert environments of the American West. Western expansion of Euro-Americans brought the compounding effects of unregulated hunting, pathogens from domestic livestock, and the alteration, fragmentation, and degradation of habitat, resulting in the loss of many bighorn sheep populations by the 1900s. Over the last 50 years, wildlife managers across the western states have applied the best available science to maintain and restore populations and habitats of bighorn sheep in many historically occupied areas of their range.

California's diverse mountain ranges are home to two subspecies of native bighorn sheep: state and federally endangered Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*; hereafter Sierra bighorn), endemic to that iconic range, and desert bighorn sheep (*O. c. nelsoni;* hereafter desert bighorn), which extend from the White Mountains south through the Mojave and Sonoran deserts, and east into Arizona, Nevada, and across the Southwest (Figure 1). Peninsular bighorn sheep (also in the subspecies *O. c. nelsoni;* hereafter Peninsular bighorn), a geographically defined population of desert bighorn sheep, are listed as a Distinct Population Segment (DPS) under the federal Endangered Species Act. These federally endangered and state threatened bighorn sheep occur within the Peninsular Ranges of southern California and northern Mexico and are largely isolated from other desert bighorn. As of 2025, California supports approximately 5,400 bighorn sheep, including some 400 Sierra bighorn, 750 Peninsular bighorn, and 4,250 desert bighorn.

This Conservation and Management Plan for Bighorn Sheep in California (hereafter, Plan) encompasses bighorn sheep populations throughout the State. It is intended to update and expand upon two previous statewide plans, *California's Bighorn Management Plan* (Weaver 1973) and *A Plan for Bighorn Sheep in California* (California Department of Fish and Game 1983). This Plan includes a summary of the ongoing efforts towards the conservation and recovery of the two federally listed populations, Sierra bighorn and Peninsular bighorn. These federally endangered bighorn sheep populations are addressed in depth in the respective *Recovery Plan for the Sierra Nevada Bighorn Sheep* (USFWS 2007) and *Recovery Plan for Bighorn Sheep in the Peninsular Ranges, California* (USFWS 2000*)* which guide the management and recovery of these unique populations. The California Department of Fish & Wildlife (Department) will continue to be the lead agency on these recovery efforts and acknowledges that both Recovery Plans would likely benefit from updates. This Plan also briefly addresses seasonal movement and potential range expansion of bighorn sheep, present through introductions along the Klamath River gorge on the Oregon-California border, as well as bighorn sheep that occasionally enter California across the California-Nevada border. The bulk of this Plan focuses on the conservation and management of desert bighorn, which do not currently have an overarching management plan.

Base Layer: California State Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, Esri, USGS

**Figure 1.** The historic distribution of bighorn sheep (*Ovis canadensis*) in California.

Section I of this Plan introduces populations throughout California, their shared natural history, geographic distribution, tribal traditional knowledge, and historical and current management. Section II presents specific information about desert bighorn, including habitat, life history, metapopulation dynamics, conservation concerns, and recreational hunting opportunities. Section III describes specific goals and objectives for the conservation and management of desert bighorn. This section also identifies six Bighorn Conservation Units (BCUs) representing distinct geographic regions not covered by Recovery Plans: Northern California, Northern Deserts, North Central Deserts, South Central Deserts, Southern Deserts, and Transverse Ranges. The Department will develop individual management plans for each BCU identifying specific actions to achieve the goals and objectives outlined in the broader statewide Plan locally. The BCU plans will prescribe specific management actions and will be added as Appendices to the Plan. This structure is designed to allow for this Plan to be the foundation for desert bighorn management throughout California, while the BCU plans will be adaptive, living documents that will change periodically as a result of new information gained through monitoring, research, and new technologies.

Numerous partners including California Native American tribes, federal and state agencies, non-governmental organizations, and the California public are invested in the conservation of bighorn sheep. This Plan encourages the involvement of these stakeholders by outlining goals for collaborative agreements, research, and on-the-ground projects ranging from maintenance of Wildlife Water Developments (WWD, or artificial water sources) to the development of educational and interpretive materials. This Plan also supports the sustainable hunting of desert bighorn in designated hunt zones. Regular communication and collaboration between the Department, its partners, and the public are central to the success of bighorn sheep conservation and management in California.

## STATE OF CALIFORNIA LEGAL AUTHORITY

As the trustee agency for the state's wildlife resources, the Department is responsible for the conservation and management of California's diverse fish, wildlife, and plant resources and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. Conservation through management, protection, enhancement, and reestablishment of wildlife resources and habitat are critical to providing cultural, scientific, educational, recreational, aesthetic, and economic benefits for present and future generations of Californians.

In 1986, the California Legislature declared it the policy of the state to encourage the preservation, restoration, utilization, and management of California's bighorn population. The California Fish and Game Code (Fish & G. Code) identifies bighorn sheep as an important wildlife resource of the state (Fish & G. Code, §4900 et seq.) and defines the overarching policy for the conservation of wildlife resources (Fish & G. Code, §1801 et seq.) with objectives of:

- Providing for the beneficial use and enjoyment of wildlife
- Conserving wildlife for their intrinsic and ecological values and direct benefits to people
- Providing aesthetic, educational, and non-consumptive uses
- Maintaining diversified recreational uses, including hunting
- Providing economic contributions through management as a renewable resource

The Department is further directed (Fish & G. Code, §4901 et seq.) to determine the status and trends of bighorn sheep populations in each management unit and to develop a plan for each unit that includes the following:

- Population abundance estimates and demographic ratios
- Distribution within each conservation unit
- Range conditions and the influences of humans, livestock, and feral burros
- Potential for augmentation or reestablishment
- Prevalence of disease and parasites
- Recommendations for conserving sustainable populations through restoration, utilization, and management

Bighorn sheep populations that have federal endangered status (Sierra bighorn and Peninsular bighorn) are jointly managed by the Department and federal agencies such as the United States Fish and Wildlife Service (USFWS) and the National Park Service (NPS).

Through California Executive Order B-10-11(2011), state policy reaffirmed that California Native American tribes have sovereign authority over their territories and activities, and thus cross-jurisdictional issues require effective government-to-government consultation between state agencies and Tribes. The policy of the Department is to notify and consult with Tribes regarding proposed activities affecting fish, wildlife, and plant resources and other Tribal interests, and to encourage collaborative relationships resulting in co-management of resources, such as bighorn sheep (CDFW 2014).

## PLAN DEVELOPMENT AND REVIEW

The Department developed its first management plan for bighorn sheep in California in 1973 (Weaver 1973). This initial plan laid the foundation for the Department to meet the objectives outlined in the Fish and Game Code (above). Ten years later, in 1983, the Department released a second plan, providing more specific goals, objectives, and actions to ensure populations continue to persist into the future (CDFG 1983). Starting in the late 1980s, with the legalization of hunting select populations of desert bighorn, individual management plans were created for each new hunt zone (see Section II Hunting). In 2003, the Department also wrote the Sonoran Mountain Sheep Meta-population plan for desert bighorn in the southernmost part of the State (CDFG 2003). The Recovery Plans were developed in conjunction with the USFWS for the Peninsular and Sierra bighorn recovery programs in 2000 and 2007, respectively. This Plan is intended to provide an overview and update for bighorn sheep management across California and has been developed by Region, Wildlife Health Laboratory, and Wildlife Branch staff.

In accordance with Executive Orders B-10-11 and N-15-19, the Department sent a Notice of Preparation letter to all California Native American tribes inviting feedback and consultation on a draft of this Plan, in October 2020 and again in June 2024. The Department hosted two Tribal Listening Sessions in July 2024 and participated in several consultations in August 2024. Throughout these various opportunities, the representatives of California Native American tribes provided the Department with their perspective, management recommendations, and Traditional Ecological Knowledge (TEK, see Page 31).

Drafts of this Plan were shared with peer reviewers including bighorn sheep wildlife managers, land managers, and academic researchers. Reviewers provided valuable comments and recommendations in 2020, 2023, and 2024. Their expertise provided valuable input and direction to this Plan. The Plan was released for a 45-day Public Comment period in September 2024. The Department hosted a Public Information Session on October 10, 2024, and received a total of nine public comments during the public comment period. Numerous comments have been incorporated to improve this document. In some cases, comments did not result in changes.

Regular communication between the Department and other agencies, California Native American tribes, stakeholder groups, and the public will allow interested parties to monitor progress toward implementing this Plan and provide opportunities for the Department to receive public input on specific management measures. To address ecological, technological, social, and regulatory changes in a timely manner, the Department intends to update this Plan at 10-year intervals. The Department may update BCU plans at the same or at more frequent intervals as new information becomes available.

## RULEMAKING PROCESS

This Plan summarizes the conservation and management framework for bighorn sheep in California, and identifies associated goals, objectives, and actions of the Department. It does not propose or enact any regulatory changes. The process for how the conservation and management activities described in this Plan may inform and lead to regulatory changes (e.g., changes of hunting quotas and seasons) is explained below.

The California State Legislature has delegated a variety of powers to the Fish and Game Commission. These powers are delegated within California Statutes that comprise Fish and Game Code. The Fish and Game Code establishes the basis of fish, wildlife, and native plant management and protection in California, and can only be established and modified by the State Legislature. The Fish and Game Code more specifically establishes the Fish and Game Commission's authority in fish and wildlife rules, regulations, and policy making, whereas the Department is designated as the trustee for fish and wildlife resources. The Department is charged with implementing and enforcing regulations set forth by the Fish and Game Commission, as well as providing biological data and expertise to inform the Fish and Game Commission's decision-making process. Under administrative law, the California Code of Regulations codifies general and permanent rules and regulations to be enacted by the agency responsible for implementation. The California Fish and Game Commission and Department work within the California Code of Regulations Title 14 - Natural Resources. Regulations routinely addressed under Title 14 include general harvest regulations including harvest quota, season dates, and hunt zone boundaries. Management features can be adopted, amended, or repealed via the Administrative Procedures Act (APA) rulemaking process. The APA is a requirement by law that allows for the public to participate in the adoption of state regulations to ensure that the regulations proposed are clear, necessary, and legally valid.

The Department provides recommendations for adopting, amending, or repealing regulations based on inventory and monitoring of resources, as well as both biological and social economic conditions. In terms of hunting regulations for any species, an additional parallel document is required through the California Environmental Quality Act (CEQA). CEQA requires all public agencies to evaluate the environmental impacts of projects, including regulation changes which may have potential to significantly affect the environment.

The APA process for enacting new Title 14 regulations generally requires a 12-18 month timeline composed of five public meetings (Table 1). The process begins with 2 initial public discussion meetings of the Wildlife Resources Committee (WRC) which is chaired by one member of the Fish and Game Commission. An initial scoping meeting of the WRC is held to discuss general rulemaking needs, typically in May, followed by a recommendation meeting of the WRC in September to approve or reject moving the rulemaking under consideration forward to present to the Fish and Game Commission. If a rulemaking is approved to move forward by the WRC, the proposed regulation change is presented to the Fish and Game Commission at a public notice hearing in December. A public comment period follows this meeting. In February, a public discussion hearing is held, where the details of the proposed changes are discussed by the Fish and Game Commission and general public, and comments are responded to by Department staff. Adoption hearings are held in April, where final recommendations are presented by Department staff, formed in part by public comments and inquiry/discussion with the Fish and Game Commission. The regulatory framework is a public process that provides multiple opportunities for the public to engage with the Fish and Game Commission and the Department to manage resources effectively. The Fish and Game Commission has final approval authority to adopt, amend, repeal, or reject proposals set forth by the Department or the general public. If a new regulation is approved, the Department is responsible for implementation. Generally, this occurs starting July 1st after the April adoption vote.

**Table 1.** Administrative process and timeline for adopting Title 14 regulations affecting desert bighorn hunting and conservation.

| ACTION | GOVERNMENT AUTHORITY | TIMEFRAME |
|---|---|---|
| **Initial scoping** | Wildlife Resources Committee | May, year 1 |
| **Recommendation to proceed** | Wildlife Resources Committee | September, year 1 |
| **Notice hearing** | Fish and Game Commission | December, year 1 |
| **Public discussion** | Fish and Game Commission | February, year 2 |
| **Adoption vote** | Fish and Game Commission | April, year 2 |
| **Implementation** | Department | July 1st, year 2 |

# INTRODUCTION

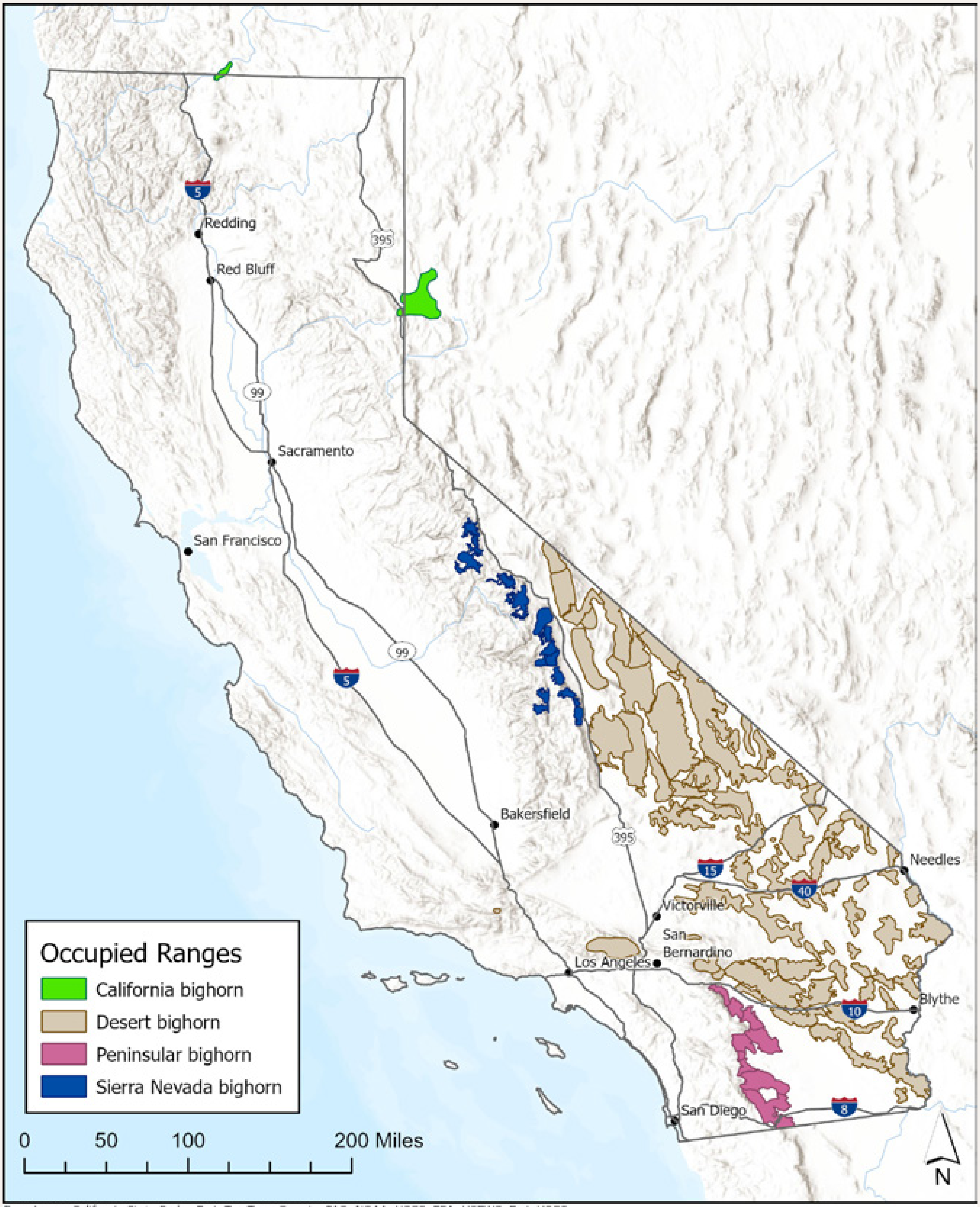
*Photo by Paige Prentice*

# I. NATURAL HISTORY OF BIGHORN SHEEP IN CALIFORNIA

## DISTRIBUTION

Historically, bighorn sheep populations occurred in four distinct geographic regions in California (Figure 1). Three of these populations persist, although their distributions are reduced from their historical extent (Figure 2): Sierra Nevada bighorn in the Sierra Nevada Mountains; desert bighorn in the Transverse Ranges and Great Basin, Mojave and Sonoran deserts; and Peninsular bighorn in the Peninsular Ranges. A fourth population of bighorn sheep once inhabited northern California, but this population was extirpated in the early 1900s (Blaisdell 1971). However, bighorn sheep are occasionally seen in this region due to the reintroduction of California bighorn sheep (*O.c. californiana*) by both Oregon and Nevada wildlife agencies to areas immediately across the California border—despite its name, this subspecies is not native to California. It is also worth noting that Peninsular bighorn in the southernmost portion of the Peninsular Ranges regularly spend a portion of the year on the Mexico side of the United States-Mexico border. The rest of this section focuses on populations residing primarily in California.

*Photo by Pat Woods*




Base Layer: California State Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, Esri, USGS

**Figure 2.** Distribution of mountain ranges currently and formerly occupied by bighorn sheep (Ovis canadensis) in California, including occupied ranges that cross state boundaries.

## LIFE HISTORY

Bighorn sheep are sexually dimorphic, with males (rams) weighing approximately 30–40% more than females (ewes). As adults, males may weigh 60–105kg. Females are smaller, typically weighing 50–70kg. Males and females sexually segregate for most of the year but overlap during the breeding season, or rut (Geist and Petocz 1977, Bleich et al. 1997, Ruckstuhl 1998, Mooring et al. 2003). Bighorn sheep have a polygynous mating system, wherein dominant males breed with multiple females, with subordinate males having less reproductive success. Female mate choice is influenced by male body mass, horn size, and social rank, the latter being determined through a variety of interactions between males including displacement, butting, kicking, mounting, and frontal clashes of the horns (Pelletier and Festa-Bianchet 2006). If females achieve adequate body size and nutritional condition, they can breed as yearlings (1–2 years old) and annually thereafter (Wehausen 1984a), but young males are less likely to mate until they are older and able to compete with larger males.

Females typically give birth to one lamb each year after a six-month gestation (Shackleton et al. 1984, Hass 1995). During lambing, females isolate themselves by moving to escape terrain that is largely inaccessible to terrestrial predators (Forshee et al. 2022). Following lambing, ewes with lambs congregate in nursery groups. Sometimes ewes leave lambs on escape terrain while they feed in less steep and, consequently, less safe terrain. Lambs begin foraging at a few weeks of age and vegetation steadily increases as a proportion of their nutrient intake until about 5–6 months of age, when they are usually weaned (Hansen and Deming 1980).

*A desert bighorn ewe nursing her lamb in the White Mountains. Photo by Pat Woods.*

## HABITAT

Bighorn sheep occupy some of the most rugged, highly seasonal environments in North America, ranging from the highest, snowiest mountains to the lowest, hottest deserts. A combination of behavioral, nutritional, and physiological adaptations facilitate life in environments with great seasonal variation in temperatures, food quality and availability, and availability of surface water (Hansen 1982).

Optimal bighorn sheep habitat is visually open and contains steep, rocky slopes, referred to as escape terrain (Risenhoover and Bailey 1985, Bleich et al. 2008). Short legs and a stocky build provide a low center of gravity and favor agility on steep, rocky slopes, but limit the ability of bighorn sheep to generate the speed to outrun predators on level ground. Consequently, bighorn sheep select areas of unobstructed visibility, where their keen eyesight allows detection of predators from far away, giving them time to reach the safety of precipitous terrain. Large expanses lacking escape terrain increase the risk of predation and can be substantial barriers to movement (Epps et al. 2007).

## METAPOPULATION DYNAMICS

A metapopulation is a network of spatially-separated populations, within and between which there are dynamic and changing levels of genetic and demographic flow through time (Hanski and Gilpin 1991). Movement of individuals between populations and subsequent interbreeding generates gene flow, which plays an important role in maintaining genetic diversity. While dispersal by either sex can move genes between populations, male dispersal is the most common type of movement and source of gene flow for bighorn sheep (Lassis et al. 2022). Metapopulation persistence requires colonization of vacant habitat patches by both sexes. A core tenant of metapopulation persistence is that the colonization rate of habitat patches must exceed the extinction rate (Hanski and Gilpin 1991). In other words, if individual populations are extirpated faster than they can be recolonized, the entire metapopulation will eventually go extinct. Short of overall metapopulation extinction, reduced connectivity and gene flow between populations can cause genetic diversity to erode over time and close inbreeding can lead to inbreeding depression (Whittaker et al. 2004). The Department was one of the first agencies to apply these metapopulation concepts to inform management actions (Torres et al. 1994). Some of this pioneering work on desert bighorn metapopulations highlighted the importance of how dispersal, recolonization, and gene flow are critical to maintain a viable metapopulation and are therefore important management considerations.

The monitoring of metapopulation dynamics of bighorn sheep in California is not only important for long-term persistence but also for considering individual population dynamics. Bighorn sheep display a behavioral strategy known as philopatry, a reluctance to disperse from their natal range. Philopatry makes bighorn sheep slow to colonize unoccupied habitat (Geist 1967, 1971) and has important implications for metapopulation dynamics such as the resistance of connectivity between ranges (i.e. the ability of the metapopulation to stay connected despite disturbance) and the establishment of new movement patterns (Epps et al. 2010). Due to high environmental and topographic heterogeneity across the landscape, movement between ranges is neither consistent nor balanced, and therefore the individual population dynamics vary greatly. As such, it is critical that the Department understands population level dynamics to better inform management actions at broader spatial and temporal scales. For example, inbreeding may negatively influence lamb survival and horn growth in bighorn sheep (Sausman 1982, Stewart and Butts 1982, Fitzsimmons et al. 1995), whereas outbreeding can substantially increase adult survival and their reproductive success (Hoggs et al. 2006). Increasing evidence indicates that genetic variation significantly improves disease resistance (Carrington et al. 1999, Coltman et al. 1999, Dugovich et al. 2023), suggesting that low genetic diversity could make populations more susceptible to novel and endemic pathogens. Severed connectivity may also hinder stable populations from providing "demographic rescue" to populations with high extinction risk in the face of climate change (Epps et al. 2004). Research has suggested that movement barriers like highways can reduce genetic connectivity by 15% in as little as 40 years (Epps et al. 2005). Thus, scientific evidence increasingly suggests that managing robust metapopulations may result in individual bighorn populations that are more resilient to disease and climate change.

The phylogenetic relationships between and evolutionary history of these metapopulations are also important to consider when managing bighorn sheep (Jahner et al. 2019). Bighorn sheep recovery throughout western North America is largely the result of translocation management, often across government jurisdictions and sometimes using inappropriate source stock (i.e., specific subspecies introduced to habitats outside their native range). While translocations have been an important tool for restoration in California, none of the extant populations contain translocated stock from other states, thus there has been no mixing of non-native stock into the system (Bleich et al. 2021). As a result, California populations largely represent true evolutionary relationships among lineages, including potential adaptations to local habitat and climate. Research supports that there is substantial genetic structuring across the desert bighorn metapopulations (Epps et al. 2010, Buchalski et al. 2015, Buchalski et al. 2016) and this is reinforced by observed behavioral and reproductive variation throughout desert bighorn range (Wehausen 2005). Management should consider these factors when planning actions that could impact overall metapopulation function. Effective management requires the Department to understand the life history, habitat requirements, intermountain/corridor requirements, and key threats and causes of population decline. Maintaining intact habitats occupied by native desert bighorn adapted to local conditions is an important component of such efforts. Therefore, long-distance translocation of bighorn sheep between genetic lineages or distinct desert ecosystems is not advisable without further scientific investigation of the potential consequences.

## MORBIDITY AND MORTALITY

Wildlife health is not simply the absence of disease, but more appropriately defined as the resilience of animals and their ecosystem and the ability to cope with change based on individual, population-level, and environmental factors (Stephen 2014). Morbidity and mortality in bighorn sheep is often multifactorial and dependent on determinants extending beyond those of a discrete disease and/or pathogen. For example, variation in juvenile survival in response to the bacteria *Mycoplasma* *ovipneumoniae* (*M. ovipneumoniae*) has been hypothesized to originate from many factors including strain type, nutritional status, genetic diversity, and population density, though teasing apart these potentially contributing factors can be difficult (Spaan et al. 2021). Bighorn sheep health management therefore should not only focus on pathogen or parasite presence and load but also take into account important factors and potential compounding effects of predation, habitat quality, population connectivity, and extreme environmental events (e.g. drought and avalanches). This is particularly important for small and/or disease-naïve populations where outbreaks have the potential to significantly alter demographic rates such as survival and recruitment (e.g., *M. ovipneumoniae* and Sierra Nevada bighorn).

## Pathogens and Parasites

Bighorn sheep are susceptible to a variety of pathogens (Jessup 1985, Bunch et al. 1999, Besser et al. 2012), many of which can originate from domestic livestock, particularly sheep (*Ovis aries*) and goats (*Capra hircus*), but also cattle. Diseases originating from domestic sheep and goats may partially explain the widespread historical extirpation of bighorn sheep throughout North America, resulting in significant wild sheep population declines (Grinnell 1928). There is extensive experiential and peer-reviewed acknowledgement that when bighorn sheep and domestic sheep have contact, bighorn sheep herds do not remain healthy and can die in large numbers (Martin et al. 2016). This unanimous recognition led to the first action of the Western Association of Fish and Wildlife Agencies (WAFWA) Wild Sheep Working Group (now Wild Sheep Initiative) being to develop guidance on wild sheep-domestic sheep and goat interactions (WAFWA 2012).

Effective disease management options for free-ranging wildlife are limited and prevention, where possible, is more feasible than control or eradication (Wobeser 2002). In the case of *M. ovipneumoniae*-mediated pneumonia, chronic carriers (also referred to as chronic shedders) are individuals that continue to harbor and spread the pathogen without showing clinical signs of disease. Some evidence suggests removal of chronic carriers, from a population, either by selectively or via natural causes (emigration, death) can result in improved recruitment (Cassirer et al. 2018, Garwood et al. 2020, Spaan et al. 2021). Selective removal efforts, however, require substantial investment of resources to enable the capture and testing of all individuals within a population. Such efforts may be futile when re-infection risk is high due to exposure to domestic sheep and goats or when movements of infected or chronically shedding bighorn sheep are likely. Still, selective removal may be a tool to consider for mitigating outbreaks in isolated *M. ovipneumoniae*-free populations, or when recruitment is so low in an infected population that the population is at risk of extinction.

### Pneumonia

Of the various infectious agents that can affect bighorn sheep, those contributing to respiratory disease continue to present the most significant challenge for wildlife managers across the western United States (WAFWA 2017). Respiratory disease has resulted in mass die-offs in many bighorn sheep populations, with substantial reductions in lamb recruitment in subsequent years (Cassirer et al. 2007, 2018, Besser et al. 2008, 2012, Plowright et al. 2013, Epps et al. 2016, Manlove et al.

2016, Dekelaita et al. 2020, Shirkey et al. 2021). These common pathogens can spread effectively between bighorn sheep and domestic sheep or goats, as well as among bighorn sheep (Post 1971, Dassanayake et al. 2009, Lawrence et al. 2010, Wolfe et al. 2010, Subramaniam et al. 2011, Wehausen et al. 2011, Besser et al. 2012, 2013, 2014, Cassirer et al. 2018). Once such diseases become endemic to bighorn sheep, they can become a chronic source of mortality such as the case with *M. ovipneumoniae*-mediated pneumonia (Plowright et al. 2017).

*Mycoplasma ovipneumoniae* is considered a primary pathogen in the respiratory disease complex that can set the stage for severe pneumonia and death by allowing other pathogens to affect the lungs more effectively (Besser et al. 2012). Bighorn sheep ewes exposed to *M. ovipneumoniae* appear to develop antibodies and some immunity, but that immunity is not passed to their offspring (Plowright et al. 2013). Furthermore, adult immunity may wane after two to three years (Plowright et al. 2013, California Department of Fish and Wildlife [CDFW] unpublished data), but "super-shedders" may produce high pathogen loads during infection, and chronic carriers may persist in a population for years, serving as a pathogen reservoir (Plowright et al. 2017). Current surveillance (tests for infections or antibodies indicating recent exposure) indicates that most bighorn sheep populations in California have recent or continued exposure to *M. ovipneumoniae* (Figure 3, Shirkey et al. 2021), with Sierra bighorn and a reintroduced population of desert bighorn (i.e., San Rafael Peak) being exceptions with no evidence of infection in the past decade. Limited connectivity between those contemporary *M. ovipneumoniae*-naïve populations and other bighorn populations may be limiting pathogen spread, however long-distance dispersal events by rams coupled with pervasive threat of exposure from domestic sheep and goats present significant unknown conservation risks.

In addition to *M. ovipneumoniae*, other respiratory pathogens are often involved in polymicrobial pneumonia (Besser et al. 2013). In particular, bacteria from the *Pasteurellaceae* family with hemolytic and leukotoxic activity (e.g., *Mannheimia haemolytica*, *Bibersteinia trehalosi, Pasteurella multocida*) are often cultured from lesions in pneumonic sheep. These pathogens are thought to play a secondary or opportunistic role in many pneumonia epizootics (Wolfe et al. 2010, Besser et al. 2012), though they are also capable of causing mortality independently of *M. ovipneumoniae* (Dassanayake et al. 2013). Other bacteria cultured from pneumonic bighorn mortalities include *Trueperella pyogenes* and various *Streptococcus* and *Staphylococcus sp.* (CDFW unpublished data). Viral pathogens, such as respiratory syncytial viruses and parainfluenza virus have also been associated with respiratory disease (CDFW unpublished data), however past research indicates these viruses probably cause non-fatal pneumonia (Dassanayake et al. 2013).

Another consideration for management of pneumonia risks for bighorn sheep is lungworm infection by organisms in the genus *Protostrongylus*. Lungworms can increase the susceptibility of bighorn sheep to pneumonia and associated mortality when levels of lungworm infection are high (Forrester 1971, Woodard et al. 1974). Protostrongylid lungworms complete part of their life cycle in a snail. Snails that host protostrongylid lungworms have been detected in coniferous forests in the Rocky Mountains (Boag and Wishart 1982) and pinyon pine forests in Nevada (McQuivey 1978). Habitats in the Mojave and Sonoran deserts are typically too arid to support the snails that serve as intermediate hosts for protostrongylid lungworms, hence they are not generally considered an important parasite among desert bighorn in California. However, lungworms have been detected in desert bighorn in the Great Basin (i.e., White Mountains and Inyo Mountains), where pinyon-juniper woodlands may provide adequate habitat for the intermediate-host (Wehausen 1983, 1984b, Clark et al. 1985).

*A sick Peninsular bighorn lamb on a golf course. Photo by Janene Colby*

### Scabies

Disease caused by the ectoparasite *Psoroptes ovis* (also called mange or psoroptic or common scabies in sheep) can also impact populations of bighorn sheep (Jones 1950, Buechner 1960); however, the significance of this disease has varied temporally and regionally. Psoroptic scabies is considered eradicated from livestock in the United States, though small outbreaks in cattle in the Southwest have occurred since the 1970s. Outbreaks are reportable to the United States Department of Agriculture and the California Department of Food and Agriculture. While scabies was an important mortality factor among desert bighorn in the San Andres Mountains of New Mexico (Lange et al. 1980, Hoban 1990, Rominger and Weisenberger 2000), it does not appear to be a source of significant clinical disease or mortality in California despite having a wide distribution among desert bighorn (Clark et al. 1988; Mazet et al. 1992, Singer et al. 1997; Bleich et al. 2014, Bleich et al. 2015).

### Other Pathogens

Surveillance for a variety of other pathogens is conducted through live animal capture, mortality investigation, and hunter-harvest sampling. This includes routine testing for bluetongue virus, epizootic hemorrhagic disease virus, contagious ecthyma, *Chlamydia*, Border Disease Virus, *Brucella ovis*, and *Anaplasma sp*. There is currently little evidence to support any of these as major population drivers to the extent of the respiratory disease complex.

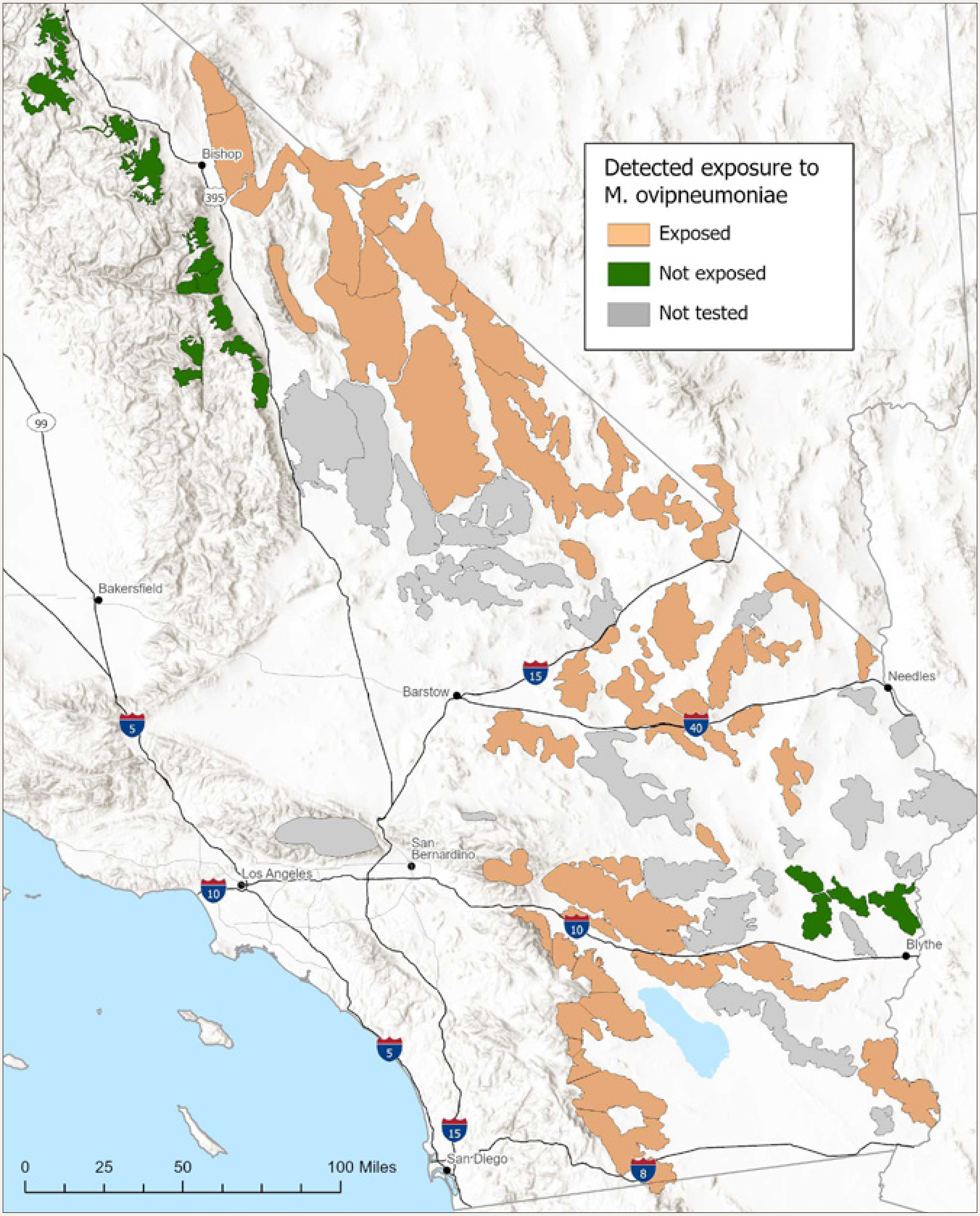



**Figure 3:** Mountain ranges occupied by bighorn sheep (*Ovis canadensis*) with detected exposure to the pathogen *Mycoplasma ovipneumoniae* 2013-2024. Some populations that were not tested in this period have previously tested positive for *Mycoplasma ovipneumoniae*.

## Predation

The most prevalent source of predation on bighorn sheep in California is the mountain lion (*Puma concolor*), with occasional instances of predation by coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and golden eagles (*Aquila chrysaetos*.; Ober 1931, Kelly 1980, Berger 1991, Bleich 1999). While historically documented, wolves (*Canis* lupus) and wolverines (*Gulo* gulo) are not currently considered predators of bighorn sheep in California due to minimal overlap in range (Ober 1931, Nichols and Bunnell 1999). Because cervids (i.e., members of the deer family) generally comprise the primary prey of mountain lions in North America (Ross et al. 1997), bighorn sheep near deer or elk herds are more likely to suffer sustained losses to mountain lions, in what is termed apparent competition (Johnson et al. 2013). Where bighorn sheep ranges overlap or are adjacent to higher density mule deer populations, mountain lions are likely the primary predator of bighorn sheep and may constitute the single largest source of mortality. Where mountain lion predation on bighorn sheep has been studied, kills of bighorn sheep have been attributed to relatively few mountain lions that have learned to effectively prey on bighorn sheep (Ross et al. 1997, Ernest et al. 2002, Festa-Bianchet et al. 2006, Gammons et al. 2021).

Populations of bighorn sheep are generally small (Epps et al. 2004), owing to limited availability of the habitats they occupy. Thus, allowing even occasional predation by one or more mountain lions to have large negative effects on population dynamics (Ernest et al. 2002, Gammons et al. 2021), even if bighorn sheep make up a relatively small proportion of a mountain lion's diet. Because the primary prey of mountain lions is often deer or elk, opportunistic predation on bighorn can therefore be density independent (i.e., even as a bighorn population declines, predation pressure can remain high). This can result in greatly reduced annual adult survival (Hayes et al. 2000, Rominger et al. 2004, Gammons et al. 2021) resulting in rapid population declines (Gammons et al. 2021). Mountain lion predation effects can be further compounded by concentrated bighorn sheep populations as a result of heavy snowfall, this is especially true for the endangered Sierra Nevada bighorn sheep population.

*Adult Sierra Nevada bighorn ram killed by a mountain lion.*
*Photo with CDFW trail cameras.*

Mountain lions are considered a "specially protected" species in California; however the FGC Section 4801 states that the Department may remove or take any mountain lion, or authorize an appropriate local agency with public safety responsibility to remove or take any mountain lion, that is perceived to be an imminent threat to public health or safety or that is perceived by the department to be an imminent threat to the survival of any threatened, endangered, candidate, or fully protected sheep species. Due to the protected status of both mountain lion and bighorn sheep any perceived threat of a mountain lion to bighorn sheep is handled on a case-by-case basis. The Recovery Program for the endangered Sierra Nevada bighorn sheep, has its own document, "A Strategy for Managing Predation on Sierra Nevada Bighorn Sheep" (Gammons et al. 2025) which explains the different translocation and removal strategies that may be considered for mountain lions threatening the survival of this subspecies.

### Other Causes of Morbidity and Mortality

In addition to disease and predation, other concerns for bighorn sheep conservation include malnutrition; severe winters and avalanche; drought and declining surface water availability; changes to weather patterns due to climate change; habitat loss or degradation; land use and management practices, including fire suppression, presence or incursion of non-native vegetation, and resource competition with non-native and/or domestic species (Marshall 2008, St. John 1995); vehicle collisions; poaching; and increased disturbance due to human recreational activities (Papouchis et al. 2001).

Undernutrition (not enough nutrients) can be estimated in living animals through a visual assessment (Smiley et al. 2020), or by measuring body fat via ultrasound during capture (Stephenson et al. 2020). Emaciation suggesting starvation can be observed post-mortem by evaluating kidney fat or bone marrow (Cook et al. 2001, Bender et al. 2008, Stephenson et al. 2020). Even when bone marrow condition is poor, suggesting starvation is the ultimate cause of death, the proximate cause of death may be difficult to determine. Animals in poor nutritional condition may be susceptible to other causes of mortality including predation and disease (Davidson and Doster 1997, Bender and Hall 2004, Bender et al. 2008). Forage can become unavailable in the deserts due to prolonged drought, heavy winters in the high mountains, habitat loss, loss of habitat connectivity, or change in land management practices. Reduced availability of nutrients in forage may contribute to lamb mortality (Wehausen 2005) and metrics of summer and autumn vegetation growth have been linked to adult survival (Dekelaita et al. 2020). For aging animals, malnutrition and eventually starvation can also occur from tooth wear, damage, or alignment (Lyman 2010).

*This is an example of a bighorn sheep crossing sign used to alert motorist in the Mojave Desert.*

While the majority of bighorn habitat is located away from roads, in areas of proximity, vehicle collisions are of concern both for bighorn sheep survival and public safety. Vehicle collisions are of particular concern in the Peninsular Ranges where regular instances of roadkill occur along Highway 74 and Interstate 8. Mortality of desert bighorn has also been documented within, and in proximity to, the Mojave National Preserve, along Interstates 15 and 40, Kelbaker Road, and due to train collision in Afton Canyon. The Department is working with local, state, and federal agencies to reduce the number of vehicle collisions—including the use of signage, speed reduction zones, and wildlife overcrossings.

## MANAGEMENT: TRADITIONAL, HISTORICAL, AND MODERN APPROACHES

### Traditional Ecological Knowledge

Since time immemorial California has been home to a great diversity of Native American Tribes. Although these Tribes vary considerably in terms of language and culture, they share a strong ecological, cultural, and spiritual connection to the land (Rawls 1984). This includes a long history of using fire and other tools to manage habitats for the plant and wildlife resources which supported Tribal peoples in California (Anderson 2005).

European settlement of California severely impacted Tribal populations, their cultures and livelihoods, and their tenure over the land (Rawls 1984). Yet approximately 180 distinct Tribes remain active in the state today. Many are providing leadership in wildlife science, conservation, and management (Matthews et al. 2008, Ramos 2022, Connor et al. 2022).

Indigenous people in California and throughout North America have coexisted on the same land as bighorn sheep for millennia. This coexistence has often led to an accumulation of valuable knowledge, sometimes referred to as Traditional Ecological Knowledge, and can complement contemporary scientific methods to inform effective conservation and management planning for wildlife species (Huntington 2000).

Through the Tribal Review and Plan development process, the Department had the opportunity to listen to, learn from, share with, and discuss information about bighorn sheep with multiple California Native American tribes. Through a variety of engagements including listening sessions, consultations, and writing, the Department received valuable feedback on the history, conservation, and management of bighorn sheep in California. Below is a summary of the comments received:

- Bighorn sheep are of great cultural and ecological value to many California Native American tribes. For some, the health and wellbeing of bighorn and the California Native American people are intimately linked.
- There is interest in finding a way to allocate a portion of desert bighorn hunting tags to citizens of California Tribes.
- There is interest in finding a way to provide parts of harvested desert bighorn (e.g., hooves) to Tribes because these items are of cultural significance. During hunter orientation hunters are encouraged to donate harvested parts to Tribes.
- There is interest in reintroducing bighorn sheep into their native range in Northern California.
- There is a commitment and interest in investing in restoration of wildlife habitat and recovery of bighorn sheep.

In addition, the following statements were provided by California Native American tribes on their ecological and cultural relationship with bighorn sheep:

**The Yuhaaviatam of San Manuel Nation**

*Desert bighorn sheep are of immense value and concern to the Yuhaaviatam of San Manuel Nation, as this species is an integral part of Serrano culture. The Serrano practiced sustainable hunting methods throughout their ancestral lands, including portions of the Transverse Ranges and the mountains of the Mojave Desert. This practice is attested to in the ethnographic and archaeological record, as well as the traditional ecological knowledge of the Serrano, which has been transmitted from generation to generation since time immemorial. The Serrano are keenly aware of the symbiotic relationship they have with culturally important biological resources such as desert bighorn sheep and know that these must remain healthy so that they may continue to utilize them from one generation to the next. Like the desert bighorn sheep, the Serrano have suffered from the negative impacts of settler-colonial society, having been removed from their traditional spaces and lack of ability to engage in the practice of their culture on state lands. The health and wellbeing of desert bighorn sheep and the Serrano people are intimately linked. Both would benefit from a management plan that prioritizes decreasing the exposure of desert bighorn sheep to domesticated sheep, thus isolating them from the primary cause of their decimation, while allowing tribal members to engage in the practice of culturally informed and sustainable hunting practices.*

### The Modoc Nation

*Since time immemorial, ancestors of the Modoc Nation carefully stewarded a large landscape in northeastern California and south-central Oregon. Though modern members are still working to recover their connections to their Traditional Homelands after their violent removal 150 years ago, they are making large investments through their "Homelands Effort" to enhance wildlife habitat and recover extirpated populations of sacred ku'il (mountain sheep) to the 3,200-acre Modoc Ranch and surrounding co-stewarded federal landscape in Siskiyou and Modoc counties. The Modoc Nation is actively engaged in multiple collaborative efforts and have secured millions in grant funding to recover endangered and threatened species. Highest priority is given to wild bighorn sheep as they work to recover the connections and knowledge taken by the ecocide of their Traditional Homelands.*

As a result of this information and feedback, the Department encourages hunters outreach curriculum at its annual hunter orientation to consider voluntarily donating parts of harvested animals. The Department also added a sixth BCU for Northern California to acknowledge the historic presence of bighorn and to explore the potential for future reintroductions. Last, but certainly not least, the Department staff have established new contacts and connections with local Tribes and are actively exploring ways to collaborate.

## European Impacts and History of State Management

It is likely that bighorn sheep populations in the California declined shortly after Euro-Americans began grazing domestic sheep on the landscape. This explanation for decline is consistent with the historic record across the range of bighorn sheep in the United States and has been attributed to disease transmission from domestic sheep and goats (WAFWA 2017). In addition, unregulated hunting, including market hunting of wildlife, occurred following Euro-American settlement in California.

As a result of this information and feedback, the Department encourages hunters at its annual hunter orientation to consider voluntarily donating parts of harvested animals. By the late 1870s it is estimated that over 45 populations of bighorn were extirpated since the start of the Gold Rush in 1849 (Wehausen et al.1987). In 1876, bighorn sheep were added to the earlier California Penal Act: 597 (1872) that protected elk, deer, and pronghorn for eight months of the year. The 1872 Act was amended again in 1878 to establish a four-year moratorium on the taking of any pronghorn or bighorn sheep. For bighorn sheep, the Act was extended indefinitely in 1883 (Wehausen et al.1987). Bighorn sheep were designated as Fully Protected Mammals in 1933 by the state of California. However, funding specifically for the conservation of bighorn sheep was not available, as classification as a non-game animal precluded generating revenue from the sale of hunting licenses (Wehausen et al.1987). Consequently, monitoring of bighorn sheep populations was not consistent during much of the 20th century.

*A group of Sierra bighorn near Bishop, CA. The ewe on the left is wearing a VHF collar. Photo by Chris Cleveland.*

### Northern California

The Department attempted reintroduction of bighorn sheep to northern California during the 1970s and 1980s using a mix of source stock (Bleich et al. 2021). In 1971, the Department translocated 10 bighorn sheep from British Columbia and one ram from Nevada to an 1,100-acre enclosure with the objective of reestablishing a population in Lava Beds National Monument (Blaisdell 1982). The population within the enclosure grew to 42 animals, and in 1980 four of these animals and 10 bighorn sheep from the Sierra Nevada were translocated to the Warner Mountains (Sleznick 1980). This is the only time a source population from out-of-state was used to establish a free-ranging bighorn sheep population in California (Bleich et al. 2021). In 1980, all bighorn sheep in the enclosure died following contact with domestic sheep from a nearby ranch and grazing allotment, now owned by the Modoc Nation. The population in the Warner Mountains increased substantially before it was exposed to domestic sheep and extirpated by respiratory disease in 1988 (Bleich et al. 1990a, Bleich et al. 2021). Any future efforts to reestablish these populations will need to assess and consider the disease risks across the landscape.

In addition to disease risks, potential future reintroduction efforts of bighorn sheep in Northern California will also need to consider the distance from other bighorn sheep populations in neighboring states. Bighorn sheep reintroduction efforts by the Oregon Department of Fish and Wildlife (ODFW) and Nevada Department of Wildlife (NDOW) have been successful in areas adjacent to the California border. Consequently, California bighorn, a subspecies native to the Rocky Mountains of British Colombia, currently occupy some of the range along the Klamath River Gorge on the Oregon-California border and areas of the California-Nevada border (Figure 2). Only small, transient portions of these populations enter California, and these are not actively managed by the Department. Furthermore, a morphometric analysis by Wehausen and Ramey (2000) suggests that the native bighorn sub-species to northern California was likely the Great Basin Desert adapted *O. c. nelsoni*. Careful consideration of nearby ranges and genetic stock will need to be considered prior to future reintroduction efforts.

Through the Tribal Review and consultation process with the Modoc Nation, the Department has gained valuable information and insight about the history and potential future of bighorn sheep in Northern California. In 2020, the Modoc Nation acquired the ranch from which the domestic sheep trespassed onto federal lands in 1980, exposing the bighorn in the enclosure to pneumonia. The Modoc Nation has demonstrated a commitment to dedicating their land holdings and co-stewardship efforts to bighorn sheep reintroduction. They are already conducting collaborative landscape-scale habitat improvement efforts in preparation and have offered to build a landscape-scale enclosure and dedicate their landholdings and Homelands resources to wild bighorn sheep recovery. While the possibility of a future reintroduction remains uncertain, the Department is planning to add a sixth BCU Plan for Northern California to continue assessing the risks, exploring the possibilities, and inviting others to the conversation.

### Sierra Nevada

Prior to the arrival of Europeans, Sierra bighorn were widely distributed throughout the Sierra Nevada. By the 1970s, Sierra bighorn persisted in only three herds (USFWS 2007). The California Fish and Game Commission listed the subspecies as rare in 1972 and threatened in 1984. The Department implemented translocations of Sierra bighorn during 1979–1988 to portions of their historical range (Sierra Nevada Bighorn Sheep Interagency Advisory Group 1984). By the mid-1990s the total population had declined to just over 100 individuals (Figure 4) and in 1999, the California Fish and Game Commission and the USFWS listed Sierra bighorn as endangered.

The California Legislature funded the Sierra Nevada Bighorn Sheep Recovery Program in 1999, and the Department became the lead agency in implementing recovery efforts. The two primary challenges to recovery were, and still are, predation by mountain lions and the continued threat of disease from domestic sheep and goats. Upon listing, the Department started monitoring and managing mountain lions through capture and collaring, and individuals that threatened Sierra bighorn were lethally removed (Gammons et al. 2021). During the early 2000s, considerable progress was made in closing and vacating grazing allotments for domestic sheep adjacent to occupied bighorn sheep habitat. In addition, extensive monitoring and research efforts led to a better understanding of the ecology of Sierra bighorn.

The Recovery Plan for Sierra bighorn specifies minimum abundance and distribution goals that must be met for the subspecies to be downlisted or delisted (USFWS 2007). In an effort to achieve the required downlisting distribution, a second wave of translocations began in 2013 using native source stock, which at that time had risen to more than 500 individuals.

Between 1995 and 2016, the population grew from an estimated 100 individuals to 600 and the distribution increased from 7 to 14 herds through natural dispersal and translocation (Greene et al. 2016). Unfortunately, between 2016 and 2023 there was a decline to just over 300 individuals largely driven by three above-average snowfall winters (2017, 2019, 2023) with losses of 33%, 25% and 50%, respectively (Greene et al. 2024). Mortality was predominantly snow-related (e.g., avalanche and starvation) during heavy snow years. Predation by mountain lions has become a chronic and increasing cause of mortality since 2017 across a range of elevations. As of April 2025, the Department estimates there are 400 Sierra Nevada bighorn range-wide, including adults, yearlings, and lambs. More information about recovery goals and progress can be found in the Recovery Plan and in annual reports of the Sierra Nevada Bighorn Sheep Recovery Plan website.

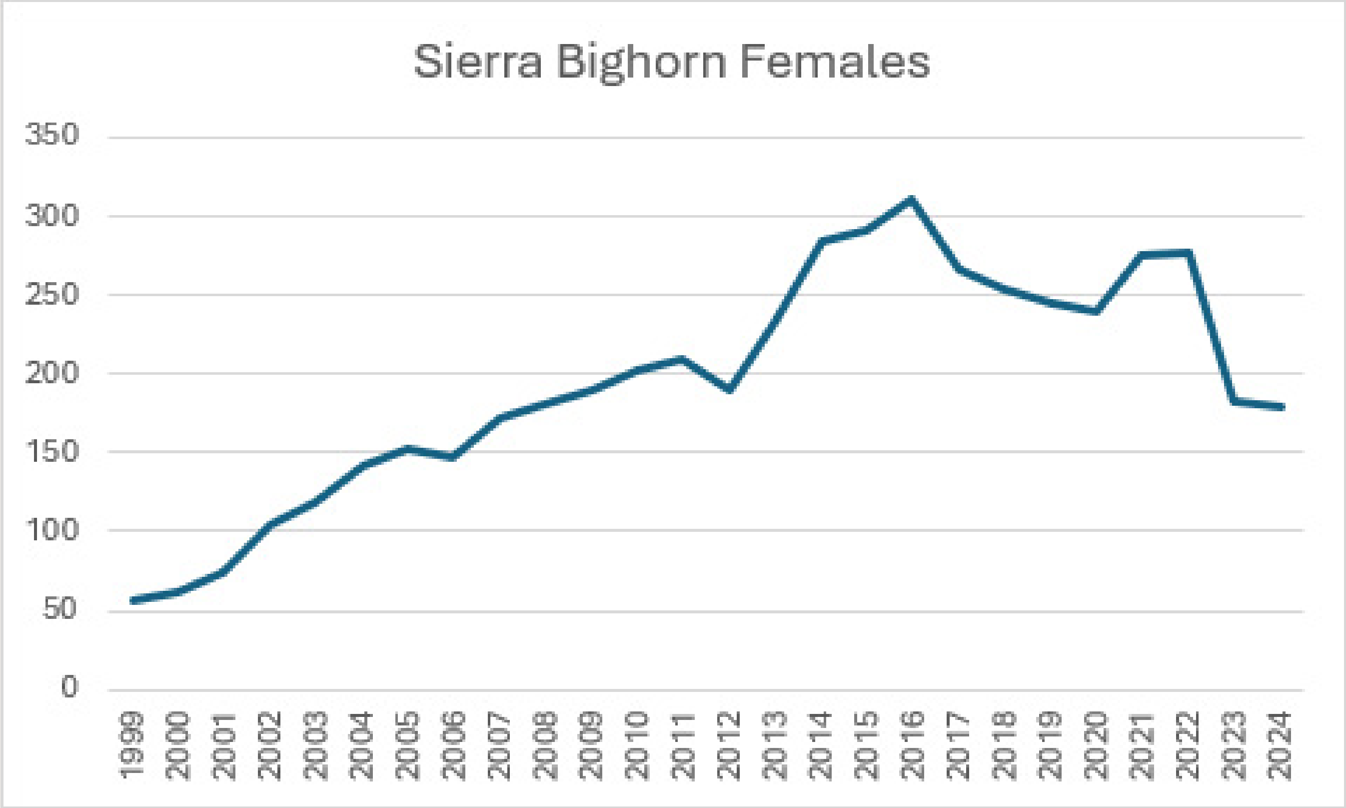



**Figure 4.** Population estimate of Sierra Nevada bighorn females from 1999-2024.

### Peninsular Bighorn

The Peninsular bighorn population declined from approximately 1,100 bighorn sheep in the 1970s to 276 in 1996 (USFWS 2000). This decline was attributed to respiratory disease, habitat loss and fragmentation, predation, and mortality related to proximity to human development, including from vehicle strikes, entrapment and drowning in canals and swimming pools. The California Fish and Game Commission listed Peninsular bighorn as rare in 1971 and threatened in 1984. In March 1998, USFWS recognized Peninsular bighorn as a Distinct Population Segment (DPS) and listed the DPS as endangered. A recovery plan was published in 2000.

The Department has been active in the recovery of Peninsular bighorn since 1971 and has taken the lead in implementing a multi-agency Recovery Program since 1998. The Recovery Plan for Peninsular bighorn (USFWS 2000) identified several criteria for delisting, including minimum abundance (750 individuals) and distribution (minimum of 25 ewes in each of nine designated recovery regions) thresholds, the persistence of these metrics and a stable or increasing population growth trend for 12 consecutive years without population augmentation, and the establishment of regulatory mechanisms and land management commitments to provide long-term protection of bighorn sheep and all essential habitat. Furthermore, connectivity among all portions of habitat must be reestablished to allow bighorn sheep to move freely throughout the Peninsular Ranges.

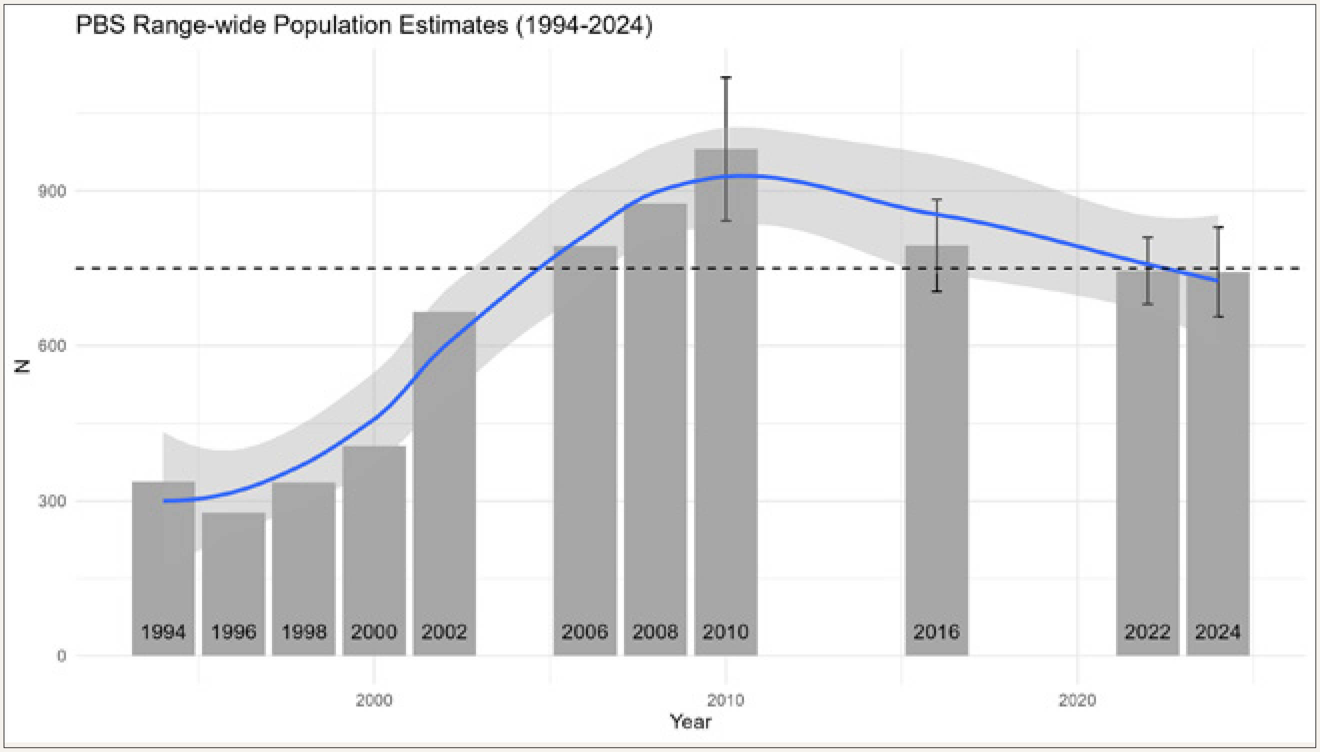



**Figure 5.** Population estimates of adult Peninsular bighorn sheep from 1994-2024. Starting in 2010, populations were estimated using mark-resight with 95% confidence intervals. The dotted line denotes the recovery goal of 750 individuals. The blue line represents the population trajectory, using a LOWESS regression.

As of 2024, a range-wide helicopter survey yielded a mark-resight estimate of 742 [95% CI: 656-829] adult and yearling Peninsular bighorn sheep. These results are consistent with the 2022 range-wide estimate of 745 [95% CI: 681-810]. Despite an overall increase in the population since 1996, the Peninsular bighorn population remains extremely vulnerable to demographic and environmental stochasticity, habitat loss and fragmentation, disease, human disturbance, and predation. The potential decline in the population between 2016 and 2022 likely result from several years of severe drought, coupled with chronic low lamb recruitment due to disease, and continual mortalities due to predation, vehicle collisions, and individuals drowning in canals. Continued implementation of the Recovery Program remains crucial to the development and refinement of management and recovery strategies and to achieving recovery objectives for Peninsular bighorn. Further details about the status and recovery of Peninsular bighorn can be found in the Recovery Plan and on the Peninsular Desert Bighorn Sheep website.

### Desert Bighorn

The first comprehensive effort to survey desert bighorn in California began in the 1960s (Weaver et al. 1968, Weaver and Mensch 1969, and Weaver et al. 1969). Estimates of desert bighorn abundance in California have increased as survey methods have improved, and effort has intensified. Between 1983-2006, the Department translocated desert bighorn within southern California to reestablish historic populations, increase population numbers to sustainable levels, and provide increased opportunities for recreational, aesthetic, and educational use (Bleich et al. 1990b, Bleich et al. 2021). Further information about desert bighorn natural history and management challenges are presented in Section II of this Plan, while management goals, objectives, and actions are presented in Section III. Between 2015-2023, the Department conducted population surveys in 48 of 70 desert bighorn populations yielding an estimate of 3,250 individual animals. The Department plans to survey the remaining populations, but based on historical data it is estimated that in 2025 the statewide desert bighorn population is around 4,250 individuals (Figure 6).

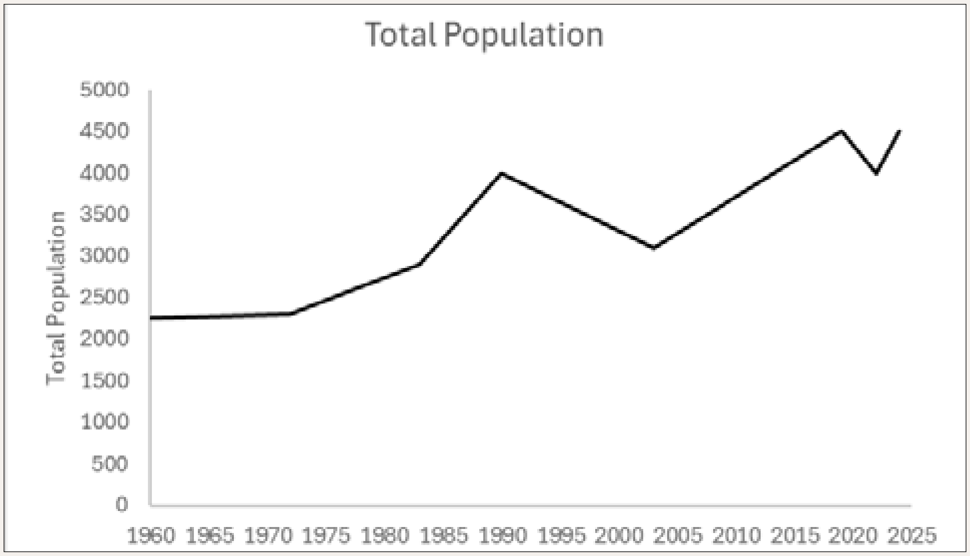



**Figure 6.** Population estimates of desert bighorn (excluding Peninsular bighorn) in California during 1960–2024. Early estimates likely reflect less robust methods used to count bighorn across >70 mountain ranges.

## Adaptive Management

The Department employs adaptive management when making decisions about bighorn conservation. Adaptive management has been described as learning by doing; it integrates science and management. The approach implements actions with a planned level of monitoring. The data collected during implementation is then analyzed and the results are used to adapt and continuously modify what actions are implemented.

The three bighorn sheep programs (desert bighorn, Peninsular bighorn, and Sierra Nevada bighorn) aim to use the best available science to direct and adapt monitoring and management strategies. Current population estimation methods include aerial surveys, ground counts, camera traps, and fecal DNA-based spatial capture recapture surveys. Methods are selected for a given subpopulation based on efficiency and effectiveness. Integrated population models (IPMs) facilitate the combination of multiple data sources to efficiently and robustly estimate interannual variation in population abundance, composition, and spatial distribution (Hatter et al. 2017). Vital rates (juvenile recruitment and adult survival) are routinely collected with the aid of GPS and VHF collars that are deployed during capture by helicopter net-gun. The use of an IPM can help address sampling challenges and mitigate inevitable data gaps. Combining vital rates from telemetry and population counts can reduce the uncertainty in demographic parameter estimates. The Department uses IPMs, along with other modeling tools, to maximize the utility of data collected and to provide annual estimates of size and trend for each monitored subpopulation.

An adaptive management approach is essential when implementing translocations given the need to know the availability of translocation stock and the outcomes of reintroduced and augmented populations. The Department has implemented translocations for Sierra Nevada and desert bighorn population management over the last 50 years (Bleich et al. 2021). While not used in recent years in the desert, translocations still play an essential role in recovery efforts of the Sierra Nevada Bighorn Sheep Recovery Program and may have a role in future desert bighorn management, particularly in northern California.

For more information about the methods and associated objectives used for monitoring and management of bighorn sheep in California, see pages 66-71.

# II. DESERT BIGHORN IN CALIFORNIA: NATURAL HISTORY AND CHALLENGES

*Photo by Ashley Evans*

# DESERT BIGHORN IN CALIFORNIA: NATURAL HISTORY AND CHALLENGES

## DISTRIBUTION

The westernmost extant population of desert bighorn in California is in the San Rafael Mountains (Figure 2). This and the San Gabriel Mountains population, (northeast of Los Angeles) are the most geographically isolated populations of desert bighorn in California. South of I-10 at San Gorgonio Pass and west of the Salton Sea, the federally endangered Peninsular bighorn population occupies the Peninsular Ranges extending south to Baja California, Mexico. The non-endangered desert bighorn in California occupy mountain ranges east of the Salton Sea, from the Mexican border to the White Mountains (east of Bishop, California). With this distribution, desert bighorn form a large metapopulation that spreads across California's desert and connects with Nevada and Arizona to the east. This metapopulation was once largely interconnected but is now fragmented by anthropogenic barriers.

*Two rams head-butt during the rut in the White Mountains. Photo by Pat Woods.*

## LIFE HISTORY

Desert bighorn demonstrate philopatry, meaning they generally spend their entire lives within their natal range. Females are generally more philopatric than males. Philopatry causes desert bighorn to be slow to naturally colonize unoccupied areas (Geist 1967, 1971). Despite this, both sexes of desert bighorn occasionally move between mountain ranges and subpopulations (Schwartz et al. 1986, Bleich et al. 1990a, 1996, Prentice et al. 2018, Dekelaita et al. 2023). The timing of the breeding season, or "rut," can vary widely between ranges and between years within ranges, but typically falls between May and late summer in southern populations of desert bighorn in California. In the White Mountains, where higher elevations create a unique climate and phenology, the rut can occur as late as December. The timing of lambing varies among populations of desert bighorn because of this variation in timing of the rut. Most lambing occurs December–May (CDFW unpublished data); however, 2–5% of births also can occur in August and September (Witham 1983, Rubin et al. 2000). Extreme weather events have the potential to greatly impact reproductive cycles; for example, a yearling cohort having >30% of births during summer (vs. the usual winter season) was observed in fall of 2023 in the Little San Bernardino Mountains following the end of a severe drought in 2022 (CDFW unpublished data).

## HABITAT REQUIREMENTS

Optimal bighorn sheep habitat is visually open and contains steep, generally rocky, slopes. The many islands of desert bighorn habitat across the southwestern United States and northern Mexico may provide adequate escape terrain but often are separated by intermountain zones less suitable as habitat (Figure 7). These large expanses lacking precipitous escape terrain can represent substantial barriers to movement, and result in natural fragmentation between populations and habitat patches (Bleich et al. 1990a). However, these intermountain zones are occasionally traversed by individuals, and as such, are critical for maintaining connectivity and metapopulation dynamics (Epps et al. 2005, 2018, Creech et al. 2014). Desert bighorn habitat varies considerably in size and other habitat characteristics important to bighorn sheep, such as quality and abundance of forage and availability of surface water. Consequently, habitat patches vary considerably in their ability to support desert bighorn populations. Habitat use varies temporally with changes in predation risk, resource needs, and availability of resources.

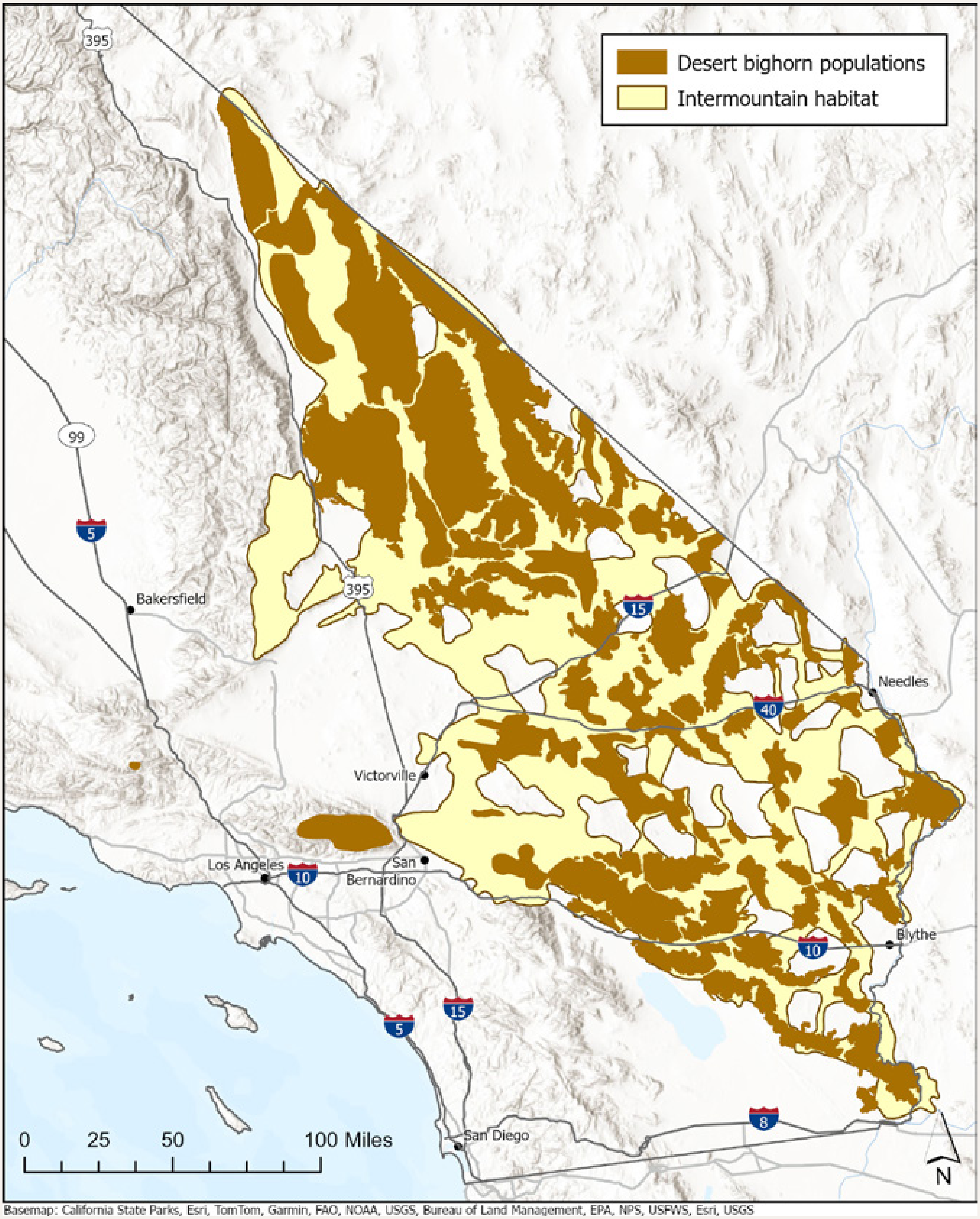



**Figure 7:** Desert bighorn distribution and habitat in southern California. Conservation and management actions must consider desert bighorn populations and habitat (brown); as well as, intermountain or connectivity corridor habitat (yellow).

## Forage

The life history strategies and demographic rates of desert bighorn are greatly affected by rainfall patterns because diet quality is highly dependent on the amount of green, growing vegetation in desert bighorn habitat (Wehausen 2005). Summer rainfall occurs largely as intense, localized, cloud bursts from monsoonal moisture that moves into the desert from a variety of southern sources (the Gulf of Mexico to the Pacific Ocean). When those storms encounter mountain ranges, much of the water leaves the habitat as flash floods, while hot temperatures quickly evaporate what moisture penetrates the soil. Consequently, most summer rain prompts little forage growth or associated increase in diet quality for bighorn sheep (Wehausen 2005). In contrast, cool-season storms tend to produce gentle, soaking, rains that are geographically widespread and derived from moisture that moves across California primarily from the north and west. Because cooler temperatures preserve soil moisture and temporally extend its availability for plant growth, the major nutrient pulse for desert bighorn occurs in winter and spring (Wehausen 2005).

In the Mojave Desert, the amount of October–April rainfall enabling winter–spring forage growth is highly variable, with bighorn sheep nutrient intake strongly correlated with that rainfall variation (Wehausen 2005) and lamb recruitment and overall population performance directly following annual productivity. Early rainfall (October–November) primarily enhances bighorn sheep nutrition through germination of annual forage species and initiation of the growth of some perennial forbs. Late rainfall (January–February) enhances diet quality later in the growing season by initiating growth of additional perennial species and extending the growth of species initiated by earlier rains (Wehausen 2005). In years when adequate early rainfall initiates germination of annual plants, these species make up a large proportion of bighorn sheep diets during the growing season, and they may also be consumed in dried form after the growing season. Some perennial species play a key nutritional role after the growing season too. For example, catclaw acacia (*Senegalia greggii*), a deep-rooted deciduous species, maintains green leaves throughout the summer when other plant species have largely ceased growing. Bighorn sheep substantially enhance the nutritional quality of their diet in the hot season by consuming catclaw acacia where it is present (Browning and Monson 1980).

In addition to providing nutrients to desert bighorn, forage also can be an important source of moisture (Turner 1973, Bleich et al. 1992, Bleich et al. 1997). During cooler months, desert bighorn primarily satisfy water intake requirements from forage consumption (Turner 1973, Gedir et al. 2016, Cain et al. 2017). In contrast, during the hot season, when available moisture from forage is low, desert bighorn will regularly drink from surface water sources, though some individuals may be able to survive solely on water from forage (Krausman et al. 1985, CDFW unpublished data).

*Photo by Janene Colby*

## Surface Water

Surface water availability strongly influences desert bighorn habitat selection, particularly during the hot season when daily high temperatures are 35°C (Turner 1973, Bleich et al. 1997, Glass et al. 2022). Home ranges of desert bighorn contract during the hot season because of the need to be relatively close to water sources (Blong and Pollard 1968, Leslie and Douglas 1979, Cunningham and Ohmart 1986, Krausman et al. 1999, Longshore et al. 2009), but expand again during the cool-season. The relative importance of surface water for desert bighorn varies across the southwestern United States (Cain et al. 2008) and is strongly influenced by temperature (Cain et al. 2006, Glass et al. 2022), forage quality and availability (Turner 1973, Cain et al. 2017, Gedir et al. 2020), and tradeoffs in habitat selection for escape terrain (Gedir et al 2020).

Desert bighorn may access perennial natural surface water at desert springs, seeps, and tinajas (surface pockets in bedrock forming natural water catchments). Springs and seeps are fed from groundwater, while tinajas can be filled by a spring or directly by precipitation. Springs can further be divided into local springs, influenced only by conditions in their immediate watershed, and regional springs with connections to regional aquifer systems (Zdon and Love 2020). Local springs have shallower catchments and rely on precipitation for groundwater recharge. Because of this, they can be ephemeral and highly sensitive to both drought and invasive vegetation, which may deplete limited water stores by increasing evapotranspiration. Regional springs draw from larger, older, groundwater sources, and may be more resilient to annual variation, but may be impacted by groundwater pumping. While reliable information on the status of natural desert water sources, and hence their availability to bighorn sheep, remains scarce, a series of recent studies in the Mojave and Sonoran deserts (Dekker and Hughson 2014, Zdon et al. 2018, Zdon and Love 2020, Parker et al. 2021) have focused on characterizing the hydrology and wildlife ecology of desert springs.

Since the 1940s, wildlife biologists and conservation groups built and maintained hundreds of Wildlife Water Developments (WWDs, also known as guzzlers or drinkers) in desert ecosystems to enhance or increase habitat for species like quail (*Callipepla gambelii*) and desert bighorn (Halloran and Deming 1958, Blong and Pollard 1968, Krausman et al. 2006). These water systems were built to impound rainwater or tap high water tables (Bleich et al. 1982a, Bleich and Weaver 1983, Lesicka and Hervert 1995). These WWDs help to offset the ongoing loss of surface water resources via climate change and human development across the Mojave and Sonoran Deserts. WWDs in the Mojave Desert are utilized by desert bighorn and many different species of wildlife during the hot summer months, and as well as in other seasons when forage moisture is inadequate (Rich et al. 2019). These systems require regular maintenance and monitoring and many of the older WWDs are in need of major repair or replacement.

*Ewes drink from a Wildlife Water Development (WWD; or guzzler) in the Newberry Mountains. Photo CDFW trail camera.*

## CONSERVATION CONCERNS

### Metapopulation Function

A general explanation of metapopulation dynamics is detailed in the section starting on page 19. The term metapopulation was introduced to desert bighorn management in California by Schwartz et al. in 1986. Their research was one of the first to document gene flow and establish intermountain movement between desert bighorn populations in the Mojave Desert. Habitats of desert bighorn in California are naturally discontinuous and patchily dispersed across the landscape, resulting in a metapopulation structure wherein geographically distinct populations are connected by variable movements of individuals. Connectivity between mountain ranges maintains genetic diversity within the desert bighorn metapopulation in Southern California (Epps et al. 2005, 2018, Creech et al. 2014), although connectivity can also pose risks by increasing the possibility of disease transmission. Major barriers such as Interstate Highways 15, 40, and 10 pose some of the greatest threats to connectivity by severing gene flow across the metapopulation (Epps et al. 2005, Aiello et al. 2024). However, when connectivity is restored, the genetic structure of California's bighorn sheep populations can change in as few as two generations (Epps et al. 2018). Movement models for desert bighorn in the Mojave Desert suggest that restoring connectivity across these barriers (i.e. wildlife overpasses) may increase accessible habitat by up to 138% for some populations (Aiello et al. 2023).

Because metapopulation processes are critically important to the persistence of desert bighorn and these processes rely upon continuity of unimpeded native habitat among mountainous habitat patches, maintaining, restoring, and enhancing connectivity between patches of habitat is an important objective of desert bighorn conservation. Intermountain habitat that connects patches of mountainous terrain and corridors that enable crossing of major barriers should be high priorities in desert bighorn conservation (Schwartz et al. 1986, Bleich et al. 1990a, Creech et al. 2014).

### Climate Change

Climate change and the resulting patterns of increased mean temperatures, maximum temperatures, and precipitation variability are an existential threat to the persistence of desert bighorn populations (Epps et al. 2004, 2006). Climatic modeling predicts that the southwestern United States will become increasingly arid (Cook et al. 2004, Seager et al. 2007), and drought conditions once considered historic will become common within the next few decades (Seager et al. 2007). Climate change models encompassing the Mojave and Sonoran Deserts predict warmer temperatures, while the quantity of precipitation, its seasonal timing, and extremes of interannual variation are expected to become more variable (Bachelet et al. 2016). Regional temperature increases and vegetation shifts have already been observed (Bachelet et al. 2016).

The impacts of those changes on desert bighorn populations and habitat are multifaceted. Drought has caused a significant decline in forage quality and quantity in the Sonoran and Mojave deserts (McAuliffe and Hamerlynck 2010). During drought periods, the dietary breadth consumed by desert bighorn decreases, with forage selection focused on protein and moisture content (Cain

et al. 2017). Drought conditions can continue to impact forage quality over subsequent seasons, leading to increased reliance by bighorn sheep on surface water when the ability to compensate through forage moisture is limited (Whiting and Bowyer 2009). In addition to general nutritional requirements, the demands of gestation and lactation in desert bighorn are closely tied to plant phenology (Wehausen 2005). Therefore, changes in nutritional quality and timing of vegetation can have significant impacts on population growth and viability.

Climate change is likely to have a significant impact on the availability of surface water for desert bighorn. Hydrological models of groundwater recharge in the southwestern United States predict decreased recharge in rainwater and runoff-based systems due to decreased precipitation and increased evapotranspiration (Meixner 2016). In the last century, natural water sources in the Mojave Desert have become increasingly unreliable. Joshua Tree National Park and Mojave National Preserve have noted both a decline in the number of springs with reliable surface water and a decrease in discharge from springs with surface water (Douglas and White 1975, Dekker and Hughson 2014). Climate change and long-term groundwater pumping have been implicated as contributing factors to those conditions (Galloway et al. 1998, Cook et al. 2004, Parker et al. 2021).

Variability in the distribution and seasonality of precipitation, and the variable impacts of increasing temperatures, are likely to have differential effects across different desert bighorn habitats in California (Bachelet et al. 2016). Baseline precipitation amounts vary widely across bighorn ranges

(Figure 8) and populations with ranges extending to high elevations of 3,000 m (~10,000 ft.) or more, such as the White, Inyo, San Gabriel, Panamint, and San Bernardino Mountains, may be more resilient to elevated temperatures, increased evaporation rates, and changes to precipitation patterns than lower-elevation desert ranges. Such high-elevation habitats may serve as climate refugia wherein populations may persist even in the event of severe drought and heat waves that have more dramatic effects at lower elevations (Epps et al. 2006).

Such effects of climate change have implications for both desert bighorn populations and their management. Water may limit the distribution of wildlife in desert environments (Rich et al. 2019) and limit reproduction and recruitment in large desert herbivores (Heffelfinger et al. 2018). In a scenario of decreased precipitation, desert bighorn are predicted to exhibit a greater dependence on surface water sources (Epps et al. 2004) and summer habitat, which has decreased in areas and will continue to be reduced (Longshore et al. 2009). The percentage of desert bighorn in the Mojave Desert visiting water daily increases approximately 30% as temperature rise from 30°C to 40°C (Glass et al. 2022), suggesting that longer heat waves caused by climate change will cause desert bighorn to visit water sources more frequently. Those effects are magnified by habitat fragmentation and decreased metapopulation connectivity, limiting the availability of desert bighorn habitat containing high quality forage where water is available.

In a future of climate unpredictability and increasing human demand for water, actively managing for water availability at both natural sources and WWDs will become increasingly crucial to maintaining viable populations of bighorn sheep (Rich et al. 2019). Recent studies have shown that WWDs can provide relief for bighorn sheep in hot and water-limited conditions (Terry et al. 2022, Glass et al. 2022) and compensate for impacts of climate change on summer range (Longshore et al. 2009). The Department's population monitoring has determined that many desert bighorn use WWDs during the hot summer months (Prentice et al. 2018).

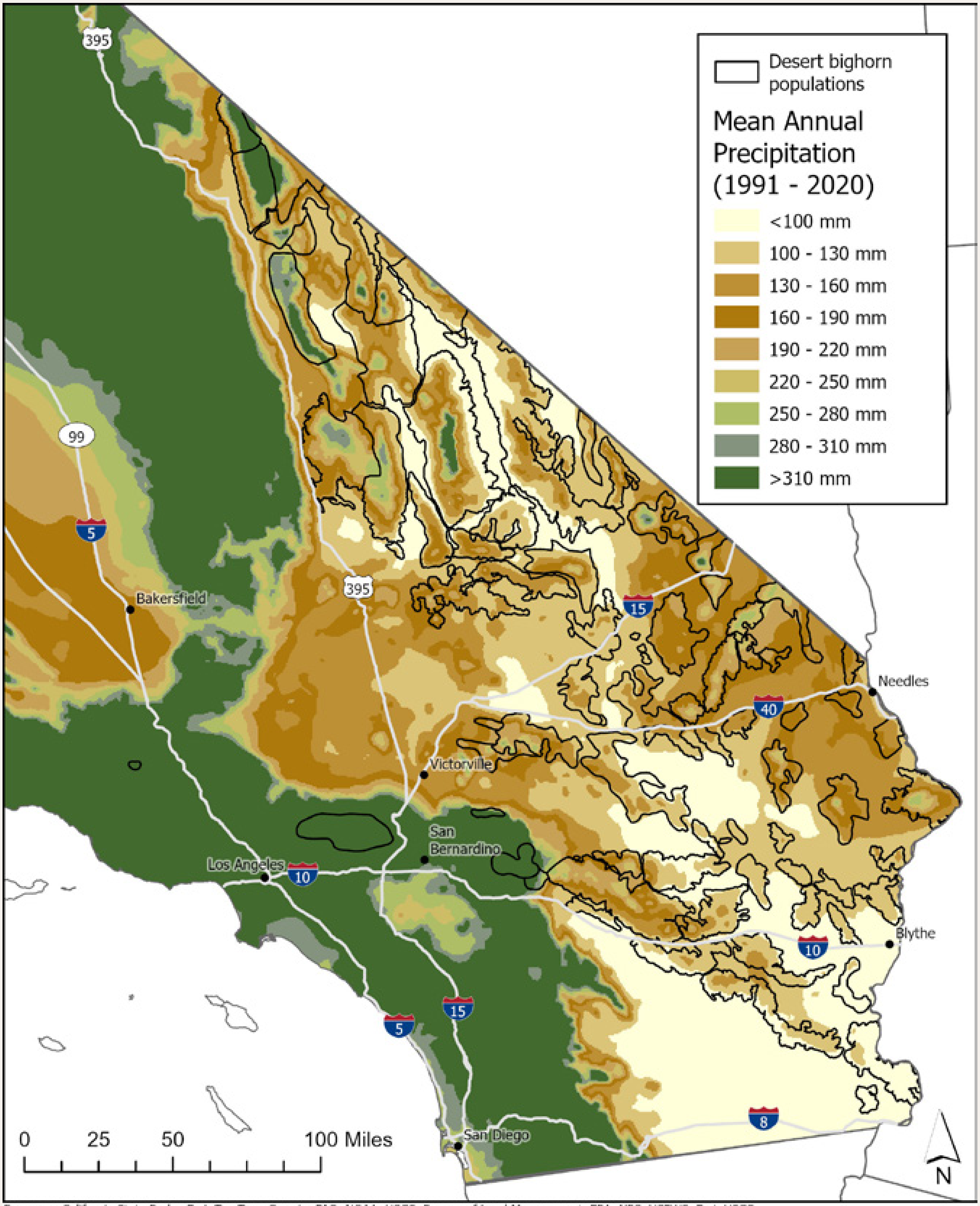



**Figure 8:** Variation in mean annual precipitation across desert bighorn habitat (black polygons) from 1991-2020.

## Land Use and Management

Desert bighorn habitat is also impacted by land use changes and fire. Large-scale projects encroaching on bighorn sheep habitat, such as new transportation infrastructure and large solar energy developments, may directly and indirectly affect desert bighorn habitats. Those impacts include direct loss of habitat, increased fragmentation, and creation of barriers to movement and gene flow, with additional impacts from increased disturbance, microclimate alteration, pollution, water consumption, and fire (Lovich and Ennen 2011). Groundwater extraction activities, as well as diversions of surface water for human use, may impact the availably of water sources for wildlife (Iknayan and Beissinger 2018, Patten et al. 2008). While desert bighorn habitat experiences natural wildfire cycles, fire regimes across the arid West are changing due to land use changes, alteration in fire management, drought, and increased temperatures. Fire risk models (Moritz et al. 2012) predict an increase in fire frequency in the desert due to both climate change and the introduction of invasive grasses (Brooks et al. 2004). Such exacerbated fire risks are likely to negatively impact bighorn sheep habitat by decreasing forage quality and quantity. Negative impacts may be more pronounced during periods of drought or when fires are widespread (Clapp and Beck 2016). Conversely, in some habitats, fire may play an important role in reducing desiccated vegetation, maintaining or expanding bighorn sheep habitat (Clapp and Beck 2016). In desert bighorn habitats that are heavily vegetated and adapted to periodic wildfire, such as the San Gabriel mountains, suppression of wildfire can detrimentally alter habitat quality both by decreasing forage quality and reducing desirable visibility by promoting the persistence of desiccated chaparral (Bleich 2008).

## Disease

In 2013, an outbreak of respiratory disease associated with *Mycoplasma ovipneumoniae* caused an all-ages die-off of desert bighorn in the Old Dad Peak area of the Mojave National Preserve (Epps et al. 2016, 2018, Dekelaita 2020, Shirkey et al. 2021). During 2013–2019, serological surveys testing samples from bighorn sheep captures via enzyme-linked immunosorbent assay (ELISA) revealed that at least one individual had detectable *M. ovipneumoniae* antibodies, confirming exposure in each of 22 populations across all five occupied BCUs (Epps et al. 2016, 2018, Prentice et al. 2018, Prentice et al. 2019, Shirkey et al. 2021). Survival for captured adults testing positive for *M. ovipneumoniae* was lower than for captured adults testing negative in several ranges between 2013 and 2017 (Dekelaita et al. 2020). Lamb recruitment has also declined following outbreaks, with continued poor recruitment in the Old Dad Peak area until 2019 (Prentice et al. 2018, Dekelaita et al. 2020, CDFW unpublished data). A serologic survey utilizing archived serum samples dating back to 1986 confirmed historic exposure to *M. ovipneumoniae* in each of the four populations tested (Marble, South Bristol, Old Woman and Old Dad Mountains; Shirkey et al. 2021). These results suggest that *M. ovipneumoniae* has had historical presence in these desert bighorn populations, but the extent, strain type, and longevity of these exposures is unknown.

In the winter of 2018–2019, an all-age class mortality event of desert bighorn was observed in the San Gorgonio subpopulation. While population estimates sufficient to determine the scale of this event were unavailable, the number of observed mortalities indicated a significant die-off.

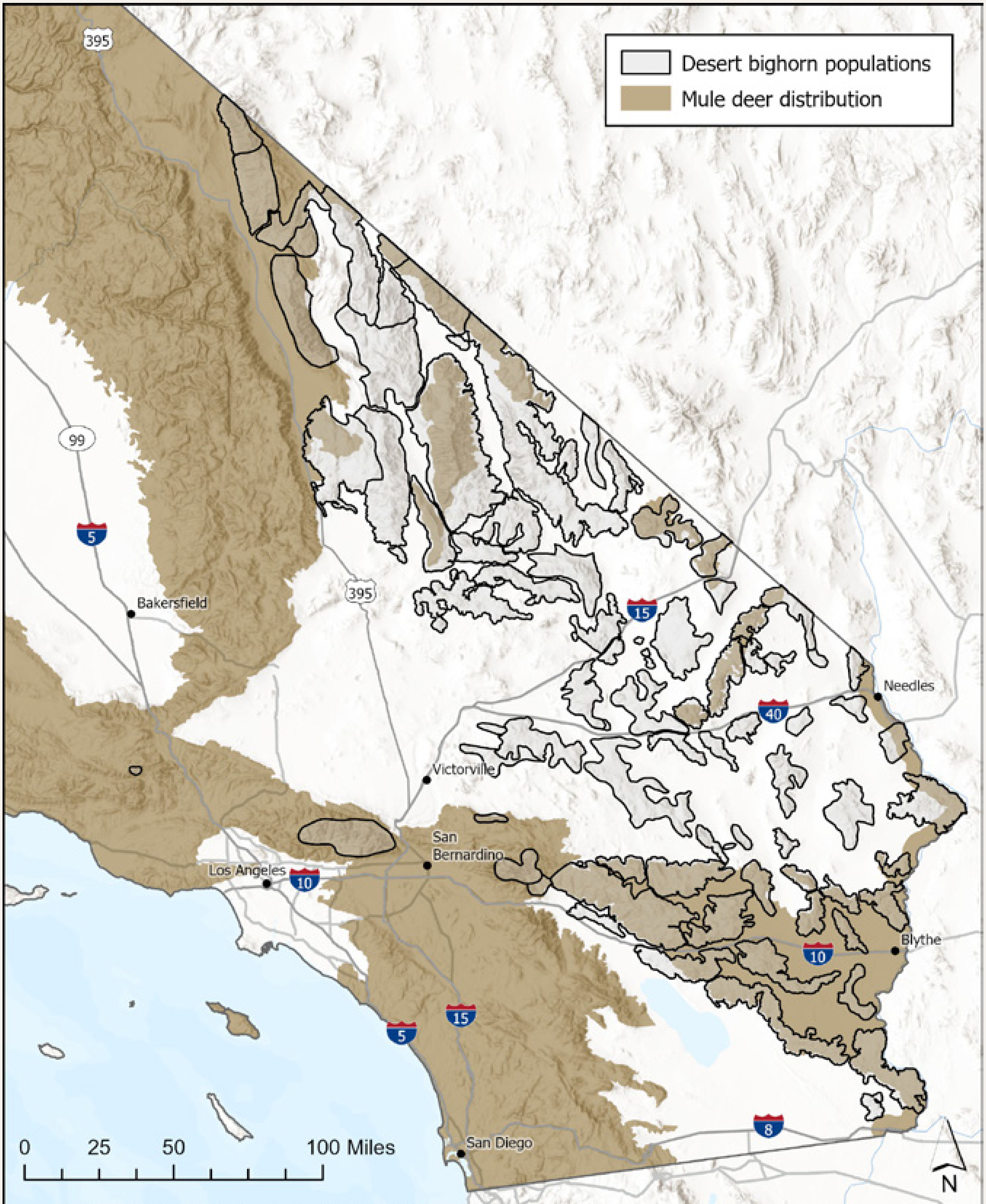
Thirteen deceased desert bighorn were investigated, including full carcasses with clear evidence of pneumonia, swabs and lung tissues, and heads in varying states of decay. Only one of these individuals tested positive for *M. ovipneumoniae*, implicating a different or successive pathogen in the die-off. The observed pneumonia and rigorous testing for known pathogens suggested an as-yet unidentified causal agent. In subsequent years, lamb survival was affected by this event, with only moderate recruitment documented over the subsequent five years.

An all-age-class die-off was observed in the northern half of the South Bristol subpopulation with a large number of ewe mortalities in the fall of 2019, followed by a similarly large number of ram mortalities in the summer of 2020. Collared-ewe mortalities in that period indicated losses possibly exceeding one third of the population. All carcasses were too desiccated for pathological investigation except one ram, which showed obvious signs of pneumonia, but tested negative for *M. ovipneumoniae*. Population estimates between 2019, 2020, and 2021 did not show a significant decline, likely due to strong lamb recruitment in 2019, despite the die-off. Lamb survival in 2020 and 2021 were low, as seen in all neighboring ranges during an extreme drought.

## Resource Competition

### Native Ungulates

The potential for competition for resources between desert bighorn and other native ungulates, primarily mule deer (*Odocoileus hemionus*), is low due to differences in habitat use and diet. Mule deer densities tend to be low in the areas where the two species overlap (Figure 9; Thompson and Bleich 1993, Andrew et al. 1997, Marshal et al. 2006); therefore, this species is unlikely to be an important competitor for forage.




Basemap: California State Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, Bureau of Land Management, EPA, NPS, USFWS, Esri, USGS

**Figure 9:** Mule deer distribution (*Odocoileus hemionus*) relative to desert bighorn populations and habitat.

### Cattle

Cattle grazing has been documented within or adjacent to desert bighorn habitat since the mid-1950s (Wehausen and Hansen 1986). Bighorn sheep tend to use steeper habitats than cattle, but when resources (i.e. water or forage) are limited, habitat use may overlap (Photo 5). Cattle may influence habitat available to bighorn sheep by interfering with or excluding bighorn sheep from access to resources (Irvine 1969, Albrechtsen and Reese 1970, Wilson 1975a, King and Workman 1984). Where cattle have been introduced, subsequent declines in populations of bighorn sheep have occurred; similarly, where cattle have been removed, bighorn sheep populations have grown (Webb 1972, Gallizioli 1977, Bates 1982). Cattle grazing also degrades forage quality in desert bighorn habitat (Gallizioli 1977) and can foul water holes (Albrechtsen and Reese 1970). Cattle may indirectly influence desert bighorn populations through apparent competition, especially where calves are important prey for mountains lions (Rominger et al. 2004), which may also prey on sympatric desert bighorn.

*Cattle and desert bighorn overlap foraging areas in the Newberry, Rodman, Ord Mountains during the middle of summer when resources are limited. Photo with CDFW trail camera.*

*A feral burro in the Mojave Desert*

**Feral Burros**

Burros were introduced into desert bighorn habitats beginning in the late 19th and early 20th centuries, likely the result of escape or release of pack stock (McKnight 1958). In the mid-20th century, California deserts supported 2,000–5,500 of burros in the Southwest, estimated at in 1957 (McKnight 1958). In 2017, National Park Service biologist Neal Darby suggested that the Mojave Preserve may contain over 1,000 burros (Brulliard 2017). In 2022, Death Valley National Park estimated roughly 4,000 feral burros in the park. In 2024, the BLM estimated 3,700 burros on BLM land in California (BLM 2024). Large numbers of feral burros also reside on Department of Defense land at Fort Irwin, China Lake, and the Chocolate Mountains Aerial Gunnery Range, indicating that current numbers may exceed 10,000. Uncontrolled populations of feral burros overlap with desert bighorn in many ranges and pose substantial risks of competition with and potential negative demographic influences on desert bighorn (Jaeger 1950, McKnight 1958, Sumner 1959, Weaver 1972).

While not as agile on steep, rocky slopes, burros use rough terrain and therefore can overlap with desert bighorn and compete for forage. The digestive system of burros differs from the ruminant digestive system of bighorn sheep, which allows burros a wider breadth of diet and, hence, a larger forage base (Janis 1976, Seegmiller and Ohmart 1981, Marshal et al. 2008). Wider dietary breadth, coupled with a higher potential rate of population growth (Seegmiller and Ohmart 1976), gives burros a competitive advantage over desert bighorn (Seegmiller and Ohmart 1981, Ginnet and Douglas 1982). Burro densities can be high enough to result in overgrazing, especially near water sources (Sumner 1959, St. John 1965, Seegmiller and Ohmart 1976, Douglas and Norment 1977, Hanley and Brady 1977).

Burros can make water sources unusable by fouling them (i.e., by walking on and impacting spring substrates, urinating, or defecating in the water; Weaver 1959, Dunn and Douglas 1982) or monopolizing them through aggressive behavior (Weaver 1959, St. John 1965). Desert bighorn tend to avoid water sources used by burros, which may represent a form of interference competition (Dunn and Douglas 1982). Further, burros cause considerable physical damage to desert bighorn habitat by causing soil compaction and erosion (Sumner 1959, Weaver 1959, Walters and Hansen 1978). Wild horses may have similar negative impacts on habitat quality for bighorn sheep where those equids overlap bighorn sheep range.

The Wild and Free-Roaming Horses and Burros Act of 1971 mandates the protection and management of wild horses and burros on public lands administered by the Bureau of Land Management (BLM) and the U.S. Forest Service (USFS). However, this protection does not extend to all federal land management agencies, such as the NPS, wildlife refuges managed by USFWS, or military bases. Various federal agencies with jurisdiction over lands inhabited by bighorn sheep have established programs to manage feral burros across the landscape. On BLM lands, feral burros are managed by Burro Management Areas, a subset of their known distribution (Figure 10). Where permitted by land management agencies, control and elimination of burro populations that overlap with desert bighorn are expected to benefit populations of desert bighorn (Sumner 1959, Weaver 1959, 1972, Wilson 1975b).

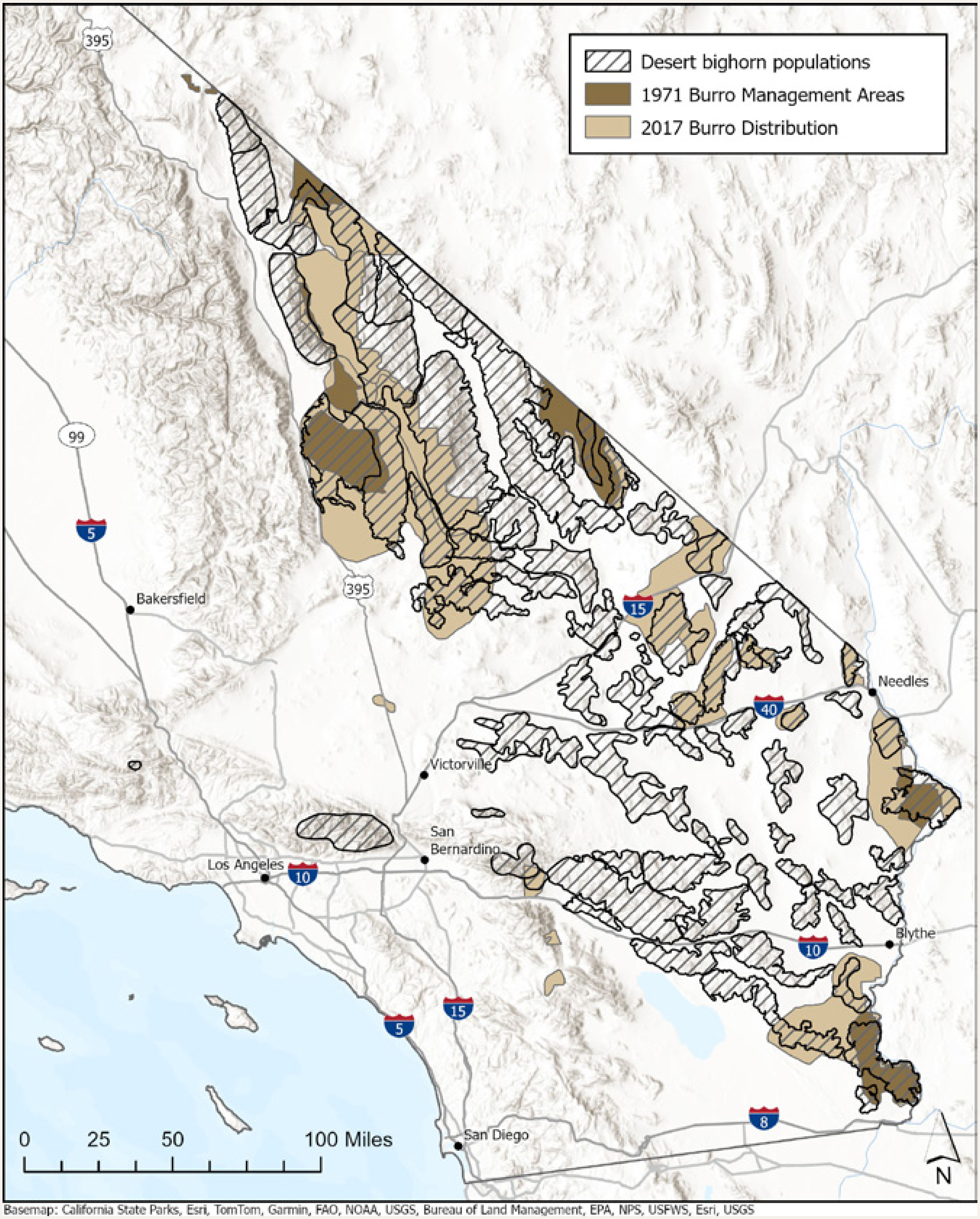



**Figure 10.** Distribution of feral burros in California, 2017, Burro Herd Management Areas established in 1971, and occupied desert bighorn mountain ranges. Burro distribution data from BLM.

## RECREATIONAL AND HUNTING OPPORTUNITIES

Several decades after the moratorium on the taking of any bighorn sheep was extended indefinitely in 1883 (Wehausen et al.1987), legislative attempts to return desert bighorn to game animal status began in the 1920s. In 1922, California Senate Bill (SB) 527 proposed an open season with a $100 license fee and tag system, with the funds to be set aside for desert bighorn studies. However, the bill was opposed and defeated, because its steep fee catered to the wealthy (Scofield 1923). Subsequently, crude population inventories occurred roughly once per decade, beginning in the late 1930s (Wehausen 1999). In the late 1960s, California Senate Resolution 43 was passed and provided funding for surveys during 1968–1972 (Weaver 1969). From these surveys, biologists concluded that populations of desert bighorn in California were declining and several populations had been extirpated in the preceding three decades. Biologists also identified factors that likely limited desert bighorn populations and developed detailed recommendations to enhance populations by constructing surface water catchments. This resulted in a cooperative program involving the Department, the BLM, and the Society for the Conservation of Bighorn Sheep (SCBS) to build WWDs (Bleich et al. 1982b). This marked the beginning of significant change in the conservation of desert bighorn in California from a passive to an active approach.

In 1979, SB 833 proposed classifying desert bighorn as a game animal, but the bill was defeated. In 1983, a similar bill, California Assembly Bill (AB) AB 1548, was proposed, and in addition to calling for classification of desert bighorn as a game animal, it also called for extensive data collection. Although AB 1548 passed the Assembly, it failed in a Senate Committee in 1984. Instead, funding was allocated from the Environmental License Plate Fund to collect information on desert bighorn, initiating a new period of increased funding for research.

In 1986, AB 3117 became law, designating desert bighorn as a game animal for a seven-year experimental period in Old Dad Peak and the Marble Mountains, both of which had served as sources of translocation stock. The legislation established a hunting program in which hunting tags could not exceed 15% of the estimated mature ram population. AB 3117 also provided financial support for conservation activities for desert bighorn in California by allowing one hunting tag to be sold for fundraising and establishing a dedicated account in the Fish and Game Preservation Fund for revenues from this hunting program. In 1990, the California legislature removed the seven-year expiration date of AB 3117. Building on the success of this hunting program, AB 977 amended sections 4902 and 4903 of the Fish and Game Code (Appendix A) to permit hunting in additional populations with completed conservation unit plans, maintain the tag limitation at no more than 15% of mature rams estimated for each population, increase the number of allowable fundraising tags to three, limit administrative overhead to reasonable costs associated directly with the Department's Desert Bighorn Program, and allocate revenue from tag fees and fundraising sales to the preservation, restoration, utilization, and management of bighorn sheep. Since 1987, the Department has opened 11 hunt zones across 13 mountain ranges and had to permanently close one (Table 2).

**Table 2:** Historic timeline of the establishment of management plans for hunt zones in California.

| MOUNTAIN RANGE | MANAGEMENT PLAN ESTABLISHED | HUNT ZONE |
|---|---|---|
| **Marble** | 1987 | Zone 1 |
| **Old Dad, Kelso, and Marl** | 1987 | Zone 2 |
| **Clark** | 1991 | Zone 3 |
| **East Chocolate** | 1991 | Closed in 1997 |
| **Orocopia** | 1991 | Zone 4 |
| **San Gorgonio** | 1991 | Zone 5 |
| **Sheep Hole** | 1991 | Zone 6 |
| **Clipper** | 1992 | Zone 1 |
| **Kingston** | 1992 | Zone 3 |
| **White** | 2004 | Zone 7 |
| **South Bristol** | 2010 | Zone 8 |
| **Cady** | 2010 | Zone 9 |
| **Newberry, Rodman, Ord** | 2019 | Zone 10 |

With respect to hunted populations of desert bighorn, the Fish and Game Commission is responsible for adopting seasons, bag limits, tag quotas, and methods of take. The Department implements and enforces the regulations promulgated by the Commission and provides the Commission with the biological data, expertise, and recommendations that guide the formulation of these regulations. The Department must also comply with the California Environmental Quality Act (CEQA). CEQA requires state and local agencies to identify the environmental impacts of their actions, to avoid or minimize any significant negative effects, where possible, and to disclose their decision-making process to the public. Relative to desert bighorn hunting, the Department meets these requirements through an Environmental Document (ED) Regarding Nelson Bighorn Sheep Hunting (CDFW 2019) The ED is the state equivalent of a federal Environmental Assessment prepared under the National Environmental Policy Act (NEPA), and presents a number of management options for varying harvest levels.

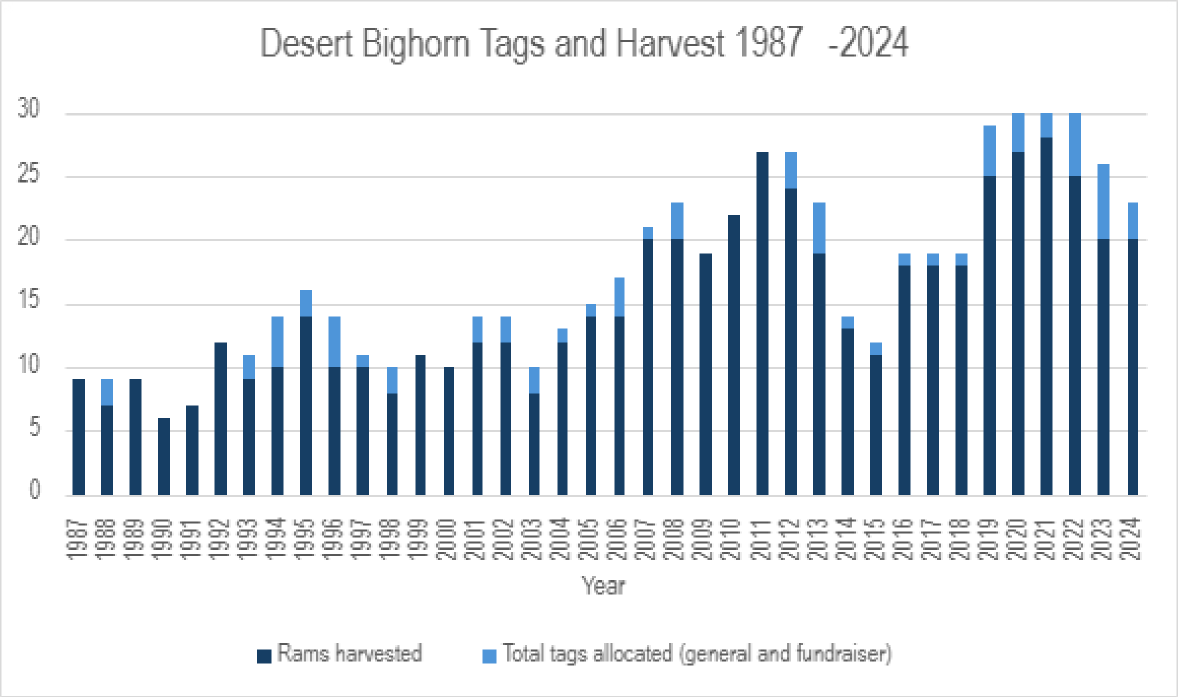



**Figure 11:** Desert bighorn hunting tags and harvest between 1987 and 2024. These numbers include general draw and fundraising tags.

The opportunity to harvest bighorn sheep is a highly valued experience among hunters. Since the first season in 1987, there have been just over 500 desert bighorn rams harvested through the hunt program in California (Figure 11). As of 2024, the program has raised over $9 million for the Department's Big Game Management Account (Figure 12), including revenue from auction tags.

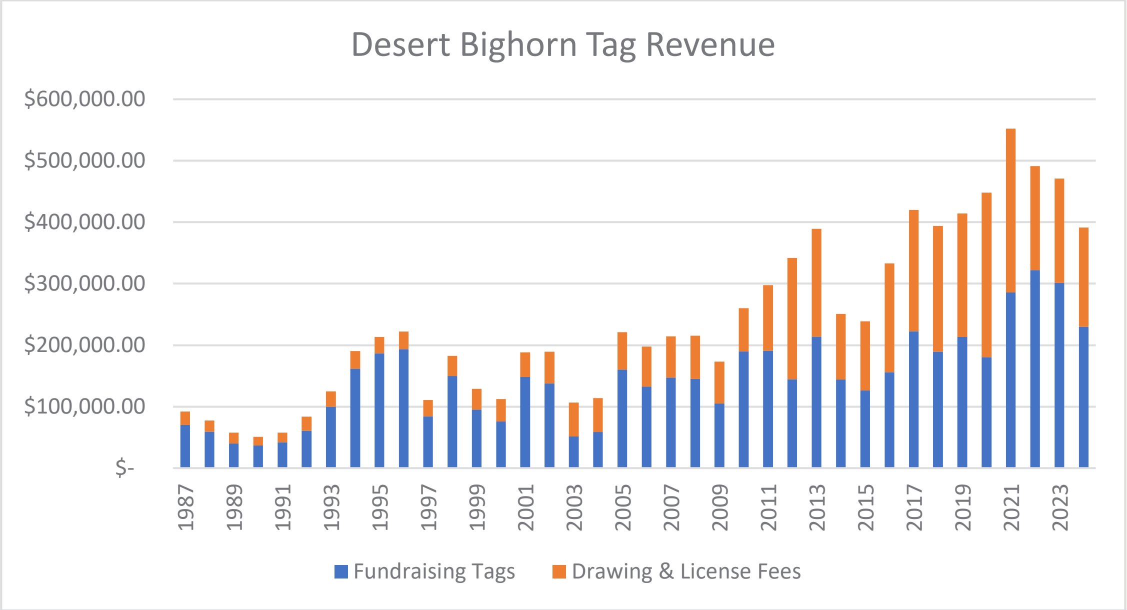



**Figure 12:** Annual revenue from 1987-2024 for desert bighorn Drawing & License Fees (orange) and Fundraising Tags (blue) sold at auction. This money is allocated to the Big Game Management Account to help support program staff as well as monitoring and management efforts.

# III. CONSERVATION AND MANAGEMENT OF DESERT BIGHORN

*Photo by Rick Halter*

# III. CONSERVATION AND MANAGEMENT OF DESERT BIGHORN

Desert bighorn occupy a vast and ecologically diverse region of California and conservation and management needs vary across the state. Fundamental to this Plan are adaptive management and implementation of science-based strategies to assess, monitor, and manage populations of desert bighorn. To facilitate management of this complex network, the region is separated into smaller units:

**Bighorn Conservation Unit (BCU):** A management area defined by manmade barriers or unique geography. Desert bighorn are divided into five distinct BCUs: Northern Deserts, North Central Deserts, South Central Deserts, Southern Deserts, and Transverse Ranges (Figure 13). There is a sixth BCU for Northern California but as of 2025 there are only transient bighorn populations from neighboring states.

**Subpopulation:** Bighorn sheep that occupy an area contained within a BCU, often more than one mountain range, connected by regular, annual movements of individuals (typically males).

Fish and Game Code sections 4900-4903 guide the overarching management of bighorn sheep in California (Appendix A). For the purposes of this Plan, and per Fish and Game section 4901 et seq., the Department considers each BCU to represent a management unit. The Goals and Objectives, below, are designed to address management priorities at the BCU level. The Department will monitor every subpopulation but will prioritize subpopulations where hunting occurs or is proposed and where specific conservation concerns arise.

While the desert bighorn metapopulation in California could be divided by ecoregion (e.g., Sonoran vs. Mojave Desert) or by modeled historic metapopulation subsections, the six BCUs listed above represent the Department's understanding of the current metapopulation fragments. In Southern California, the main interstates bisecting the desert bighorn metapopulation act as barriers that limit animal movement (Aiello et al. 2024). This physical isolation has reduced genetic diversity and increased genetic isolation within the BCUs (Epps et al. 2005). If the BCUs are successfully and consistently re-connected using management tools such as wildlife overpasses, BCU boundaries may be reconsidered based on a categorization other than manmade barriers.


Basemap: California State Parks, Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, USFWS, Esri, USGS

**Figure 13:** The six Bighorn Conservation Units (BCUs, dark grey) and current and historical bighorn subpopulations (light grey) within them.

## GOALS AND OBJECTIVES FOR MANAGEMENT OF DESERT BIGHORN

The Legislative declaration (Fish & G. Code, §4900 et seq.) for the management of bighorn sheep in California is to encourage their preservation, restoration, and utilization. The Department's vision is to have healthy desert bighorn subpopulations that benefit from management by the State of California, while the mission is to conserve bighorn for their intrinsic, ecological, and utilitarian values. To achieve this, many factors must be considered, monitored, and addressed through government-to-government consultation, collaborative effort, and partnerships. Below, we present a high-level overview of tools, recommendations, and actions for accomplishing the Department's goals and objectives for the management of desert bighorn (Table 3). These goals and objectives provide a framework for the development of individual plans for each BCU. The individual plans will contain a more detailed analysis of conservation challenges, as well as management recommendations specific to its geographic region and subpopulations. Achieving the goals and objectives identified in this Plan will help the Department maintain, enhance, and restore desert bighorn subpopulations throughout the state while allowing for traditional-cultural, recreational, and aesthetic use and enabling coordination with government agencies, California Native American Tribes, non-governmental organizations (NGOs), and the public.

**Table 3:** Conservation and management goals and objectives for desert bighorn in California.

| **GOAL 1: Manage desert bighorn subpopulations for their long-term persistence in the face of changing environmental conditions.** |
|---|
| **Objective 1.1** Monitor the population size and demographic rates for each desert bighorn subpopulation. Use this information to identify trends of conservation concern and inform management recommendations. |
| **Objective 1.2** Monitor subpopulation health and identify threats from emergent disease, predation, or other factors, which may be mitigated by management action. |
| **Objective 1.3** Develop and implement science-based recommendations to maintain, enhance, restore, and monitor connectivity and genetic diversity while considering the risks of disease transmission. |
| **Objective 1.4** Explore alternative monitoring strategies to reduce direct and external costs, including greenhouse gas emissions, risk to personnel, and stress or injury to desert bighorn. |
| **Objective 1.5** Develop and update Bighorn Conservation Unit (BCU) plans to incorporate new information and guide the management, conservation, possible reintroduction, and long-term persistence of desert bighorn subpopulations. |

| |
|---|
| **GOAL 2: Conserve, restore, and manage habitat and water availability to support sustainable desert bighorn subpopulations.** |
| **Objective 2.1** Increase the Department's capacity to monitor and manage desert bighorn habitat. |
| **Objective 2.2** Ensure adequate distribution of surface water through protection of existing natural sources and maintenance, expansion, and improvement of existing, or construction of new wildlife water developments where appropriate. |
| **Objective 2.3** Implement long-term monitoring of nutritional quality of desert bighorn habitats by measuring body condition of desert bighorn and/or by quantifying forage using remotely sensed imagery or ground sampling. |
| **Objective 2.4** Collaborate with Tribes, land management agencies, and private entities to evaluate and eliminate or minimize the impacts of competition from non-native ungulates. |
| **Objective 2.5** Work with Tribes and land management agencies to identify and minimize negative impacts on desert bighorn subpopulations due to human activities, fire, or other local threats to desert bighorn habitat. Evaluate and provide feedback on proposed transportation, energy, ground water pumping, or other developments to minimize disturbance to bighorn and avoid impacts to habitat and connectivity. |
| **GOAL 3: Provide opportunities for recreational, traditional-cultural, aesthetic, educational, and ecological benefit of desert bighorn.** |
| **Objective 3.1** Provide opportunities for consumptive use of desert bighorn through hunting quota recommendations consistent with sustainable subpopulation objectives. |
| **Objective 3.2** Establish cooperative projects to create educational and interpretive materials that enhance opportunities for public viewing and learning about desert bighorn. |
| **Objective 3.3** Facilitate research on desert bighorn interspecific interactions and ecosystem-level effects that could inform management. |
| **GOAL 4: Develop, enhance, and maintain communication and collaboration with Tribes, stakeholders, agencies, and researchers regarding desert bighorn conservation and management.** |
| **Objective 4.1** Collaborate with Tribes, public agencies, and stakeholders to facilitate management actions on public land for the conservation of desert bighorn. |
| **Objective 4.2** Cultivate and maintain relationships between Department staff, Tribes, NGOs, and stakeholders. |
| **Objective 4.3** Pursue opportunities for collaborative research with academic institutions, Tribes, state and federal agencies, and stakeholders to address conservation issues and develop scientifically rigorous management actions. |
| **Objective 4.4** Periodically report to the public on the status of desert bighorn in California and the program's management activities. |

*Photo by Lily Harrison*

### Goal 1. Manage desert bighorn subpopulations for their long-term persistence in the face of changing environmental conditions.

This Goal is guided by Fish and Game Code sections 4900 et seq., and 4901, subdivisions (a), (c), (d), and (e) (Appendix A). Management will include a systematic approach to population assessment appropriate to each BCU and subpopulation. The resulting data will guide management priorities and provide managers with information to make adaptive management decisions and to meetFish and Game Code sections 4900 et seq., and 4902 et seq.

> **Objective 1.1.** Monitor the population size and demographic rates for each desert bighorn subpopulation. Use this information to identify trends of conservation concern and inform management recommendations.

The Fish and Game Code section 4901 tasks the Department with determining the status and trend of bighorn sheep populations by management unit, and specifically subsection (a) collecting data on population size, composition (age and sex ratios), and spatial distribution. The Department considers each BCU as a management unit but will continue to monitor each subpopulation.

Hunted subpopulations will be monitored most intensively. Five hunted subpopulations have been identified as focal ranges where annual surveys will enable efficient collection of higher resolution data for analysis of long-term trends. Based upon geographical distribution, existing data, and feasibility of monitoring, these focal ranges have been identified as follows: The White Mountains, the Kingston Range, Old Dad Mountain, the Marble Mountains, and the Orocopia Mountains. Other hunted subpopulations will be monitored every other year. The Department will estimate size and composition of those subpopulations, and demographic rates, representing juvenile recruitment and adult survival, to assess conservation status and evaluate the effects of hunting. An integrated population model will be applied to these estimates and other data sources to facilitate inferences across metapopulations.

Non-hunted subpopulations will also be monitored on a regular basis, at a timescale of 5–10 years, as resources allow. Initial monitoring of these subpopulations is by necessity intensive, requiring captures and comprehensive surveys, to establish baseline data on size, dynamics, home range, and habitat use. Following these initial assessments, subsequent surveys will focus on estimating abundance at water sources where possible. Renewed intensive monitoring efforts may be required if evidence suggests a population decline, such as following a disease outbreak, or in anticipation of potential changes in range or habitat use resulting from human development or natural causes, or in the event data suggest a subpopulation may qualify as a new hunt zone. Vacant ranges also will be surveyed for occupancy.

Current subpopulation monitoring methods include aerial surveys, ground counts, camera traps, and fecal DNA-based spatial capture recapture surveys. The study design for these surveys and associated statistical modeling focuses on the subpopulation scale as the fundamental basis for inference. Techniques of integrated modeling and statistical extrapolation will be employed to combine multiple sources of survey and demographic data to scale population and demographic estimates to the BCU-scale, providing insights into landscape scale metapopulation dynamics. Notably, subpopulations and the mountain ranges they occupy vary drastically in terms of size, terrain, accessibility, water sources, and land management. Each method of subpopulation monitoring has strengths and weaknesses (discussed below). Consequently, the Department employs an adaptive management approach, wherein the most efficient and effective monitoring method is applied to a given subpopulation to generate required data.

Prior to mark-resight survey animals generally must be captured to attach ear tags and GPS telemetry collars as individual 'marks.' For fecal DNA and camera trapping, GPS collar data is used to identify survey locations (e.g., water sources). For ground and helicopter surveys, GPS collar data can inform the geographic area that needs to be covered by survey polygons. Based on current monitoring and modeling techniques, the coefficient of variation (CV) generated from mark-resight estimates help quantify the variability and allow standardized comparisons across datasets, with lower CVs indicating less variability and greater confidence in the estimate. The CV is influenced by factors such as the percentage of the population surveyed, the number of marks available, and the amount of survey effort. A CV of less than 20% is ideal for mark-resight estimates and will generally enable maintenance of harvest quotas, which may require reduction in cases where high CVs yield low confidence in an estimate. Because of behavioral differences, rams and ewes need to be estimated independently. Additionally, GPS collars can be used to estimate adult survival (Conner et al. 2018) and facilitate detection of mortality events.

Aerial surveys are an effective monitoring tool in subpopulations occupying extensive mountain ranges where access by ground is difficult or in those ranges where water sources are dispersed or limited in number. Aerial surveys are currently best implemented using human observers in helicopters; however, as technology advances the Department will assess the feasibility of using unmanned aerial vehicles, aerial photography, and machine learning for automating photographic detection of animals (Bernatas and Wilson 2004, Vargas-Felipe et al. 2021). The most applicable current survey method using helicopters is mark-resight (Neal et al. 1993, Blum et al. 2021). This method can provide robust estimates of abundance, composition, and spatial distribution, either using sampling design inferences or by means of covariate modeling. Covariates can apply weighting to factors expected to influence abundance estimates and detection probabilities. In subpopulations where marks are unavailable, the simultaneous double-count method (Graham and Bell 1989) can be used to incorporate sighting probabilities and observer bias. This method provides a confidence interval around a numerical estimate, however, its estimates are inherently conservative and difficult to compare to other estimation methods, as they do not account for the portion of the population outside of the survey area or not available to be observed (e.g. under a rock). Where topography and distribution of animals allow, the Department also may explore the use of aerial distance sampling, incorporating covariates (Batter et al. 2022) or test other novel methods in subpopulations where marks are limited. Helicopter surveys are expensive, hazardous, and may be challenging to sustain over the long term; as such, the Department is actively exploring other options.


*Photo by Josh Schulgen*

Ground surveys where animals are counted visually by an observer on foot or in a vehicle are best suited for subpopulations in smaller mountain ranges with vehicle access. For such surveys, suitable habitat is divided into multiple survey routes, each with ≥1 observer. Teams systematically survey the entire area over one or multiple days. Mark-resight estimates then may be generated in the same manner as for aerial surveys, with a shared prerequisite of prior capture and marking of animals. In addition to population estimates, ground surveys are a useful tool for supplementing other data sources (e.g.

fecal DNA) and enabling estimation of age and sex ratios. Those age ratios can be used as a proxy for recruitment, a key parameter for monitoring and assessment of demographic performance. Lastly, GPS collars can be used to track individuals, enabling determination of lambing status, visual assessment of body condition, and as aids in the collection of fecal samples for nutritional, microbiome, parasite, or genetic analyses, especially when targeting known individuals. While effective in some mountain ranges, such methods are labor intensive and logistically infeasible in areas with limited vehicle access and topographically complex terrain.

Camera traps, generally deployed at water sources in the summer months, are a preferred method for monitoring composition, recruitment, and population sizes of desert bighorn. This method is best used in subpopulations with non-dispersed, or point-water, sources (e.g. artificial drinkers and small springs) where desert bighorn seek water in the hot summer months. Such point-water sources are prevalent in ≥75% of subpopulations. In some cases, camera traps may be strategically set along game trails. This method is not as effective in mountain ranges with dispersed access to water sources (e.g., perennial streams). Camera surveys may also incorporate marked individuals, (captured via helicopter and net-gun), to estimate subpopulation size using either spatial or non-spatial capture-recapture modeling (Ruprecht et al. 2021). The Department may also use naturally marked individuals with recognizable horn wear or damage. Because cameras can be set once and last for an entire summer, three or four survey periods can easily be selected for most deployments. New methods will continue to be explored such as the feasibility of using unmarked methods (e.g., Royle Nichols, N-mixture, spatial count, and time/space to event models) for estimating abundance from cameras (Kery and Royle 2016), as time and staffing allow. Machine-learning or artificial intelligence (AI) is currently helpful in differentiating pictures of desert bighorn from non-target pictures. Should AI eventually enable a count of individual desert bighorn in a photo, determination of age and sex class, or perhaps even identification of individuals, such tools could prove extremely powerful.

In fecal DNA surveys, DNA is extracted from fecal pellets collected in the field to genetically identify individuals, and use of these data in spatial capture-recapture models provide a robust means to monitor subpopulation abundance (Pfeiler et al. 2020). This method is most effective in desert bighorn subpopulations with water sources that can be safely accessed by field personnel in the hot summer months. While collared animals are not required for this survey method, GPS collar data may aid in identifying target water sources. Although this method is effective for estimating abundance, it does not capture age class and recruitment data, nor provide observations helpful in evaluating potential health concerns. Consequently, this method must be combined with cameras and GPS telemetry if the ability to estimate composition, recruitment, and survival are desired (Furnas et al. 2018).

The Department will assess the use of model-based inference using covariates representing biophysical factors (e.g., vegetation, elevation, climate) to extrapolate density predictions over large geographical regions and explore the accuracy of those extrapolated results to other desert bighorn subpopulations. In practice, quantifying demographic parameters will likely be challenging to implement for some subpopulations due to logistical constraints of travel by foot across remote, rugged terrain. The Department will evaluate the feasibility of using model-based inference and integrated modeling of multiple data sources to mitigate the need for extensive sampling in difficult to access locations. Lastly, fecal pellets collected for fecal DNA have additional research benefits and can be used for population genetics as well as diet and parasite analyses.

*Photo by Paige Prentice*

The Department may employ a variety of subpopulation monitoring methods across >40 diverse subpopulations of desert bighorn, making an adaptive management and modeling approach essential. Integrated population models (IPMs) facilitate the combination of different data sources to efficiently and robustly estimate interannual variation in population abundance, composition, and spatial distribution (Hatter et al. 2017). Those data sources may be used to evaluate the effects of different harvest scenarios as well as to show the association of population trends with conservation stressors such as disease and climate change. IPMs can also be used to forecast the expected future population trajectory under different conditions which can be used in population viability analysis (Zipkin and Saunders 2017). Another advantage of integrated analyses is an ability to combine inferences from multiple sources of data, each of which may not be reliable alone. Such an IPM approach can help address sampling challenges and mitigate for inevitable data gaps.

The Department plans to utilize IPMs, along with other modeling tools, to maximize the data collected and to provide annual estimates of size and vital rates (juvenile recruitment and adult survival) for each monitored subpopulation. Estimates may be extrapolated to the BCU scale but may not be available on an annual basis (e.g. updated every five years), or annual estimates may be available but less precise than for monitored subpopulations. These results will be used to develop and support any recommendations to the Fish and Game Commission about changes to hunting quotas and seasons and for guiding conservation planning (e.g., increasing water availability) in response to conservation stressors including climate change, land use, connectivity barriers, predation, and disease.

The survey and analytical activities described under this objective will require sufficient organizational support, funds, and coordination to sustain. This includes staff and supplies for conducting wildlife surveys; scientific and statistical design of surveys considering the analytical modeling methods to be used; extensive logistical planning in advance of field surveys; development of external contracts (e.g., helicopters, fecal genotyping) and purchasing agreements for key equipment (e.g., GPS collars, trail cameras); and development and efficient implementation of data management and statistical modeling pipelines. The Department acknowledges that these activities are critical to the timely and effective completion of this objective, which directly supports all other objectives of this Plan. Successful implementation of this objective will require close coordination between Wildlife Branch and Regional staff within the Department. It will also require sufficient funding through appropriate fund sources including Pittman-Robertson Wildlife Restoration Act grants and the Big Game Management Account.

Monitoring of subpopulations will be scheduled based upon available resources, including collaborative opportunities with partners. The Department will also encourage and support partner agencies, namely the Department of Defense (DOD) and NPS, in leading similar monitoring activities to create a shared dataset.

- **Action 1.1.1.** Utilize existing subpopulation data in appropriate models to identify data gaps, prioritize monitoring actions, and calculate sample sizes necessary to achieve objectives.
- **Action 1.1.2.** Capture and mark desert bighorn to provide marks for various subpopulation survey methods and influence survey design.
- **Action 1.1.3.** Deploy camera traps, and conduct ground surveys, helicopter surveys, and fecal DNA collection efforts to estimate abundance, density, demographic composition, survival, and recruitment rates of subpopulations of desert bighorn.
- **Action 1.1.4.** Monitor the survival of individuals from Action 1.1.2. and recover mortalities in a timely manner to investigate cause of death.
- **Action 1.1.5.** Explore alternative monitoring and analytical approaches as new technology is developed, for example the use of fixed-wing, or unmanned, aircraft using photographic and machine leaning identification methods.
- **Action 1.1.6.** Encourage, support, and collaborate with partner agencies to conduct monitoring of desert bighorn.
- **Action 1.1.7.** Build and maintain Department capacity and the support necessary to implement and sustain these monitoring efforts.

*A ram harvested by D. Sims in the Newberry, Rodman, and Ords (Zone 10).*

**Objective 1.2.** Monitor subpopulation health and identify threats from emergent disease, predation, or other factors, which may be mitigated by management action.

The most serious and immediate threat to the conservation of desert bighorn is infectious disease (Jessup 1985, Bunch et al. 1999, Besser et al. 2012). Disease management techniques commonly used in controlled or captive settings are of limited use in free-ranging wildlife. Endemic respiratory disease already has measurable demographic impacts on desert bighorn populations where it is present (Plowright et al. 2017, Cassirer et al. 2018, Spaan et al. 2021) and the threat of unknown emergent infectious diseases poses an unknown risk to continued conservation. Therefore, the focus should be on prevention of emergent infectious diseases, the monitoring of known endemic pathogens, and management for disease-resilient subpopulations.

Prevention is best achieved through engagement with the public to maintain separation between desert bighorn and domestic sheep and goats. Education and outreach to professional and hobby sheep and goat owners should focus on the importance of separation and the risks of bighorn interaction with domestics. Education of recreators on the risks of interactions may improve reporting of sightings of domestics in desert bighorn habitat, or the presence of sick bighorn sheep.

Regular disease surveillance is an important component for the detection of emergent infectious disease and the tracking of endemic disease. Surveillance via the live capture of individuals for testing (blood, swabs, etc.), is the most effective and least biased means to monitor disease. Subpopulation-level data (outlined in Objective 1.1) can be paired with active disease surveillance to determine the impact a disease has on the population, opening the door for management action. Due to the nature of desert bighorn habitat, helicopter net-gun capture is currently the most efficient method of individual testing and disease surveillance.

Sampling of mortalities (opportunistic or collared) and hunter harvest represents an additional sampling pool for disease surveillance that can improve the odds of detecting pathogens by selectively targeting diseased individuals and/or increasing the number of samples. When feasible, rapid response to collar mortality alerts and public reports offers the best chance to identify the cause of mortality through necropsy and diagnostic tests. Carcasses in fair to good post-mortem condition with no obvious cause of death should be sampled thoroughly, either in the field by trained staff or at a diagnostic laboratory. When carcasses are not fresh or cause of death is known (e.g. hunter harvest, hit by car, etc.), upper respiratory swabs (nasal, oropharyngeal, tracheal) should be collected for surveillance efforts.

Once introduced, a novel pathogen may spread quickly throughout the population, and eventually between BCUs. Emergent disease should be considered when survival and recruitment rates fall dramatically, abundance estimates decline, a novel pathogen is detected through samples taken during captures or mortality investigations, or sick bighorn or loose domestic sheep or goat are observed in a population. Removal of a stray domestic sheep or goat in bighorn sheep range requires an immediate response to the sighting. Collaboration with federal and state partners is of paramount importance. If the sighting is confirmed, rapid deployment of personnel in an intensive search provides the greatest likelihood of success. If it can be found, any such animal shall be removed immediately. This may also apply to wandering bighorn sheep that are suspected of being sick and/or of carrying disease from another population.

When emergent infectious disease is suspected, the Department will prioritize efforts to identify and classify the pathogen(s) involved and increase disease monitoring and demographic impacts (as described in Objective 1.1.) to the focal and surrounding subpopulations. If monitoring efforts indicate the disease poses a risk to the greater metapopulation, the Department may pursue aggressive management options, including culling.

The Department also recognizes the possibility of non-infectious disease affecting desert bighorn, such as botulism related to contaminated water sources. As with infectious disease, prevention of such outbreaks is ideal and proper maintenance and inspection of WWDs could prevent outbreaks of botulism. However, if an outbreak occurs, an immediate response of draining, cleaning, and potentially refilling the system is required.

Aside from the direct impact of disease on individual bighorn's survival, there is also the risk of compounding effects of disease in conjunction with other threats such as predation, drought, heat waves, etc. Predation can have devastating effects on smaller, isolated subpopulations of bighorn sheep (Gammons et al. 2021). As such, the Department acknowledges the importance of monitoring non-disease-related mortalities, especially in subpopulations impacted by disease.


*Photo by Josh Schulgen*

- **Action 1.2.1.** Use a combination of survey results, collared animal survival, and direct observations to detect potential outbreaks or die-offs. Sample individuals from capture (1.1.2) and mortality (1.1.4) events and test for pathogen presence, exposure, or disease.
- **Action 1.2.2.** Explore risk of disease transfer by tracking presence of livestock operations within and adjacent to desert bighorn, particularly those involving domestic sheep or goats, along with data from Objective 1.1.
- **Action 1.2.3.** Create educational materials highlighting the risks of disease and mitigation actions for the public and distribute them to appropriate locations such as feed stores.
- **Action 1.2.4.** Develop and outreach agricultural groups and extension offices, livestock veterinary clinics, etc. on conservation of desert bighorn through mitigation of disease risk.
- **Action 1.2.5.** Minimize risk of contact with domestic sheep or goats, create barriers to transmission and remove stray or feral goats and sheep. If data suggest significant subpopulation decline related to emergent disease or if emergent disease is otherwise suspected, increase monitoring of the subpopulation, monitor surrounding subpopulations for signs of disease and consider removing infected individual bighorn as necessary.
- **Action 1.2.6.** Work with Department Law Enforcement Division Air Services Unit, Department contractors, DOD, NPS, BLM, CalFire, and California Highway patrol to coordinate emergency assistance, including aerial support, in case of loose domestic sheep or feral goats or emergent disease.
- **Action 1.2.7.** Monitor and manage desert bighorn subpopulations for outbreaks of non-infectious diseases such as botulism contamination in water sources.
- **Action 1.2.8.** Monitor non-disease related mortalities (1.1.4) and potential compounding effects on subpopulation health.

**Objective 1.3.** Develop and implement science-based recommendations to maintain, enhance, restore, and monitor connectivity and genetic diversity while considering the risks of disease transmission.

Metapopulations are characterized by movements of animals between mountain ranges (i.e., subpopulations), facilitating immigration, emigration, and the recolonization of unoccupied habitat. Such movement naturally facilitates the demographic or genetic rescue of subpopulations that are underperforming, and ultimately maintains genetic diversity and viability throughout the metapopulation. The persistence of desert bighorn in California will require monitoring and management to ensure a functioning metapopulation. Habitat that links subpopulations is often referred to as corridor or intermountain habitat. Corridors are critical for maintaining opportunities for gene flow between subpopulations; thus, intermountain habitat is equally as important as mountainous habitat (Figure 7). It is important to maintain connectivity where it exists within BCUs and restore it between BCUs where it has been disrupted by major highways and developments. The Department's vision is to maintain or create at least one connective point between each BCU. However, there are a few isolated subpopulations such as San Rafael Peak and potentially San Gabriel Mountains that may be too fragmented by anthropogenic impacts to reconnect with the rest of the desert bighorn metapopulation.

Desert bighorn within California move across state lines and are part of a greater metapopulation throughout California, Nevada, Arizona, and Mexico. Thus, although this Plan focuses solely on California's desert bighorn, conservation and management actions within the state have the potential to influence populations in other states, and vice versa. Specific locations of corridors that should be targeted for restoration are described in the BCU plans. Management actions include identifying and protecting key corridors from development, encouraging the building of wildlife overpasses where corridors have already been blocked, removing fences or obstacles, developing and manipulating water sources, and other means of encouraging movement and maintaining, enhancing, and restoring connectivity across intermountain habitat. Furthermore, data on subpopulation trends (1.1) and disease status (1.2) must be considered as part of assessing for and planning management actions.


*Photo by Paige Prentice*

Additionally, some desert bighorn habitat, such as San Rafael Peak and the San Gabriel Mountains are effectively isolated from the greater metapopulation. While connectivity between these subpopulations and the metapopulation may prove difficult to restore, the Department may choose to augment such populations through translocations to enhance genetic diversity and population viability or expand occupied range. Careful monitoring of genetic diversity may be required to maintain these isolated subpopulations, particularly in subpopulations of less than 50 ewes.

- **Action 1.3.1.** Collaborate with partners to collect and analyze genetic information through tissue, blood, and fecal samples to monitor genetic diversity and connectivity between subpopulations, BCUs, and potentially states.

- **Action 1.3.2.** Analyze GPS, telemetry, genetic, disease, and observational data to monitor connectivity between subpopulations, BCUs, and states.

- **Action 1.3.3.** Maintain and increase connectivity and gene flow among subpopulations by managing water, mitigating, and preventing barriers such as fences or development, and limiting further fragmentation.

- **Action 1.3.4.** Create and maintain one or more wildlife overpasses across major highways and between each BCU.

- **Action 1.3.5.** Monitor vacant and transient habitat for occupancy and recolonization.

- **Action 1.3.6.** If supported by careful examination of risks and benefits, conduct translocations to augment or reintroduce populations of desert bighorn to promote stable occupancy of suitable habitats.

**Objective 1.4.** Explore alternative monitoring strategies to reduce direct and external costs, including greenhouse gas emissions, risk to personnel, and stress or injury to desert bighorn.

While global climate change is recognized as one of the most serious risks to desert bighorn and the environment, many management activities also result in greenhouse gas emissions that may be counterproductive to wildlife conservation. Also, helicopter surveys and captures are conducted at a risk to the safety of Department personnel, and cause stress and potential injury to desert bighorn. Therefore, it is in the best interests of both the Department and desert bighorn conservation to consider alternative management strategies that generate comparable or better data sources while reducing costs and risks.

- **Action 1.4.1.** Use available alternatives that generate comparable or better data to helicopters where feasible for captures and surveys.

- **Action 1.4.2.** Utilize new technologies such as drone surveys and machine learning for trail camera-based mark-resight as they become available and are validated.

**Objective 1.5.** Develop and update Bighorn Conservation Unit (BCU) plans to incorporate new information and guide the management, conservation, and long-term persistence of desert bighorn subpopulations.

Regular communication between the Department, Tribes, stakeholders, agencies, and researchers allows interested parties to monitor the Department's progress toward implementing this Plan and provides opportunities for the Department to receive input on specific management objectives.

To address ecological, technological, social, and regulatory shifts in a timely manner, the Department will update this Plan at 10-year intervals. The Department may update BCU plans at the same or more frequent intervals to incorporate new or meaningful information as it becomes available.

- **Action 1.5.1.** Develop BCU plans.
- **Action 1.5.2.** Review and revise BCU plans at least every 10 years.

### Goal 2: Conserve, restore, and manage habitat and water availability to support sustainable desert bighorn subpopulations.

The persistence of desert bighorn subpopulations relies on the long-term availability of suitable habitat. Managing habitat necessitates ensuring desert bighorn habitat requirements are met in terms of suitable forage, water, and subpopulation connectivity while mitigating the impacts of climate and land use changes. Current predictions of these impacts are highly variable. Consistent monitoring and analysis along with both proactive and reactive mitigation will be necessary to respond to rapidly changing conditions and to ensure bighorn sheep subpopulation resiliency.

Desert bighorn habitat in California spans land managed by multiple federal, state, local and tribal agencies including (but not limited to): BLM, NPS, DOD, USFS, California State Parks, and California state schools, as well as privately owned land. Managing desert bighorn subpopulations requires collaborating with these land managers to maintain suitable habitat in the face of anthropogenic landscape changes and human population growth and expansion. While some habitat loss may be unavoidable, working with land managers to minimize the impacts of habitat loss due to development or recreation will aid in the persistence of desert bighorn subpopulations and their habitat.

**Objective 2.1.** Increase the Department's capacity to monitor and manage desert bighorn habitat.

Since the dissolution of the departmental Desert Habitat Crew in the early 2000s, the Department has relied heavily on NGOs and partner agencies to monitor and manage desert bighorn habitat and water developments. While these efforts have been critical, the Department acknowledges this approach is not sustainable long-term and recognizes that it should reinitiate its management role in coordination with land management agencies.

The habitat in the desert region is critical to more wildlife species than desert bighorn. Mountain lions, bobcats, coyotes, kit foxes (*Vulpes macrotis*), upland birds, and others rely on limited resources, in particular water sources (Rich et al. 2019). Leaving the monitoring and management of these resources solely up to the Department's Desert Bighorn Program requires the program to triage the management of desert bighorn and the management of habitat. A designated habitat crew would be able to prioritize these issues while collaborating with the Desert Bighorn Program and other departmental programs.

- **Action 2.1.1.** Develop a dedicated crew to monitor and manage desert bighorn habitat, including a permanent project lead and multiple technicians.
- **Action 2.1.2.** Continue to work with NGOs and partner agencies to monitor and manage desert bighorn habitat.

*Photo by Josh Schulgen*

**Objective 2.2.** Ensure adequate distribution of surface water through protection of existing natural sources and maintenance, expansion, and improvement of existing, or construction of new wildlife water developments where appropriate.

Within California's desert bighorn range, adequate surface water is available in only a few high-elevation mountain ranges that receive sufficient levels of precipitation (e.g., the White, Inyo, and San Bernardino mountains). However, for most mountain ranges considered in this Plan, reliable sources of surface water are rare to nonexistent. Where they do exist, the removal of invasive or excessive vegetation may be necessary to maintain surface water. As water is one of the main limiting resources for desert bighorn, and it is not possible to manage precipitation or forage quality directly, the strategic development, maintenance, and protection of well-spaced, redundant, and reliable sources of water is a critical desert bighorn management tool.

Managing surface water enhances the availability of habitat and associated forage resources (Bleich 2009, Bleich et al. 2010), which can increase gene flow, stabilize and enhance population sizes, reduce extinction rates, and aid successful colonization, all of which will contribute to healthy metapopulation function. As the climate changes, developing and implementing a unified strategy for the adaptive management of surface water will become more and more important to create resiliency in desert bighorn subpopulations.

In order to manage water in the desert, it is necessary to create a model of water availability and wildlife usage. Compilation of past hydrological surveys and analyses (Decker and Hughson 2014, Zdon and Love 2020, Parker et al. 2021) and ongoing monitoring will allow land managers to model water availability and suitable habitat for bighorn, as well as to predict the future impacts of habitat threats. Camera surveys and GPS collar data can facilitate analysis of how desert bighorn use water features. The Department combines this data into models to examine where adding or maintaining water sources could increase connectivity, improve suitable habitat availability, and increase the resiliency of subpopulations.

WWDs are an important tool for water management. Over one hundred WWDs for desert bighorn already exist across the five southern BCUs. Maintaining these systems requires regular inspections, repairs, and water hauls to keep them operational. These activities necessitate extensive collaboration with volunteer organizations and land management agencies. Some of these systems exist in designated wilderness and require careful evaluation of all activities to minimize impacts. Further evaluation of all systems will allow the Department to more effectively use these resources to benefit desert bighorn subpopulations and prioritize repairs, replacements, or installation of new systems. This includes a careful analysis of usage, water collection efficiency, and critical or recurring maintenance issues. Because conditions vary considerably over time and space, even lightly used systems might be important for maintaining connection in subpopulations and redundancy against unexpected failures at other water sources.

- **Action 2.2.1.** Conduct surveys and compile hydrological data on desert water sources to map water availability and suitable habitat for desert bighorn both currently and under future climate change scenarios.

- **Action 2.2.2.** Encourage the development of numerical groundwater models for groundwater basins where water sources are observed to be in decline, or where proposed surface or groundwater management actions may impact water availability.

- **Action 2.2.3.** Use GPS collar and camera survey data to determine desert bighorn usage of water sources and identify critical sites.

- **Action 2.2.4.** Regularly monitor water sources to identify changes in water level signaling potential scarcity issues or maintenance needs, and to facilitate planning for water augmentation when warranted. Enhance remote monitoring capabilities via installation of satellite sensor systems where needed to ensure up-to-date data.

- **Action 2.2.5.** Maintain existing WWDs in functional condition, including repairs and water hauls as necessary. Work with land management agencies and NGOs to coordinate these actions.

- **Action 2.2.6.** Protect and maintain wildlife access to natural surface water by removing invasive or excessive vegetation, maintaining minor developments, and limiting surface water diversions or groundwater extraction that may impact water availability in some groundwater basins.

- **Action 2.2.7.** Evaluate non-functional or unused WWDS for possible redesign, relocation, or removal according to assessed habitat needs.

- **Action 2.2.8.** Install new WWDs where necessary to replace outdated systems, supplement loss of natural water sources, expand summer habitat, or increase connectivity.

**Objective 2.3.** Implement long-term monitoring of nutritional quality of desert bighorn habitats by measuring body condition of desert bighorn and/or by quantifying forage using remotely sensed imagery or ground sampling.

The availability of quality forage is a major driver of body condition and, in turn, health and performance of bighorn sheep populations (Stephenson et al. 2020). While few management options exist to improve desert forage over large areas, documentation of nutritional resources available to desert bighorn can inform decisions related to population objectives and protection of critical habitat.

Vegetation conditions may be assessed via imagery derived from remote sensing platforms (e.g., satellite, aerial, or unmanned aerial vehicle [UAV]), and indices such as the Normalized Difference Vegetation Index (NVDI) and NDVI rate of change (Gedir et al. 2020, Terry et al. 2021), though large amounts of spatiotemporal variation in desert plant phenology can make interpretation more difficult than in temperate environments. Additional information about vegetation cover and quality can be done via survey transects, forage sampling, and nutritional sampling of vegetative material (Cain et al. 2017). Combined with water and forage species data, this information can be used to assess habitat suitability, model population impacts of changes in forage, evaluate changes in diet composition, and direct further subpopulation management actions.

- **Action 2.3.1.** Measure body condition of desert bighorn during captures.
- **Action 2.3.2.** Measure forage quality and availability via remote sensing, ground surveys, and direct sampling of bighorn fecal pellets and plants used by bighorn.
- **Action 2.3.3.** Evaluate changes in diet composition relative to environmental change.

**Objective 2.4.** Collaborate with land management agencies and private entities to evaluate and eliminate or minimize the impacts of competition from non-native ungulates.

Non-native ungulates can transmit diseases to desert bighorn and compete with them for forage and water. Land management agencies track the presence and abundance of burros and domestic livestock, including cattle, sheep, and goats on public land across the state. The Department intends to cooperate with these agencies to obtain these data and manage non-native ungulates in a way that allows for the maintenance of suitable desert bighorn habitat.

Cattle can directly compete with desert bighorn for forage and water, particularly in terrain that is more accessible to cattle (Gallizioli 1977). Cattle also present some risk of disease to bighorn sheep (Wolfe et al. 2010) In cases where cattle grazing can be minimized within suitable habitat, the Department will work with land management agencies and interested ranchers to promote the retirement of grazing allotments, the exclusion of cattle from key water sources with fencing, and other mitigative measures.

Non-native burros effectively compete with desert bighorn for forage and water sources (Weaver 1959). While the BLM is tasked by the Wild Scenic Horses and Burros Act of 1971 to maintain populations of non-native burros, these animals are incompatible with desert bighorn. Within desert bighorn habitat, the Department seeks to encourage their removal and exclusion from water sources with fencing.

- **Action 2.4.1.** Coordinate with land management agencies to track the presence and abundance of domestic livestock and burros.
- **Action 2.4.2.** Encourage the retirement of grazing allotments and exclusion of cattle from key water sources where ranchers and land managers agree.
- **Action 2.4.3.** Encourage the removal of burros and their exclusion from desert bighorn water sources wherever possible.

**Objective 2.5.** Work with land management agencies and Tribes to identify and minimize negative impacts on desert bighorn subpopulations due to human activities, fire, or other local threats to desert bighorn habitat. Evaluate and provide feedback on proposed transportation, energy, ground water pumping, or other developments to minimize disturbance to bighorn and avoid impacts to habitat and connectivity.

Human activities such as mining, surface water diversion and ground water extraction, off-road vehicle use, hiking, energy development, and military training and testing can affect desert bighorn by altering habitat quality and use, increasing animal stress, or causing vehicle collisions. Though desert bighorn sheep may tolerate human disturbance if that disturbance is predictable and consistent (Lowrey & Longshore 2017), bighorn sheep suffer negative impacts from disturbances that are unpredictable or novel (Papouchis et al. 2001, Kelley & Bender 2007, Longshore et al. 2013, Wiedmann & Bleich 2014, Sproat et al. 2019, Brushett et al. 2023). Documented responses by bighorn sheep to disturbance include fleeing (Papouchis et al. 2001) and overall shifts in home range (Keller & Bender 2007, Longshore et al. 2013). Resources, including critical water sources consistently used by individual bighorn sheep, may be abandoned (Leslie & Douglas 1980). Bighorn sheep also demonstrate increased vigilance and decreased foraging activity in response to disturbance (Sproat et al. 2019), responses that impact fitness and ultimately, survival. A population displaced by disturbance may experience lower recruitment of young, reducing numbers in the population long after cessation of the disturbance (Wiedmann & Bleich 2014).

These landscape-level changes often intersect with desert bighorn interspecific interactions to alter individual behavior. Fire or changes in fire and vegetation management strategies can similarly impact bighorn populations. Management of fire typically prioritizes factors such as human health and safety, air quality, and property loss without considering preservation of desert bighorn habitat.

Desert bighorn movement data, observations, and population metrics can be combined with remotely sensed habitat data, land use change records, and fire history to monitor and identify the impacts of local habitat threats. Most of these impacts tend to be local, they can vary considerably between BCUs and subpopulations, and both monitoring and management actions will be specific to those areas. Some impacts, such as a high-speed rail, or any human activity that alter disease risk to desert bighorn can have wide ranging impacts that require broadscale monitoring and management actions across the metapopulation.

*Photo by Lily Harrison*

- **Action 2.5.1.** Monitor the overlap between human activities, fire, and local bighorn habitat threats for any changes in desert bighorn behavior, movements, or population metrics.
- **Action 2.5.2.** Collaborate with land managers to identify areas where desert bighorn subpopulations and habitat are most at risk from human activities, large-scale developments, and habitat threats.
- **Action 2.5.3.** Evaluate and provide feedback on proposed transportation, energy, ground water pumping, or other developments to minimize disturbance to bighorn and avoid impacts to habitat and connectivity.
- **Action 2.5.4.** Coordinate with land managers, regulatory agencies, and utilize the Department's legal authorities to ensure the protection of desert bighorn water sources and the underlying aquifers.
- **Action 2.5.5.** Work with land management agencies and landowners to prevent or mitigate habitat loss whenever possible.

### Goal 3: Provide opportunities for recreational, traditional-cultural, aesthetic, educational, and ecological benefit of desert bighorn.

The public plays a critical role in the conservation and management of desert bighorn, influencing the laws and regulations that directly affect both desert bighorn and their habitat.

**Objective 3.1.** Provide opportunities for consumptive use of desert bighorn through hunting quota recommendations consistent with sustainable subpopulation objectives.

The iconic desert bighorn is a highly sought-after game animal. In California, a combination of fundraising, random drawing, and preference-point drawing tags are offered. The Department may propose new regulations or changes to existing regulations to the Fish and Game Commission, which may adopt regulations for the sport hunting of no more than 15% of the mature rams in a given management unit based on the Department's estimate of the population in that hunt zone (Fish & G. Code, §4902 et seq.). In compliance with CEQA, the potential impacts of hunting on the environment are addressed in an Environmental Document (CDFW 2019) and subject to public review. Hunt zones are legally defined areas and have an associated range of tags that may be allocated for a hunt season (Table 4, Figure 15). Although there are 65 mountain ranges with extant or extirpated populations of desert bighorn, many are not accessible to hunting due to land jurisdiction.

**Table 4:** Existing desert bighorn hunt zones and tag ranges in California.

| HUNT ZONE OR TAG | TAG RANGES PER HUNT ZONE AS EVALUATED BY THE 2019 ENVIRONMENTAL DOCUMENT |
|---|---|
| Zone 1 - Marble and Clipper | 0–5 |
| Zone 2 - Kelso Peak/Old Dad | 0–4 |
| Zone 3 - Clark/Kingston | 0–4 |
| Zone 4 - Orocopia | 0–2 |
| Zone 5 - San Gorgonio | 0–3 |
| Zone 6 - Sheep Hole | 0–2 |
| Zone 7 - White Mountains | 0–6 |
| Zone 8 - South Bristol | 0–3 |
| Zone 9 - Cady | 0–4 |
| Zone 10 - Newberry, Rodman, Ord | 0–6 |
| Open Zone Fund-Raising Tag | 0–1 |
| Marble/Clipper/South Bristol Mountains Fund-Raising Tag | 0–1 |
| Cady Mountains Fund-Raising Tag | 0–1 |
| TOTAL | 0–42 |

The population of mature rams can be modeled three to four years ahead by using integrated population models and data on adult ram and ewe estimates, yearling to ewe and lam to ewe ratios, normal age-based survival, and hunt tag allocations. Currently, hunt tag quota recommendations are set at either 15% of the projected mature ram population, or 15% of the lower confidence interval of all adult rams (two years or older), whichever is lower. This helps prevent overharvest when range conditions or other circumstances prevent precise estimates.

An open hunt zone will be closed if a minimum of seven mature rams cannot be confirmed, or if a decline to such a low population appears possible in the following years given recruitment rates, disease, or habitat conditions. Considerations for opening a new hunt zone include land ownership (Figure 15) and existing use, public access, disease status, and evidence of a persistent and stable subpopulation. Prior to recommending a new zone, GPS collars will be deployed to determine home range, water use, and population dynamics, and a comprehensive survey of the range will be conducted to ensure sufficient population size.

The Department also provides mandatory educational orientation to each desert bighorn hunter and conducts check-outs after they have successfully harvested rams.

- **Action 3.1.1.** Use findings from population surveys as outlined in Goal 1 to provide recommendations for tag quotas annually.
- **Action 3.1.2.** Use findings from population surveys and disease monitoring to close hunt zones if necessary.
- **Action 3.1.3.** Use findings from population surveys as outlined in Goal 1 to provide recommendations for new hunt zones.
- **Action 3.1.4.** Conduct an annual hunter orientation.
- **Action 3.1.5.** Conduct check-outs of harvested rams. Summarize and report hunter success rates, harvested ram age, and morphometric data.

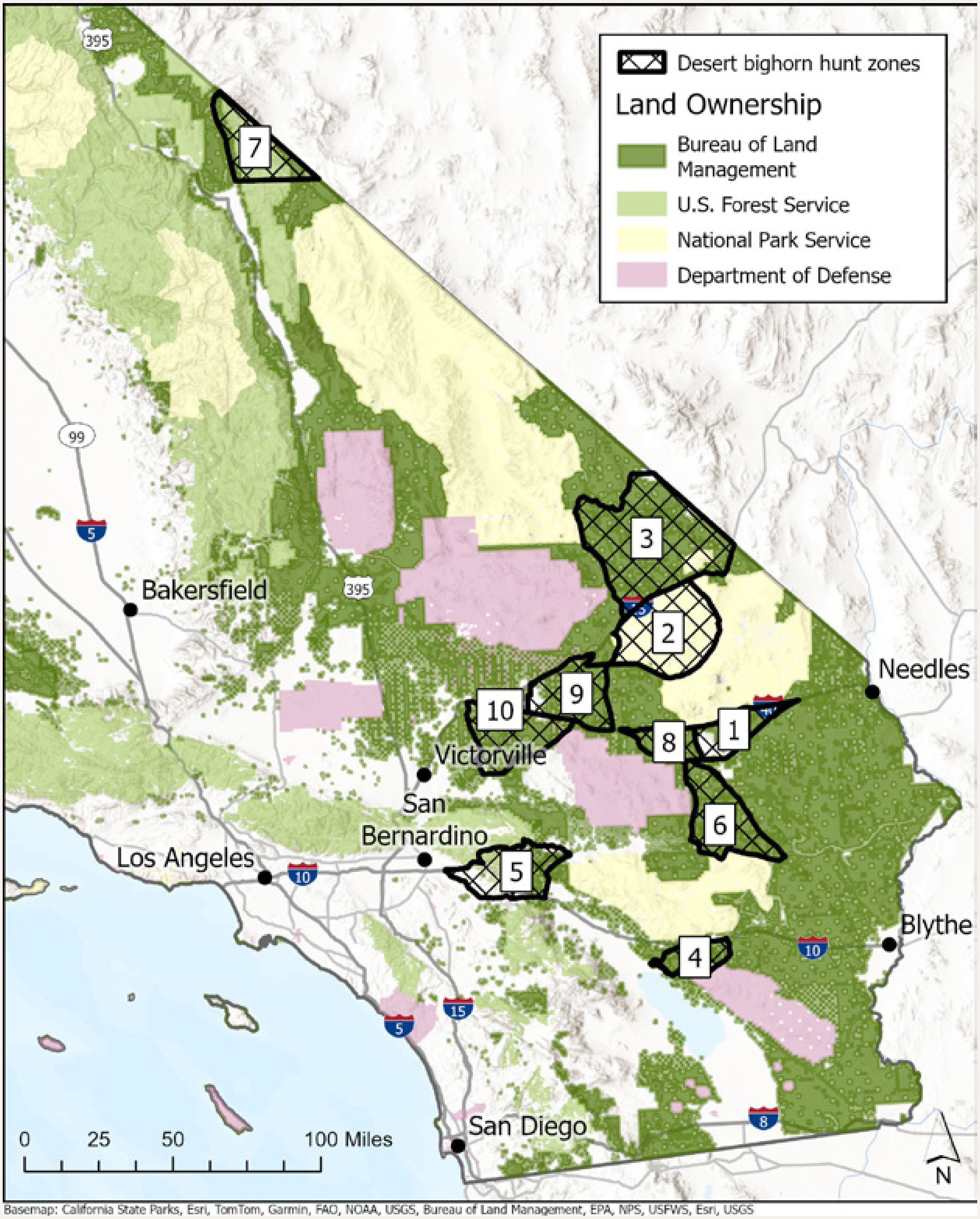



**Figure 14:** A map of the desert bighorn hunt zones and land managing agencies.

**Objective 3.2.** Establish cooperative projects to create educational and interpretive materials that enhance opportunities for public viewing and learning about desert bighorn.

Providing education and opportunities for viewing can enhance the public's interest in and knowledge of the species. Interpretive staff at partner agencies already educate the public on desert bighorn through materials and programs. The Department itself also has a direct educational role, and the Desert Bighorn Program maintains informational links on the Department's website.

Allowing direct participation in activities related to desert bighorn is one of the best ways to engender strong interest in the species. While partner NGOs already provide plentiful opportunities to assist with WWD construction, repair, and filling projects, the Department can also provide viewing opportunities to the public while meeting monitoring objectives by recruiting volunteers for ground surveys.

- **Action 3.2.1.** Contact interpretive staff at partner agencies and express willingness to assist in developing educational materials for the public.
- **Action 3.2.2.** Coordinate with the Department's education and outreach team to provide website or social media-based educational content and classroom and field activities for schools and the public where opportunities arise.
- **Action 3.2.3.** Work with NGOs to provide volunteers with opportunities to assist in monitoring and management of desert bighorn.
- **Action 3.2.4.** Contribute quarterly updates on the Desert Bighorn Program to the California Wild Sheep Foundation Newsletter.

**Objective 3.3.** Facilitate research on desert bighorn interspecific interactions and ecosystem-level effects that could inform management.

Though research has occurred on desert bighorn population biology, predation, and disease dynamics, much remains unknown about the species' interspecific interactions and ecosystem-level effects. As such, the Department encourages further inquiry into these topics that could lead to better management of the species.

The fields of biogeochemistry and zoogeochemistry have recently recognized large mammals such as desert bighorn as important mediators of nutrient flows, ecosystem structure, and carbon cycling (Hyvarinen et al. 2021, Rizzuto et al. 2024a, Rizzuto et al. 2024b). All animals, but particularly those of large body size, act as vectors as they transfer nutrients across the landscape through their bodies, consumption, and excretion (Ellis-Soto et al. 2021). Due to the complexity of food webs and interspecific interactions, these large animals can have a substantial impact on a landscape's fire disturbance regime and carbon sequestration (Schmitz & Leroux 2020). For example, bison and elk in Yellowstone National Park increase carbon capture in vegetation and soil through their grazing pressure, defecation, and urination (Frank et al. 2002, Schmitz & Sylvén 2023). In the African savanna, the grazing and trampling of multiple ungulate species reduces the number and intensity of wildfires while increasing the amount of vegetation on the landscape (Hyvarinen et al. 2021, Schmitz & Sylvén 2023). As a medium-large mammal species, desert bighorn may affect the nutrient cycling and fire regimes throughout their range though nothing has been published specifically investigating the effects of the species.

The Department also remains committed to understanding the positive and negative effects of desert bighorn on other flora and fauna, including endangered, threatened, and fully protected species. Increased understanding will allow the Department to better manage both desert bighorn and the other species of interest.

- **Action 3.3.1.** Collaborate with other Department programs working within the range of desert bighorn.
- **Action 3.3.2.** Identify and collaborate with biogeochemistry and zoogeochemistry researchers.
- **Action 3.3.3.** Evaluate the effects of WWDs and other habitat improvement projects on other species.
- **Action 3.3.4.** Maintain an ecosystem-level perspective in desert bighorn research and management.

### Goal 4: Develop, enhance, and maintain communication and collaboration with Tribes, stakeholders, agencies, and researchers regarding desert bighorn conservation and management.

Many Tribes, organizations, agencies, stakeholders. and individuals play key roles in desert bighorn management in California. Successful management requires regular communication and cooperation between these parties--including neighboring state and federal agencies responsible for managing fish, wildlife, and the habitats in which they rely.

> **Objective 4.1.** Collaborate with Tribes, public agencies, and stakeholders to facilitate management actions on public land for the conservation of desert bighorn.

The Department will continue to build and maintain collaborative partnerships with Tribes, state and federal land agencies overseeing bighorn habitat, as well as stakeholders. Existing federal partners include the NPS, BLM, USFS, and DOD. The Department will also continue to engage and build relationships with neighboring state agencies, especially Nevada Department of Fish and Wildlife (NDOW), Arizona Game and Fish Department (AZGFD), and Oregon Department of Fish and Wildlife (ODFW). Collaboration on research and management will maximize benefits to desert bighorn while effectively using time and resources.

- **Action 4.1.1.** Contact Tribes to establish cooperation on habitat management and conservation. Expand dialogue with Tribes to better incorporate traditional knowledge into management practices.
- **Action 4.1.2.** Explore opportunities to allocate a portion of hunting tags to citizens of California Tribes.
- **Action 4.1.3.** Develop and sustain opportunities to provide culturally significant parts of harvested desert bighorn (e.g., hooves) to California Tribes.
- **Action 4.1.4.** Work with each NPS unit to support or collaborate on management and monitoring activities.
- **Action 4.1.5.** Meet annually with BLM to inform on management and monitoring activities within each district.
- **Action 4.1.6.** Complete BLM California Desert District water monitoring and maintenance Environmental Assessment.

> **Objective 4.2.** Cultivate and maintain relationships between Department staff, Tribes, NGOs, and stakeholders.

NGOs and volunteer-based groups, like SCBS, the California Wild Sheep Foundation (CAWSF), and the national Wild Sheep Foundation (WSF), have been instrumental in the work that has been done for desert bighorn across the five BCUs, especially with water management and WWD maintenance, repair, and construction. These organizations have provided volunteer crews for projects and surveys, as well as funding for researchers and Department projects. NGOs and their volunteers continue to be a vital part of desert bighorn conservation.

- **Action 4.2.1.** Develop open and effective communication and reporting channels between the Department, Tribes, and NGOs including SCBS, CAWSF, and Desert Wildlife Unlimited (DWU).
- **Action 4.2.2.** Attend biannual Sheep Summit meetings with partners.
- **Action 4.2.3.** Provide Department personnel to assist with and be present for NGO projects when needed.

> **Objective 4.3.** Pursue opportunities for collaborative research with academic institutions, Tribes, state and federal agencies, and stakeholders to address conservation issues and develop scientifically rigorous management actions.

Much of the Department's current understanding of desert bighorn is derived from research conducted through partnerships with academic institutions. In addition, many Tribes across California are conducting their own research regarding the management of various species and collaborating in those efforts will help support decisions and actions being made. Management relies on scientifically rigorous research for guidance, making the implementation and continuation of these partnerships critical to Department goals. Department support for staff involvement and attendance in the WAFWA Wild Sheep Working Group Initiative (WSWGI), the WAFWA Wildlife Health Committee (WHC), and the Desert Bighorn Council (DBC) facilitates information sharing necessary to support the best management practices for addressing conservation challenges for desert bighorn.

- **Action 4.3.1.** Continue collaborative research with academic partners on bighorn genetics and connectivity, microbiome and nutritional analysis, and any future research projects.
- **Action 4.3.2.** Pursue and support collaborative research opportunities with Tribes.
- **Action 4.3.3.** Maintain regular communication with state and federal agencies in neighboring states and collaborate on desert bighorn research and management, as needed.
- **Action 4.3.4.** Identify gaps in knowledge and facilitate future research opportunities with partners.
- **Action 4.3.5.** Participate in the research and publishing of peer-reviewed journal articles.
- **Action 4.3.6.** Attend relevant professional meetings and conferences (especially WAFWA WSWGI & WHC and DBC) to showcase program efforts, facilitate collaboration with relevant partners, and gain exposure to contemporary management techniques.
- **Action 4.3.7.** Develop data-sharing policies that facilitate collaboration with partners and maintains the public's best interest.

**Objective 4.4.** Periodically report to the public on the status of desert bighorn in California and the program's management activities.

- **Action 4.4.1.** Publish regular reports on findings and accomplishments from Goals 1, 2 and 3.

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# APPENDIX A – RELEVANT FISH AND GAME CODE SECTIONS

## DIVISION 2. Department of Fish and Wildlife
## CHAPTER 8. Game Conservation of Wildlife Resources
## ARTICLE 2. Policy
## SECTIONS 1801 - 1802

**§1801. Policies and Objectives**

It is hereby declared to be the policy of the state to encourage the preservation, conservation, and maintenance of wildlife resources under the jurisdiction and influence of the state. This policy shall include the following objectives:

(a) To maintain sufficient populations of all species of wildlife and the habitat necessary to achieve the objectives stated in subdivisions (b), (c), and (d).

(b) To provide for the beneficial use and enjoyment of wildlife by all citizens of the state.

(c) To perpetuate all species of wildlife for their intrinsic and ecological values, as well as for their direct benefits to all persons.

(d) To provide for aesthetic, educational, and non-appropriative uses of the various wildlife species.

(e) To maintain diversified recreational uses of wildlife, including the sport of hunting, as proper uses of certain designated species of wildlife, subject to regulations consistent with the maintenance of healthy, viable wildlife resources, the public safety, and a quality outdoor experience.

(f) To provide for economic contributions to the citizens of the state, through the recognition that wildlife is a renewable resource of the land by which economic return can accrue to the citizens of the state, individually and collectively, through regulated management. Such management shall be consistent with the maintenance of healthy and thriving wildlife resources and the public ownership status of the wildlife resources.

(g) To alleviate economic losses or public health or safety problems caused by wildlife to the people of the state either individually or collectively. Such resolution shall be in a manner designed to bring the problem within tolerable limits consistent with economic and public health considerations and the objectives stated in subdivisions (a), (b) and (c).

(h) It is not intended that this policy shall provide any power to regulate natural resources or commercial or other activities connected therewith, except as specifically provided by the Legislature.

### §1802. Jurisdiction of the Department

The department has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species.
The department, as trustee for fish and wildlife resources, shall consult with lead and responsible agencies and shall provide, as available, the requisite biological expertise to review and comment upon environmental documents and impacts arising from project activities, as those terms are used in the California Environmental Protection Act (Division 13 (commencing with Section 21000) of the Public Resources Code).

## DIVISION 3. Fish and Game Generally
## CHAPTER 1.5 Endangered Species [2050-2089.26]

### § 2050. Chapter Title

This chapter shall be known and may be cited as the California Endangered Species Act.

### § 2051. Findings and Declarations

The Legislature hereby finds and declares all of the following:

(a) Certain species of fish, wildlife, and plants have been rendered extinct as a consequence of man's activities, untempered by adequate concern and conservation.

(b) Other species of fish, wildlife, and plants are in danger of, or threatened with, extinction because their habitats are threatened with destruction, adverse modification, or severe curtailment, or because of overexploitation, disease, predation, or other factors.

(c) These species of fish, wildlife, and plants are of ecological, educational, historical, recreational, esthetic, economic, and scientific value to the people of this state, and the conservation, protection, and enhancement of these species and their habitat is of statewide concern.

### § 2052. Land Acquisitions to Protect Endangered Species

The Legislature further finds and declares that it is the policy of the state to conserve, protect, restore, and enhance any endangered species or any threatened species and its habitat and that it is the intent of the Legislature, consistent with conserving the species, to acquire lands for habitat for these species.

### § 2052.1. Legislative Finding and Declaration

The Legislature further finds and declares that if any provision of this chapter requires a person to provide mitigation measures or alternatives to address a particular impact on a candidate species, threatened species, or endangered species, the measures or alternatives required shall be roughly proportional in extent to any impact on those species that is caused by that person. Where various measures or alternatives are available to meet this obligation, the measures or alternatives required shall maintain the person's objectives to the greatest extent possible consistent with this section.

All required measures or alternatives shall be capable of successful implementation. This section governs the full extent of mitigation measures or alternatives that may be imposed on a person pursuant to this chapter. This section shall not affect the state's obligations set forth in Section 2052.

**§ 2053. Projects; Threat; Alternatives**

(a) The Legislature further finds and declares that it is the policy of the state that public agencies should not approve projects as proposed which would jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species, if there are reasonable and prudent alternatives available consistent with conserving the species or its habitat which would prevent jeopardy.

(b) Furthermore, it is the policy of this state and the intent of the Legislature that reasonable and prudent alternatives shall be developed by the department, together with the project proponent and the state lead agency, consistent with conserving the species, while at the same time maintaining the project purpose to the greatest extent possible.

**§ 2054. Project Approvement; Mitigation and Enhancement Measures**

The Legislature further finds and declares that, in the event specific economic, social, or other conditions make infeasible such alternatives, individual projects may be approved if appropriate mitigation and enhancement measures are provided.

**§ 2055. Conservation – policy**

The Legislature further finds and declares that it is the policy of this state that all state agencies, boards, and commissions shall seek to conserve endangered species and threatened species and shall utilize their authority in furtherance of the purposes of this chapter.

**§ 2056. Landowners; Cooperation; Exempt From Liabilities**

The Legislature further finds and declares that the cooperation of the owners of land which is identified as habitat for endangered species and threatened species is essential for the conservation of those species and that it is the policy of this state to foster and encourage that cooperation in furtherance of the purposes of this chapter. Therefore, a landowner of property on which an endangered, threatened, or candidate species lives shall not be liable for civil damages for injury to employees of, or persons under contract with, the department if the injury occurs while those persons are conducting survey, management, or recovery efforts with respect to those species.

**§ 2060. Definitions Govern Construction of Chapter**

The definitions in this article govern the construction of this chapter.

**§ 2061. Conserve; Conserving; Conservation**

"Conserve," "conserving," and "conservation" mean to use, and the use of, all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary. These methods and procedures include, but are not limited to, all activities associated with scientific resources management, such as research, census, law enforcement, habitat acquisition, restoration and maintenance, propagation, live trapping, and transplantation, and, in the extraordinary case where population pressures within a given ecosystem cannot be otherwise relieved, may include regulated taking.

**§ 2062. Endangered Species**

"Endangered species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant 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. Any species determined by the commission as "endangered" on or before January 1, 1985, is an "endangered species."

**§ 2063. Feasible**

"Feasible" means feasible as defined in Section 21061.1 of the Public Resources Code.

**§ 2064. Project**

"Project" means project as defined in Section 21065 of the Public Resources Code.

**§ 2064.5. Recover and Recovery Defined**

"Recover" and "recovery" mean to improve, and improvement in, the status of a species to the point at which listing is no longer appropriate under the criteria set out in this chapter and any regulations adopted thereunder, and, if the department has approved a recovery plan, satisfaction of the conditions of that plan.

**§ 2065. State Lead Agency**

"State lead agency" means the state agency, board, or commission which is a lead agency under the California Environmental Quality Act (Division 13 (commencing with Sec. 21000) of the Public Resources Code).

**§ 2067. Threatened Species**

"Threatened species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant 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 this chapter. Any animal determined by the commission as "rare" on or before January 1, 1985, is a "threatened species."

**§ 2068. Candidate Species**

"Candidate species" means a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant that the commission has formally noticed as being under review by the department for addition to either the list of endangered species or the list of threatened species, or a species for which the commission has published a notice of proposed regulation to add the species to either list.

## DIVISION 4. Birds and Mammals
## PART 3. Mammals
## CHAPTER 1. Game Mammals

**§ 3953. Big Game Management Account; Use of Funds**

(a) The Big Game Management Account is hereby established within the Fish and Game Preservation Fund.

(b) Except as provided in Section 709, all revenues from the sale of antelope, elk, deer, wild pig, bear, and sheep tags, including any fundraising tags, shall be deposited in the Big Game Management Account to permit separate accountability for the receipt and expenditure of these funds. Within 30 days of the date of the sale, the selling nonprofit organization shall send the department 95 percent of the total auction sale price of the tag, with an itemized receipt showing the sale price and the 5-percent reduction retained by the nonprofit organization as a vendor's fee.

(c) Funds deposited in the Big Game Management Account shall be available for expenditure upon appropriation by the Legislature to the department. These funds shall be expended solely for the purposes set forth in this section and Sections 3951 and 3952, and Chapter 5 (commencing with Section 450) of Division 1, Chapter 7 (commencing with Section 4650), and Chapter 11 (commencing with Section 4900), including acquiring land, completing projects, and implementing programs to benefit antelope, elk, deer, wild pigs, bear, and sheep, and expanding public hunting opportunities and related public outreach. Any land acquired with funds from the Big Game Management Account shall be acquired in fee title or protected with a conservation easement and, to the extent possible, be open or provide access to the public for antelope, elk, deer, wild pig, bear, or sheep hunting. The department may also use funds from the Big Game Management Account to pay for administrative and enforcement costs of the programs and activities described in this section. The amount allocated from the account for administrative costs shall be limited to the reasonable costs associated with administration of the programs and activities described in this section.

(d) The department may make grants to, reimburse, or enter into contracts or other agreements, as defined in subdivision (a) of Section 1571, with nonprofit organizations for the use of the funds from the Big Game Management Account to carry out the purposes of this section, including related habitat conservation projects.

(e) An advisory committee, as determined by the department, that includes interested nonprofit organizations that have goals and objectives directly related to the management and conservation of big game species and primarily represent the interests of persons licensed pursuant to Section 3031 shall review and provide comments to the department on all proposed projects funded from the Big Game Management Account to help ensure that the requirements of this section have been met. The department shall post budget information and a brief description on an Internet Web site for all projects funded from the Big Game Management Account.

(f) Big game projects authorized pursuant to this section are not subject to Part 2 (commencing with Section 10100) of Division 2 of the Public Contract Code or Article 6 (commencing with Section 999) of Chapter 6 of Division 4 of the Military and Veterans Code.

(g) The department shall maintain the internal accountability necessary to ensure compliance with the collection, deposit, and expenditure of funds specified in this section.

## CHAPTER 8. Fully Protected Mammals [4700-4700]

**§4700. Take or Possess Fully Protected Mammals Prohibited**

(1) Except as provided in this section, Section 2081.7, or Section 2835, a fully protected mammal may not be taken or possessed at any time. No provision of this code or any other law shall be construed to authorize the issuance of a permit or license to take a fully protected mammal, and no permit or license previously issued shall have any force or effect for that purpose. However, the department may authorize the taking of a fully protected mammal for necessary scientific research, including efforts to recover fully protected, threatened, or endangered species. Before authorizing the take of a fully protected mammal, the department shall make an effort to notify all affected and interested parties to solicit information and comments on the proposed authorization. The notification shall be published in the California Regulatory Notice Register and be made available to each person who has notified the department, in writing, of his or her interest in fully protected species and who has provided an e-mail address, if available, or postal address to the department. Affected and interested parties shall have 30 days after notification is published in the California Regulatory Notice Register to provide relevant information and comments on the proposed authorization.

(2) As used in this subdivision, "scientific research" does not include an action taken as part of specified mitigation for a project, as defined in Section 21065 of the Public Resources Code.

(3) A legally imported fully protected mammal may be possessed under a permit issued by the department.

(b) The following are fully protected mammals:

(1) Morro Bay kangaroo rat (*Dipodomys heermanni morroensis*).

(2) Bighorn sheep (*Ovis canadensis*), except Nelson bighorn sheep (subspecies *Ovis canadensis nelsoni*) as provided by subdivision (b) of Section 4902.

(3) Northern elephant seal (*Mirounga angustirostris*).

(4) Guadalupe fur seal (*Arctocephalus townsendi*).

(5) Ring-tailed cat (*genus Bassariscus*).

(6) Pacific right whale (*Eubalaena sieboldi*).

(7) Salt-marsh harvest mouse (*Reithrodontomys raviventris*).

(8) Southern sea otter (*Enhydra lutris nereis*).

(9) Wolverine (*Gulo luscus*).

## CHAPTER 10. Mountain Lions

**§4801**. The department may remove or take any mountain lion, or authorize an appropriate local agency with public safety responsibility to remove or take any mountain lion, that is perceived to be an imminent threat to public health or safety or that is perceived by the department to be an imminent threat to the survival of any threatened, endangered, candidate, or fully protected sheep species.

## CHAPTER 11. Bighorn Sheep [4900 – 4904]

### §4900. Legislative Declaration of Policy to Encourage Preservation, etc.

The Legislature declares that bighorn sheep are an important wildlife resource of the state to be managed and maintained at sound biological levels. Therefore, it is hereby declared to be the policy of the state to encourage the preservation, restoration, utilization, and management of California's bighorn sheep population. The management shall be in accordance with the policy set forth in Section 1801.

### §4901. Management Unit Plans

The department shall determine the status and the trend of bighorn sheep populations by management units. A plan shall be developed for each of the management units. The plan for each management unit shall include all of the following:

(a) Data on the numbers, age, sex ratios, and distribution of bighorn sheep within the management unit.

(b) A survey of range conditions and a report on the competition that may exist as a result of human, livestock, wild burro, or any other mammal encroachment.

(c) An assessment of the need to relocate or reestablish bighorn populations.

(d) A statement on the prevalence of disease or parasites within the population.

(e) Recommendations for achieving the policy objective of Section 4900.

**§4902. Nelson Bighorn Rams; Management, Hunting, Fees, etc.**

(a) The commission may adopt all regulations necessary to provide for biologically sound management of Nelson bighorn sheep (subspecies *Ovis canadensis nelsoni*).

(b) (1) After the plans developed by the department pursuant to Section 4901 for the management units have been submitted, the commission may authorize sport hunting of mature Nelson bighorn rams. Before authorizing the sport hunting, the commission shall take into account the Nelson bighorn sheep population statewide, including the population in the management units designated for hunting.

(2) Notwithstanding Section 219, the commission shall not, however, adopt regulations authorizing the sport hunting in a single year of more than 15 percent of the mature Nelson bighorn rams in a single management unit, based on the department's annual estimate of the population in each management unit.

(c) The fee for a bighorn ram tag for a resident of the state, except for a bighorn ram tag issued to a resident junior, to take a Nelson bighorn ram shall be four hundred dollars ($400), as adjusted pursuant to Section 713. The fee for a bighorn ram tag for a resident junior to take a Nelson bighorn ram shall be twenty dollars ($20), as adjusted under Section 713. On or before July 1, 2015, the commission shall, by regulation, fix the fee for a nonresident of the state at not less than one thousand five hundred dollars ($1,500), which shall be adjusted annually pursuant to Section 713. Fee revenues shall be deposited in the Big Game Management Account established in Section 3953 and, upon appropriation by the Legislature, shall be expended as set forth in that section.

(d) The commission shall annually direct the department to authorize not more than three of the tags available for issuance that year to take Nelson bighorn rams for the purpose of raising funds for programs and projects to benefit Nelson bighorn sheep. These tags may be sold to residents or nonresidents of the State of California at auction or by another method and shall not be subject to the fee limitation prescribed in subdivision (c). Commencing with tags sold for the 1993 hunting season, if more than one tag is authorized, the department shall designate a nonprofit organization organized pursuant to the laws of this state, or the California chapter of a nonprofit organization organized pursuant to the laws of another state, as the seller of not less than one of these tags. The number of tags authorized for the purpose of raising funds pursuant to this subdivision, if more than one, shall not exceed 15 percent of the total number of tags authorized pursuant to subdivision (b). All revenue from the sale of tags pursuant to this subdivision shall be deposited in the Big Game Management Account established in Section 3953 and, upon appropriation by the Legislature, shall be expended as set forth in that section.

(e) No tag issued pursuant to this section shall be valid unless and until the licensee has successfully completed a pre-hunt hunter familiarization and orientation and has demonstrated to the department that he or she is familiar with the requisite equipment for participating in the hunting of Nelson bighorn rams, as determined by the commission. The orientation shall be conducted by the department at convenient locations and times preceding each season, as determined by the commission.

(f) This section shall become inoperative on July, 2025, and, as of January 2, 2026, is repealed.

**§4903. Revenue from Fees and Expenditures**

Revenue from the fees authorized by this chapter shall be deposited in the Big Game Management Account established in Section 3953 and, upon appropriation by the Legislature, shall be expended as set forth in that section. Administrative overhead shall be limited to the reasonable costs associated with the direct administration of the program. These funds shall be used to augment, and not to replace, moneys appropriated from existing funds available to the department for the preservation, restoration, utilization, and management of bighorn sheep. The department shall maintain internal accountability necessary to ensure that all restrictions on the expenditure of these funds are met.

**§4904. Annual Report; Content**

[Repealed Stats. 2012]

# APPENDIX B – DESERT BIGHORN CONSERVATION UNIT PLANS

In 1986, Assembly Bill 3117 was enacted by the California Legislature. That legislation amended Fish and Game Code section 4700 et seq., and added sections 4900-4904. The legislature declared that the bighorn sheep is an important wildlife resource in California and is to be managed and maintained at sound population levels. It also directed the Department of Fish and Wildlife to determine the status and trend of bighorn sheep populations by management units.

The six Bighorn Conservation Unit plans are intended to comply with legislative policy as set forth in Fish and Game Code sections 1801 et seq., and 4900-4904, which mandate that management plans be prepared for each bighorn sheep management unit, and that those plans provide information on (1) the numbers, age, sex ratios, and distribution of bighorn sheep within the conservation unit; (2) range conditions and a report on the competition that may exist as a result of human, livestock, wild burro, or any other mammal encroachment; (3) the need to relocate or reestablish bighorn populations; (4) the prevalence of disease or parasites within the population; and (5) recommendations for achieving the policy objective of Fish and Game Code section 4900.

The BCU plans will be added to this Appendix as they are completed.