California Grizzly Alliance

# Recovering Grizzly Bears in California

## A Feasibility Study

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**Editors:**

Peter S. Alagona, PhD
University of California, Santa Barbara

Alex McInturff, PhD
U.S. Geological Survey Washington Cooperative Fish and Wildlife Research Unit, University of Washington

Ellen M. Pero, PhD
University of Washington

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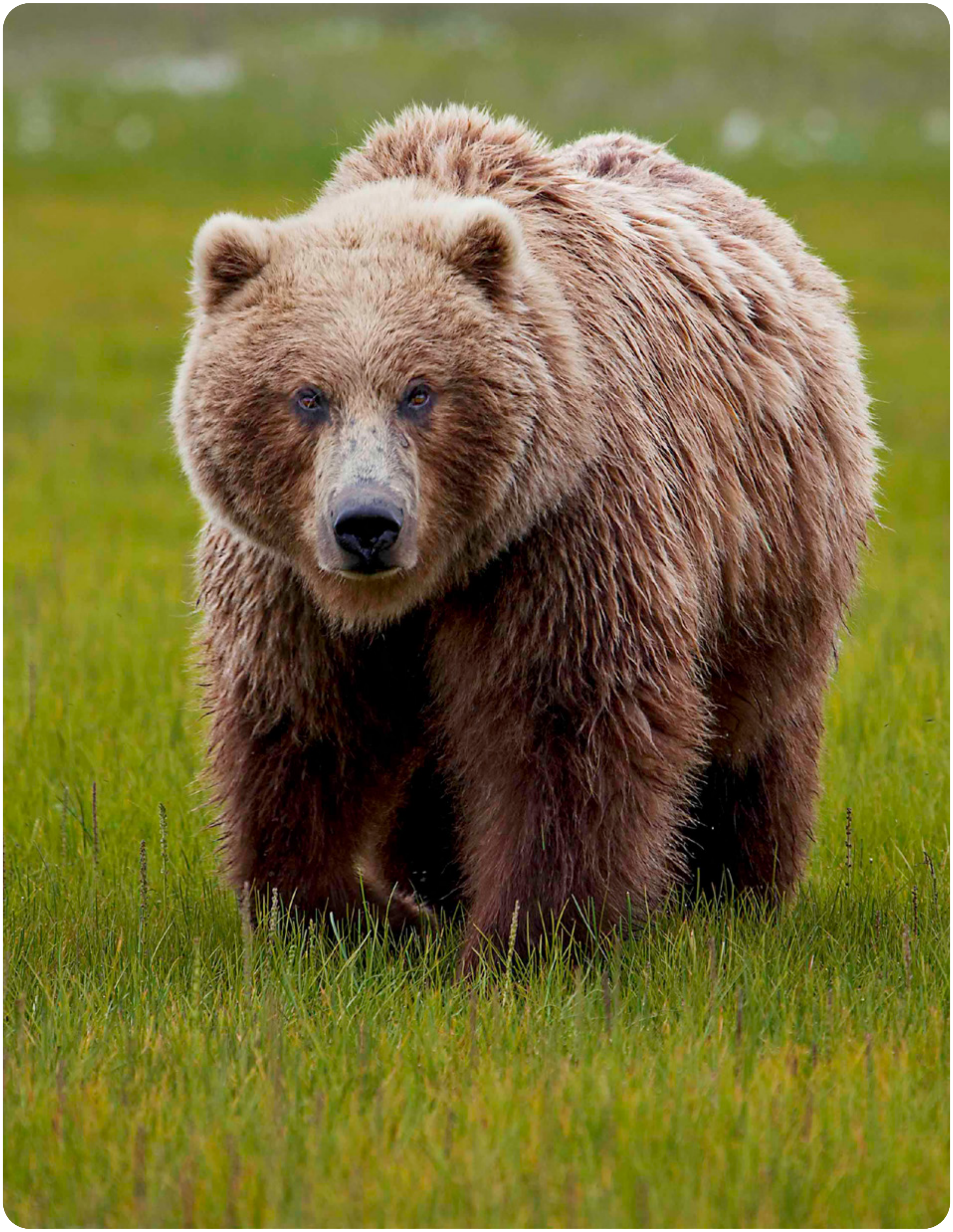
* indicates co-lead authors

California Grizzly Alliance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# Editors

**Peter S. Alagona** is a professor in the Environmental Studies Program at the University of California, Santa Barbara. Before joining the faculty at UCSB, he received his PhD from UCLA, and held postdoctoral fellowships at Harvard and Stanford Universities. He is the author of more than 70 articles in environmental history and conservation science, as well as 2 books: *After the Grizzly: Endangered Species and the Politics of Place in California* (2013) and *The Accidental Ecosystem: People and Wildlife in American Cities* (2022).

**Alex McInturff** is the Assistant Unit Leader of the USGS Washington Cooperative Fish and Wildlife Research Unit and an Assistant Professor at the School of Environmental and Forest Sciences at the University of Washington, where he leads the *People and Wildlife Lab*. He received his PhD from UC Berkeley and completed a postdoctoral fellowship at UCSB studying the California grizzly. He is the author of over 30 articles, and his research focuses on the social and ecological dimensions of wildlife conservation and recovery.

**Ellen M. Pero** is a research scientist in the School of Environmental and Forest Sciences at the University of Washington and within the USGS Washington Cooperative Fish and Wildlife Research Unit. She earned her PhD at the University of Montana where she studied wildlife population-level responses to conservation translocation. Prior to investigating the feasibility of grizzly bear recovery in California, she contributed to wildlife restorations or post-restoration assessments for elk, fisher, swift fox, and beach mice.

# Acknowledgments

This Feasibility Study could never have been completed without the help of dozens of individuals and organizations who took the risk of supporting a project that many of them probably, at first, considered pretty wild. For those who placed their faith in us, provided us with crucial resources, or took the time and energy to collaborate with us, meet with us, review our drafts, and encourage us when we most needed it, we owe you a tremendous debt of gratitude. We hope this document reflects the quality of your contributions and exceeds your expectations.

This study is a product of the California Grizzly Alliance, which was formed in 2022 to advance a public conversation about the future of grizzlies in California—and ultimately recover the golden bear in the Golden State. Special thanks to past and present alliance members Cooper Freeman, Brendan Cummings, Octavio Escobedo, Devlin Gandy, Landon Peppel, Rick Ridgeway, and Shannon Labuschagne. The alliance's work could not have been possible without generous funding from the Holdfast Foundation. Thanks also to Re:wild, which has served as an ideal institutional home for the alliance as a sponsored project.

This study builds on work that began in 2016 with the establishment of the California Grizzly Research Network at the University of California, Santa Barbara. The more than two dozen original and continuing members of that group—who are now based in universities, agencies, and nongovernmental organizations across the United States and Canada—have provided a uniquely rigorous intellectual community in which to cultivate the ideas explored in the chapters that follow. Thanks also to Fuse Consulting and Speedgoat, organizations with whom we collaborated on analyses and illustrations for this study.

Several other individuals and institutions have provided material or financial support. These include the University of California, Santa Barbara, the University of California's Sedgwick Reserve and Valentine Eastern Sierra Reserves, the University of Washington, and the California Academy of Sciences.

We would like to extend a very special thank you to the reviewers who read multiple drafts of chapters for this study and provided their rigorous, in-depth feedback: Michael Proctor, David Garshelis, Vincenzo Penteriani, Libby Metcalf, Silvio Marchini, Rich Beausoleil, Chris Servheen, Matthew Williamson, Julian Rode, Daniel Lewis, Michael Mitchell, Michelle McLellan, and Christine Wilkinson. Any errors contained in this study are the authors' sole responsibility.

Finally, we owe a very big thank you to our wonderful editor, Tracey Westfield, and superb graphic designer, Verelle Tomford.

## Foreword

# Octavio Escobedo III

Photo courtesy of Bakersfield College Foundation

My name is Octavio Escobedo III, and I am Chairman of the Tejon Indian Tribe. My Tribe's homelands encompass one of California's most diverse ecological regions, covering portions of the San Joaquin Valley, Transverse Ranges, Sierra Nevada, Tehachapi Mountains, and Mojave Desert. For thousands of years, we shared this landscape with the grizzly. I am thus honored to provide a foreword for this Feasibility Study.

It has been several years since I first learned about the California Grizzly Research Network. At that initial meeting, I was asked if our Tribe would support the network's research. I wasn't sure what this support would look like, or if I understood the issue well enough to form a position on the question of grizzly reintroduction and recovery. Over time, however, I realized that this was an opportunity for me and my Tribe to take a fresh look at our past and reflect on how the grizzly has influenced our history and culture.

In Kitanamu, the language of the Kitanemuk people who make up the Tejon Indian Tribe, we call the grizzly bear Hunaet. Roughly 100 years ago, a government agent asked Tejon Chief Juan Lozada how long our people had lived here. He replied: "We were here on the first day the sun came up." In the Tejon worldview, Hunaet was here even before us—before the sun first illuminated our homelands.

At the onset of California's Reservation Era, our relationship to the grizzly was a source of astonishment and conversation for Indian agents and soldiers. In 1853, Edward A. Hitchcock, commander of the Pacific Division of the United States Army, wrote: "Most of the Tejon Indians would starve before eating grizzly bear meat." The Tejon people, he added, said that "man was first inspired with courage from seeing a display of it in the bear." Hitchcock's words reflect the deep respect and spiritual significance the grizzly held for our ancestors.

Further research into our Tribe's ancestral connection to the grizzly has revealed profound and unexpected insights. Our ancestors understood the grizzly, possessing deep knowledge, passed down since time immemorial, of how to coexist with the bear. It is said that some of our chiefs, including signatories of the 1851 Tejon Treaty, kept grizzlies as pets and even gifted them to other tribal leaders.

Eventually, I realized that Native people and grizzlies had been forced to walk parallel paths. On January 6, 1851, Peter Burnett, California's first U.S. governor, declared in his State of the State address that "a war of extermination will continue to be waged between the races until the Indian race becomes extinct." This ideology drove the relentless persecution of both Indigenous people and grizzly bears, leaving a legacy of destruction and disregard from which Native Californians and the land itself are still healing.

The Tejon Indian Tribe is one of hundreds of Indigenous Nations that value and revere the grizzly. More than 170 signed *The Grizzly: A Treaty of Cooperation, Cultural Revitalization, and Restoration*, highlighting the bear's cultural importance and calling for stronger protections. Across North America, Tribes, First Nations, and other Indigenous organizations continue to lead efforts in grizzly conservation and coexistence, drawing on traditional knowledge and practices. In October 2024, members of several California Tribes gathered in Sacramento to reflect on our connections with the bear. Through stories, songs, and shared knowledge, marking its long absence while honoring its enduring presence.

Although California has changed dramatically over the last century, our Native cultures, stories, and history remain interwoven with the grizzly, allowing us to remember and imagine what once was. This Feasibility Study, grounded in both science and historical knowledge, will help us envision what could be.

Historical grizzly habitat at the Wind Wolves Preserve on Tejon ancestral lands. Photo: Peter S. Alagona.

## Foreword

# Kris Tompkins

My first grizzly sighting came on a long summer's day in Alaska's Denali National Park. While making my way through great meadows, I glanced their hulking shapes on the horizon, the distance shrinking these tawny giants to mere caterpillars. And yet, there they were, magnificent and untamed, nature raw and powerful. That first, indelible experience was followed by sightings in Yellowstone and Grand Teton National Parks, each time filling my cup with awe.

Coming into the presence of an iconic species like a grizzly is an electric bolt to the senses. With one look, the meek dimensions of human existence are laid bare. We are humbled, which is a very good thing. We are living at a time when our own rapaciousness could do us in. It's time to think of the other creatures with which we share the Earth, those that have no say in the future but are fundamental to an intact and thriving planet.

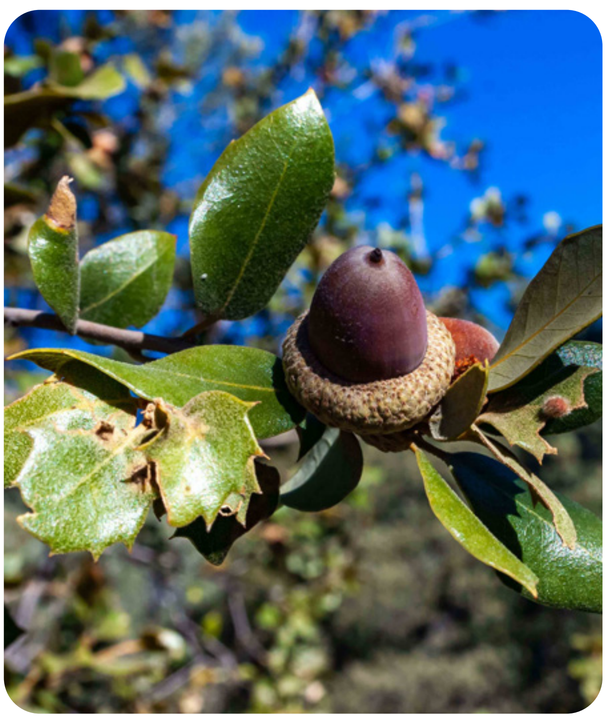


Photo: Oleg Kovtun - stock.adobe.com

Photo courtesy of Tompkins Conservation

So, I am delighted to share this Feasibility Study with you. Alongside growing citizen support for the return of the grizzly, this study will play a crucial role in creating a road map for the species' full recovery a century after its obliteration. Now is the time to rewrite the story of grizzlies in California.

But can we bring back the grizzly? From where I stand, it's not only possible but absolutely necessary. I not only believe this, I've lived it.

Some 30 years ago, my husband Doug Tompkins and I left successful business careers, Doug as the co-founder of the North Face and Esprit, and me as the longtime CEO of Patagonia, to move to a roadless part of Chilean Patagonia. It was there that we began our true vocation: creating teams of local experts, purchasing vast tracts of land to donate as national parks, and later bringing back species that were low in numbers or driven locally or nationally extinct.

The return of keystone species has had an outsized impact. In Argentina, jaguars that had been extinct for 70 years in the province of Corrientes, have returned, assisting in the recovery of wetlands and grasslands by controlling herbivore numbers, and helping avian populations that smaller carnivores had decimated. As a result of the jaguar's return, the wetlands are more diverse and resilient, and wildlife watching has helped remote communities build restorative economies while revitalizing local traditions.

Rewilding is more than just a conservation strategy; it is the opportunity to restore what has been lost and reclaim our kinship with the natural world. In this vision, all of us have a role to play. But first, we have to embrace the wildness within ourselves and recognize our interconnectedness with all living beings.

As a Californian, I look forward to the day when the grizzly once again roams our state—when the bear is back where it belongs.

Cathedral Lake and Peak. Photo: adonis_abril - stock.adobe.com

# Executive Summary

This is the first comprehensive study ever conducted to assess the feasibility of recovering grizzly bears in California. It builds on a large body of literature, gathers nearly a decade of research by the California Grizzly Research Network, and presents new data and analyses. It concludes that recovering grizzly bears in California is very likely biologically feasible; the success of a recovery program depends on people's willingness to undertake it.

## Recovering grizzlies in California is a choice

Grizzly bears have been extinct in California for a century, but they need not remain so. Grizzlies are extremely unlikely to return to the state on their own at any time in the near future. A well-planned, well-resourced, and well-managed reintroduction and recovery program could, however, likely, establish a sustainable California grizzly population in one or more recovery areas over several decades. This program may encounter a variety of challenges, but given public support and modest investments, there are probably no insurmountable obstacles to recovering grizzlies in California. Whether the bears return depends on the choices people make.

## Grizzlies did not have to go extinct in California

Indigenous people lived alongside large numbers of grizzlies in California for thousands of years, and the bears continued to thrive during the eras of Spanish and Mexican rule. After California became a U.S. state, human population growth and habitat loss limited the bears' range and reduced their numbers. Grizzlies went regionally extinct, however, mainly due to a violent campaign of eradication. The state's last grizzlies died in the 1920s, but even after they disappeared, large areas of their former habitat remained.

## Bears from other regions are available for a California grizzly recovery program

The California grizzly has traditionally been considered a distinct subspecies, but current research shows that the state's grizzlies were genetically indistinguishable from grizzlies living today in the Northern Rockies. A small number of bears from this or other nearby areas, including British Columbia, could be recruited to serve as a founder population for a California grizzly recovery program without hindering conservation efforts elsewhere.

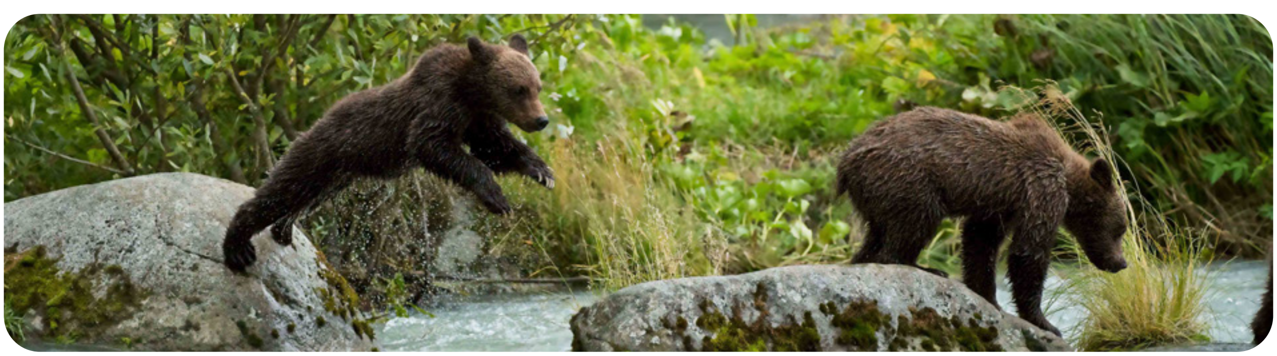


Photo: Don - stock.adobe.com

## Three California regions stand out as potential recovery areas

Models suggest that California still has three large areas of high-quality potential grizzly habitat, which are probably sufficient to support one or more viable populations. The Northwest Forest includes the Klamath Mountains, Trinity Alps, and other nearby ranges in the northwest quarter of the state. The Sierra Nevada includes the entire range, but most of our analyses point to the importance of the high-quality habitats in the southern Sierra. The Transverse Ranges include the chain of mountains that span from San Bernardino County in the east to Santa Barbara County in the west, with a focus on the large protected areas of the Los Padres backcountry.

## Recovering grizzlies would involve opportunities and challenges

Recovering grizzlies in California could, over time, help restore and build the resiliency of some native ecosystems while providing economic opportunities for communities near recovery areas. Ensuring success, however, will require clear goals, consistent monitoring, flexible decision-making, effective communication, cooperation among diverse institutions, and public and private investments in education and infrastructure that reduce risks to both people and bears. Investments made for grizzlies would benefit a variety of other native species, as well as the communities working to coexist with them.

## A California grizzly recovery program would come with uncertainties

This Feasibility Study presents the best available information about the prospects for a California grizzly recovery, but key questions remain. These involve the shifting legal and political contexts for conservation, California's ability to reconnect fragmented habitats through land management and infrastructure investments, and the extent to which bears reintroduced to California will thrive in their new habitats under various future scenarios. Some of these questions can be addressed through models, such as those presented in the following chapters, but others can only be answered by observing bears on the ground. Uncertainty is an inherent aspect of species recovery programs and should not be used to justify inaction.

## Recovering grizzlies in California would be about more than just bears

Sound science must inform species reintroduction and recovery efforts, but science alone cannot answer the question of why the bears should return—or what it would mean if they do. Science cannot account for the histories of violence, loss, and trauma that drove grizzlies extinct in California, nor can it quantify the sense of humility, wonder, inspiration, and pride these animals bring. Ultimately, the question of whether or not to recover grizzlies in California is as much about values as it is about science, and about people as it is about bears.

# Guide for Readers

This Feasibility Study builds on nearly a decade of research conducted by the California Grizzly Research Network and its partners about the past and potential future of grizzly bears in California. The chapters that follow draw from papers published by the research network, new analyses undertaken specifically for this study, and a large body of relevant literature from North America, Europe, and Asia. This study focuses on the feasibility of a grizzly recovery in California and is not intended to serve as a comprehensive review of grizzly bear ecology or human relations. More in-depth treatments of the topics covered here can be found in the scholarly literature.

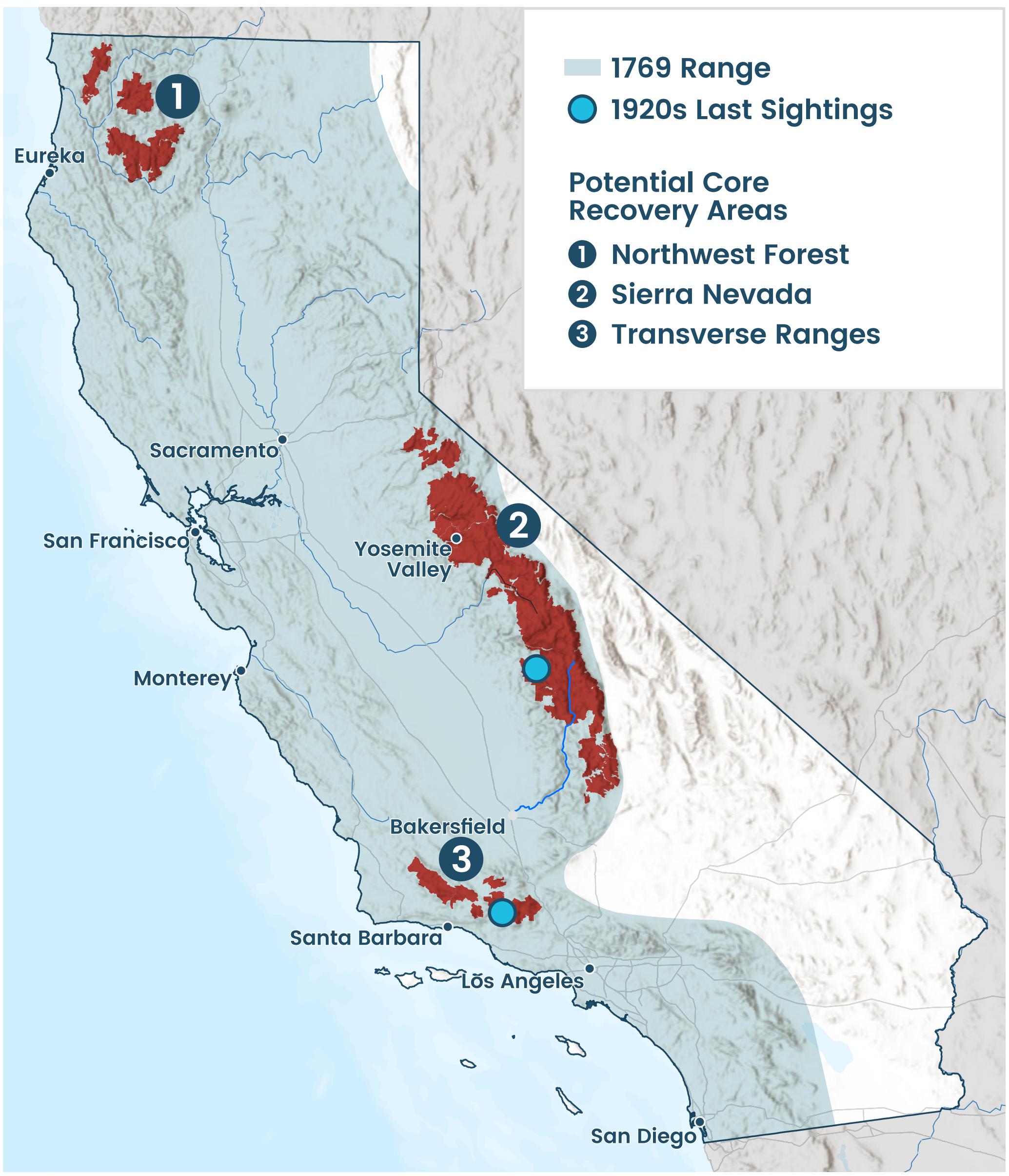
This project began in late 2023 and took about 15 months to complete. Drafts of the chapters that follow were each reviewed at least three times, twice by independent experts listed in the acknowledgments and once by members of the California Grizzly Alliance, which supported and published this study.

This document is designed so that readers with different backgrounds and interests may use it in several ways. The chapters that follow have different authors with different styles and tones. We have edited them to provide a more cohesive reading experience and removed academic jargon wherever possible. Some readers may be interested only in certain aspects of this study. To aid these targeted readers, we have divided each chapter into a series of key questions, with concise summary answers followed by longer discussions with supporting and contextual information. This structure requires us to address some topics under more than one key question, so readers of the entire document may notice some repetition.

Some specific features of this study warrant explanation here. After much discussion, we chose not to include a stand-alone chapter on Indigenous peoples' relations with grizzly bears in California. Instead, readers will find references to this crucial topic, which is a subject of ongoing collaborative research, in numerous places throughout the study. At the beginning of each chapter, we include a list of key points. Some of these are original findings, whereas others draw from the established literature. At the end of each chapter, we include a brief list of opportunities for future research. These are not intended to be exhaustive, and research gaps, however important, should not be seen as impediments to action. Four of the chapters (2, 3, 4, and 5) have appendixes that precede the reference lists of their associated chapters, offering further details about data and methodology.

Throughout this study, we use several terms that require upfront explanation. We use the term *brown bear* to refer to the entire *Ursus arctos* species wherever it occurs throughout its global range. We use the term *grizzly bear* to refer to brown bears living in North America outside coastal southern Alaska, which is home to some brown bear populations with unique histories and from different evolutionary lineages. We use the words *Native* and *Indigenous* interchangeably when discussing Tribes and First Nations. Because these are generic and problematic labels, we refer to particular people or groups whenever possible using the names they prefer. The term *translocation* refers to moving and releasing individual members of a species, whereas the term *reintroduction* refers more specifically to translocations into areas where a species historically lived but is currently absent. We use the word *recovery* when discussing the longer and more involved process of establishing and maintaining one or more sustainable populations.

Finally, throughout this document, we discuss three regions in California that our analyses highlight as potentially important for a grizzly recovery. The *Northwest Forest* includes the Klamath Mountains, Trinity Alps, and other nearby ranges in the northwest quarter of the state. The *Sierra Nevada* includes the entire range, but most of our work points to the importance of the high-quality habitats in the southern Sierra. The *Transverse Ranges* include the chain of mountains that span from San Bernardino County in the east to Santa Barbara County in the west, with a focus on the large protected areas of the Los Padres backcountry.



Chapter 1

# History of the California Grizzly

By Peter S. Alagona

California Grizzly Alliance

## Key Points

Grizzlies arrived in California recently in their evolutionary history from a source population further north.

California grizzlies were genetically indistinguishable from grizzlies currently living in the Northern Rockies of Montana and Wyoming.

As late as 1848, on the eve of the Gold Rush, California contained as many as 10,000 grizzly bears.

Grizzlies lived everywhere in California except in the state's deserts, but they were most numerous in its coastal plains and valleys, foothill woodlands, and chaparral shrublands.

Indigenous Californians forged rich, complex, and diverse cultural and ecological relations with grizzly bears.

Human population growth and habitat loss helped drive the grizzly's decline, but grizzly bears disappeared from California mainly because a small group of settlers killed them.

California's last grizzlies survived into the 1920s in remote mountainous areas of the Transverse Ranges and the western foothills of the Sierra Nevada.

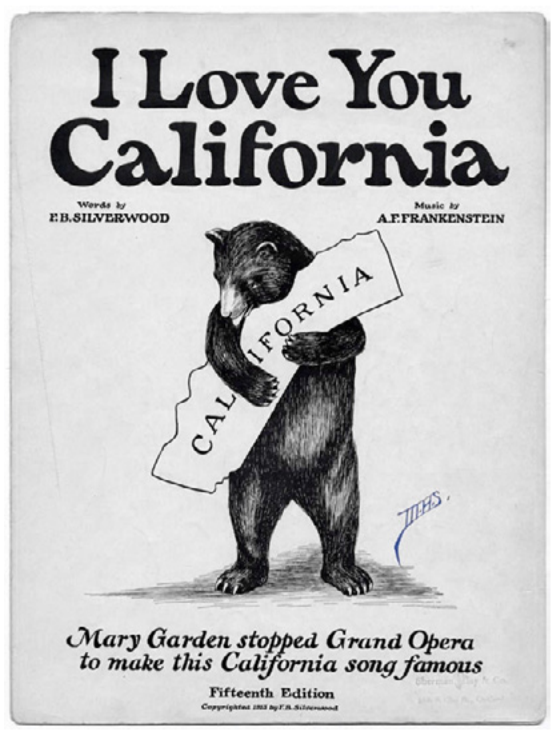
The loss of grizzlies has probably affected California ecosystems in numerous ways, but more research will be necessary to better understand these consequences.

# Introduction

In 1848, on the eve of the Gold Rush, California contained as many as 10,000 grizzly bears, probably more than any current U.S. state other than Alaska. By the mid-1920s, they were all gone. Since then, California has changed immensely. Its population has grown tenfold, but almost all of this growth has occurred in its coastal and valley cities, and it is now nearly stable. California's ecosystems have experienced tremendous pressures—from resource extraction and urban development to climate change and mass recreation—but most are better understood, more protected, and more valued than they were a century ago. California contains more endangered species than any state except Hawaii, but extensive efforts are underway to restore its ecosystems and reconnect its habitats, and some species that were decimated or eradicated there decades ago are now recovering or returning. As this Feasibility Study shows, grizzly bears could, with some help, become one of these returning and recovering species.

This chapter describes the history of grizzlies in California, from before European colonization to their extinction in the state a century ago. It explains how social and ecological changes affected the bears, the reasons for their decline, and the process by which they disappeared. It also identifies key historical lessons and legacies that could shape a recovery effort. It concludes that although today California faces many environmental challenges, nothing in the state's past rules out recovering grizzly bears in its future.

There are three main reasons why including history is crucial in a feasibility study mainly focused on the future. First, the grizzly generates great public interest but also many misconceptions. Historical research enables us to correct the record with regard to the myths surrounding these bears. Second, historical research enables us to better understand how grizzly bears actually lived in California. This is essential because no scientific studies of grizzlies were conducted while they still lived in California, and because many of the places in the state where the bears used to dwell are quite different from the places where scientists and managers study them today in North America. Third, historical sources explain why grizzlies disappeared from the state. This is crucial because a key step in assessing the feasibility of any recovery effort is determining what caused the species' decline and whether a recovering population may face similar obstacles. For these and other reasons, history also plays an important supporting role in several of the chapters that follow.




1913 cover illustration for *I Love You, California* sheet music.

# Questions

## 1 Where did California's grizzlies come from?

***Grizzly bears came to California from the north, likely arriving after the last ice age very recently in their evolutionary history.***

Grizzly bears lived in California for only about 0.2% of their species' evolutionary history. Modern bears originated around 5 million years ago, and the first brown bears appeared in Asia about 3.5 million years ago. Polar bears (*Ursus maritimus*) split off from brown bears by 600,000 years ago, but these two different-looking species remain so closely related that they can mate in the wild and produce fertile offspring. Brown bears are believed to have migrated into North America via Alaska in at least four waves, starting around 200,000 years ago [1]. The brown bears whose ancestors dispersed widely throughout the American and Canadian West, excluding those in coastal southern Alaska, are known as grizzly bears. Throughout this study, the term *brown bear* refers to the entire *Ursus arctos* species, whereas the term *grizzly bear* refers more narrowly to brown bears living in North America outside coastal southern Alaska.

Grizzlies arrived in California recently in the region's ecological history. During the Pleistocene epoch, from 2.5 million to around 12,000 years ago, California was home to a spectacular array of large mammals, as represented in fossil deposits such as those at the La Brea Tar Pits [2]. By 11,000 years ago, most of these creatures had disappeared, likely owing to a combination of factors, including climate change and human activities [3]. Until recently, researchers estimated that grizzly bears reached California around 35,000 years ago, but newer results suggest the actual date, especially in Southern California, may be closer to 8000 years ago [4]. Regardless of the exact date of their arrival, it is clear that, compared with most other native wildlife species, grizzlies are new additions to California ecosystems, and that they probably succeeded in these ecosystems partly by filling niches left behind by extinct Pleistocene megafauna.

## 2 Were California's grizzlies unique?

***California grizzlies are still considered a distinct subspecies* (Ursus arctos californicus), *but genomic evidence suggests they were indistinguishable from grizzlies in other nearby regions.***

Biologists use several criteria—including physical traits, geographic ranges, evolutionary relationships, and tradition—to classify organisms. Brown bears were first described and named scientifically in 1758 by the pioneer of modern taxonomy, Carl Linnaeus. Several attempts to categorize the world's brown bears into distinct groups followed, including C. Hart Merriam's infamous scheme, which identified 86 subspecies in North America [5]. The current taxonomic arrangement for brown bears dates to the 1960s [6]. Under this system, the brown bear is a single global species comprising around a dozen subspecies (Figure 1.1).

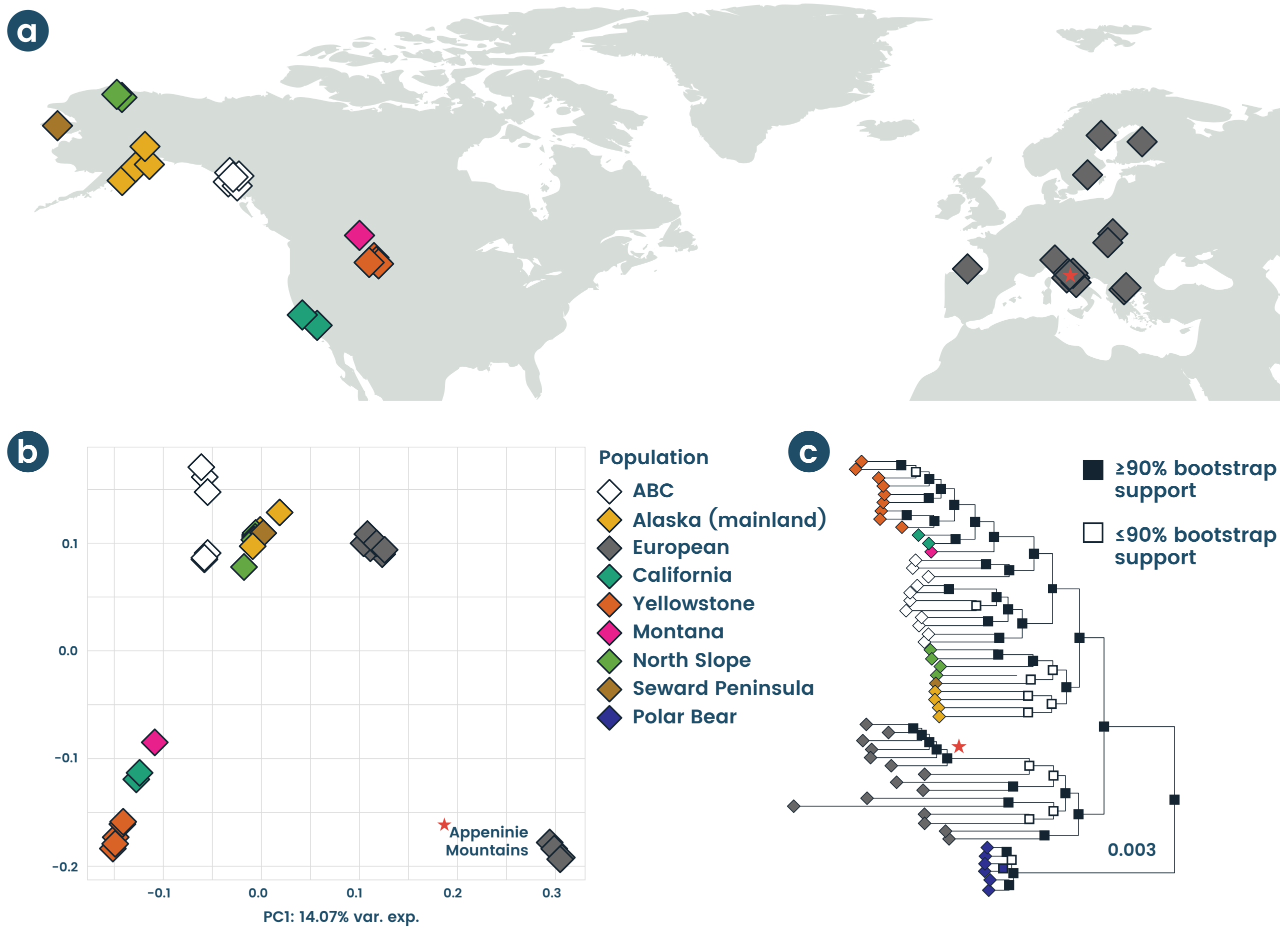



**Figure 1.1.** Genomic research by Wooldridge et al. [7] suggests that California grizzlies were essentially indistinguishable from grizzlies currently living in the Northern Rockies, labeled here as the "Yellowstone" and "Montana" samples. In this figure, (a) shows the locations of brown and polar bear samples used in this study, (b) shows the similarity of these samples, based on Principal Component Analysis (PCA) of genome-wide autosomal genotype likelihoods, and (c) shows the likely phylogenetic relationships of these samples. Reproduced from [7].

In 2025, researchers [7] used genomic methods to investigate how closely related California grizzlies were to brown bears in other regions. They found that grizzly bears in California were genetically indistinguishable from grizzly bears living today in the Northern Rockies of Montana and Wyoming. This conclusion matches with the carbon dating results described above; together, they suggest that grizzlies migrated to California recently from a source population further north, in the Northern Rockies or Pacific Northwest, and that the bears in these areas remained closely related. It is reasonable to conclude, therefore, that although California's grizzly bears lived in a unique ecological region, there is little justification, other than tradition, for maintaining the California grizzly as a unique subspecies. Instead, California's grizzlies were probably more like Mexican grizzlies, now also extinct, which were originally considered a unique subspecies (*Ursus arctos nelsoni*) but then later reclassified to the status of a regional population.

## 3 Where did California's grizzlies live?

***Prior to 1800, grizzlies lived throughout California in all but the most arid regions, though at varying densities that reflected the quality of the habitats in each area***

Between 2016 and 2019, the California Grizzly Research Network conducted an archival survey to identify historical sightings of grizzly bears in the region [4]. Researchers produced a database of around 330 accounts, spanning from the first recorded European observation of a California grizzly bear in 1602 to the last commonly accepted sighting of one in 1924. The research network also surveyed natural history collections to identify specimens from verified locations. These sources have great potential value, but because they were not recorded and preserved systematically, they require nuanced interpretation. They consist, for example, almost entirely of accounts by white, English-speaking men rather than a more diverse cross-section of society that, if better represented, would likely have provided a richer range of descriptions, perspectives, and even locations.

Most Americans probably think of brown bears as living in high mountains and cold northern landscapes, but this image does not accurately reflect their historical range, which included a more diverse assortment of temperate climate ecosystems. Not long ago, brown bears roamed throughout a variety of arid, subtropical regions, including parts of northern Mexico, central Asia, the Middle East, and even North Africa. Many of these populations disappeared during the 19th and early 20th centuries (Figures 1.2 and 1.3).

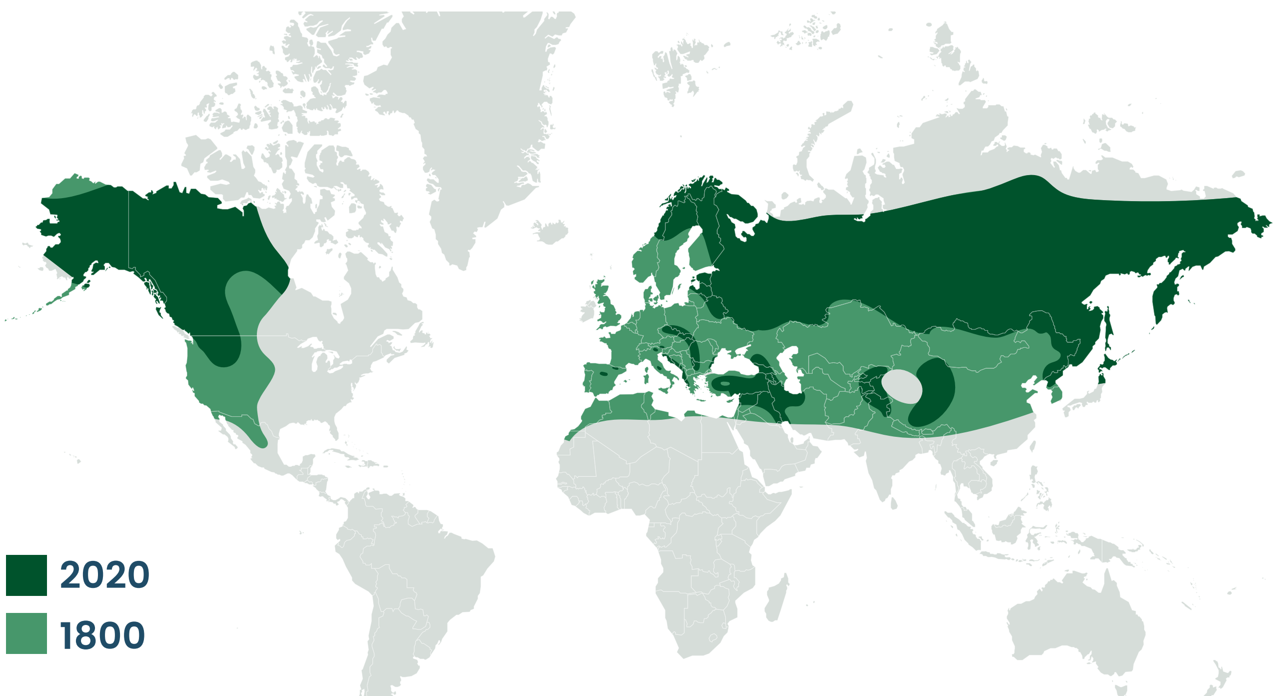



**Figure 1.2.** Brown bears' global range, in 1800 and 2020. Brown bears are a species of least concern, as defined by the International Union for Conservation of Nature. Since 1800, however, they have lost most of the southern half of their global range, and today, many live in small, isolated populations.

In California, grizzlies inhabited almost every major ecoregion and habitat type, but they were not evenly distributed (see Chapter 2). They were rare in its high deserts and largely missing from its low deserts, though they may occasionally have moved through these areas using riparian corridors as sheltered pathways. They were particularly abundant along coastlines and in montane forests, foothill woodlands, chaparral shrublands, and savannas [8]. As their populations declined, the state's grizzlies grew increasingly isolated in the rugged mountain ranges of Central and Southern California.

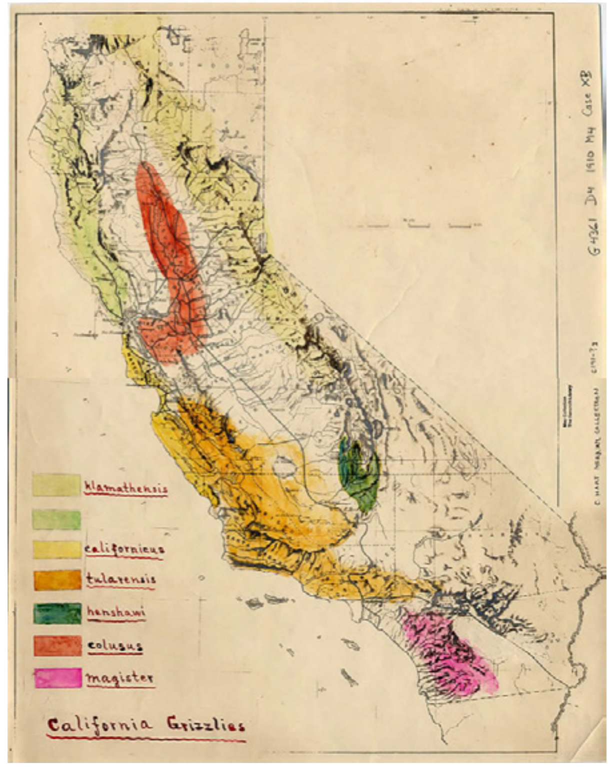



**Figure 1.3.** Range map drawn by C. Hart Merriam for grizzly bears in California (ca. 1910). Merriam believed that there were at least seven unique subspecies of grizzlies in the state. His range map excluded portions of the Northwest Forest, Southern California coast, and Great Central Valley for which there are historical records of grizzlies.

## 4 What did California's grizzlies eat?

***California grizzly diets probably varied considerably among the state's diverse habitats. Prior to European colonization, California's grizzlies subsisted on diverse, plant-based diets. Afterward, their consumption of terrestrial protein increased.***

Brown bears are often referred to as "large carnivores" or "apex predators," but these descriptions are misleading (see Chapter 5). Brown bears are members of the order Carnivora, and they are, indeed, large—at least relative to most modern terrestrial animals. Yet behaviorally and ecologically, they are better thought of as flexible omnivores whose diets vary throughout their lives, over the seasons, by habitat and geographic region, by sex, and as a function of their relations with people. Of all the world's large animals, brown bears may have the second most diverse diet after humans.

Brown bears in more northern latitudes tend to eat more meat, but even in temperate latitudes, some brown bears are efficient predators of newborn elk (*Cervus canadensis*), bison (*Bison spp.*), caribou (*Rangifer tarandus*), and other ungulates [9]. Brown bears' imposing size also enables them to steal carcasses, a behavior known as kleptoparasitism, from wolves (*Canis spp.*), pumas (*Puma concolor*), coyotes (*Canis* *latrans*), and lynx (*Lynx spp.*). In temperate coastal regions such as southern Alaska, brown bears consume large quantities of fish and shellfish and, when available, feed on the carcasses of marine mammals. In Europe, some brown bears receive more than a quarter of their calories from human-provided food, including apples and corn [10]. Male brown bears sometimes eat the cubs of other bears, and brown bears are occasionally eaten themselves by polar bears and tigers (*Panthera tigris*). In most places, however, most brown bears receive the majority of their nutrition from plants.

Archival sources from the 19th and early 20th centuries suggest California's grizzlies were among the world's largest and most carnivorous brown bears [8]. Yet the reality does not live up to the legend. Brown bears may continue to grow well into adulthood, reaching maximum sizes varying from 150 lb (68 kg) for females in the Gobi Desert to 1500 lb (680 kg) for the biggest males in southern Alaska. The sizes of individual bears, as with humans, are determined by both their genes and their diets, but bears living in the richest coastal ecosystems are usually the biggest. California's bears, which lived in diverse ecoregions with different kinds and amounts of available foods, may have varied considerably in size. Research published in 2024, however, used museum specimens to show that adult California grizzlies were, on average, between 350 and 750 lb (159–340 kg)—about the same size as a typical Yellowstone grizzly [4]. This finding matches with others discussed above, suggesting that bears in California and the Northern Rockies had a recent common ancestor and were genetically indistinguishable [7].

In the Mychajliw et al. [4] study, researchers also examined California grizzly diets using stable isotope analysis, a method that enables biologists to track the flow of nutrients through organisms and ecosystems using stable (rather than radioactive) forms of elements such as carbon and nitrogen. The researchers found that, prior to European colonization, California's grizzlies were 80% to 85% herbivorous. After European colonization, the proportion of terrestrial protein in grizzlies' diets roughly doubled, making them about 70% herbivorous. This increase in protein came mostly from free-roaming European livestock. The rest came from native animals, such as deer (*Odocoileus spp.*), whose populations appear to have temporarily increased during the early 19th century owing to a host of social and ecological changes, including the dramatic decline in Indigenous hunting and gathering [11]. This picture contrasts with historical accounts of California grizzlies as hypercarnivorous apex predators, but it closely resembles the results of scientific studies conducted on the mostly herbivorous brown bears of Southern Europe (e.g., [12])—a region that is, in many ways, climatically and ecologically similar to California.

Photo: Schame87 - stock.adobe.com

## 5 How many grizzly bears lived in California?

***No reliable studies of grizzly populations were conducted prior to the decline of the species in California. Most estimates, based on the grizzly's geographic range and the quality of the habitats within it, place the population in the 1830s and 1840s at up to 10,000 bears.***

There is no way to know exactly how many grizzlies lived in California at any specific date in the past. Paleoecological research suggests that grizzly populations in other regions, such as the Northern Rockies, fluctuated over time, in part owing to climate-driven ecological changes that affected the availability of their key foods [13]. Based on the carbon-14 dates cited above, grizzly bears spread throughout California mostly during the middle Holocene epoch, approximately 5000 to 7000 years ago, a period of widespread regional warming [14]. Grizzly bears remained in California both during the cooler period that began around 4000 years ago and the more variable conditions of the past millennium.

Joseph Grinnell was the founding director of the Museum of Vertebrate Zoology at the University of California, Berkeley. In 1938, Grinnell [15] estimated that, prior to 1830, suitable habitats in California contained an average of around one grizzly bear for every 20 $mi^2$ (52 $km^2$), producing a total population number of 2595 adults. Grinnell noted, however, that he considered this a conservative estimate. In their 1955 book, California Grizzly, Tracy Storer and Llyod Tevis argued the actual number was probably closer to 10,000 [8]. In 2021, longtime grizzly bear researcher David Mattson recalculated these numbers, arriving at a population estimate of between 5945 and

Box 1.2.

### Visualizing California's historical grizzly population

Large numbers can be difficult to visualize. Here are some additional statistics to help put into perspective the grizzly population estimates described under Question 5:


/ **11 $mi^2$** in 1840

California has a land area of 163,696 $mi^2$ (423,971 $km^2$). If this area contained 10,000 grizzlies in 1848, then there would have been an average of around 1 grizzly for every 16 $mi^2$ (41 $km^2$). If we eliminate the roughly one-third of California that was probably too arid to support any bears, then the rest would have contained an average of 1 grizzly for every 11 $mi^2$ (28 $km^2$).


**San Francisco**

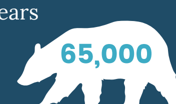

**Los Angeles**

Using the above estimates, an area the size of San Francisco, which is 47 $mi^2$ (122 $km^2$) and is now home to around 800,000 people, would have had about four grizzlies; an area the size of Los Angeles, which is 502 $mi^2$ (1300 $km^2$) and has 3.8 million human residents, would have had around 46 grizzlies.

California has about one-quarter of Alaska's land area. Today, Alaska contains around 35,000 brown bears and 734,000 human residents. In 1769, California contained an estimated 350,000 people and perhaps around 8000 grizzlies, assuming the bears' population increased by 25% during the Mission and Rancho eras that followed. Based on these estimates, prior to European contact, California had a brown bear population density similar to, and a human population density double that of, present-day Alaska.


By 1848, after decades of population decline among the region's Native peoples, California is believed to have contained only around 110,000 human residents, or around 1 grizzly bear for every 11 humans.

The California Department of Fish and Wildlife estimates that the state currently contains around 65,000 black bears (*Ursus americanus*), 6.5 times the maximum number of grizzly bears believed to have lived in California in 1848.



11,840, for an average of 8893 grizzlies [16]. These numbers are the main sources for the often-cited phrase that "in 1848, on the eve of the Gold Rush, California contained as many as 10,000 grizzly bears."

## 6 How did California's grizzly bears interact with humans?

***Relations between humans and grizzly bears in California shifted dramatically over at least three historical periods in response to changes in the region's ecology, culture, economics, and human behavior.***

Relations between humans and grizzly bears in California unfolded over at least three historical periods. The first phase, which encompassed some 97% of the grizzly bear's history in California, spanned from the first encounters of humans with grizzlies at least 8000 years ago to the onset of the Mission era in 1769. Throughout this long history, humans and grizzlies engaged in complex and diverse relationships that included a dynamic and interrelated set of cultural practices and ecological systems. For many Indigenous groups, the grizzly was not only an ecological engineer but also a *cultural keystone species*—a species that plays a disproportionate role in the social relations of the people who live with it.

Throughout nondesert California, humans and grizzly bears consumed nearly identical diets, and they likely competed, to some extent, for common resources such as acorns, pine nuts, fish, and wild game [8]. Yet humans and bears also likely collaborated to maintain and enrich the habitats they shared. Grizzly bears enriched riparian ecosystems by ferrying salmon (*Oncorhynchus spp.*) from rivers into nearby forests, as they do today in Alaska and British Columbia. Grizzly bears are active tillers, and they are remarkably effective at dispersing the seeds of fruit- and berry-producing shrubs. Many of these plants germinate vigorously in disturbed soil and in areas subject to seasonal burning. Intentionally burned landscapes produced other crucial resources, such as deergrass (*Muhlenbergia rigens*), which some Native people used as fiber for woven materials, including ornate baskets passed down in families and given as gifts. Landscapes enriched with nutritious shrubs and grasses supported robust populations of wild game, including ungulates such as deer and elk, which fed humans, bears, and other species. They also provided patchy habitats for rare plants, some of which are now endangered. In dense chaparral shrublands, grizzlies carved vast networks of trails. Dozens of other animal species likely benefited from these open forests and shrublands, which also provided clear lines of sight, enabling humans and grizzlies to give one another ample space.

California Tribes fostered these relationships through cultural traditions, including rituals, artworks, performances, and stories. Many of these traditions have endured, and efforts to revive or renew others are underway. California contains thousands of landscape features with Indigenous names related to bears. Many of these toponyms allude to bears but do not directly mention them because some groups discourage referring to bears directly in ways that could arouse their suspicion or anger. Bear-related rock art is common in many areas, including evocative images of figures appearing to be part human and part bear. California's official State Prehistoric Artifact is the *Chipped*

**Figure 1.4.** The *Chipped Stone Bear*, a figurine 7000 to 8000 years old, found in San Diego County in 1985, is one of California's oldest known artworks and the state's official artifact [18].

*Stone Bear*, a figurine 7000 to 8000 years old discovered in a Payómkawichum, or Luiseño, site in San Diego County (Figure 1.4).

Many Tribes prohibited killing grizzlies, and some had taboos against eating them, but others hunted them regularly, on special occasions, or when deemed necessary. No evidence exists that any group actively sought to eradicate grizzlies, though most were probably capable of doing so. Evidence from the Central Coast and Sierra Nevada shows that people sometimes kept captive grizzlies [8]. There was also a widespread shamanistic tradition of bear doctors who possessed both practical and supernatural powers [17]. Biannual bear dances continue today as festive gatherings where bears are celebrated as symbols of core community aspirations and values, including strength, respect, humility, solidarity, and healing.

The second phase of human relations with grizzly bears in California spanned both the Mission era, from 1769 to 1823, and the Rancho era, from 1823 to 1848. The earliest recorded European observation of a grizzly in North America occurred many years earlier, in 1602, when members of the Vizcaíno Expedition first reported seeing grizzly bears in the vicinity of Monterey [19]. California's colonial history began with the Portolá Expedition of 1769 and the establishment of the first missions in the years that followed. Over nearly 8 decades of Spanish and Mexican rule, epidemics of disease, violence, dispossession, and missionization, including forced labor that in many ways resembled mass incarceration and slavery, decimated Native communities and disrupted their traditional lifeways [20]. California's human population plummeted from at least 350,000 in 1769 to as few as 110,000 by 1848.

These social and ecological changes had mixed consequences for grizzly bears. Early Spanish settlers ate bears, and later, vaqueros and rancheros shot and lassoed them for status and sport (Figure 1.5). Some captured grizzlies were placed in pits, where they were forced to entertain crowds by fighting against bulls [21]. For most of California's grizzlies, however, the Mission and Rancho eras were probably a time of plenty. Declines in Indigenous hunting and gathering may have led to temporary flushes in the availability of native foods, such as deer and salmon [11]. The number of European livestock skyrocketed from a few dozen in 1772 to more than a half-million by 1848 [22]. Free-roaming livestock provided an unprecedented source of exotic nutrition because ranchers tended their herds intermittently, barbed wire was not widely adopted until the 1870s, and many animals went feral [4]. Settlers also butchered tens of thousands of cattle for the hide and tallow industries, providing scavengers with vast quantities of animal waste. Grizzly bears may have reached their greatest numbers in California by the 1830s and 1840s, the first

**Figure 1.5.** *Roping the Bear at Santa Margarita Rancho of Juan Foster* by James Walker (1818–1889), c. 1870 (oil on canvas). Reproduced with permission from the California Historical Society.

decades that English-speaking settlers arrived in the state in significant numbers.

The third phase in California's history of human-bear relations lasted from 1848 to the last commonly accepted sighting of a California grizzly in 1924. In 1848, the Mexican-American War concluded with the Treaty of Guadalupe Hidalgo, which ceded California to the United States. The Gold Rush of 1849 (Figure 1.6) and the admission of California as a U.S. state in 1850 ushered in a dizzying series of changes, including rapid urban growth in the San Francisco Bay Area, industrial mining in the Sierra Nevada foothills, agricultural expansion in the Sacramento Valley, and logging along the redwood coast [23]. During the 1850s, 60s, and 70s, the state's remaining Indigenous people suffered a series of horrific massacres that, under current international law, meet the definition of genocide [24]. California's first major dams were erected in the 1870s, and its first national parks and forests were established in the 1890s. Large-scale urban, agricultural, and fossil fuel development also began in Southern California not long after.

Grizzly bears were still widespread during the early statehood period. In the 1850s, they remained common along the Pacific Coast from Oregon to Mexico, as well as in the Northwest Forest, the Sierra Nevada, and the Cascades, Coast, Peninsular, and Transverse Ranges (see Chapter 2). By the 1860s, grizzlies could no longer be found in populated areas of Northern California, including the San Francisco Bay Area, Sacramento Valley, and Sierra Nevada Gold Country. Over the next few decades, they largely disappeared from the Northwest Coast and Cascades. By 1900, grizzlies were extremely rare and isolated to a handful of remote mountainous areas in Central and Southern California.


**Figure 1.6.** Grizzly bears figured prominently in California Gold Rush-era propaganda. *Mose in California: Set To With Bear* by H. R. Robinson. Reproduced from [25].

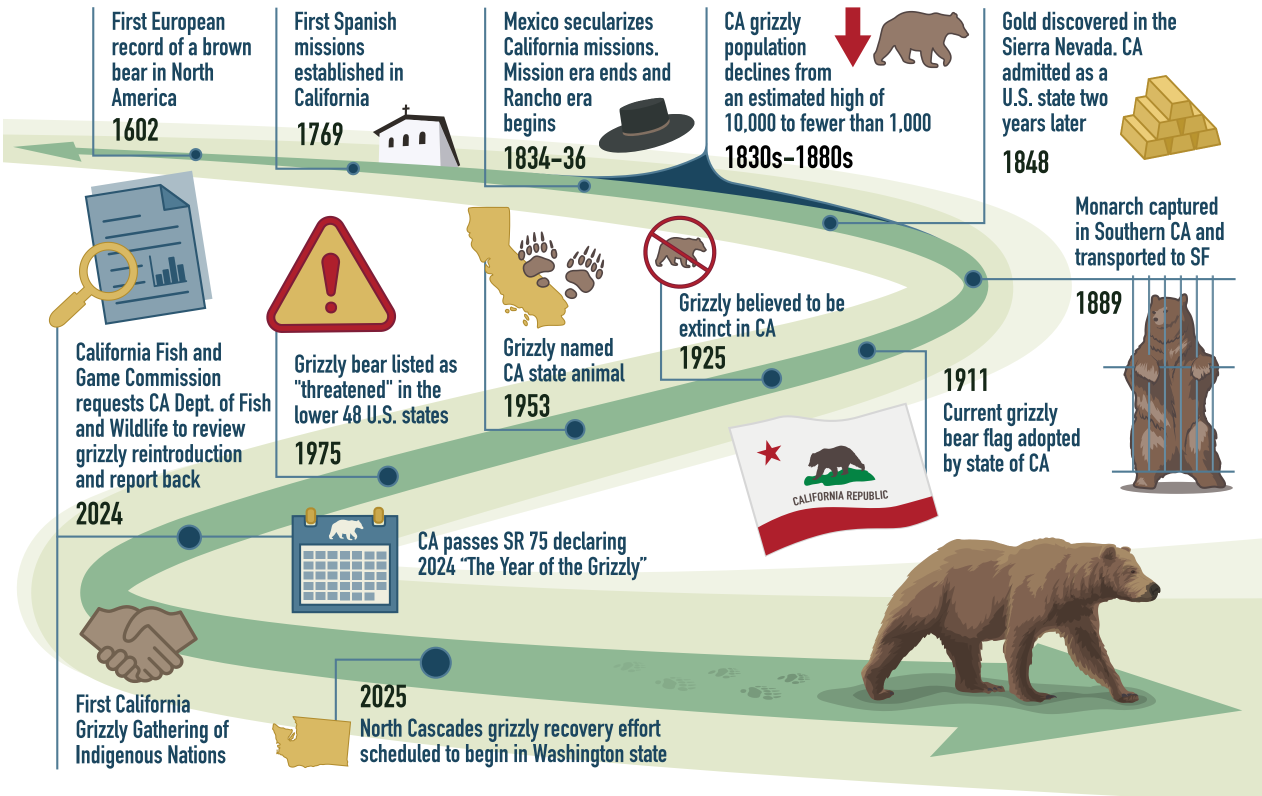



**Figure 1.7.** Timeline of grizzly bears in California since the first written record of the species in this region. The 423-year period covered in this figure accounts for, at most, only one half of one percent of grizzly's history in California.

## 7 Where and when did the last California grizzlies live?

***California's last grizzlies lived in the Sierra Nevada and Transverse Ranges of Central and Southern California. The final few of these bears probably died in the mid-1920s, though the location of the last California grizzly remains uncertain.***

By the 1880s, grizzlies had become so rare that finding one was a newsworthy event. In a famous 1889 episode, the journalist Allen Kelly set out from San Francisco to Southern California with the goal of capturing a live grizzly bear [26]. Kelly's excursion was, at least initially, funded by the publishing magnate William Randolph Hearst as a publicity stunt for one of his newspapers. After weeks of unsuccessful trapping efforts, Kelly purchased a captive bear from a band of sheepherders. The details of this transaction remain disputed; according to Kelly's 1903 memoir, it occurred near Mt. Gleason in Los Angeles County, but the actual location may have been in Ventura County. The bear, named Monarch after one of Hearst's newspapers, was shipped to San Francisco, where he lived in various enclosures until 1911. Researchers have used his remains for diet and genomic studies cited in this chapter [4], [7]. In 2024, the California Academy of Sciences restored Monarch's taxidermized hide and placed it on display as part of the museum's new *State of Nature* exhibit (Figure 1.8).

Monarch may have been the last captive California grizzly, but he was not the last wild one [8]. In 1908, Orange County's last known grizzly bear was baited and then shot in Trabuco

Canyon, near the town of Mission Viejo. In 1916, in another episode with disputed details, a farmer named Cornelius Johnson trapped a bear that became known as the Sunland Grizzly at the head of Big Tujunga Canyon in the San Gabriel Mountains, within view of downtown Los Angeles. In 1924, grizzly bears were sighted at least twice on the western slopes of Sequoia National Park in the southern Sierra Nevada, but neither produced physical evidence. The April 1924 incident, which took place near a granite dome called Moro Rock, is often considered the last credible sighting. The men who reported it were part of a U.S. National Park Service road crew building the new Generals Highway. The crew had previously worked in Yellowstone, where its members had seen both black and grizzly bears, and apparently, they had learned to tell the difference between the two species [27].

Recently discovered archival evidence suggests the Moro Rock grizzly may not have been California's last. In August 1926, the *Lompoc Review* newspaper reported that the previous year, the Santa Barbara (now Los Padres) National Forest Supervisor, William V. Mendenhall, had received reports from two district rangers of grizzly prints near Big Pine Mountain [28]. This appeared in the Lompoc newspaper on that date because a third district ranger had just reported actually seeing a grizzly in the Ventura County mountains above Ojai. We will probably never know exactly where the last California grizzly lived or when it died. Still, these records suggest that some may have survived in remote corners of Central and Southern California into the second half of the 1920s.

**Figure 1.8.** Monarch, the last captive California grizzly, on display in 2024 in the *State of Nature* exhibit at the California Academy of Sciences. Photo by Paige Laduzinsky.

## 8 Why did California's grizzlies disappear?

***Grizzlies disappeared from California not only because human population growth and habitat loss drove them out but also because a relatively small group of people killed them.***

Human population and economic growth created a context for the California grizzly's decline, and habitat loss undoubtedly lowered the state's carrying capacity for grizzlies. But these factors alone do not explain why the species went extinct in the state. In California, as in most of the American West, grizzlies were hunted, trapped, and poisoned to extinction even as vast areas of otherwise suitable habitat remained. The main reason California's grizzlies died off is that, in an era before modern conservation laws, a relatively small group of people killed them.

Several factors fueled the killing spree that eradicated grizzly bears from California. During the Mission and Rancho eras, some California grizzlies acquired a taste for livestock, bringing them into conflict with Spanish-speaking ranchers. These conflicts escalated dramatically with the arrival of English-speaking cattlemen, who raised beef for capitalist markets and forcefully defended their property (e.g., [29]). Some settlers, legitimated and incentivized by "predator bounties," went out of their way to hunt down bears, wolves, coyotes, pumas, and other animals. Trappers, dealers, and showmen earned money from the sale and display of grizzly bears—in whole or in part, alive or dead. Improved transport networks and cheaper, more powerful weapons made finding and killing these animals easier. California established its Fish and Game Commission in 1870, but the first regulations governing black bear hunting in the state were not enacted until 1948.

Another factor undoubtedly drove the grizzly's decline: the grizzly was the California animal most closely associated with Indigenous culture at a time when Native people were under attack (e.g., Figure 1.9). Some Anglo settlers slaughtered grizzlies while speaking out against the mistreatment of Indigenous people, but many considered native animals and humans equally out of place in the new California. Between 1840 and 1880, settlers and vigilantes—sometimes alone, sometimes in self-appointed posses, sometimes under the guise of the U.S. military, and often egged on by pundits and politicians—set out to cleanse California of anything, or anyone, that could not be commodified or controlled. Well-known figures, such as the Army Major General John C. Fremont and the hunter Seth Kinman, used the same words to describe, the same arguments to vilify, and often the same weapons to kill grizzlies and other wildlife as they did Native people [30].

The loss of grizzly bears in California was not, therefore, part of a lamentable but inevitable process in which agriculture, urbanization, and population growth squeezed animals out of their wilderness habitats (Figure 1.10). Instead, the California grizzly's story, like that of the plains bison, was part of a brutal colonial project aiming to clear the landscape for American settlement. The California grizzly did not disappear due to some inexorable force of human progress. Grizzlies disappeared from the state because a relatively small group of individuals—many of whom also had histories of violent acts toward other people—killed so many of them.

We all know that no nation upon the face of the globe ever had greater cause for war than has the Indian, to fight us to the last. But it is a cause such as the grizzly has against the pioneer, who invades his native wilds; both are to be dealt with in a like manner. Indians are like wolves—pests to the country. They will not, or cannot be civilized, hence must die out, and the sooner the better.

***Los Angeles Daily News***
Friday, April 30, 1880

Strychnine has killed more Indians than bullets ever did or ever will.

***Carson Daily Appeal***
Friday, December 7, 1880

"bait" for the grizzlies in the shape of a "dope" containing pounded glass, strychnine, and other ingredients, and whenever one of the animals get a dose of this preparation, it is gone up, for if the strychnine does not kill it, the pounded glass is sure to hash up its in'ards sufficiently to produce death.


**Carson Daily Appeal**
Friday, December 7, 1880

**Figure 1.9.** Nineteenth century newspapers supported the eradication of both Native people and wildlife including grizzlies (*Los Angeles Daily News*, Friday, Apr. 30, 1880). Some even went so far as to print ads recommending tools, such as strychnine, for killing them (*Carson Daily Appeal*, Dec. 7, 1880).

## 9 What have been the consequences of the California grizzly's extinction?

***It is difficult to know exactly how the grizzly's loss has affected California ecosystems, but evidence suggests it has had a range of important, though often unrecognized, social and ecological consequences.***

There are three main reasons why it is so difficult to know exactly how the grizzly's loss has affected California ecosystems. First, no studies were conducted prior to the grizzly's decline in California that would have provided a baseline for measuring changes over time. Second, even if such studies had been conducted, it would be difficult to isolate the consequences of the grizzly's local extinction because so many other forces have also reshaped California's ecology in the years since. Third, although most researchers are familiar with ideas such as "traditional ecological knowledge," itself a Western scientific concept, the discipline of ecology has exerted surprisingly little effort to understand the role of wild animals like grizzly bears in Indigenous socio-ecological systems. We thus have both a lack of data and an insufficient conceptual framework for explaining how the grizzly's disappearance has affected California ecosystems.

The loss of California's grizzlies has likely had several consequences. It reduced the ecological diversity of the brown bear as a species. It robbed California of a key ecosystem engineer that shaped the state's landscapes, from soil quality to ungulate populations to seed dispersal. Some researchers have speculated that the loss of grizzlies and most wolves has enabled black bear and coyote populations to increase, but the roles these losses played remain uncertain (see Chapter 5). The loss of this cultural keystone species was yet another affront to Indigenous Californians who value grizzlies in myriad ways. For people living in California today, whether they have Indigenous roots or not, the loss of the grizzly represents the loss of a complicated but powerful symbol, as well as an opportunity for research, education, and inspiration.

## 10 How have grizzly bears fared outside California, and how might their return to this state contribute to a broader recovery?

***In the lower 48 U.S. states, grizzly populations have roughly doubled over the past half-century, but remain far below their pre-colonial levels. A broader recovery effort would provide greater long-term protection while restoring the bears' ecological functions over a larger portion of their historical range.***

The brown bear is the world's most widespread bear species, with a total population of more than 200,000 spread across Asia, Europe, and western North America. (The American black bear has a smaller geographic range but is much more numerous, with an estimated population of more than 900,000.) The International Union for the Conservation of Nature considers the brown bear a *species of least concern*, meaning that it is in no danger of going globally extinct in the foreseeable future.

Over the past 2 centuries, however, brown bears have lost around half of their global range, and today, many survive in small, isolated populations. Brown bears can still be found in some unlikely places, including Japan's northern island of Hokkaido and the Gobi Desert of central Asia. Around 17,000 brown bears live in at least 22 European countries outside Russia—including places as different as Spain, Finland, Romania, Italy, and Greece—while more than 100,000 live in Russia itself, which is by far the largest share of any country. North America contains around 60,000 brown bears, including 25,000 in Canada, around 60% of which live in British Columbia, and up to 35,000 in Alaska.

In 1975, after 150 years of declining populations, the U.S. Fish and Wildlife Service (USFWS) listed grizzlies in the lower 48 states as threatened under the U.S. Endangered Species Act. The Grizzly Bear Recovery Plan, first published in 1982 and then updated to its current version in 1993, identifies *six grizzly bear ecosystems*. These were places where at least a few grizzlies still lived or had very recently lived at the time of the species' listing, and that scientists and managers believed could serve as recovery zones. Grizzlies now occupy at least four of these zones—the Greater Yellowstone, Northern Continental Divide, Cabinet-Yaak, and Selkirk Ecosystems—as well as some adjacent areas. Two additional recovery zones, the Bitterroot Mountains of Idaho and Montana and the North Cascades of Washington state, see occasional migrants, but as of this writing, neither contains viable breeding populations. The North Cascades reintroduction and recovery effort received approval in 2024 and, barring any last-minute political roadblocks, has scheduled bears to arrive there in 2025. Shortly before this Feasibility Study went to press, the Service proposed a new recovery framework, discussed in Chapter 9, which would integrate the six current zones into a single unit, but this proposal's approval is not guaranteed.

The lower 48 states now contain around 2000 grizzly bears, representing an important but limited conservation success story. The population of grizzlies in the lower 48 states has more than doubled over the past 4 decades and is no longer in imminent danger of extinction, although it remains threatened. If the USFWS's recovery plan were to fully succeed in all six designated ecosystems, there would be about 3500 grizzlies in the lower 48 states. The U.S. government could, therefore, declare the grizzly fully "recovered" with a population 93% below the level that existed before European colonization.

In its 1993 recovery plan, the USFWS wrote that the six designated recovery zones "had the potential to provide adequate space and habitat to maintain the grizzly bear as a viable and self-sustaining species." It also noted, however, that given a range of uncertainties, other areas may be required to fulfill this basic goal [31], [32]. The USFWS thus pledged to study other potential recovery zones within the grizzly's historical range. This effort was expected to take 5 years.

In 2011, the USFWS published a 5-year review that again pointed to the need for a study to assess the feasibility of recovering grizzlies outside the six recovery zones [33]. Eight years later, in 2019, the USFWS settled a lawsuit in federal court in the District of Montana, agreeing to conduct the study it had called for back in 1993 [34]. For this assessment, the USFWS applied a measure of roadlessness known as "secure habitat" (see Chapter 2) to two regions, the San Juan Mountains of Colorado and the Sierra Nevada of California, which had large historical grizzly populations [35]. It noted that California's Sierra Nevada contained the largest area of secure habitat outside the six current recovery zones, but it concluded that neither place could support a recovery. Subsequent research has challenged these conclusions, as well as similar USFWS modeling results limiting the scope of recovery for other threatened or endangered species [36], [37].

If conservation efforts in the lower 48 U.S. states are ever to achieve a broader grizzly recovery—one that moves beyond the standard of mere population viability and begins to restore the bears' cultural and ecological roles throughout other significant portions of their historical range—then scientists, managers, and advocates will need to look beyond the current six recovery zones to other potential grizzly bear ecosystems, like those in California.

## Opportunities For Future Research

- Further archaeological and ethnographic research is needed to better understand the richness, diversity, and ecological repercussions of Indigenous relations with grizzly bears prior to European colonization.
- Additional archival work will be needed to determine the actual locations of the last California grizzlies.
- Further research in historical ecology could help illuminate the consequences of the grizzly's extinction in California—for the state's habitats, biodiversity, ecological processes, and native species.

Photo: Lucaar - stock.adobe.com

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Chapter 2

# Suitable Habitat

By Alex McInturff, Peter S. Alagona,
Bruce Kendall & Ellen M. Pero

California Grizzly Alliance

## Key Points

This chapter presents and compares 3 ecological modeling approaches—historical, geographic, and taxonomic—to better understand where grizzlies might thrive in California.

These 3 modeling approaches produce somewhat different results, but they also overlap considerably, suggesting that California still contains large areas of potential suitable habitat for grizzly bears.

Historical records show that grizzlies once occupied nearly all of nondesert California. Their highest-quality habitats were located in the ring of mountains surrounding the Great Central Valley.

In two other geographic regions, Europe and the Northern Rocky Mountains, brown bears prefer habitats that are relatively productive, high in elevation, and far from human settlements. California contains many similar areas.

Back bears and pumas both roam over large areas of California once inhabited by grizzlies. Neither of these other large carnivores is an ideal surrogate for the grizzly, but data available for pumas, which have similar habitat preferences to grizzlies, suggest that California still contains large areas of potential grizzly habitat.

Habitat suitability models can be improved by further considering a range of social factors. We discuss these factors at length in subsequent chapters.

# Introduction

In ecology, the term habitat suitability refers to the ability of an area to support a viable population of a species over some time period [1]. Just because an area was a suitable habitat in the past, however, does not mean it will remain so [2], [3]. Habitats may undergo profound social and ecological changes, and such changes can sometimes drive species declines. If managers attempt to reintroduce a species into an unsuitable habitat, their efforts will likely fail [4], [5]. Some habitats may also become more suitable owing to social, ecological, or climatic changes or changes in land management practices. Assessing habitat suitability is thus a complex but essential component of reintroduction planning [6], [7], [8].

For grizzly bears, most habitat suitability assessments focus either on an area's ecological characteristics, such as the distribution and abundance of key foods, or on its human activities, often expressed through proxies such as the extent and proportion of roadless area within a region. California contains diverse and abundant bear foods across a wide variety of ecosystems and land management areas throughout the state (see Chapter 5) [9]. In 2021, the U.S. Fish and Wildlife Service (USFWS) studied the Sierra Nevada using a "secure habitat" roadless area approach. It determined that the Sierra Nevada contained the most roadless area outside the six previously designated grizzly recovery zones but did not contain a sufficient proportion of roadless areas to support a viable grizzly population [10]. Other researchers have critiqued this approach, however, suggesting it can underestimate suitable habitat [11], [12].

In this chapter, we present a new approach that considers the state in its entirety, uses multiple established modeling approaches, and produces a conservative area of overlap across them. We describe each of these approaches and their overlap in the sections below. The results show that even using conservative estimates, California likely still contains large areas of suitable grizzly habitat—many of which are already protected as parks and wilderness areas.

Photo: giedriius - stock.adobe.com

# Questions

## 1 How do we model suitable habitat for grizzly bears in California?

***Most researchers estimate grizzly suitable habitat based on available foods and roadless areas. For this chapter, we use a more multifaceted approach that combines models from different places, times, and species. This approach enables us to produce a conservative yet robust estimate of grizzly suitable habitat in California.***

In this chapter, we describe a novel approach for assessing suitable habitat for grizzly bears in California. Instead of focusing primarily on foods or roads, we describe three alternative modeling approaches: (1) a historical approach based on where grizzlies lived in California in the past, (2) a geographic approach using models from two other regions where brown bears live, and (3) a taxonomic approach based on the current distributions of another large carnivore in California. We also refer to these approaches as analogies because they help us understand the distribution and abundance of suitable grizzly habitat in California using indirect means [13], [14]. Further technical details of these modeling approaches are described in McInturff et al. [14] and in Appendix 2.1: Section S1. To compare and contrast the results of these analogies, we used qualitative and quantitative approaches to identify areas in which the models both agree and disagree [15], [16].

There are several reasons why none of these three approaches offers a perfect method for assessing suitable grizzly habitat. No systematic scientific data was collected on grizzlies while they still lived in California; California's ecosystems have changed dramatically since grizzlies inhabited them; habitat models may become unreliable when transferred from one region to another; and different species have different ecological preferences, making comparison among them inherently problematic. Our three approaches, moreover, only partly account for a range of social factors—including laws, institutions, policies, public attitudes, management practices, and the roles of Tribes—which may shape habitat suitability. We discuss these social factors at length in subsequent chapters. With these shortcomings in mind, our multiple-model approach enabled us to identify key gaps in our knowledge and paint a richer, more multifaceted picture of the California landscape for future grizzly bears.

## 2 Which areas of California were suitable habitat for grizzly bears in the past?

***Grizzly bears once occupied almost all of nondesert California. Historical data suggests the highest-quality, or most suitable, grizzly habitats were in the ring of mountains surrounding the Great Central Valley, especially in the Coast and Transverse Ranges and the western foothills of the Sierra Nevada.***

Paleontological studies suggest grizzly bears arrived in California as recently as 8000 years ago [17] and then spread to a wide variety of ecosystems throughout virtually all of nondesert California. Written records of grizzly bears in California began in 1602 (see Chapter 1) and ended in 1924 with the last reliable sighting of a grizzly bear in Sequoia National Park.

These written records were not systematically collected but rather appeared in a variety of sources—including official reports, newspaper articles, books, correspondence, museum records, and other formats—and are now accessible through paper and digital archives [18], [19]. As described in previously published work, the California Grizzly Research Network scoured these written records to create an incomplete but robust database of around 330 sightings (Appendix 2.1: Section S1) [20]. These records show grizzlies lived in every ecoregion and almost every county of the state, from coastal redwood forests and chaparral to alpine and high desert ecosystems (Figure 2.1.). To improve our understanding of past grizzly habitat, McInturff et al. [14] applied techniques from habitat suitability modeling to historical data from 1850 to 1880 (Appendix 2.1: Section S1).

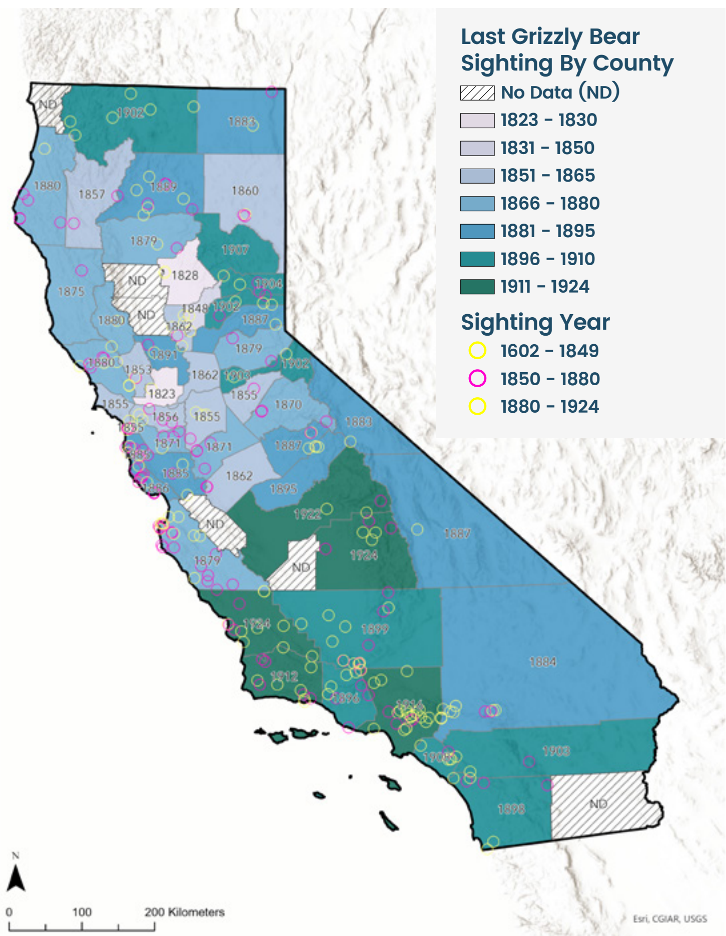


**Figure 2.1.** For each of California's 58 current counties, we determined the year of the last credible sighting of a grizzly bear using a database of historical observations and museum specimens. Six counties lack records in our database, but this does not necessarily mean they lacked bears. Bears disappeared from population centers around the state capital of Sacramento first and persisted longest in the Transverse Ranges and southern Sierra Nevada.

This analysis produced a model of historical habitat suitability for grizzly bears based on both ecological and social variables (Figure 2.2a; Appendix 2.1: Tables S1, S2, and S3). The model identified large areas of the state as having once contained suitable grizzly habitat. It also showed that although grizzlies ranged widely throughout California during our study period, their highest-quality habitats were in the Coast and Transverse Ranges, the western foothills of the Sierra Nevada, and other mountainous areas ringing the Great Central Valley (Figure 2.2a).

The historical analogy helps us better understand grizzly habitat in the past, but it is limited in what it can tell us about grizzly habitat in the present and future [21]. The era of steepest grizzly decline in California occurred after 1850, but by then, California's grizzlies may have disappeared from or declined in parts of their historical range [19]. Had older records been included, however, these would have come from historical periods that were even more different from and probably less applicable to today. It is also important to recognize that our data came from published or preserved records of grizzly encounters, not from a scientific sampling process, which may have rendered a more representative dataset. Finally, the historical approach says nothing about how once-suitable grizzly habitats have changed in the years since the bears inhabited them. To assess grizzly habitat suitability in present-day California, we must turn to other methods.

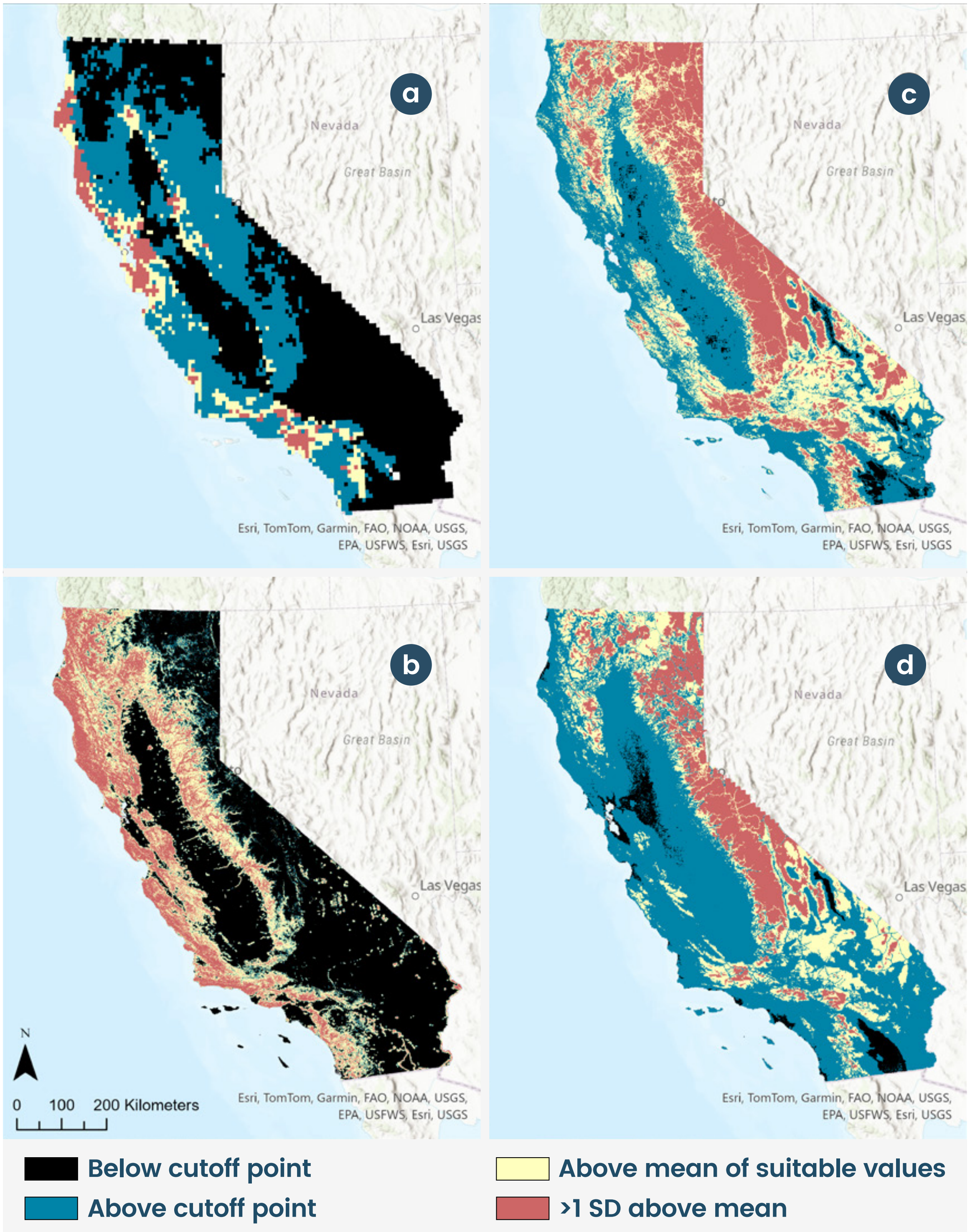


**Figure 2.2.** Potential grizzly bear habitat suitability in California based on the (a) historical model, (b) taxonomic model, (c) European (geographic) model, and (d) Northern Rocky Mountains (geographic) model. For each model, habitat areas above a conservative suitability cutoff point are shown in blue, and areas below are shown in black. Areas shown in yellow are above the mean, and in red are at least one standard deviation above the mean, for model outputs. Reproduced from McInturff et al. [14].

## 3 What do habitat suitability models developed for brown bears in other regions say about habitat suitability in California today?

***Brown bears in Europe and the Rocky Mountains prefer productive, remote, high-elevation areas. When we apply models from these regions to California, using these criteria, they suggest that large areas of the state probably still contain suitable grizzly habitat.***

The most common approaches for identifying suitable habitat for species reintroductions begin by studying the habitat preferences of the same species in similar areas [22]. The nearest region to California where brown bears live today is the Northern Rockies. This region is ecologically similar to some parts of California—particularly the High Sierra, Cascades, and Trinity Alps—but differs considerably from most of the rest of the state. California has a much larger human population than the Northern Rockies, but because its populace is so clustered—California is the most urban U.S. state, with around 95% of its residents living in cities [23]—most of the areas in California with suitable grizzly habitats do not have higher resident population densities than the Northern Rockies.

Considerable cultural, economic, and political differences, however, exist between these two regions. For a more multifaceted perspective, we also considered models from Europe, which contains Mediterranean-style ecosystems, diverse agricultural economies, and large urban centers that are, in some ways, more similar to California than California is to the Northern Rockies [24]. The methods used for transposing these models to California are described in McInturff et al. [14] and in Appendix 2.1: Section S1.

Both the European and Rocky Mountain models suggest that California possesses large areas of suitable habitat. Both of these models also predict that California's most suitable habitats exist in the Sierra Nevada, Coast Ranges including the Northwest Forest, and Transverse Ranges. The European and Northern Rockies models contained somewhat different assumptions and, thus, produced modestly different results. Yet they overlapped considerably, with both identifying mid- to higher-elevation areas as more suitable (Figure 2.2; Appendix 2.1: Tables S1, S4, and S5).

The two geographic models produced results that generally corresponded with those from the historical model, though there were some notable differences. Overall, the two geographic models identify a greater amount of total suitable habitat compared with the historical model. The geographic models, which identify greener, more productive ecosystems as higher-quality habitat, also rate California's Northwest Forest more highly than the historical model, which contains relatively few observations from that region (Figure 2.2). These complementary but not identical findings illustrate both the usefulness and inherent challenges of applying a model developed in one region to another [25].

## 4 Which areas of California currently contain other large carnivores, and what can these species' habitat uses tell us about potentially suitable habitat for grizzly bears?

***Black bears are the California species most similar to grizzly bears, but the best available habitat data for a native large carnivore comes from pumas. Pumas differ from grizzlies in many ways, but as with grizzlies in the past, pumas today occur throughout California while finding their highest-quality habitats in the ring of foothills and mountains surrounding the Great Central Valley.***

No two species are exactly the same or do exactly the same things. Evolutionarily, black bears are the California species most similar to grizzlies, but even black bears differ from grizzlies in their behavior and ecology. At the time of this writing, the California Department of Fish and Wildlife was working to update its black bear data and population modeling approach. The last attempt to model black bears' habitat suitability had taken place more than 15 years ago and was based on even older information [26], [27], [28]. This lack of quality data made black bears an obvious but ultimately unattractive analog for modeling potential grizzly habitat in California.

That said, recent work does suggest that habitat suitable for black bears in California is almost identical to that of pumas [29]. Though ecologically and behaviorally very different from grizzly bears, pumas share a number of key qualities with grizzlies. They are habitat generalists, are sensitive to human activities, and studiously avoid people. In California, they enjoy a specially-protected status like that of an endangered species [30], [31], [32], [33], [34], [35]. Some research has suggested that conservation activities for pumas and grizzlies may complement one another [36]. Finally, a recent study by Dellinger et al. using the best available scientific data and tools has analyzed puma habitat suitability in California [37]. Pumas can thus offer useful insights into the constraints California's current landscapes pose for large, wide-ranging carnivores.

For our taxonomic analogy, we reproduced the model from Dellinger et al. [14] ,[37], which identified 39% of the state as suitable puma habitat (Figure 2.2; Appendix 2.1: Tables S1 and S6). Here, too, the mountains ringing California's Great Central Valley stand out as the highest-rated potentially suitable habitat (Figure 2.2b). These results also point out that deserts and urban areas are likely to limit the habitat suitability of large carnivores, helping constrain the findings of the historical and geographic models.

As with the other analogies described above, this approach has several shortcomings. Pumas are obligate carnivores that prey mainly on deer and other ungulates, whereas California grizzly bears were omnivores, with most of their diets coming from plants [20]. Grizzly bears would interact very differently with other California wildlife, including wolves and black bears, with potential consequences for these and other species. Grizzly bear interactions with humans would likely be quite different as well, depending on the bears' number, density, and location, not to mention a variety of social factors, including public support, coexistence measures, and other management practices [38], [39]. The taxonomic model should, therefore, be interpreted cautiously, and it is best used as a way of further focusing the outputs of other models.

## 5 Is there sufficient suitable habitat for brown bears in California?

***We compared and contrasted the models mentioned above to identify areas where they agree and disagree. Using a conservative approach, we found that California probably still contains a large area of suitable habitat for grizzly bears.***

Each of the models we describe above represents an imperfect but useful approach for identifying suitable habitat for grizzly bears in California. Each has a history of use in other reintroduction and recovery projects [13], [22], [40], but each also comes with shortcomings, biases, and uncertainties. This is part of what makes the outcomes of species reintroductions so difficult to predict [25], [41]. These results suggest, however, that from an ecological perspective, California still probably contains ample suitable habitat for grizzly bears.

When taken together, our modeling approaches offer several important insights [13], [16]. Despite their different methods, data sources, and conceptual underpinnings, all of our models partially overlapped, identifying the same 34.5% of California as potentially suitable grizzly habitat. Based on this analysis, it is likely that

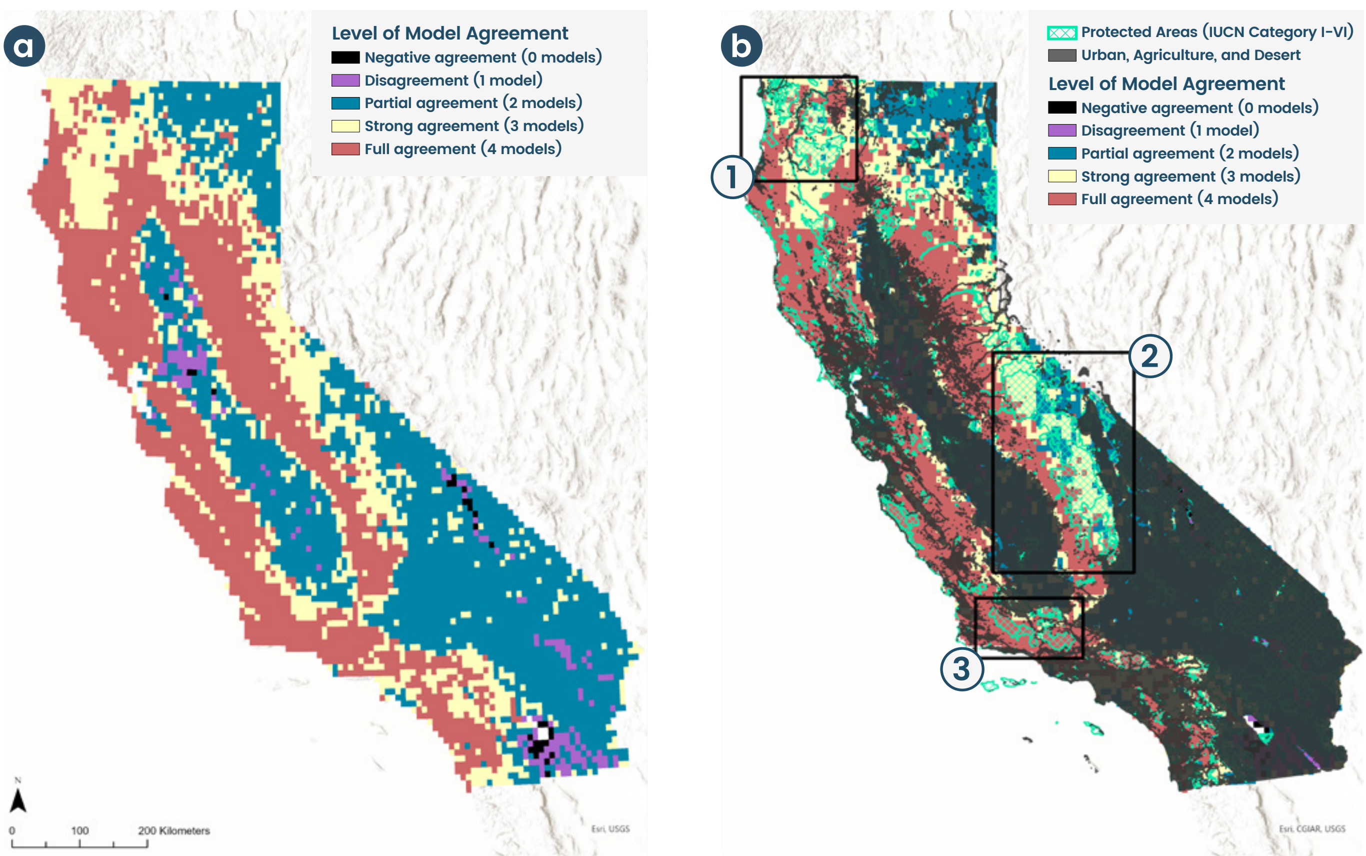


**Figure 2.3.** To predict the total suitable habitat for grizzly bears in California, we compared our model results to identify areas of agreement. (a) Large areas of the state—especially in the Sierra Nevada, Coast Ranges including the Northwest Forest, and Transverse Ranges—show high levels of agreement among three (yellow) or four (red) models. (b) These areas of high agreement contain desert regions, agricultural land, and urban areas that can be masked out. They also contain several blocks of large, mostly or nearly contiguous protected land, including national parks, wilderness areas, national monuments, and other conservation-focused public and private lands. Three such areas stand out: (1) the Northwest Forest, (2) the Sierra Nevada Mountains, and (3) the Transverse Ranges. Reproduced from McInturff et al. [14]

California contains sufficient suitable habitat to make a grizzly recovery feasible (Figure 2.3a). When urban, agricultural, and desert land uses are masked out to make predictions even more conservative, large areas of potentially suitable habitat still remain (Figure 2.3b)

This conclusion differs from the results reached by the USFWS using the "secure habitat" roadless area approach [42]. For its model, the USFWS looked only at the Sierra Nevada and used a single approach to draw its conclusions. By contrast, the conservative approach presented in this chapter uses multiple models and considers all of California. Whereas the USFWS results claim to show that no areas outside its current recovery zones contain sufficient suitable habitat to support a recovering grizzly population, our results suggest that the opposite is probably true. California contains large areas of protected land that are likely to be highly suitable habitats for grizzly bears (Figure 2.3). In Chapters 3 and 4, we explore how the bears may fare in these habitats by focusing on population viability and space use.

## 6 Will there be suitable habitat for grizzly bears in California in the future?

***Climate change, demographics, and shifts in land use and wildlife management have the potential to significantly alter the future distribution and amount of suitable grizzly habitat. Climate change may have mixed but somewhat beneficial effects for grizzlies. California's human population has entered a period of slow or no growth. And although demand for housing and other forms of development remains high, California has seen a significant shift toward greater public and private land protection.***

Climate change may alter future habitat suitability for grizzly bears in California, but its strength, direction, timing, and ultimate effects are difficult to predict. For many species, climate change poses ominous medium- and long-term threats [43]. In some parts of California, particularly in alpine areas, climate change is likely to degrade grizzly habitats. The models presented above prioritize higher-elevation areas, but only to a point, with models converging more strongly in middle-elevation areas where landscape productivity is higher.

In other areas, climate change may improve grizzly habitats by increasing the productivity of key foods. A study of Washington state's North Cascades National Park, for example, found that climate change is likely to improve bear habitat [44].

Human demographic patterns affect future grizzly habitats, but over the coming decades, this is likely to be less important in California than in some other areas. California's population increased from 4.5 million in 1924 to nearly 40 million people in 2024. Yet current data and models show that California's population is plateauing [45] and is unlikely to increase rapidly again any time soon. California's stable or very slow-growing population differs from both the rapid current growth in the Northern Rockies and the precipitous population declines common throughout much of rural Europe. Shifts in the distribution of California's human population are a greater concern. If the high cost of living in major cities, remote work, and the popularity of mountain towns continue to draw more people to the fringes of California's parks and wilderness areas, increased development and recreational use could require greater investments in human-wildlife coexistence.

Although most people are accustomed to hearing about worsening environmental conditions, California has, in fact, made major strides in conservation and ecological restoration. If continued in the years to come, these could significantly increase the amount, quality, and connectivity of grizzly habitat. New federal protections, including wilderness and national monument designations, state investments in conservation and restoration through bond measures and legislation, ambitious work by private conservation land trusts, public-private partnerships on infrastructure projects such as wildlife highway crossings, and the dramatic decline of damaging extractive industries are enabling ecosystems and native species throughout California to recover in ways that would have been difficult to imagine decades ago (see Chapter 8). While many questions remain about the future, it thus appears likely that California will continue to contain plenty of suitable habitat to support a recovering grizzly bear population.

## Opportunities For Future Research

- Future research could build on these results with finer-scale analyses of the ecological and social determinants of habitat suitability.
- Future research examining the potential of climate change on habitat suitability, including its effects on human-bear interactions, would be an important step toward evaluating long-term habitat suitability if decision-makers opt to consider a grizzly bear reintroduction in more depth.
- Future research could seek to develop a better understanding of the food availability (see Chapter 5) provided by California landscapes, which is a critical complement to the habitat suitability models presented in this chapter.
- While all the models presented here incorporate human dimensions both explicitly and implicitly, future research linking patterns of human activities and tolerance for bears with habitat suitability can help refine model predictions.
- In addition to improving spatial models, site-specific social science to understand the local attitudes, values, and behaviors of people living near potential reintroduction sites would be an essential addition to this study.

# Appendix 2.1. Supporting Information

## Section S1. Methods

Full details of technical approaches discussed in this chapter are provided in McInturff et al. [14]. Briefly, each analogy was modeled using logistic regression, a standard analytical approach for determining habitat suitability. We used a statistical technique called the Akaike information criterion (AIC) to select the best possible models for each analogy.

### 1 Historical analogy

This paper used a comprehensive record of historical sources gathered by members of the California Grizzly Research Network between 2016 and 2020. The description of these sources and methods, given below, matches that given in the supplementary materials for a related project by Mychajliw et al. [20] for the research network.

To conduct our primary source research, we used a modified snowball sampling strategy. We began with known primary and secondary sources, used these sources to identify additional sources, and then used these to locate still more. We searched biological databases containing specimen records, scoured paper archives at institutions such as the Museum of Vertebrate Zoology at the University of California, Berkeley, and used the Online Archive of California to search the collections of more than 300 museums, libraries, manuscript collections, and other archives. In these searches, we used the following key terms:

- bear
- grizzly
- grizly
- grisly
- silver tip
- bruin
- cinnamon bear
- brown bear
- ursus
- ursine
- sow
- cubs/yearlings
- oso/osa/osos/osas (oso is the Spanish word for bear)

To determine the accuracy of each location, we developed a scoring system based on how precisely we were able to identify the described location in historical records. Locations were determined based on verbal descriptions containing landmarks, place names, and other features that could be located on contemporary and/or historical maps. Some of these descriptions made it possible to identify locations with high precision, whereas other descriptions provided little detail, such as only naming the county in which a sighting took place. We developed a categorization scheme based on the order of magnitude of precision, ranking the precision of locations on a scale from 1 to 5, with 5 representing a known location of 100 m or less, 4 representing a known location of more than 100 m to 1 km, and 3 representing a known location of more than 1 km to 10 km. Scores of 1 and 2, representing locations of more than 10 km, were excluded from this analysis.

Although we were able to build a collection of 330 records, it probably represents only a fraction of the relevant records that exist, including a variety of more obscure, less discoverable English, Spanish, French, or even Russian-language sources pertaining to grizzlies in California. It is also important to recognize that our historical sources contain no records from Indigenous people because Indigenous populations had been decimated and cultures profoundly disrupted before the late 19th century, so they left few written records. This absence is also because, in many California Indigenous traditions, it is taboo to speak directly about bears, which many people consider ancestors with powers to influence human affairs. In such cultures, bears are often alluded to using indirect or metaphorical terms.

We used this database to create Figure 2.2, which is found in the main body of this chapter. For each county, we identified the year of the latest grizzly record occurring within that county and created a map using these data points.

The analysis was limited to records of the early statehood period of California history, from 1850 to 1880. During this period, many grizzlies still lived in California, but the new state's landscape patterns had begun to resemble those of today. We examined historical grizzly habitat selection using variables reported in the current scientific literature, including natural habitat characteristics, such as elevation, ecosystem type, and distance to water, as well as social characteristics, including human population density, livestock grazing, and distance from roads, mines, and settlements. In cases where important historical information was unavailable, the best available proxy data was used (see Appendix 2.1: Tables S3 and S4). We then applied approaches from contemporary habitat suitability modeling, including model selection using the AIC and a conservative estimation of cutoff points above which habitat can be deemed suitable [21], [22], [23].

We conducted model selection using the 'dredge' function in R, retained models within a score of 2 on the AIC of the best-fit model, and calculated an AIC-weighted average for each parameter. To determine the lower threshold for suitable habitat, we calculated the model-predicted suitability at each of the 141 known locations and discarded the lowest 10% of predicted suitability values to conservatively account for uncertainty, following Radosavljevic and Anderson [46], [47], [48]. We then used the lowest remaining suitability value as our cutoff point, above which our model predicted a habitat would have been suitable.

## 2 Geographical analogy

To identify the most appropriate models, McInturff et al. [14] conducted a systematic literature review of habitat modeling research on brown bears in Europe and the Northern Rockies. We only considered studies that examined field data collected from brown bears between 2000 and 2022. Also, only those studies focusing on first-order habitat suitability (the geographic distribution of a species at the landscape scale) and second-order habitat suitability (the distribution of species within its range) were considered, rather than those focusing on third-order and fourth-order habitat use (specific areas and favored sites, respectively) [25]. Understanding first- and second-order habitat suitability is most relevant to the scale of planning needed to determine reintroduction feasibility in California, as these scales help identify the broad scope of suitable habitat based on both environmental and human drivers. Based on these criteria, 59 candidate studies were identified, but only one study from each region met all criteria: Proctor et al. [50] for the Northern Rockies and Milanesi et al. [49] for Europe.

To complete the analysis, we applied the model estimates from these two source models to California, ensuring that data sources across sites were as similar as possible and that units of measurement matched (Appendix 2.1: Section S1, Table S4, and Table S5).

Each of the source studies mirrored methods used in our historical model, as they used logistic regression and model selection to create habitat suitability models for their respective sites. Following Lyons et al. [22], we penalized the habitat suitability scores for grid cells adjacent to roads and populated areas by 60% within 250 m of roads and by 40% within 251–500 m of roads. Similar to the historical analogy, for each model, we calculated cutoff points for the potential suitable habitats predicted by each model. First, for the European geographic model, we reproduced the model presented in Milanesi et al. [49] and calculated the model values of cells at sites of permanent bear occupancy. We excluded the bottom 10% of these values and used the lowest value as a cutoff point for our California model, as described above for the historical analogy. Second, for the Rocky Mountain geographic model, we used the cutoff points reported by Proctor et al. [50], which followed a similar procedure. Both the European and Rocky Mountain models used social and ecological variables to predict habitat suitability (Appendix 2.1: Tables S1, S4, and S5).

## 3 Taxonomic analogy

For the taxonomic analogy, we used the cutoff points described in Dellinger et al. [37] to identify potential suitable habitat for grizzly bears in the state of California.

## Tables

**Table S1.** Comparison of variables and estimates in each of the four models used in this analysis. The Northern Rocky Mountains model did not scale variables, but all other models did so. More detailed information on each model can be found in Tables S3 to S6. Reproduced from McInturff et al. [14].

| Variable | Historical | Geographic (European) | Geographic (Rocky Mountains) | Taxonomic (puma) |
|---|---|---|---|---|
| Elevation | -0.144 | 83.984 | 0.108 | 0.796 |
| Human population | 0.21 | -1.161 | | |
| Distance to human settlement | -0.173 | 0.087 | | |
| Distance to road | | 0.127 | | -2.093 |
| Distance to road (quadratic) | | | | 0.308 |
| Road density within 32 km | 0.395 | | | |
| Distance to gold mine | 0.242 | | | |
| Converted rangeland area | -0.2 | | | |

**Table S1, cont.**

| Variable | Historical | Geographic (European) | Geographic (Rocky Mountains) | Taxonomic (puma) |
|---|---|---|---|---|
| Distance to river | 0.141 | | | |
| Slope | | | | 1.02 |
| Slope (quadratic) | | | | -0.591 |
| Greenness | | | 14.597 | |
| Canopy openness | | | 0.014 | |
| Alpine vegetation | | | 0.801 | |
| Riparian vegetation | | | 1.091 | |
| Shrubland (linear) | | 38.674 | | |
| Shrubland (quadratic) | | -25.93 | | |
| Forest cover (linear) | | 1.016 | | |
| Distance to open landscape | | | | 0.476 |
| Distance to open landscape (quadratic) | | | | -1.884 |
| Distance to forest cover (quadratic) | | | | -8.865 |
| Distance to shrub cover | | | | -4.39 |
| Deer presence limited | | | | -1.741 |
| Deer present year-round | | | | 1.051 |
| Shannon habitat diversity (linear) | 22.658 | | | |
| Shannon habitat diversity (quadratic) | -32.574 | | | |
| Night light brightness | | -0.303 | | |
| Ecoregion: Northern Basin and Range | -13.673 | | | |
| Ecoregion: Coast Range | 2.705 | | | |
| Ecoregion: Southern California Mountains | 2.454 | | | |
| Ecoregion: Central California Foothills and Coastal Mountains | 1.982 | | | |
| Ecoregion: Mojave Basin and Range | -1.939 | | | |
| Ecoregion: Sierra Nevada | 1.114 | | | |
| Ecoregion: Central California Valley | -0.9 | | | |
| Ecoregion: Southern California/ Northern Baja Coast | 0.447 | | | |
| Ecoregion: Sonoran Basin and Range | -0.423 | | | |
| Ecoregion: Klamath Mountains/ California High North Coast Range | 0.392 | | | |
| Ecoregion: Central Basin and Range | 0.198 | | | |
| Ecoregion: Eastern Cascades Slopes and Foothills | 0.126 | | | |

**Table S2.** Candidate variables in historical habitat suitability modeling. Reproduced from McInturff et al. [14].

| Variable | Category | Hypothesized effect on sighting likelihood | Source |
|---|---|---|---|
| 1880 human population | Human population | Positive. We expect more frequent encounters near human populations due to shared habitat preferences and a greater encounter likelihood. | HYDE 3.2 [51] |
| 1880 rural human population | Human population | Positive. We expect more frequent encounters near human populations due to shared habitat preferences and a greater encounter likelihood. | HYDE 3.2 |
| 1880 urban human population | Human population | Positive. We expect more frequent encounters near human populations due to shared habitat preferences and a greater encounter likelihood. | HYDE 3.2 |
| Distance to human settlements | Human population | Negative. We expect less frequent encounters further from human populations due to shared habitat preferences and a greater encounter likelihood. | HYDE 3.2, Asher and Adams (1874) [52] |
| 1880 converted rangelands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict with humans. | HYDE 3.2 |
| 1880 croplands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| 1880 grazing lands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| 1880 pasturelands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| 1880 rangelands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| 1880 irrigated lands | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| 1880 rain-fed agricultural land | Agriculture | Negative. We expect fewer encounters due to reduced food resources and a greater likelihood of conflict. | HYDE 3.2 |
| Ecoregion (Level 3) | Biophysical | Mixed. We expect strong, varied influences on the encounter likelihood. | Griffith et al. 2016 [53] |
| Elevation | Biophysical | Hump-shaped. We expect encounter rates to increase with elevation due to bears' use of refugia but decrease at the highest elevations where resources are scarce. | EROS GTOPO30[54] |
| Slope | Biophysical | Hump-shaped. We expect encounter rates to increase at higher slopes due to bears' use of refugia but decrease at the highest slopes where resources are scarce. | EROS GTOPO30 |
| Distance to rivers and lakes | Biophysical | Negative. We expect encounter rates to be higher near water sources. | USGS NHD [55] |
| Distance to mines | Resource extraction | Positive. We expect extractive activities to reduce encounters due to human activity, increased conflict, and reduced resources. | MRDS [56], CADOC [57], DMR [58] |
| Mine density (32km) | Resource extraction | Negative. We expect extractive activities to reduce encounters due to human activity, increased conflict, and reduced resources | MRDS, CADOC, DMR |
| Distance to roads | Resource extraction | Positive. We expect extractive activities to reduce encounters due to human activity, increased conflict, and reduced resources | Asher and Adams (1874), Mitchell (1868) [59] |
| Road density | Resource extraction | Negative. We expect extractive activities to reduce encounters due to human activity, increased conflict, and reduced resources | Asher and Adams (1874), Mitchell (1868) |

Notes. EROS = Earth Resources Observation and Science. GTOPO30 = Global 30 Arc-Second Elevation. USGS = U.S. Geological Survey. NHD = National Hydrography Dataset. MRDS = Mineral Resources Data System. CADOC = California Department of Conservation. DMR = Division of Mine Reclamation.

**Table S3.** Predictors of brown bear encounters from 1850–1880 from the top-scoring model by AIC. Reproduced from McInturff et al. [14].

| Variable | Estimate** | SE | p-value |
|---|---|---|---|
| (Intercept) | -2.465 | 0.758 | 0.001 |
| Human population | 0.21 | 0.129 | 0.103 |
| Distance to gold mine | 0.242 | 0.123 | 0.049 |
| Road density within 32 km | 0.395 | 0.138 | 0.004 |
| Converted rangeland area | -0.2 | 0.129 | 0.124 |
| Distance to river | 0.141 | 0.189 | 0.455 |
| Distance to settlement | -0.173 | 0.222 | 0.438 |
| Elevation | -0.144 | 0.211 | 0.497 |
| Ecoregion: Northern Basin and Range* | -13.673 | 750.494 | 0.985 |
| Ecoregion: Coast Range | 2.705 | 0.84 | 0.001 |
| Ecoregion: Southern California Mountains | 2.454 | 0.843 | 0.004 |
| Ecoregion: Central California Foothills and Coastal Mountains | 1.982 | 0.815 | 0.015 |
| Ecoregion: Mojave Basin and Range | -1.939 | 1.275 | 0.129 |
| Ecoregion: Sierra Nevada | 1.114 | 0.788 | 0.158 |
| Ecoregion: Central California Valley | -0.9 | 0.94 | 0.339 |
| Ecoregion: Southern California/Northern Baja Coast | 0.447 | 1.031 | 0.665 |
| Ecoregion: Sonoran Basin and Range | -0.423 | 1.061 | 0.69 |
| Ecoregion: Klamath Mountains/ California High North Coast Range | 0.392 | 0.897 | 0.663 |
| Ecoregion: Central Basin and Range | 0.198 | 1.065 | 0.853 |
| Ecoregion: Eastern Cascades Slopes and Foothills | 0.126 | 1.068 | 0.906 |

*Notes.* SE = standard error.
*Reference ecoregion: Cascades.
**Variables were scaled.

**Table S4.** Predictor variables for the Rocky Mountain model. Reproduced from Proctor et al. [50]AIC.

| Variable | Estimate* | Robust SE | Robust probability | Lower 95% CI | Upper 95% CI | Original data source and units | CA data source and units |
|---|---|---|---|---|---|---|---|
| Intercept | -11.524 | 1.33 | < 0.001 | -14.122 | -8.927 | NA | NA |
| Greenness | 14.597 | 1.517 | < 0.001 | 11.625 | 17.57 | Landsat 8 [60], unitless 0–1 | Landsat 8, unitless 0–1 |
| Canopy openness | 0.014 | 0.002 | < 0.001 | 0.009 | 0.018 | USFS [61], 0%–100% | USFS, 0%–100% |
| Alpine | 0.801 | 0.312 | 0.01 | 0.19 | 1.412 | USFS, categorical | NLCD [62], categorical |
| Elevation | 0.108 | 0.049 | 0.025 | 0.013 | 0.204 | EROS GTOPO30 [54], meters ASL | EROS GTOPO30 |
| Riparian | 1.091 | 0.407 | 0.007 | 0.292 | 1.89 | USFS, categorical | NLCD, categorical |

*Notes.* SE = standard error. CI = confidence interval. NA = not applicable. USFS = U.S. Forest Service. NLCD = National Land Cover Database. EROS = Earth Resources Observation and Science. GTOPO30 = Global 30 Arc-Second Elevation. ASL = above sea level.
*Variables were not scaled, meaning coefficients should not be compared directly.

**Table S5.** Predictor variables for the European model. Reproduced from Milanesi et al. [49]

| Variable | Estimate* | Probability | Original data source and units | CA data source and units |
|---|---|---|---|---|
| Elevation | 83.984 | < 0.0001 | ASTER [63] meters ASL | EROS GTOPO30 [54] meters ASL |
| Shrublands (linear) | 38.674 | < 0.0001 | CORINE [64], categorical | NLCD [62], categorical |
| Shrublands (quadratic) | -25.93 | < 0.0001 | CORINE, categorical | NLCD, categorical |
| Forest cover (linear) | 1.016 | < 0.0001 | CORINE, categorical | NLCD, categorical |
| Shannon diversity (linear) | 22.658 | < 0.0001 | CORINE, unitless | NLCD, unitless |
| Shannon diversity (quadratic) | -32.574 | < 0.0001 | CORINE, unitless | NLCD, unitless |
| Distance to human settlements | 0.087 | < 0.0001 | CORINE, km | NLCD, km |
| Distance to roads | 0.127 | < 0.0001 | OpenStreetMap [65], km | OpenStreetMap, km |
| Night light brightness | -0.303 | < 0.0001 | NOAA [66], NIR | NOAA, NIR |
| Human population density | -1.161 | < 0.0001 | Eurostat [67], people/km$^2$ | CIESIN [68], people/km$^2$ |

*Notes.* EROS = Earth Resources Observation and Science. GTOPO30 = Global 30 Arc-Second Elevation. CORINE = Coordination of Information on the Environment. NLCD = National Land Cover Database. NOAA = U.S. National Oceanic and Atmospheric Administration. NIR = near infrared. CIESIN = Center for Integrated Earth System Information. ASL = above sea level
* Variables were scaled.

**Table S6.** Resource selection function model for puma habitat in California. Reproduced from Dellinger et al. [37]

| Variable | Estimate* | Standard error | Probability |
|---|---|---|---|
| Elevation | 0.796 | 0.153 | < 0.001 |
| Slope | 1.02 | 0.272 | < 0.001 |
| Slope (quadratic) | −0.591 | 0.264 | 0.025 |
| Distance to open landscapes | 0.476 | 0.249 | 0.056 |
| Distance to open landscapes (quadratic) | −1.884 | 0.469 | < 0.001 |
| Distance to forest cover | −3.727 | 2.655 | 0.161 |
| Distance to forest cover (quadratic) | −8.865 | 5.013 | 0.077 |
| Distance to shrub cover | −4.390 | 2.301 | 0.056 |
| Distance to secondary road | −2.093 | 0.362 | < 0.001 |
| Distance to secondary road (quadratic) | 0.308 | 0.069 | < 0.001 |
| Deer presence limited | −1.741 | 0.476 | < 0.001 |
| Deer present year-round | 1.051 | 0.169 | < 0.001 |

* Variables were scaled.

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## Chapter 3

# Predicted Habitat Use and Movement

By Ellen M. Pero, Sarah Sells, Alex McInturff & Peter S. Alagona

California Grizzly Alliance

## Key Points

Accounting for suitable habitat, minimum area, and public land protections, California hosts 3 potential core recovery areas for grizzly bears in the Northwest Forest, Sierra Nevada, and Transverse Ranges.

Grizzly bears reintroduced into potential core recovery areas would use habitats mainly in middle-elevation, forested wilderness areas.

Studies show that most reintroduced brown bears remain close to well-selected release sites. Brown bears tend to move more than normal during the initial months after their release before settling into more typical movement patterns by the second year in their new location.

A grizzly population in California would likely range more widely as recovery progresses, using some habitats in buffer zones around and between core recovery areas. Our analysis shows that in California, as in other grizzly recovery areas, most of this habitat use would occur in mixed-use public lands administered by the U.S. Forest Service.

Predicted overlaps between grizzly and human land use could eventually occur along the boundaries of potential core recovery areas. Maps of these overlaps point to high-priority management areas for future coexistence efforts.

California contains considerable suitable habitat in three largely contiguous core recovery areas. Yet, these three areas are relatively disconnected from one another. Efforts to reconnect California's wildlands, particularly focusing on the corridor between the Sierra Nevada and the Transverse Ranges, would greatly improve the prospects for a successful long-term recovery.

# Introduction

Before animals are moved into a new location, it is important to have some sense of how they might use their new habitats [1]. It is impossible to predict exactly where and when a large, mobile animal will move from one place to another, but models can help us identify areas with key resources, barriers, and potential threats [2] that could shape these movements. Understanding how human presence and land use may influence an animal's movement is especially important for species such as grizzly bears, whose populations are often limited both geographically and numerically by human-caused deaths [3]. In cases where sufficient data on animals in a reintroduction area is absent, data collected and models developed in other regions can provide a helpful first step to understanding how animals may move and use resources in their new home range (e.g., [4]).

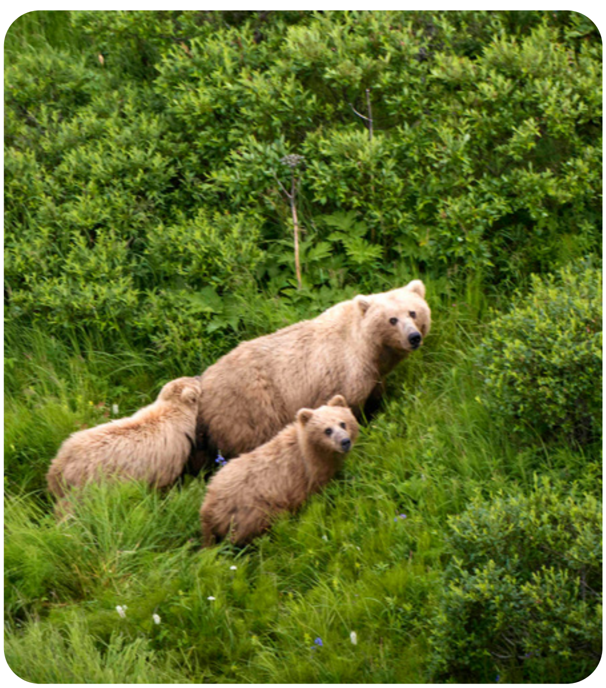

Photo: Buddy Weisse / @tandemstock

In this chapter, we build on habitat suitability findings from Chapter 2 to define three potential core recovery areas for California grizzlies, in the Sierra Nevada, Transverse Ranges, and Northwest Forest. We then apply a model developed by grizzly bear researchers in the Northern Rockies to predict space use by simulated bears within these large, mostly contiguous tracts of protected, likely high-quality grizzly habitat. In our model, predicted space use by simulated bears mostly occurred in or near core recovery areas and had limited overlap with areas of high human presence and development. Our long-range predictions indicate that some bears may wander outside the core recovery areas to nearby mixed-use public lands administered by the U.S. Forest Service. Although bears would probably take many years to expand into these areas, these results could help proactively identify high-priority areas for coexistence efforts. Our work also shows that although California's three potential core recovery areas are highly protected and contiguous internally, they are mostly disconnected from one another. The results presented toward the end of this chapter highlight areas to prioritize for future wildlife connectivity projects.

# Questions

## 1 How do reintroduced brown bears select resources and move across landscapes?

***Most but not all reintroduced brown bears remain close to well-selected release sites. Brown bears tend to move more than normal during the initial months after their release before settling into more typical movement patterns by the second year in their new location.***

In conservation, the term translocation refers to the process of moving animals to new locations, including reintroducing them to portions of their historical ranges. Translocated animals face a number of potential challenges. Once released, they must establish home ranges that meet their needs, including avoiding predators and finding food, mates, and shelter. Most translocated animals eventually settle in or near their release sites. For brown bears, such sites should have sufficient food resources and land protections and should minimize the likelihood they will come into conflict with humans [5]. Some translocated individuals may, however, abandon their release sites, potentially exposing them to greater dangers, such as traffic collisions. Animals may even attempt to return to their former ranges, a behavior known as homing [6].

Managers can reduce problems associated with site abandonment by using the best capture and transport practices and by selecting the most conducive release sites (see Chapter 10). The best release sites are typically similar to the translocated animals' places of origin. For brown bears, females that have parted with their mothers but have not yet reached full maturity are the most likely to remain near their release sites [7]. Subadult female bears are also among the most important for establishing viable populations, given their long-term reproductive potential.

Like many other species [8], [9], brown bears tend to move more than is typical for their age and sex during the period immediately following their release but then return to more normal movement patterns as they grow familiar with their new home ranges [10], [11]. Some may wander initially before settling down in a new location or returning to establish new home ranges around their release sites. In the Trentino area of northern Italy, for example, 1 out of 9 brown bears abandoned their release areas [10]. In the Cabinet-Yaak recovery zone of northwestern Montana, 6 out of 22 grizzly bears left their release area, one of which managers successfully returned [7].

Following their initial acclimatization period, most translocated brown bears move in patterns similar to resident bears, including those that have never been translocated. In the Cabinet-Yaak recovery zone, the home ranges of translocated subadult females were similar in size to those of other grizzly bears already in the area [7]. In Trentino, translocated bears had larger home ranges in the initial year after reintroduction compared with those in their native range in Slovenia (Table 3.1) [10], [12] but then settled into similar or slightly smaller home ranges during Years 3 to 16 following their arrival [13]. Reintroduced Trentino brown bears also used habitats in patterns that generally matched—with 70% to 80% agreement across most mapped landcover categories—the predictions of habitat suitability models developed for the same area [14], [15]. Reintroduced individuals used orchard, shrubland, and wetland habitats more than anticipated, but as predicted, they mostly used mixed and deciduous forests and avoided cultivated and other developed areas.

**Table 3.1**

Average home range sizes (100% Minimum Convex Polygons) of bears translocated to Trentino, Italy (female n = 8, male n = 3) [10] in their first year (Year 1) following reintroduction compared to native bears in Slovenia (female n = 9, male n = 8) [12]. Averages are reported in $km^2$ with standard deviations reported in parentheses.

| Sex | Trentino (reintroduced range – Year 1) | Slovenia (native range) |
|---|---|---|
| Females | 298 (575) $km^2$ | 73 (81) $km^2$ |
| Males | 620 (409) $km^2$ | 176 (193) $km^2$ |

## 2 Where would California grizzly recovery areas be located?

***California contains 3 regions—spanning portions of the Northwest Forest, Sierra Nevada, and Transverse Ranges—that contain large areas of protected, high-quality habitat, which could serve as potential core recovery areas.***

Chapter 2 used multiple methods to assess the suitability of potential grizzly bear habitats in California. When identifying recovery areas, important considerations beyond habitat suitability include total minimum area, availability of resources, dispersal requirements of the species, habitat connectivity, land protections, and social tolerance, including political support and coexistence measures. Potential core recovery areas should, for example, optimize habitat quality and space requirements while reducing the potential for conflicts and bear deaths [1], [16].Starting with the suitable habitat maps from Chapter 2, we identified potential core recovery areas that met two criteria:

(1) The entire area must be part of contiguous designated wilderness areas (IUCN category VI or higher as defined by the International Union for Conservation of Nature [IUCN]), and these areas must be greater than 3000 $km^2$, where contiguous means sharing a border with or being within 20 km of the nearest neighboring wilderness boundary. Maximum grizzly bear dispersal distances may reach 80–175 km, but average natal dispersal distances are 30–67 km for males and less than 15 km for females [17]. We thus identified 20 km as a conservative midpoint between male and female dispersal distances but recognized that females, with their more constrained movements, are usually the limiting factor in a population’s geographic expansion.

(2) At least 75% of a potential core recovery area must have high model agreement (≥ 3 models) for predicted suitable habitat, and 100% of the area must be within modest model agreement (≥ 2 models) for predicted suitable habitat (see Chapter 2).

Applying these conservative criteria produced three large potential core recovery areas, which we refer to as the Sierra Nevada, Transverse Ranges, and Northwest Forest (Figure 3.1). In total, the areas identified comprise 33,654 km² having 100% IUCN category VI protections, with 23,850 km² in the Sierra Nevada alone. The North Cascades Ecosystem (NCE) grizzly recovery zone in Washington state, by comparison, contains 24,773 km² of land, only around 41% of which has IUCN category VI protections.

As shown in Figure 3.2, habitats available in these three potential recovery areas share broad similarities with the current grizzly bear recovery areas designated by the U.S. Fish and Wildlife Service (USFWS): the Northern Continental Divide Ecosystem (NCDE), Greater Yellowstone Ecosystem (GYE), Selkirk Ecosystem and Cabinet-Yaak Ecosystem (SE/CYE), and Bitterroot Ecosystem (BE), along with the NCE mentioned previously. Potential core recovery areas in California span the range of primary productivity indices based on the Normalized Difference Vegetation Index (NDVI) observed in USFWS recovery zones. We found the highest NDVI values were in the Northwest Forest and the lowest in the Sierra Nevada, likely owing to the low productivity of the Sierra's extensive subalpine and alpine areas (Figure 3.2). Similarly, ruggedness values and the densities of and distances to the forest edge were generally similar across California's potential core recovery areas and the current USFWS recovery zones. The density of riparian habitat types was comparable across all current and potential California recovery areas, with the exception of California's relatively arid Transverse Ranges. Because all three of the potential core recovery areas in California are 100% designated wilderness, they contain lower building densities and lower distances to secure habitat than most of the current recovery zones. When the potential core recovery areas are extended to include a 50-km buffer zone, building densities and distances to secure habitat in two of the three potential recovery areas become comparable to the current USFWS zones. The exception is the Transverse Ranges potential core recovery area, which, if extended 50 km to the south, includes several small- and medium-sized Southern California cities (Figure 3.2).

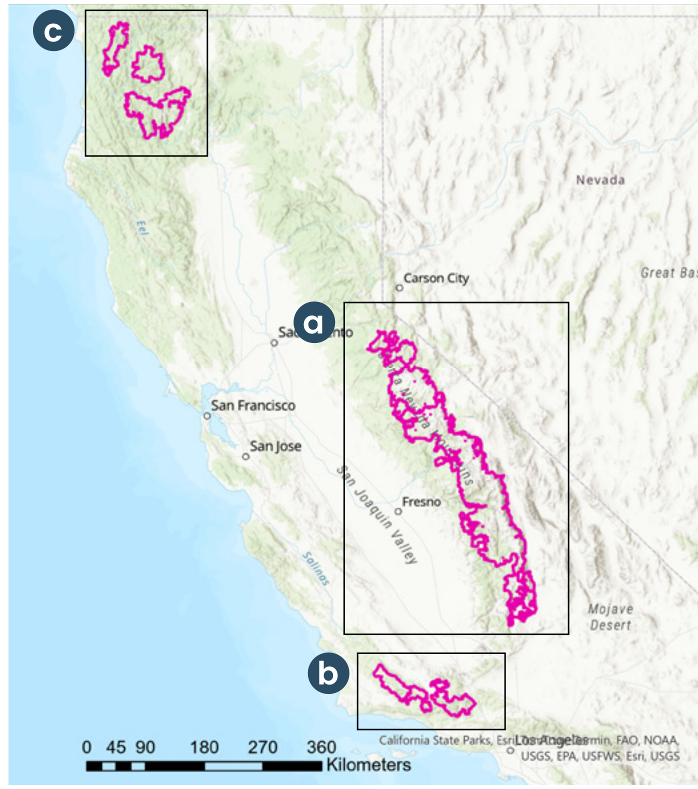


**Figure 3.1.** Map of three potential core recovery areas in California, based on suitable habitat, minimum area, and public land protections: the (a) Sierra Nevada, (b) Transverse Ranges, and (c) Northwest Forest.

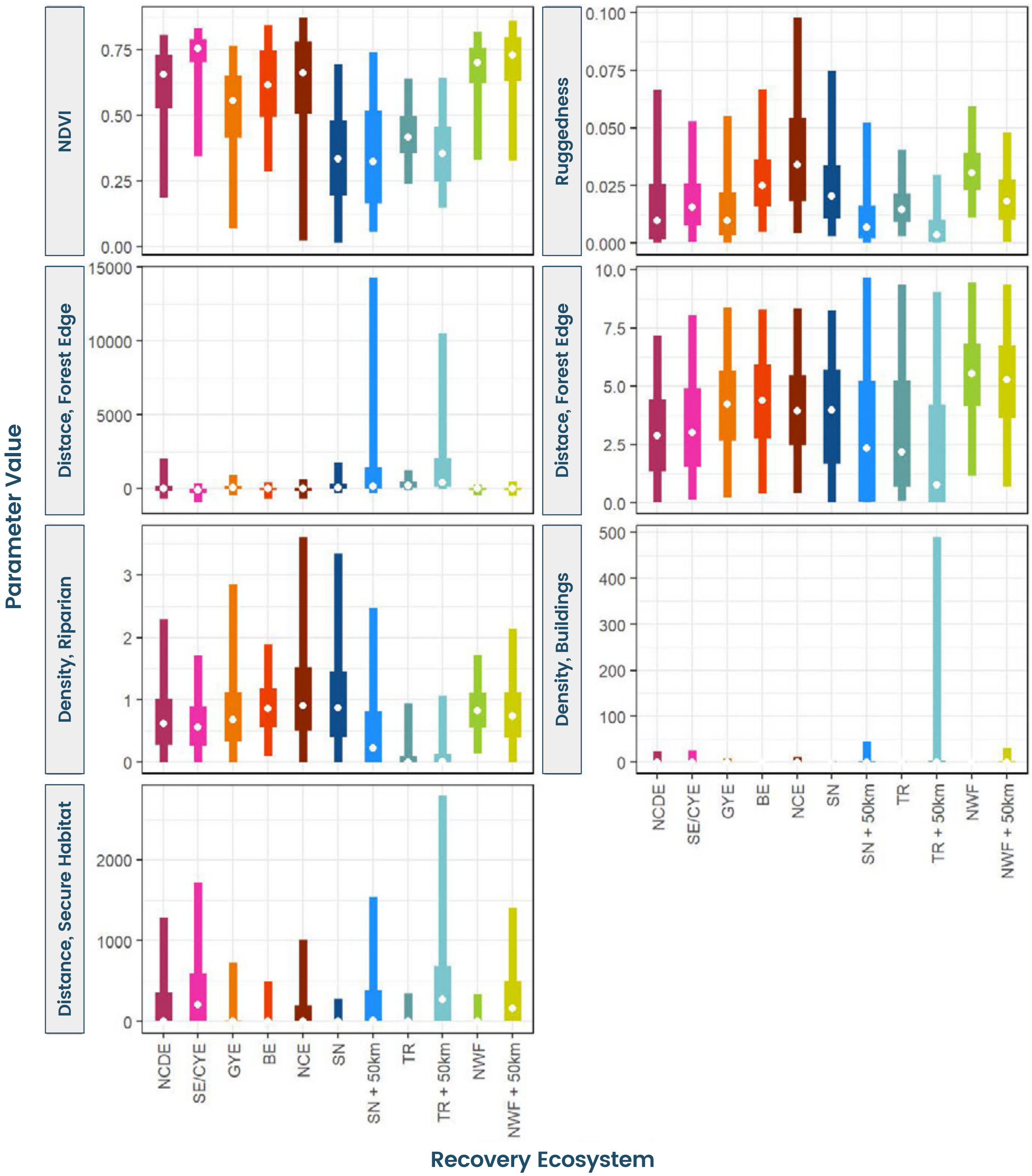


**Figure 3.2.** Some key habitat values for California's three potential core recovery areas—the Sierra Nevada (SN), Transverse Ranges (TR), and Northwest Forest (NWF)—along with their 50-km buffer zones, when compared with grizzly bear ecosystems currently designated by the U.S. Fish and Wildlife Service: the Northern Continental Divide (NCDE), Selkirk/Cabinet-Yaak (SE/CYE), Greater Yellowstone, (GYE), Bitterroot (BE), and North Cascades (NCE) Ecosystems. White dots represent median values, rectangles reflect 50% interquartile ranges, and lines capture the 95% value range for each habitat characteristic and recovery ecosystem. NDVI = Normalized Difference Vegetation Index.

## 3 How would grizzly bears use space in California's potential recovery core areas?

***Model results suggest that grizzly bears reintroduced into potential core recovery areas would use habitats mainly in middle-elevation, forested wilderness areas.***

The habitat suitability models presented in Chapter 2 tell us where potential grizzly habitats are located, but spatial models of bear movement are needed to predict how bears might use these habitats and circulate within them. We used a model built by Sells et al. [18] to predict how reintroduced grizzly bears may use potential core recovery areas in California. This model uses data from GPS-collared grizzly bears in Montana's NCDE to produce "virtual grizzly bears" that mimic movement patterns shown in the GPS data. These virtual bears are then placed at random locations within potential core recovery areas and set to roam across the landscape over a predetermined number of steps. To guide the virtual bears' movements, Sells et al. [18] applied their GPS collar data to seven landscape variables: terrain ruggedness, distance to the forest edge, density of the forest edge, density of riparian areas, density of buildings, a proxy for food abundance (NDVI during the peak green-up of Jun. 15 to Jul. 15), and the distance to secure habitat (defined by the USFWS as areas on public, state, and tribal lands > 500 m from roads). We describe these methods further in Appendix 3.1: Section S1 and refer readers to Sells et al. [18], [19], [20], as well as Sells and Costello [4], [21], for additional details and applications.

Using the approach from Sells et al. [19], [20] and Sells and Costello [4], [21], we applied space-use models from Sells et al. [18] to California's three potential core recovery areas and to 50-km buffer areas around them (Figure 3.1). Previously, this approach had been applied to and validated in other areas, including the GYE, SE, and CYE [19]; the BE [4]; areas between the NCDE, SE, CYE, BE, and GYE [20]; the NCE of Washington state and British Columbia [22]; and the Great Plains of central and eastern Montana [21]. Although California's potential core recovery areas differ ecologically from other studied landscapes, we can apply established models to California as an initial step toward understanding how future grizzlies may move and use habitats within the state.

In all three of California's potential core recovery areas, predicted space use by simulated grizzly bears was highest in mid-elevation forests. In the Sierra Nevada, higher predicted habitat use occurred on middle-elevation western slopes (1100 m to 3000 m), with the greatest levels of use in the central and southern portions of the potential core recovery area (Figure 3.3a). In the Transverse Ranges, higher predicted use areas were focused in the central and eastern portions of the potential core recovery area, with the highest use in middle and upper elevations (1200 m to 2500 m; Figure 3.3.b). In the Northwest Forest, lower-elevation use was more common, with relatively high use under 2000 m in the central and southern portions of the core area (600 m to 1900 m; Figure 3.3c). It is important to note that these patterns likely differ from where grizzlies would actually appear in the landscape, particularly in the early years of a recovery effort. This difference arises because our model released virtual bears at randomly selected locations throughout the potential recovery

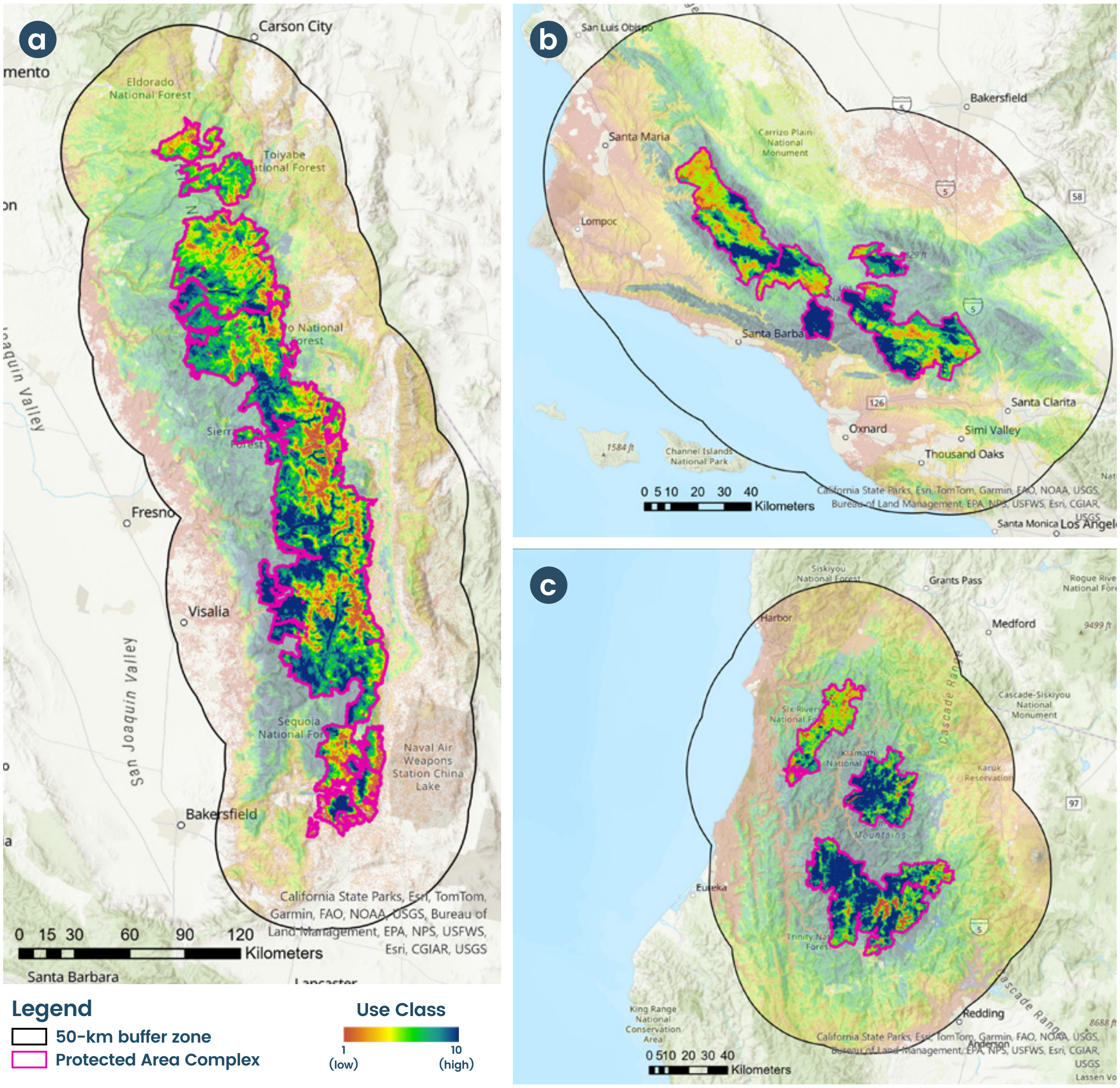


**Figure 3.3.** Predicted grizzly bear use in the (a) Sierra Nevada, (b) Transverse Ranges, and (c) Northwest Forest. Potential core recovery areas are outlined in pink, and 50 km buffer areas are outlined in black. Predicted use is shown on a standard deviation stretched rainbow scale, with areas of opaque blue shading representing the highest predicted use and areas of opaque red shading representing the lowest predicted use. Modeled bear use outside potential core recovery areas is shown using transparent shading.

areas, whereas actual release sites would likely be placed in the recovery areas' most remote and ecologically conducive locations. Once potential release sites are identified, future research could use these locations to develop more specific modeled predictions and support decision-making (e.g., [22]).

## 4 How would reintroduced grizzly bears use space outside of potential core recovery areas?

***A grizzly population in California would likely range more widely as recovery progresses, using some habitats in buffer zones around and between core recovery areas. Our analysis shows that in California, as in other grizzly recovery areas, most of this habitat use would occur in mixed-use public lands administered by the U.S. Forest Service together with some adjacent tribal lands.***

Many reintroduced carnivores tend to avoid humans but may move through home ranges that include mixed-use landscapes beyond parks and wilderness areas. To better understand how a recovering population of grizzly bears may move in California, we extended our analyses to include a 50-km buffer beyond the boundaries of potential core recovery areas (Figure 3.4). Our model suggested that outside of core recovery areas, grizzlies would mainly use habitats on non-wilderness U.S. Forest Service lands and adjacent tribal reservation lands. In the Sierra Nevada, these sites mostly included mixed-use areas on the range's western slope (Figure 3.4a). In the Transverse Ranges, predicted use outside potential core recovery areas encompassed both lower-elevation habitats south of the potential core recovery area and higher-elevation habitats to the north (Figure 3.4b). In the Northwest Forest, predicted grizzly movement outside the potential core recovery area was concentrated mainly in forested public lands between large designated wilderness areas (Figure 3.4c).

Photo: Grant Ordelheide / @tandemstock

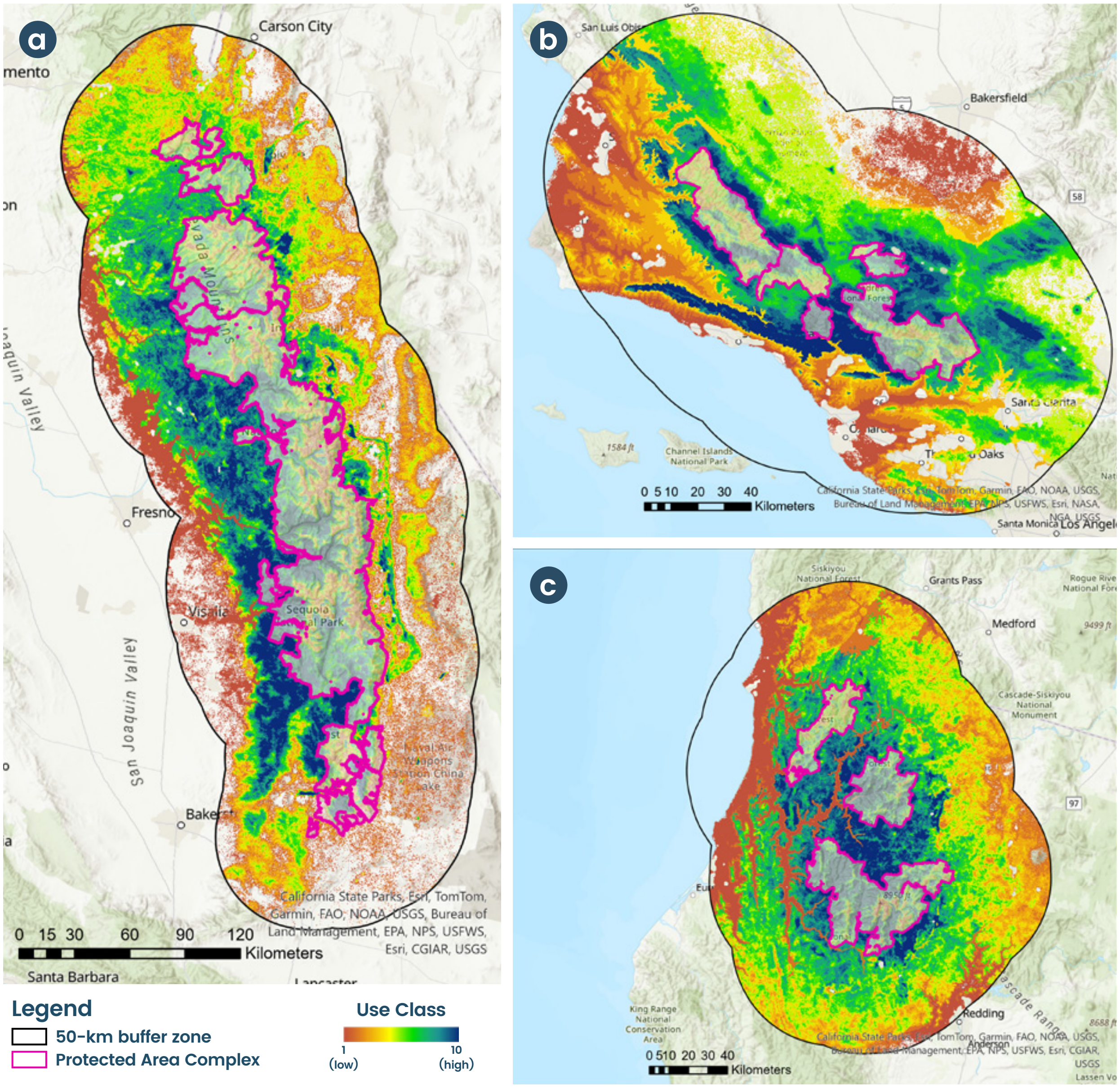


**Figure 3.4.** Predicted grizzly bear use of 50-km buffers around California's three potential core recovery areas: (a) Sierra Nevada, (b) Transverse Ranges, and (c) Northwest Forest. Potential core recovery areas are outlined in pink, and 50-km buffer areas are outlined in black. The degree of predicted use is shown on a standard deviation stretched rainbow scale, with opaque blue areas representing the highest predicted use and opaque red areas representing the lowest predicted use areas. Modeled bear use inside potential core recovery areas (the opposite of Figure 3.3) is shown using transparent shading.

## 5 How would grizzly bear space use overlap with areas of increased human use?

***Predicted overlaps between grizzly bear and human land use could eventually occur along the boundary edges of our study's potential core recovery areas, and to a lesser extent, along primary trails and roadways. Maps of potential overlap show high-priority areas to focus future coexistence efforts.***

Grizzly bears typically avoid areas of high human use [23], [24], [25], even when those areas contain otherwise high-quality habitats [26]. To identify areas of high human use in and around potential core recovery areas—and to understand potential overlap between areas of high human and potential bear space use—we performed an overlap analysis of predicted bear use with the most recent (2019) Human Influence Index (HII) [27]. The HII maps the human "footprint," drawing from data on population pressure (population density), land use and infrastructure (built-up areas, nighttime lighting, and land use/cover), and access (coastlines, roads, trails, railroads, and navigable rivers). As shown in Figure 3.5, from our overlap analysis, the output values that are near zero reflect lower levels of potential overlap (represented by yellow shading), whereas values near 1 reflect higher potential overlap areas (represented by red shading). Non-value areas in Figure 3.5 (represented with no color on the yellow-to-red shading scale) suggest little potential overlap because grizzly bear use, human influence, or both are likely to be very low. We include a more detailed account of this analysis in Appendix 3.1: Section S2.

Throughout California, areas where grizzly bears and human activities might eventually overlap were predicted to be outside core recovery areas, along wilderness boundaries, and to a lesser extent, along trails and roadways (Figure 3.5). In the Sierra Nevada, our model predicted very little overlap (0.00–0.06 on a 0–1 scale) in the potential core recovery area, most of which occurred within 500 m to 1 km of trail systems or within 3 km of roadways near wilderness boundaries. In the Sierra's 50-km buffer, the model predicted overlaps around more developed areas on the range's eastern and western slopes (Figure 3.5a). In the Transverse Ranges, predicted overlaps were mostly limited to the boundaries of wilderness areas and trails crossing them, as well as around communities near the boundaries of protected areas along the potential core recovery area's southern border (Figure 3.5b). In the Northwest Forest, the model predicted small overlaps along limited trail systems, along the boundaries of wilderness areas, and around communities and recreational sites near the eastern fringe of the recovery area (Figure 3.5c).

This overlap analysis is a first attempt to understand the most likely areas where humans and grizzly bears might cross paths in the future. Despite its speculative nature, however, it has considerable value for recovery planning. It points to areas that may be a focus for future monitoring and coexistence efforts, including educational and infrastructure investments, while also pointing to locations that could provide future bear-viewing tourism opportunities (see Chapters 7 and 8).

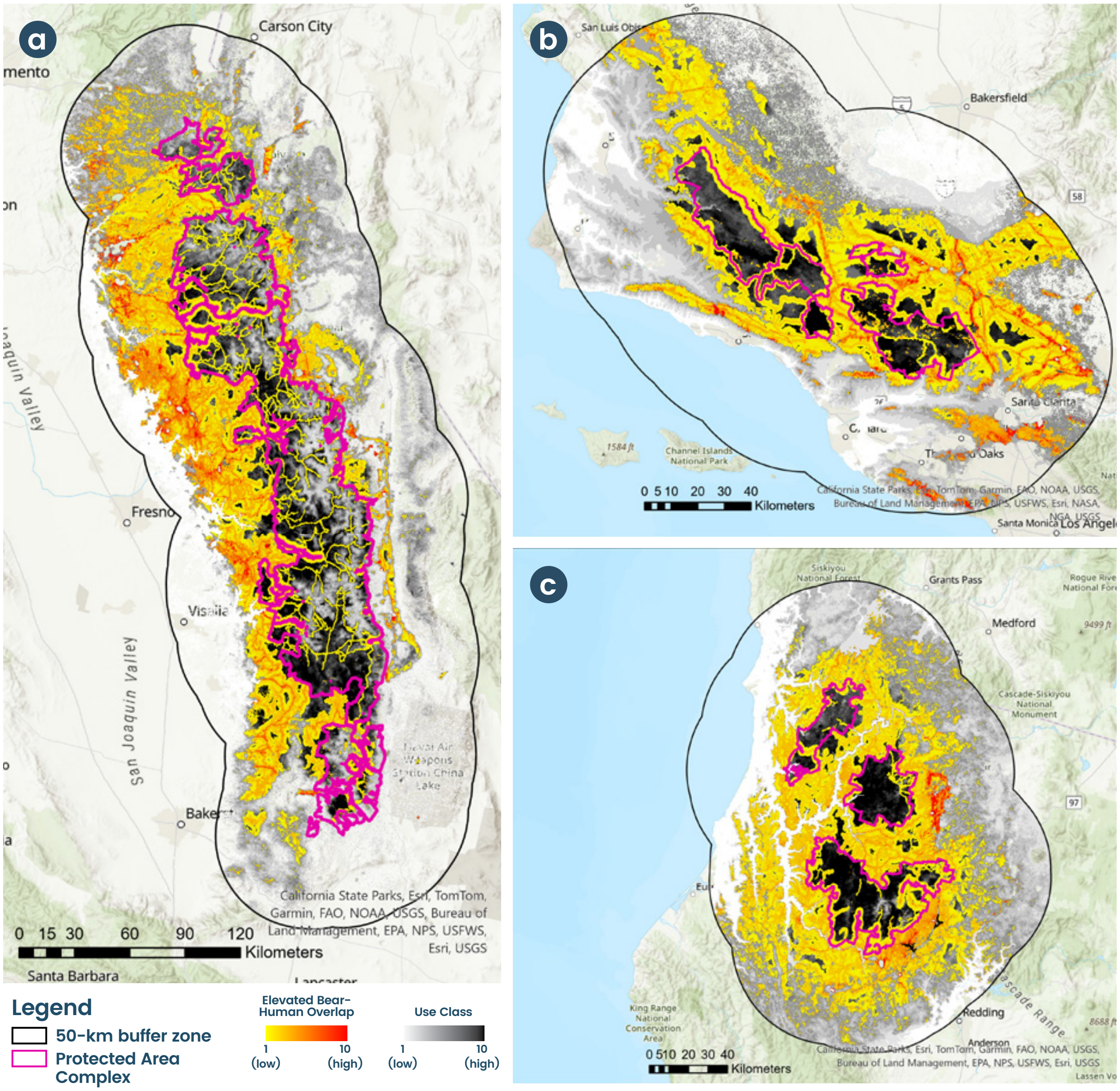


**Figure 3.5.** Overlap of predicted grizzly bear and human use in California's three potential core recovery areas—(a) Sierra Nevada, (b) Transverse Ranges, and (c) Northwest Forest—and associated 50-km buffers. Potential core recovery areas are outlined in pink, and 50-km buffer areas are outlined in black. The amount of overlap is represented with a 2% clip stretched red-yellow scale, with yellow areas having lower predicted overlap, red areas having higher predicted overlap, and areas with no red-to-yellow shading having little or no overlap. The black-to-white shading scale depicts predicted bear habitat use, with darker areas reflecting high use in areas with little or no HII overlap.

## 6 Would grizzly bears move between potential core recovery areas?

***California contains considerable suitable habitat in three largely contiguous core recovery areas. Yet, these three areas are relatively disconnected from one another. Efforts to reconnect California's wildlands, particularly focusing on the corridor between the Sierra Nevada and the Transverse Ranges, would greatly improve the prospects for a successful long-term recovery.***

Connectivity is essential to any wildlife conservation effort [5]. Animals must be able to navigate between areas of suitable habitat to respond to ecological and climatic changes [28] and to ensure long-term gene flow among populations [29]. Some species, such as pumas, are extremely sensitive to connectivity due to their propensity for long-distance dispersal, and susceptibility to inbreeding depression at low effective population sizes [30]. Brown bears are less sensitive to isolation than pumas, but researchers still consider connectivity essential for brown bears' long-term population viability (see Chapter 4).

California's three potential core recovery areas are relatively contiguous internally, with very high connectivity in the Sierra Nevada—most of the Sierra's wilderness areas share their boundaries with other wilderness areas—and relatively high connectivity in the Transverse Ranges and the Northwest Forest. Additional connectivity research that incorporates resistance surfaces, road barriers and crossing structures, and human tolerance within the state would further inform internal connectivity within target recovery areas. California also maintains some connectivity with mountain habitats further north, as illustrated by the return of wolves and occasional appearances of wolverines (*Gulo gulo*) in the state. However, grizzly bears are unlikely to return to California on their own in the foreseeable future due to their comparatively lower natural dispersal capacity (see Chapter 4 for further discussion).

Connections between California's recovery areas could improve in the coming years with investments in land conservation, habitat restoration, wildlife highway crossings, and coexistence efforts that enable animals to travel more freely across the landscape. The grizzly could serve as a flagship for these projects, but such investments would aid dozens of valued, sensitive, endangered, and recovering species while improving traffic safety in some currently hazardous areas. In recent years, the State of California has passed two laws to advance these efforts (the Safe Roads and Wildlife Protection Act of 2022 [31] and the Room to Roam Act of 2024 [32]), and the state is currently home to the world's most ambitious wildlife connectivity project, the Annenberg Crossing of the 101 Freeway in Southern California. Advocates are using such recent legislation and this high-profile effort to advance dozens of other such projects around the state.

For grizzly bears, a couple of key areas stand out as high priorities for connectivity efforts. The potential core recovery areas of the Sierra Nevada and Transverse Ranges are roughly 100 km apart. Their 50 km buffer zones are thus contiguous, but our simulations suggest that bear use in these areas would likely only occur through a narrow corridor. Other high-priority areas for future connectivity projects could include connections to new habitat areas in the northern Sierra Nevada and Cascades, as well as connections between these areas and the Northwest Forest.

## Opportunities For Future Research

- Future research could focus on prioritizing sites for wildlife connectivity projects, such as protected corridors and highway crossing structures, by integrating current road barriers into our understanding of bear movement patterns and decisions.
- Future research efforts could build on our maps of potential grizzly use outside potential recovery areas by integrating human tolerance across the landscape to better identify high-priority communities for coexistence projects.
- If grizzlies are reintroduced to California, researchers could collect data on bear movement and resource selection patterns to validate the model predictions provided in our study and, thus, refine future conservation needs.

# Appendix 3.1. Supporting Information

## Section S1. Predicted grizzly bear space use in California

We simulated grizzly bears' use of potential core recovery areas in California (Figure 3.1) using the Sells et al. [18] individual-based movement models built from 46 female and 19 male grizzly bears in the Northern Continental Divide Ecosystem (NCDE). The capture and handling of NCDE grizzly bears was conducted under permits issued by the U.S. Fish and Wildlife Service (USFWS) for technical assistance pursuant to the 4(d) rule of the Endangered Species Act. Protocols were approved in writing by the Montana Fish, Wildlife, and Parks Animal Care and Use Committee [33]. Each bear model was built as an integrated step-selection function (iSSF), which has an exponential form such that $w(x) = \exp(x\beta)$; $w(x)$ is the iSSF score, x is a vector of habitat covariates, and β is the coefficient vector estimated via conditional logistic regression [34], [35]. GPS data from bears collared (Telonics, Mesa, Arizona, USA) from 2004 to 2020 during the primary active season (May–Nov.) provided known bear locations with an interval of 3 hours (± 45 min). Each iSSF compared seven environmental covariates measured at each bear's known location with covariate measurements from 10 random locations nearby (sampled from the bear's distribution of step lengths and turn angles between 3-hour fixes). The seven covariates included in a global iSSF were an index to food abundance (i.e., the Normalized Difference Vegetation Index [NDVI] during peak green-up of Jun. 15 – Jul. 15), terrain ruggedness, distance to the forest edge, density of the forest edge, density of riparian areas, density of buildings, and distance to secure habitat (defined by the USFWS as areas on public, state, and tribal lands > 500 m from roads). To identify a final predictive iSSF for each of the 65 NCDE bears in their study, Sells et al. [18] iteratively eliminated terms from the global iSSF to identify which model formulation maximized the cross-validation score for that individual. Thus, the final model for some bears was the global iSSF, and the final model for others had fewer variables.

Simulations entailed representations of the seven environmental covariates based on raster data (300-m cell resolution, prepared using the same methods as Sells et al. [18]) for the state of California plus a 100-km planar buffer within the United States. This extent constituted the simulation boundary to provide simulated bears the opportunity to move with relatively little constraint. For each simulation iteration within Program R [36], we used a selected bear's iSSF to calculate a conductance surface across the simulation area as exp(□xi), where □ was the coefficient vector of the estimated iSSF and xi the vector of habitat covariates of cell i [37]. We trimmed extremes using the 0.025 and 0.975 quantile values and normalized the remaining values to a 0–1 scale [38].

We performed sets of simulations separately for each of the three potential core recovery areas (Figure 3.1). For each simulation, we added an individual simulated bear to a start node drawn randomly from within the potential core recovery area. For each sequential step, we generated 11 possible steps from the bear's observed step length and turn angle distributions and sampled the simulated bear's next step from the probability-weighted steps based on the iSSF. Simulated bears continued generating and selecting from 11 possible steps a total of 5000 times to provide opportunities to explore the potential core recovery area. Simulated bears could also wander from sites within the potential core recovery area to anywhere within the simulation boundary. For each individual bear and each of the three potential recovery areas, we completed 100 simulations for females and 242 simulations for males to yield approximately equal total simulation iterations per sex (4600 iterations for females and 4598 iterations for males).

Upon completing simulations, for each potential core recovery area, plus a 50-km buffer around the area (hereafter, "potential recovery area"), we summed total steps per raster cell across iterations for each sex and for combined sexes. We next disqualified step sums in cells with more than 100 buildings per square kilometer to omit areas grizzly bears are unlikely to successfully use near humans. We also manually downgraded step counts in cells with elevations less than 500 m, given the observed use patterns within the NCDE where applicable models were built and given the improved validation scores associated with this method's application to simulated bears in and near the NCE [22]. To downgrade cells with elevations less than 500 m, following [22], we divided the elevation at the cell by 500 and replaced the step sum with this value, which changed step sums to range from 0.00 for cells at sea level up to 0.99 for cells at 499 m. Next, for each sex and for combined sexes, we calculated the relative predicted use of each potential core recovery area by binning steps within each boundary area into 10 quantile classes of relative probability of use. The lowest use was given Class 1, and the highest use was named Class 10. Accordingly, the 10% of cells at elevations greater than or equal to 500 m and with the greatest use in simulations were assigned Class 10, followed by Class 9 for the next 10% of cells with the next greatest use, etc. Based on their downgraded values of 0.00–0.99, cells with elevations less than 500 m were assigned the lowest class values (e.g., 1–3, depending on how many cells occurred < 500 m, with the lowest being Class 1 at or near sea level).

## Section S2. Predicted grizzly bear use and human influence overlap

To visualize the potential overlap between the areas of human and predicted bear space use, we multiplied the simulated bear use in each potential recovery area with the most recent map of the Human Influence Index (HII) [27]. The HII indexes the human footprint of the landscape based on human population density, land use and infrastructure (built-up areas, nighttime lighting, and land use/cover), and access (coastlines, roads, trails, railroads, and navigable rivers). The index scales from 0 to 64 and is estimated at a spatial resolution of 1 $km^2$ [27].

Before multiplication, we normalized both simulated bear use and HII values to put both sets of values on the same scale and to ensure output would be on an intuitive 0–1 scale. We restricted areas of analysis to only include areas with likely simulated bear use and non-marginal levels of human use. Our threshold for simulated bear use ensured we included only areas with a classification greater than iSSF Class 5, the midpoint simulated step class from space-use simulations. For the human footprint, we included only areas with an HII greater than 1.3, the mean HII from across all potential core recovery areas' boundaries. The threshold on simulated bear use ensured that only areas with likely simulated bear use were evaluated, while the HII threshold ensured that only areas with some level of human influence were evaluated. We set the HII threshold intentionally low, at 1.3, to be conservative and capture areas where above-average simulated bear use overlaps even low areas of human influence. We then performed overlap analysis via raster multiplication. As shown in Figure 3.5, output values closer to zero reflect lower levels of potential overlap (represented by yellow shading), values closer to 1 reflect higher potential overlap areas (represented by red shading), and non-value areas reflect marginal to no potential overlap (i.e., either simulated bear use was below average, or HII was very low: < 1.3 on a 0–64 scale; represented with no color in Figure 3.5).

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## Chapter 4

# Population Viability

By Ellen M. Pero, Alex McInturff & Peter S. Alagona

California Grizzly Alliance

## Key Points

Baseline estimates suggest that California could support viable populations of grizzly bears in three potential core recovery areas, including 832 (298–1204) bears in the Sierra Nevada, 236 (85–342) in Northwest Forest, and 115 (41–167) in the Transverse Ranges. These estimates do not account for a number of social and ecological factors, pointing to a need for future research.

We conducted a simple population viability analysis using average to conservative demographic rates under four scenarios. While this model contains considerable uncertainty, our results suggest that a reintroduced founder population of 25 grizzly bears could become established and grow slowly over several decades. If growth rates are lower than expected, additional translocations could help sustain the population, giving time for adaptive management efforts to better address its limiting factors.

Challenges that may limit the growth of a recovering California grizzly population include risks involving the translocation process itself, as well as a variety of post-release effects that could hinder reproduction and/or increase mortality. Human-caused deaths could hinder the population's growth, as could a lack of habitat connectivity. The effects of climate change are unclear.

A reintroduction and recovery program with the best chance of success would establish a genetically diverse initial founder population, occasionally supplement this population with additional female bears, implement a rigorous monitoring effort, harness the data gathered to build increasingly sophisticated models, and then use this improved understanding to support flexible adaptive management.

# Introduction

The chief goal of any reintroduction effort is to establish a viable population of a species in a recovery area. An important step in this process is to gain an understanding of how the reintroduced population may fare in its new habitat, including any factors that could hinder its ability to become established, grow numerically, expand geographically, and maintain itself over time. Estimating an area's ability to support a viable population involves several practical and inherent challenges [1], such as insufficient information about habitat quality, available nutrition, space use, and the range of plausible demographic rates [2]. Human culture and land use may also be important, especially with regard to large carnivore species like brown bears that often suffer the greatest number of deaths because of humans [3].

Quantitative approaches to modeling these dynamics, known as population viability analyses (PVAs), are cornerstones of conservation biology [4]. Over the past half-century, scientists and managers in North America and Europe have collected extensive demographic data and built increasingly sophisticated PVAs to understand brown bear population dynamics. This work provides a strong foundation for a California grizzly PVA. Yet because no current data exists on grizzly populations in California, a model for the state must rely on demographic data gathered and assumptions developed elsewhere. A PVA focusing on California grizzly bears should thus be regarded as a crucial first step and building block for future research.

In this chapter, we first provide initial estimates of the maximum population sizes that California's three potential core recovery areas may sustain. We then describe the results of a California grizzly PVA we built for this Feasibility Study. Our model uses demographic rates from the small, recovering grizzly population in the Cabinet-Yaak Ecosystem (CYE) of northwest Montana, which has benefitted from a series of translocations dating back to the 1990s. We used this data to run a series of PVA simulations under four scenarios based on assumptions ranging from average to highly pessimistic (compared with the CYE data). A range of factors, from unexpectedly high human-induced mortality to climate change, could significantly alter our results. Based on the available information, however, our model suggests that a reintroduced founder population of 25 grizzly bears in one of California's three potential core recovery areas could become established and grow slowly, reaching the area's potential carrying capacity over several decades.

# Questions

## 1 How many grizzly bears can live in California?

***Baseline estimates suggest California could support viable populations of grizzly bears in three potential core recovery areas, including 832 (298–1204) bears in the Sierra Nevada, 236 (85–342) in Northwest Forest, and 115 (41–167) in the Transverse Ranges. These estimates do not account for a number of social and ecological factors that could prove important, pointing to a need for future research.***

California could likely sustain a moderate, perhaps even robust, population of grizzly bears in three large potential recovery areas today (Figure 4.1). Our estimates of maximum population size in these three areas—which are based on land area and density extrapolations from other brown bear populations—suggest that the Sierra Nevada could contain around 832 grizzlies (a minimum of 298 to a maximum of 1204), the Northwest Forest could house around 236 grizzlies (a minimum of 85 to a maximum of 342), and the Transverse Ranges could hold around 115 grizzlies (a minimum of 41 to a maximum of 167). Assuming that grizzlies could not live outside these three areas, then California could currently support around 1183 grizzlies (a minimum of 424 to a maximum of 1713). This estimate for the state is equal to one-third of the U.S. Fish and Wildlife Service's (USFWS's) current recovery target of around 3500 grizzlies for the Northern Rockies and North Cascades.

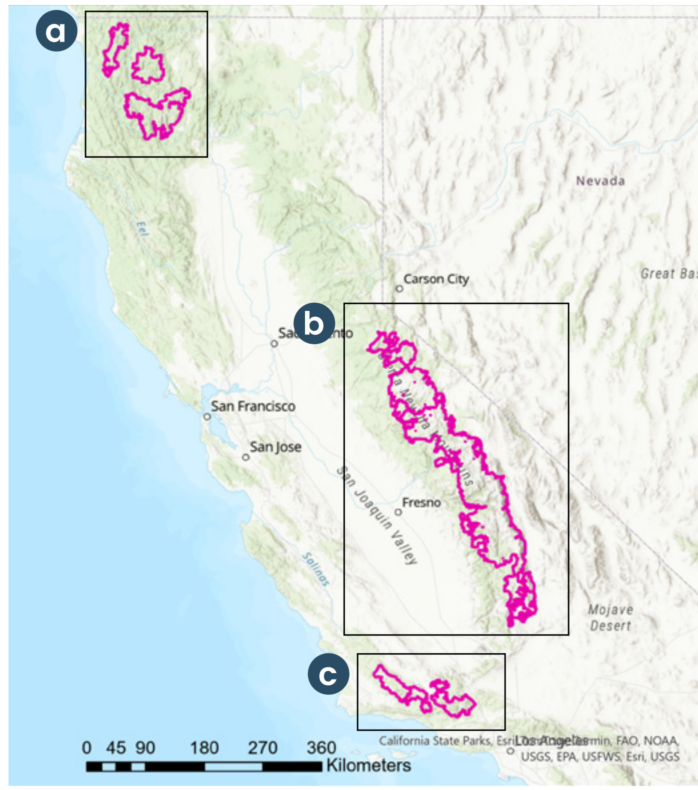


**Figure 4.1.** Map of three potential core recovery areas for grizzlies in the (a) Northwest Forest, (b) Sierra Nevada, and (c) Transverse Ranges. For more on how we defined these areas using measures of potential suitable habitat, see Chapter 3.

To arrive at these estimates for California, we used data on brown bear densities from other regions. We began with population density figures for grizzlies in the western United States and Canada, which biologists previously had used to inform estimates of the grizzly carrying capacity in the North Cascades Ecosystem (NCE) [5]. We also gathered density estimates for Eurasian brown bears living in habitats relatively similar to some of those found in California (Appendix 4.1: Table S1). We summarized these density estimates using their mean (average), 25th percentage quartile (low), and 75th percentage quartile (high). We then extrapolated these summarized density estimates to the land area contained in California's three potential core recovery areas (Figure 4.1; see Chapter 3).

As simple density extrapolations, our estimates of maximum population sizes assume that the habitat available in California is similar in quality to the habitats observed across the populations from which we summarized our density estimates (Appendix 4.1: Table S1). Our density extrapolations further assume that habitat quality does not vary within or across California's potential core recovery areas. Our estimates do not explicitly account for a number of factors that could affect, positively or negatively, grizzly bear carrying capacity in California. These include spatially variable habitat quality and the amount of nutrition available for grizzly bears in California, particularly given climate change, competition from black bears, and grizzly bears' foraging habits in ecosystems where scientists have not previously studied them. Published papers describing models of grizzly bear nutrition and carrying capacity in the North Cascades and Canadian Rockies offer useful templates for similar future work focusing on California [5], [6]. Chapter 5 provides distribution maps for some key grizzly bear food groups in California's three potential core recovery areas, which could also provide a basis for further research building on the analyses presented here. Another key question involves the potential for higher-than-expected human-caused killings, as discussed below and in Chapters 6, 7, and 8, and how such bear mortality risk may vary across the landscape.

## 2 How might a grizzly population grow over time in California?

***We conducted a population viability analysis using average to conservative demographic rates under four scenarios. Our results suggest that a reintroduced founder population of 25 grizzly bears could become established and grow slowly over several decades. If growth rates are lower than expected, additional translocations could help sustain the population, giving time for adaptive management efforts to better address its limiting factors.***

To understand how a reintroduced and recovering population of grizzly bears in California might grow over time, the best place to start is with data from other brown bear populations. Survival and growth rates for brown bears vary over time, as well as among and within populations [7]. Typically, adult female brown bears—which are, demographically, the most important members of any population—have survival rates greater than 90%. Especially high adult female survival rates are typical of populations that are not too small or isolated, are not subject to hunting pressure, and are at levels below the habitat area's carrying capacity [8]. Despite these high survival rates, however, brown bear populations tend to grow slowly, owing to the bears' long pre-reproductive maturation period, 3-year birthing and maternal care cycle, relatively small litter size, and limited rates of female dispersal [9], [10].

*Population viability analyses* (PVAs) are quantitative demographic models that forecast current and future trends in population dynamics [11]. PVAs can help scientists and managers better understand how various factors shape wildlife populations over time, including their growth rates and extinction risks. PVAs involve explicit reasoning, integrate multiple sources of information, and usually require long-term demographic data from the study area to reduce uncertainty [11], [12]. In the absence of reliable local data—for example, when modeling a potential species reintroduction—researchers can use data from other regions to compare demographic scenarios, explore the likely results of management actions, and establish benchmarks for taking management actions, such as translocating additional individuals.

We used a PVA to model the potential future population dynamics of a reintroduced grizzly bear population in California. We briefly describe the methods and results of this model here; for more detailed information, see Appendix 4.2.

We built a simple, stage-structured matrix population projection model, where the relative abundance of a given sex-age class depended on user-defined demographic parameters. These parameters included the bears' *reproduction rate* (number of cubs per female per year), survival rate, transition probabilities for when bears move between age classes, and translocation parameters, including the starting population size and supplementation rate. We then performed a series of four simulations based on different demographic and management scenarios to represent a range of potential trajectories. For each of the four scenarios, we ran 100 iterations of the model simulation. For each iteration, we projected population viability for 50 years after the initial translocation and incorporated stochasticity into demographic parameters (i.e., survival and reproduction). For all scenarios, we used a starting population of 25 bears, and we assumed, following established best practices (see Chapter 10), an approximate founder population sex ratio of 70:30 biased toward females and the subadult age class (Table 4.1). We then divided the recovering population into four age classes: cubs-of-the-year (< 1 year old), yearlings (1 year old), subadults (2–4 years old), and adults (> 5 years old).

For all our scenarios, we used parameter rates based on demographic data from the CYE grizzly bear population in northwest Montana [13]. The CYE is a small population with fewer than 50 individuals, has been closely monitored since 1983, and was used to inform population projections for the NCE [14]. This approach comes with two caveats. First, despite decades of monitoring, the small sample sizes captured in the CYE data mean that these parameter rates involve uncertainty. Second, it is unclear how similar the rates observed in the CYE population would be to rates in California, given the many differences between these regions. To account for these uncertainties, we used multiple demographic scenarios, conservatively ranging from average to pessimistic, and we more than doubled the variation observed in vital rates for the CYE (Table 4.2).

For Scenario 1, we set out to establish a baseline by simulating a California grizzly population using average values for survival and reproduction from

**Table 4.1**

Grizzly bear abundance by sex and age class for the starting population used in all simulations (1–4). Bear ages in parentheses.

| **Males** | | | | **Females** | | | |
|---|---|---|---|---|---|---|---|
| Adults (5+) | Subadults (2–5) | Yearlings (1–2) | Cubs (0–1) | Adults (5+) | Subadults (2–5) | Yearlings (1–2) | Cubs (0–1) |
| 1 | 6 | 0 | 0 | 3 | 15 | 0 | 0 |

**Table 4.2**

Vital rates for all population viability scenarios (1–4). Scenarios 1 and 2 used mean vital rates from the Cabinet-Yaak Ecosystem (CYE). Scenario 2 included 10 initial years of reduced vital rates based on low-end rate estimates from the CYE. Scenarios 3 and 4 assumed reduced vital rates for the entire study period. Scenario 3 assumed no supporting management actions, whereas Scenario 4 assumed supplemental translocations (noted as "suppl." in the table) of two female subadults (FSAs) every 10 years. Standard errors for all rates were inflated to 0.2 from observed rates in the CYE and are listed in parentheses below demographic parameters. Supplementation was not applied where NA is indicated in the table.

| | | Survival | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Male | | Female | | | | | |
| Scenario | Years | Adult | Subadult | Adult | Subadult | Yearling | Cub | Fecundity^ | Suppl. |
| (1) CYE | 1–50 | 0.881 (0.2) | 0.871 -0.2 | 0.915 (0.2) | 0.87 -0.2 | 0.902 (0.2) | 0.632 (0.2) | 0.772 -0.2 | NA |
| (2) CYE + post-release effects | 1–9 | 0.786 (0.2) | 0.871 -0.2 | 0.845 (0.2) | 0.867 (0.2) | 0.775 (0.2) | 0.481 (0.2) | 0.62 -0.2 | NA |
| | 10+ | 0.881 (0.2) | 0.871 -0.2 | 0.915 (0.2) | 0.87 -0.2 | 0.902 (0.2) | 0.632 (0.2) | 0.772 -0.2 | NA |
| (3) CYE low | 1–50 | 0.786 (0.2) | 0.871 -0.2 | 0.845 (0.2) | 0.867 (0.2) | 0.775 (0.2) | 0.481 (0.2) | 0.62 -0.2 | NA |
| (4) CYE low + suppl. | 1–50 | 0.786 (0.2) | 0.871 -0.2 | 0.845 (0.2) | 0.867 (0.2) | 0.775 (0.2) | 0.481 (0.2) | 0.62 -0.2 | 2 FSA, every 10 yr |

^ # offspring/adult female/year

the CYE (Table 4.2). This simulation resulted in a population with a positive growth rate (stochastic lambda = 1.04; confidence interval [CI] ± 0.02) that reached 150 bears within 50 years (Figure 4.2).

For Scenario 2, we sought to explore how a period of low initial fertility and survivorship might affect a reintroduced grizzly population. Most translocated wildlife populations undergo an initial period of low population growth owing to several factors known collectively as post-release effects [15]. The period with which post-release effects operate varies across taxa. For translocated elk, it appears to last for around a year, whereas some birds [16], [17] and rabbits [18] may rebound more quickly. Kasworm et al. [13] reported lower survival for both male and female translocated grizzlies (0.771 [CI = 0.531–1.0] and 0.60 [CI = 0.296–0.904], respectively) compared with resident grizzlies in northwest Montana. Sufficient data is not available, however, to draw generalizable conclusions about these effects for brown bears, including how long the period of reduced demographic rates following translocation may last.

For these reasons, in Scenario 2, we adopted a conservative approach. We simulated a 10-year period of reduced reproduction and survival across all sex and age classes, assigning the low-end parameter estimates from confidence intervals for all demographic parameters observed in the CYE (Table 4.2) [13]. This simulation produced a grizzly population that dipped to approximately 17 individuals by Year 10, but then rebounded, as post-release effects waned, to more than 60 individuals by Year 50. Population persistence in this scenario was 100%, and stochastic lambda across the projection interval was 1.02 (CI ± 0.02; Figure 4.3).

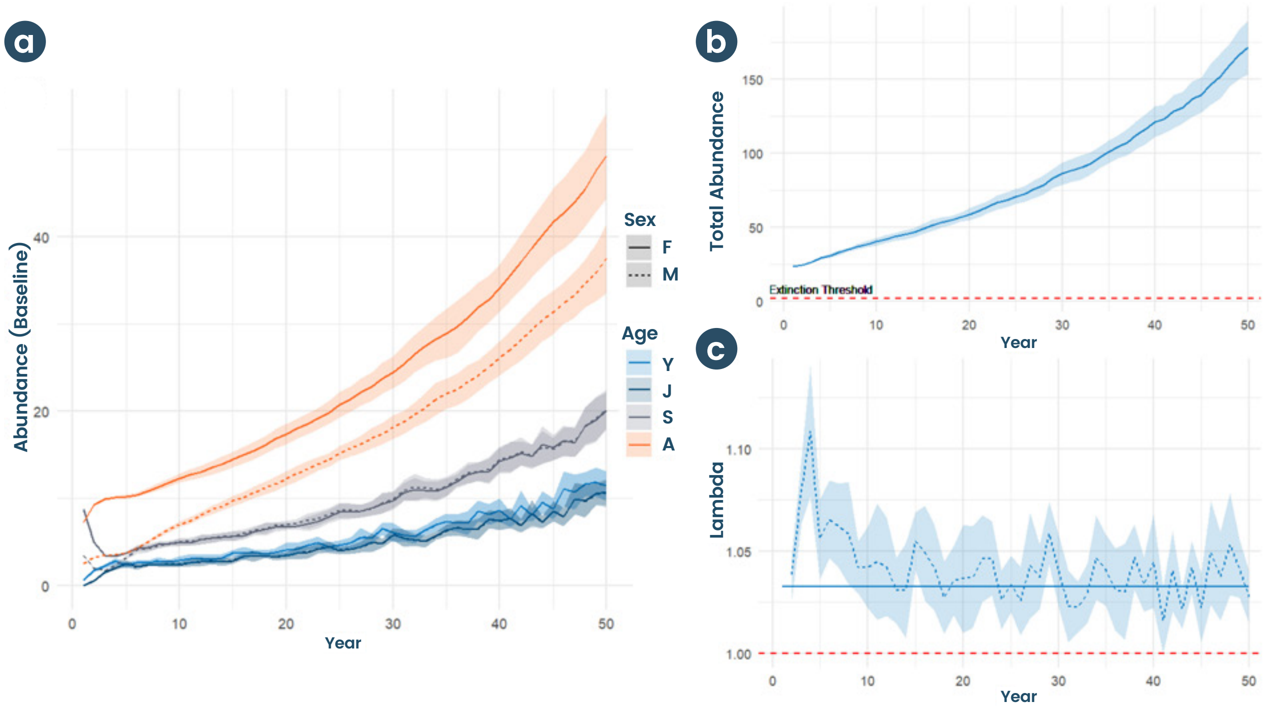


**Figure 4.2.** Baseline simulated grizzly bear (a) sex- and age-specific abundance, (b) total abundance, and (c) stochastic (dotted line) and mean (solid line) lambda for the 50 years following translocation. The simulation assumes 25 starting bears (female cub [FC]: 0, female yearling [FY]: 0, female subadult [FSA]: 15, female adult [FA]: 3, male cub [MC]: 0, male yearling [MY]: 0, male subadult [MSA]: 6, male adult [MA]: 1). The extinction threshold is set at one bear of each sex.

For Scenarios 3 and 4, we investigated the consequences of poorer-than-expected demographic rates, both without and with management interventions. In Scenario 3, our most pessimistic simulation, we assumed that demographic rates remained depressed after initial translocations and the post-release effect period, and that no measures were taken to aid the small, struggling population. In this case, the stochastic lambda across the projection interval was 0.94 (CI ± 0.02), resulting in 0% persistence probability with an average time to quasi-extinction of 37.3 years (CI ± 2.57; Figure 4.4; Table 4.2).

For Scenario 4, we used the same pessimistic demographic assumptions as in Scenario 3, but we assumed that managers would address persistently poor demographic rates by adding two subadult female grizzlies to the population once every decade. Additional translocations beyond initial founder populations, whether planned at the outset or embraced as part of an adaptive management strategy, are common features of reintroduction and recovery programs, including for brown bears in places like the CYE. According to our model, additional translocations maintained a population above the quasi-extinction level, with a population of around five individuals at Year 50. Although Scenario 4 avoids extinction, the population by Year 50 is small and declining, with a stochastic lambda of 0.97 (CI ± 0.02; Figure 4.5). Faced with such poor demographic rates, managers would need to consider further actions beyond additional once-a-decade translocations to improve the population's reproduction and/or reduce its mortality (e.g., [28]). Scenario 4 illustrates why effective monitoring of small populations can be so important (see Chapter 10).

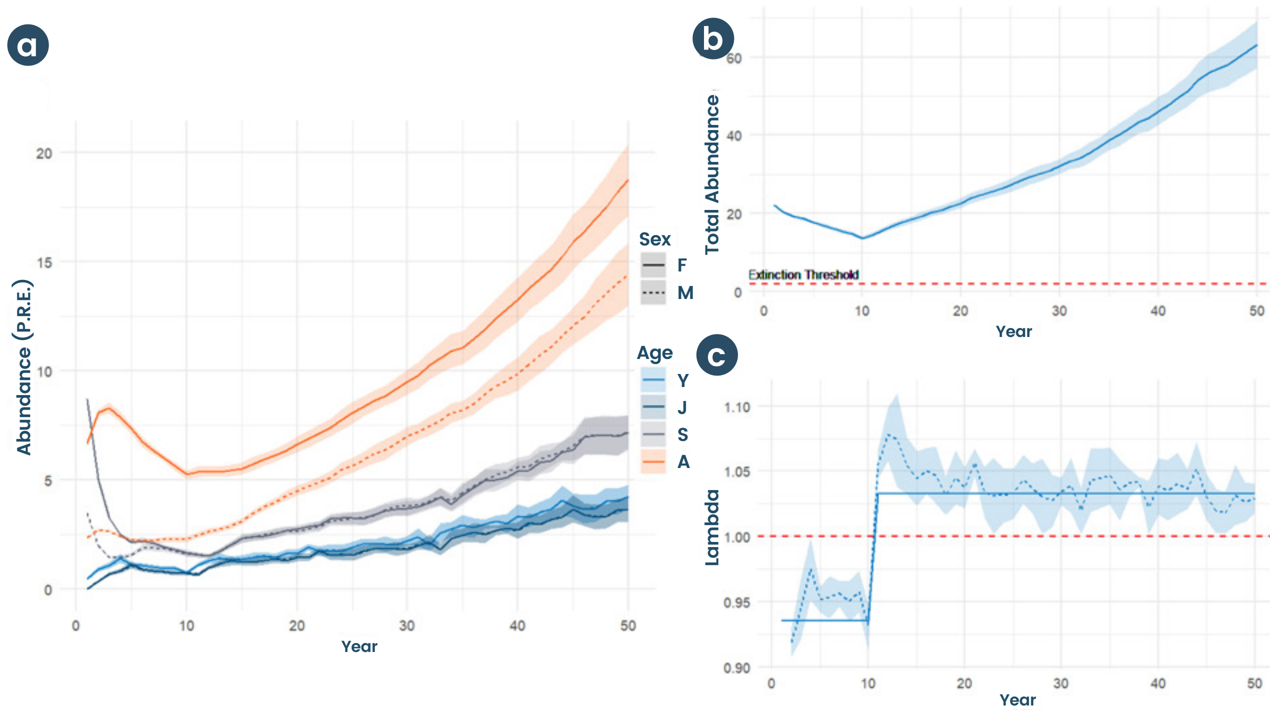


**Figure 4.3.** Simulated grizzly bear (a) sex- and age-specific abundance, (b) total abundance, and (c) stochastic (dotted line) and mean (solid line) lambda for the 50 years following translocation, assuming 10 years of post-release effects and decreasing vital rates from CYE baseline estimates. The simulation assumes 25 starting bears (FC: 0, FY: 0, FSA: 15, FA: 3, MC: 0, MY: 0, MSA: 6, MA: 1). The extinction threshold is set at one bear of each sex.

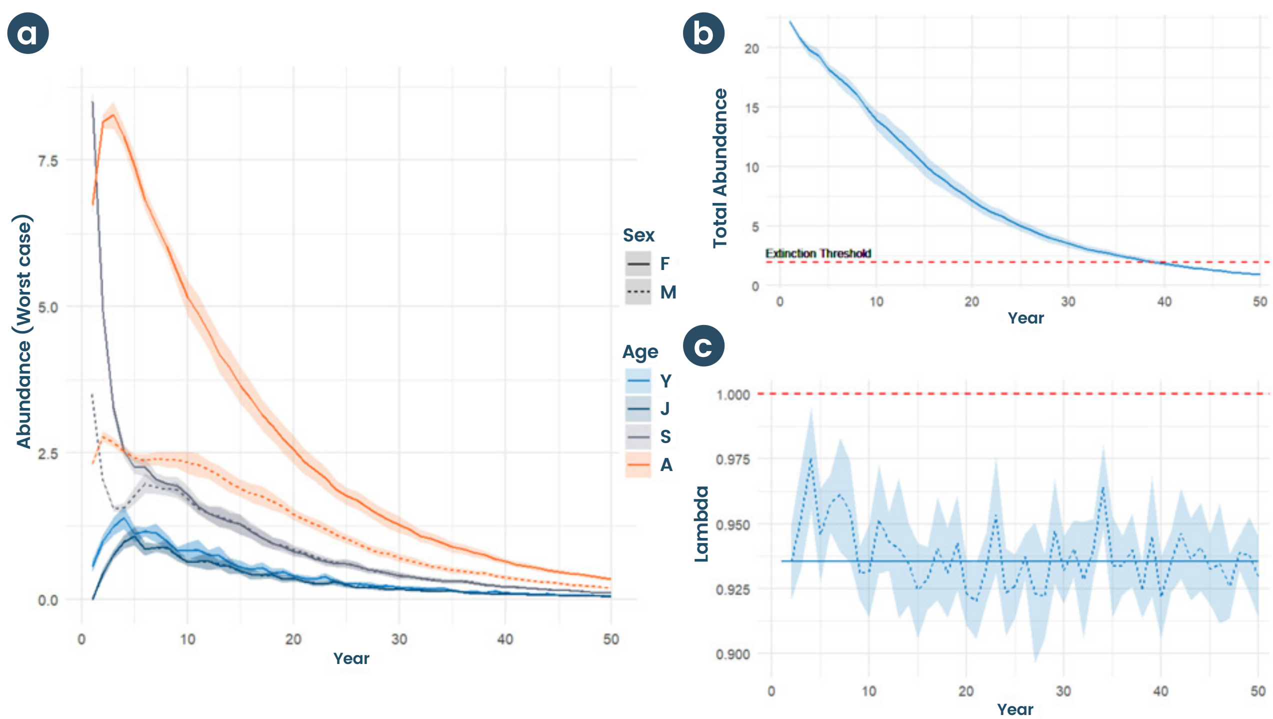


**Figure 4.4.** Simulated grizzly bear (a) sex- and age-specific abundance, (b) total abundance, and (c) stochastic (dotted line) and mean (solid line) lambda for the 50 years following translocation, assuming vital rates from low-end CYE baseline estimates. The simulation assumes 25 starting bears (FC: 0, FY: 0, FSA: 15, FA: 3, MC: 0, MY: 0, MSA: 6, MA: 1). The extinction threshold is set at one bear of each sex.

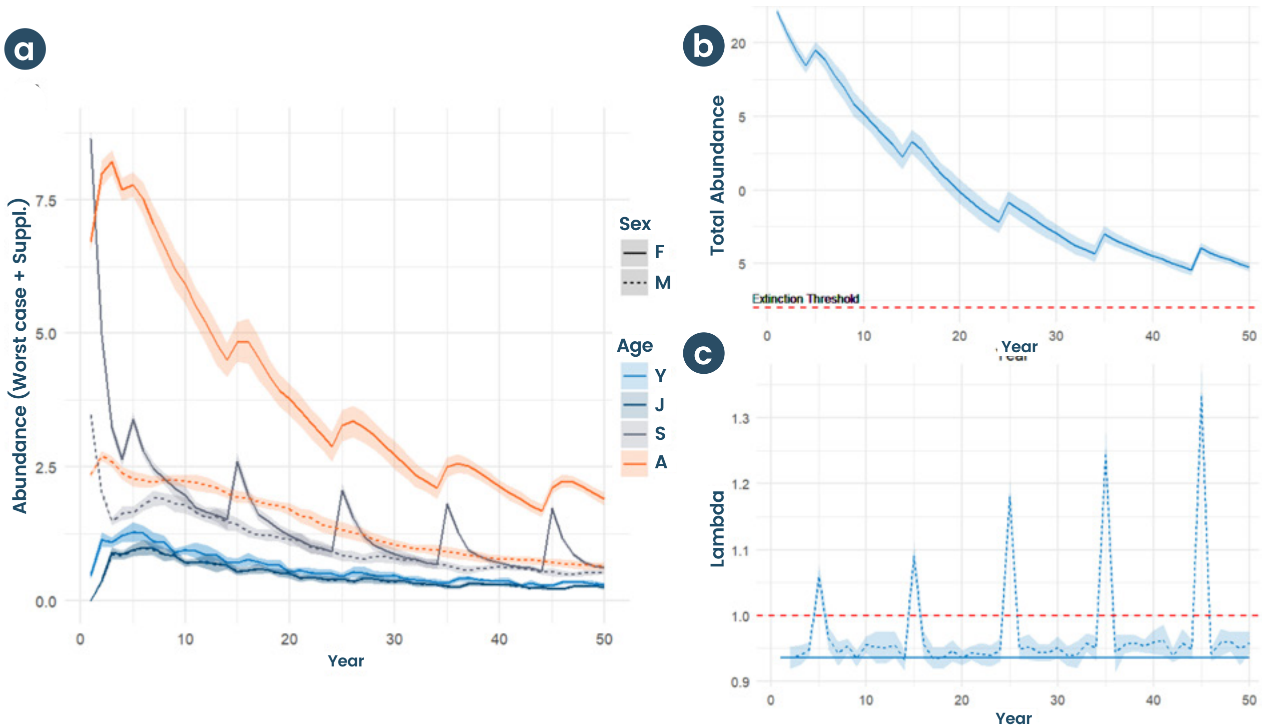


**Figure 4.5.** Simulated grizzly bear (a) sex- and age-specific abundance, (b) total abundance, and (c) stochastic (dotted line) and mean (solid line) lambda for the 50 years following translocation, assuming vital rates from low-end CYE baseline estimates but with ongoing low-level supplementation (two FSA bears every 10 years). The simulation assumes 25 starting bears (FC: 0, FY: 0, FSA: 15, FA: 3, MC: 0, MY: 0, MSA: 6, MA: 1). The extinction threshold is set at one bear of each sex.

## 3 How much uncertainty exists regarding the viability of a California grizzly population?

***The population viability analysis described under Question 2 used four scenarios to cover a range of possible population trajectories. However, the lack of California-specific data and relatively simple model structure imply that considerable uncertainty remains.***

The PVA described above used the best available data, average to conservative demographic assumptions, and two different management approaches to explore a range of potential grizzly population trajectories. Its results suggest that California could support a viable population of grizzly bears. The results do not, however, imply that this outcome is assured. The science and practice of species reintroductions and augmentations have improved dramatically over the past few decades, including for brown bears, but uncertainty lurks in even the best-planned and well-executed projects. Uncertainty is particularly prevalent in areas where the species of interest has long been absent, areas that have changed considerably since the species last inhabited the area, and areas that differ substantially from other locations where the species has been studied and currently lives.

The relatively simple structure of this model, combined with the lack of California-specific data, suggests that considerable uncertainty remains. Future research could reduce this uncertainty using a sensitivity-based modeling approach that identifies target demographic rates and trigger points, along with associated management interventions (e.g., [19]), for the post-release management of a potential reintroduced grizzly bear population in California. Post-release demographic data gathered from the NCE over the coming years could also be useful in building a more data-rich basis for modeling and planning in California.

Finally, it is important to recognize that the scenarios presented above are not intended to predict grizzly demographic trends or population sizes. Instead, they are meant to help inform discussions about recovery planning and serve as a baseline from which to develop additional research. These results suggest that a grizzly population could thrive in California, becoming established and growing slowly over several decades. Yet these results also show that unforeseen or underestimated challenges, especially higher-than-expected mortality, would hinder the recovery effort and require continuing adaptive management.

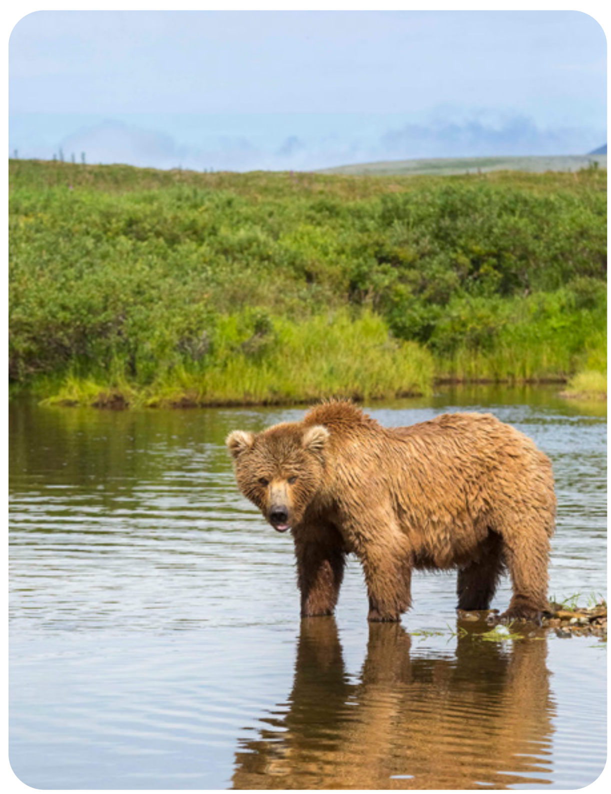

Photo: Grant Ordelheide / @tandemstock

## 4 Which factors could limit the viability of a grizzly population in California?

***Challenges that may limit the growth of a recovering California grizzly population include risks involving the translocation process itself, as well as a variety of post-release effects that could hinder reproduction and/or increase mortality. Human-caused deaths could hinder the population's growth, as could a lack of habitat connectivity. The effects of climate change are unclear, and could be either negative or positive.***

The PVA described above used different assumptions to develop four demographic scenarios for a reintroduced and recovering grizzly population. Here, we discuss how various factors could contribute to or alter these assumptions. Most of these factors would make it more difficult to reestablish a California grizzly population. Yet it is also important to recognize that a recovering grizzly population may grow more quickly than anticipated. In the 1980s, biologists worried that the two small, isolated brown bear populations in the Cantabrian Mountains of northern Spain could disappear [20]. Conservationists responded with several measures, including better anti-poaching law enforcement. In the decades since, the Cantabrian populations have increased from a low of less than 100 to the current estimate of more than 400 bears in two populations [21]. This growth rate exceeds the rate observed in Montana's CYE, which supplied the data for our PVA. Recovery planning should consider all of these possible scenarios and plan to address them proactively and effectively.

Several factors may limit rapid population growth in a California grizzly population. The first among these involves the translocation process itself. Capturing and transporting bears poses some risks to them, but the greatest risks face them in their new locations. During the initial acclimatization period, translocated populations often experience post-release effects—increased mortality and reduced reproduction associated with the challenges of being released into a new environment. As these—usually temporary—post-release effects are commonly observed in translocation events, it is likely that some percentage of translocated bears will not survive the early stages of reintroduction.

Following translocations, small populations are also often vulnerable due to insufficient genetic diversity and high levels of inbreeding [22], [23]. Genomic evidence shows California's grizzlies were virtually indistinguishable from grizzlies in the Northern Rockies [24], suggesting that populations in these two regions shared common ancestors in the relatively recent past. Yet these connections were severed more than a century ago. Landscape barriers such as highways, combined with grizzlies' slow natural dispersal rate of 2 to 3 km/year [25], suggest that for the foreseeable future, grizzlies in California would not be directly connected to other populations (see Chapters 2 and 3).

Conservation geneticists often recommend effective population sizes of at least 50 individuals in the short term and 500 in the long term to avoid inbreeding depression for isolated populations [26]. In cases where populations fail to meet these thresholds, management interventions can help. The current federal bison management plan outlines recommendations for inter-herd translocations to facilitate gene flow [27]. The U.S. National

Park Service's feasibility study for Isle Royale lynx restoration also considers translocations to maintain connections between the mainland and the island [28]. Miller and Waits [29] proposed translocations of one to two grizzlies per generation to maintain gene flow between the Greater Yellowstone Ecosystem and the NCDE. In 2024, the USFWS and Montana Fish, Wildlife, and Parks began a collaborative translocation effort to foster grizzly bear gene flow in the Northern Rockies [30].

It is worth noting that the recommended benchmarks of 50:500 for effective population sizes are frequently unmet in many small populations of brown bears [7], and despite detections of genetic diversity loss, adverse effects of genetic bottlenecks have been minimal. For example, despite a genetic bottleneck in the 1930s, the Swedish brown bear population has one of the highest rates of population growth detected in brown bears [31], [32]. This is an encouraging example, but genetic planning, management, and monitoring, including the consideration of additional translocations of one or two bears per generation, are still highly recommended to reduce the potential for later genetic problems in the absence of natural inward migration [29].

Despite these potential risks, multiple cases of successful brown bear reintroductions now exist that have led to established and increasingly secure populations (see Chapter 10 for further discussion). In the CYE, for example, few mortalities occurred during several translocations over more than 3 decades. Between 1990 and 2022, only 4 out of 22 translocated grizzly bears died, and at least 3 out of 14 females successfully bred [13]. These continuing efforts likely saved the CYE population from extinction [13] and provided important experience and information on which to build the NCE recovery effort [14]. Translocations from 1999 to 2001 restored Trentino's brown bear population [33], where numbers increased from near zero to an estimated 73 to 92 individuals by 2021 [34]. In the Pyrenees, another functionally extinct population benefitted from translocations during the 1990s, increasing to 64 to 68 individuals by 2020 [35].

Beyond challenges posed by translocation, poaching or malicious killings can further threaten reintroduced populations, especially early in these efforts when populations remain small. Such mortalities have threatened reintroduction and conservation programs for numerous species around the world, particularly for carnivores like brown bears. Between 1989 and 1994, for example, illegal killings thwarted a brown bear reintroduction effort in Austria [36]. A study reviewing 536 carnivore translocations found that human-caused deaths were the most common encountered problem [37].

Killings by people affect brown bears throughout their range—not just in reintroduction and recovery areas [38]. Such killings often result from human-bear encounters that involve food waste and other attractants [39], livestock and agriculture [40], and hunting or other activities that increase the chances of an adverse encounter [41]. Many of these problems, and the bear deaths resulting from them, could be prevented through proactive coexistence efforts (see Chapters 6 and 7), including infrastructure investments, education, community engagement, law enforcement, and habitat protection [19], [42], [43].

In addition to conflict-related mortalities, road infrastructure and bear strikes along highways and railroad tracks are serious problems for some brown bear populations [40], [39], [44]. A study from British Columbia, for example, found that collisions resulted in 6 out of 14 documented human-caused grizzly deaths [39]. While wildlife collisions are less common on unpaved forest roads, these roads provide greater access by humans to bear habitats, which can increase the threat of poaching and conflict-related mortalities [41], [45].

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Collaborative efforts elsewhere in North America show that landscapes can be made safer for grizzly bears, enabling their populations to thrive (see Chapter 7) [42], [46], [47]. In the trans-boundary region of southwest Canada and northwest Montana, multifaceted coexistence efforts have significantly reduced grizzly mortality while increasing habitat quality and connectivity [42]. Research can contribute to these efforts by helping identify challenges and opportunities for increased habitat protection and improved connectivity, including maintaining and restoring key corridors, identifying areas of potential conflict, and prioritizing wildlife crossing structures (e.g., [48]). We discuss these coexistence issues further, with reference to public support and human safety, in Chapters 6 and 7.

Climate change is having widespread effects on ecosystems, which may benefit, harm, or have neutral effects on brown bears—including for a population reintroduced in California. How climatic shifts affect wildlife populations depends on numerous interacting biological, ecological, geographic, and even social factors. Under a variety of climate scenarios, flexible, mobile species with expansive ranges and diverse diets, like brown bears, are likely to fare better than narrowly distributed specialist species. The result for a population in California will probably depend on how climate change shapes the distribution and abundance of bear foods, as well as the relations between bears and humans.

In North America, models have suggested positive (i.e., predicted increases in high-quality grizzly bear habitat) [49] or neutral [50] climate change effects on grizzly bear populations. In the Sierra Nevada, it is unclear how total precipitation, a limiting factor for some bear foods, will change under various climate scenarios, but mean temperatures, wildfire frequency, and instances of severe drought are all expected to increase [51]. In Spain, models suggest more negative effects associated with projected declines in some key food items [52]. Additional research will be needed to better understand how climate change and potential conservation responses to it may alter California landscapes with positive or negative repercussions for grizzly bear recovery (e.g., [6], [50]).

## Opportunities For Future Research

- An important area of future research includes investigating the availability of grizzly foods in California ecosystems under various climate change, management, and human-interaction scenarios.
- Future research may further explore how people's views and behaviors toward grizzly bears may affect the bears' mortality rates, and how coexistence measures could improve these relations to make California landscapes safer for bears.
- Additional sensitivity-based population modeling could improve population viability predictions and help establish critical demographic thresholds that enable populations to grow and persist.

# Appendix 4.1. Supporting Information for the Estimates of Brown Bear Population Densities in North America and Eurasia

**Table S1.** Compiled estimates of brown bear population densities from North America (from Lyons et al. [5], as indicated in the table by *) and Eurasia. Density estimates were summarized at the 25th (lower), mean (average), and 75th (upper) percentage quartiles to form baseline density extrapolations for potential core recovery areas in California..

| Location | Date of estimate | Density (bears/ 1000 km²) | Density (bears/km²) | Source |
|---|---|---|---|---|
| Jasper National Park, Alberta, Canada | 1990 | 12 | 0.012 | Schwartz et al. (2003b)* |
| Southwest Alberta (Waterton) | 2000 | 15 | 0.015 | Schwartz et al. (2003b)* |
| Northern British Columbia, Prophet River | 2001 | 21 | 0.021 | Schwartz et al. (2003b)* |
| Southeastern British Columbia (Selkirks) | 2000 | 27 | 0.027 | Schwartz et al. (2003b)* |
| Flathead River, Montana | 1989 | 80 | 0.08 | Schwartz et al. (2003b)* |
| Yellowstone National Park | 2015 | 17 | 0.017 | IGBST (2005) and YNP (2015)* |
| Greater Yellowstone Ecosystem | 2005 | 13 | 0.013 | IGBST (2005) and YNP (2015)* |
| North Continental Divide Ecosystem | 2013 | 9 | 0.009 | USFWS (2013)* |
| Alberta, Yellowhead, & South Jasper | 2015 | 8 | 0.008 | Stenhouse et al. (2015)* |
| Glacier National Park | 2000 | 30 | 0.03 | Kendall et al. (2008)* |
| Cabinet-Yaak Ecosystem | 2015 | 5 | 0.005 | Kendall et al. (2016)* |
| Yahk | 2007 | 8 | 0.008 | Proctor et al. (2007)* |
| South Purcell | 2007 | 13 | 0.013 | Proctor et al. (2007)* |
| Central Purcell | 2007 | 19 | 0.019 | Proctor et al. (2007)* |
| South Selkirk | 2007 | 14 | 0.014 | Proctor et al. (2007)* |
| Dinaric Mtns, Slovenia | 2012 | 130 | 0.13 | Jerina et al. (2013) [53] |
| Vitsi-Varnoundas, Greece | 2010 | 54 | 0.054 | Karamanlidis et al. (2015) [54]; Penteriani et al. 2020 [55] |
| Northern Pindos, Greece | 2010 | 50 | 0.05 | Karamanlidis et al. (2015) [54]; Penteriani et al. 2020 [55] |
| Central Pindos, Greece | 2010 | 51 | 0.051 | Karamanlidis et al. (2015) [54]; Penteriani et al. 2020 [55] |
| Carpathian Mountains, Romania | 2012 | 117 | 0.117 | Popescu et al. (2017) [56] |
| Caucasus Mountains, Armenia | 2015 | 59.4 | 0.0594 | Burton et al. (2018) [57] |
| Apennines, Italy | 2011 | 39.7 | 0.0397 | Ciucci et al. (2015) [58] |

***Notes.*** IGBST = Interagency Grizzly Bear Study Team. YNP = Yellowstone National Park. USFWS = U.S. Fish and Wildlife Service.

# Appendix 4.2. Supporting Information on the Population Viability Model Description

We used a population viability modeling tool focused explicitly on grizzly bears: gbear.sim. It was developed through contract and in concert with SpeedGoat Consulting Inc. The tool gbear.sim is an R package designed to simulate grizzly bear population dynamics using pre-birth, stage-structured matrix models. Pre-birth refers to the reproduction timing and assumes that breeding takes place immediately after the model census. In other words, individuals are born at the start of the year and survive as yearlings into the next year. The number of yearlings born at the start of the year is defined as the number of breeding females multiplied by the reproduction probability and litter size. Yearlings are evenly split into males and females.

Any number of stages may be defined, as well as the time an individual spends in each life stage before transitioning to the next stage. Models where all life stages last for exactly 1 year are special cases (Leslie matrices) and are defined when all transition probabilities equal 1. When transition probabilities are less than 1, individuals will remain in that stage for more than 1 year. This approach is true for all but the oldest life stage (e.g., adults), where individuals remain until death.

All vital rates in the default matrix model are constant, including (density-independent) survival. The approach of holding the vital rates constant means that, without any stochasticity, populations will either exponentially grow or decay, except for the special case when lambda equals 1. With stochastic vital rates, populations may experience fluctuations around the deterministic trajectory, potentially inducing extinction for especially small populations. The outputs of gbear.sim include population abundances, growth rates, extinction probabilities, and time to extinction.

The population viability analysis is run as follows. For each vital rate defined within the range of explored rates, the simulation is run with the changed rate while keeping all other vital rates at baseline values. The simulation is repeated with these parameters for a defined number of iterations. Extinction occurs once the population has dropped below the defined extinction threshold within the simulation period. The simulations where the population drops below the extinction threshold are recorded, and the probability of extinction is calculated as the proportion of simulations that go extinct divided by the total number of iterations. Additionally, the time to extinction is calculated as the number of years until the population falls below the extinction threshold. This process is repeated for every vital rate within the vital rate range, as defined by the user.

Model runs vary between iterations due to the stochastic vital rates, as defined by the user. Survival, litter size, and reproduction probability have options to define mean and variance values. Setting the variance to 0 will produce constant vital rates; otherwise, yearly vital rates are drawn from a distribution based on these means and variances. The distribution used depends on the vital rate (back-transformed logistic distribution for survival as well as back-transformed exponential function for litter size and reproduction probability).

Once the baseline vital rates are defined, the user may define custom vital rates and animal supplementation. These values fine-tune the simulation to create year-specific perturbations. Where the baseline means and variances define vital rates for all years, the custom vital rates define means and variances for the specified years to emulate, for example, a poor survival year. The user may also define animal supplementation for specified years to introduce new individuals into the population and simulate translocating individuals into the population. Supplementation adds individuals after all effects of survival and reproduction occur in that year.

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## Chapter 5

# Ecosystem Effects

By Ellen M. Pero, Sean Denny, Samantha Kreling, Alex McInturff, Devlin Gandy & Peter S. Alagona

California Grizzly Alliance

## Key Points

Brown bears are ecosystem engineers that influence the structures and functions of the systems in which they live by altering soils, vegetation, and food webs, and by shaping processes such as seed dispersal and nutrient cycling. Yet, because they are flexible omnivores with shifting seasonal life history patterns, their ecosystem impacts tend to be widely distributed and indirect.

Grizzly bears have the potential to affect hundreds of California native plant species, both through direct consumption and through indirect activities that shape their habitats and influence their distributions. Major grizzly plant food groups can be found throughout California's potential core grizzly recovery areas.

Grizzly bears may influence multiple animal species through a variety of direct and indirect interactions, including habitat modification, predation, competition, and changes in space use and movement.

A recovering grizzly population is unlikely to cause major changes, beyond local effects, in the populations of native plant and animal species in California. Any significant impacts would likely emerge slowly, after the initial decades of a gradual recovery effort.

# Introduction

Large terrestrial animals often exert disproportionate influences, relative to their population sizes, on the habitats in which they live [1]. As a result, they are frequently the subjects of recovery efforts aimed at restoring larger ecosystems [2]. Brown bears are ecosystem engineers that interact, both directly and indirectly, with hundreds of other species and shape numerous landscape features [3], mainly through foraging. Brown bears may consume hundreds of species of fungi, plants, insects, vertebrate animals, and more [4]. They are often referred to as "apex predators," but they are better understood as "apex consumers" with diverse and flexible omnivorous diets. Most brown bears in most places, including those that lived in California prior to 1924 (when they were last seen in the state), subsist mainly on plants [3], with meat providing relatively limited, though in some cases crucial and substantial, contributions. Almost all of the plants that grizzlies once ate continue to grow in California, and many can still be found in the state in great abundance.

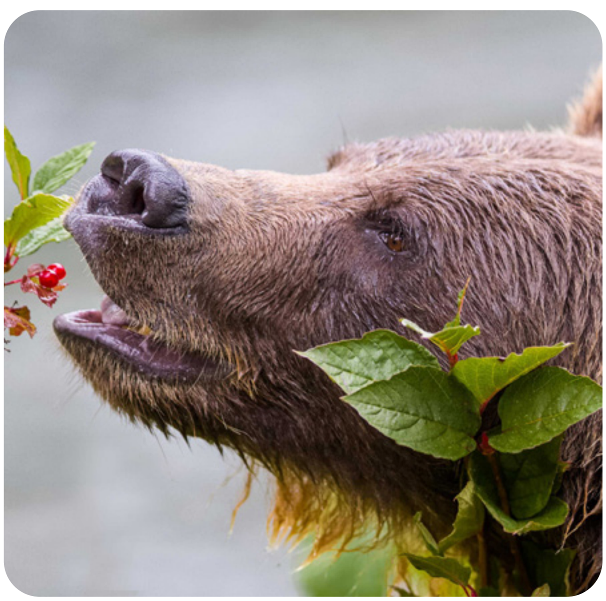

Photo: Martin Rudolf - stock.adobe.com

It is difficult to predict how grizzly bears, in a slowly recovering population, might affect California ecosystems [5]. They would likely do so in many ways, including through grazing, browsing, digging, preying, scavenging, trampling and breaking vegetation, moving across the landscape, shaping the movements of other animals, and engaging in a variety of other behaviors. These activities could alter soils, vegetation, and food webs, and could augment processes such as seed dispersal and nutrient cycling. Yet because brown bears are flexible omnivores with shifting seasonal life history patterns, unlike those of strict carnivores such as wolves, their ecological impacts are often widely distributed and indirect.

Two centuries ago, when thousands of grizzly bears still roamed California, their cumulative ecological effects were likely substantial. Yet despite their vital historical role, a recovering grizzly population would probably have only modest ecological effects on California ecosystems and native species, particularly in the short term. A recovering grizzly population in California would likely start small, grow slowly, and be limited to core recovery areas during its initial years. While the potential for local impacts on plant and animal populations is possible, most impacts on California ecosystems would likely accrue slowly over several decades, providing ample time for research, monitoring, and adaptive management (see Chapter 10).

# Questions

## 1 How do brown bears influence ecosystem structure and processes?

***Brown bears are ecosystem engineers that influence the structures and functions of the systems in which they live by altering soils, vegetation, and food webs, and by shaping processes such as seed dispersal and nutrient cycling. Yet, because they are flexible omnivores with shifting seasonal life history patterns, their ecosystem impacts tend to be widely distributed and indirect.***

Brown bears are ecosystem engineers that can shape their environments in numerous ways. Brown bears alter soil structure by turning over rocks and logs and by digging. They dig to build dens and obtain underground foods, including roots, tubers, fungi, and both vertebrate and invertebrate animals. When digging, brown bears can overturn soil across patches over 100 $m^2$ in size [6] and dig to a depth of up to at least 0.75 m [7]. In Glacier National Park, where soils are relatively thin, researchers calculated that grizzly bears displaced more soil than all of the park's avalanches [8]. Historical accounts confirm that California's grizzly bears were also active excavators [9], [10].

Grizzly bear digging can have multiple ecological effects. Clearing surface vegetation can open up forest floors, increase habitat complexity, enrich soil nitrogen levels, regulate nutrient deposition into streams, and improve soil airflow, water infiltration, and water holding capacity [8] , [11]. Soils tilled by grizzlies may improve conditions for some rare and native plants, including geophytes with subsurface growth organs [12], [13]. Over time, these activities and effects could influence California ecosystems, but such changes would likely be slow and limited during the early phases of a recovery effort owing to bears' small initial population and geographic range.

Brown bears can further shape landscapes by altering the physical structure of vegetation (Figure 5.1a). In chaparral and other brushy ecosystems, brown bears create openings and corridors as they forage in and move through the landscape. Historical accounts from California indicate that grizzly bears created obvious and ubiquitous openings and passageways through otherwise impenetrable chaparral [14]. In forested landscapes, brown bears break lower tree limbs, rub against trunks, and bite, claw, and rub against trees to scratch insect bites, remove molting fur, sharpen their claws, communicate with other bears [15], and forage for fungi, cambium, and invertebrate animals [16], [17]. In California, firsthand accounts describe grizzly bears breaking acorn-laden limbs of oak trees (*Quercus* spp.) at the ground level up to 12 ft (3.7 m) high [18].

Landscapes with robust grizzly populations may develop structural characteristics that have downstream consequences for other organisms. Openings and tunnels created by grizzly bears through dense brush enable the movements of other large and medium-sized animals [19]. Breaking the lower limbs off trees increases airflow, light penetration, and soil functions, including water retention and nutrient cycling. Trees altered by bears may offer more complex habitats for microorganisms and invertebrates (Figure 5.1a). Tree wounds created by brown bears in Europe support biodiversity by attracting fungi, insects, and insect predators such as woodpeckers and by providing habitats for cavity nesting birds, small mammals, and amphibians [20].

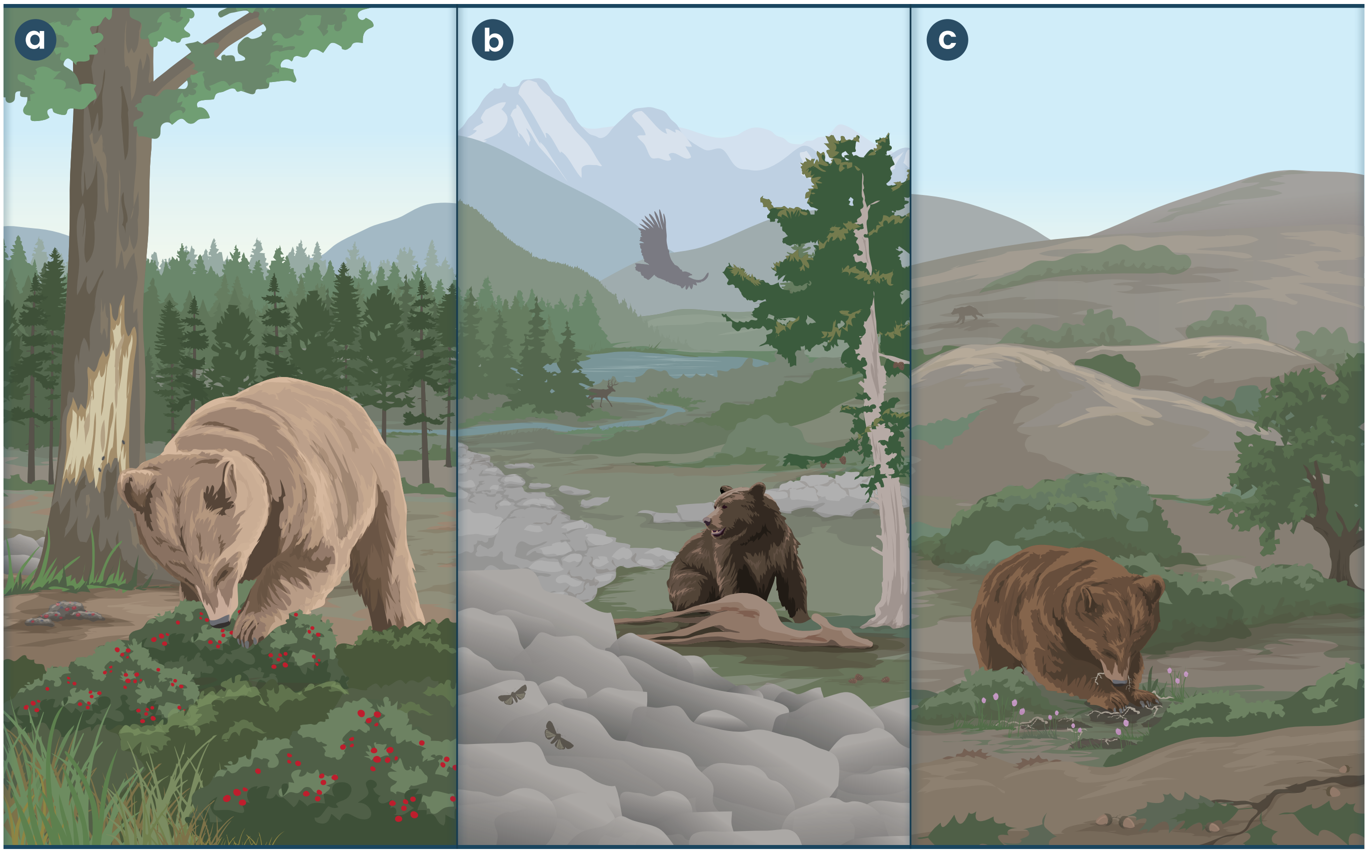


**Figure 5.1.** Some key grizzly bear behaviors that could shape California ecosystems: (a) seed dispersal and microhabitat alteration, (b) nutrient transfer and provisioning through predation and scavenging, and (c) soil turnover, aeration, and fertilization while digging for roots, tubers, and other sources of subterranean food.

When grizzly bears disappeared, California lost an ally in the struggle to live with wildland fire. Fire is an endemic and unavoidable feature of California ecosystems. By creating forest gaps, eliminating ladder fuels, and raising the minimum crown height of many trees, grizzlies may have helped moderate fire behavior in some systems. Today, foresters and fire departments in California are working to lower fire risk while encouraging low-intensity "good fire" by implementing measures that replicate the activities once performed by thousands of grizzly bears. These measures include programs that seek to reduce fuel by opening gaps on forest floors, reducing overall shrub and understory growth, and removing lower tree limbs within 3 or 4 m of the ground [21]—a height that matches the reach of adult brown bears.

Brown bears can also shape food webs in varied ways that extend beyond a specific event or interaction [1], [22]. Brown bears may influence the populations of other animal species directly through predation and competition or indirectly through a wide range of other behaviors. The proportion of meat in brown bears' diets varies widely across their range and among individuals [23], from more than 80% to less than 5% [3], [24]. In many areas, however, including California prior to 1924, animal protein makes up a small proportion of most brown bears' diets [25], [26]. Brown bears can prey on ungulates at substantial rates (Figure 5.1b), particularly on newborn animals, with the potential for population-level effects [27], [28], [29]. Yet, in part because grizzly bears are flexible omnivores that tend to consume animals opportunistically, predation by brown bears appears to be generally insufficient by itself to regulate ungulate population sizes [27], [30].

Most brown bears consume large amounts of vegetation [3], [24]. An adult brown bear can eat up to 40 kg of plant matter per day [31], [32], 20 to 40 times as much as a deer [33]. When brown bears dig, they not only displace soil but also may uproot or otherwise damage surface vegetation, thus acting as disturbance agents (Figure 5.1c) [11]. This activity may reduce the competitive dominance of some plants, which, over time, can increase local plant diversity and heterogeneity [7]. We have been unable to find documented cases in which brown bears adversely impacted plant populations or diversity. This dearth is likely due to the bears' varied diets, the seasonality of their foraging activities, and the lower population densities of brown bears relative to other largely or completely herbivorous species.

Brown bears are prodigious and effective seed dispersers. Research has found that seeds consumed by brown bears can survive gut passage and germinate—in some cases at higher rates than if they had not been eaten at all [34]. Brown bears disperse the seeds of numerous plant species, including grasses, forbs, shrubs, and trees (Figure 5.1a), and fruit species can constitute a quarter of both the items and volume of food consumed by brown bears across diverse locations. Brown bears often defecate in areas where they have dug, increasing the chances that seeds will be deposited in well-aerated, fertilized soils favorable for germination [35]. It is not uncommon for bears to pass thousands to tens of thousands of seeds in a single day or even in a single dropping [36], [37]. Research has not yet connected brown bear seed dispersal to plant community composition, but studies on seed dispersal by other animal species strongly suggest that brown bears can shape plant communities and may even help maintain vital ecosystem functions [38].

Brown bears also transfer nutrients within and across ecosystems [39]. In areas with high densities of bears and anadromous salmon runs, brown bears often move to shore to consume their catches, displacing carcasses and nutrients that may benefit other species—sometimes as far as several hundred meters from the stream [40], [41], [42]. Studies suggest these activities can affect plant and insect communities [43]. Brown bears' nutrient deposition and their caching and discarding of mammal carcasses (Figure 5.1b) may enhance the growth of invertebrate decomposers, such as beetles and flies [44], and augment plant growth and density [45], [46].

**Box 5.2**

### The Indigenous ecology of humans and grizzly bears

Little serious research has been conducted on the deep histories of Indigenous people's ecological relations with grizzly bears. Instead, most authors have assumed that although brown bears played prominent roles in diverse Indigenous cultures, our two species' ecological interactions were mostly limited to hunting, competing for resources, and occasional physical conflicts. The most likely presumed outcome of these conflicts has shifted over time as authors have adopted different assumptions about Native people's vulnerability to and dominance over the bears. Research from several disciplines now suggests unique opportunities for a new research program and synthesis. This new work would draw on evidence and theory from archaeology, anthropology, geography, ecology, and history, including the history of technology, and it would stress the dynamic, reciprocal, and even collaborative relations among humans, grizzlies, and other key components of their ecosystems. Any such work should be conducted using the best practices developed by Indigenous scholars [47].

## 2 How might grizzly bears affect California's native plant species?

***Grizzly bears have the potential to affect hundreds of California native plant species, both through direct consumption and through indirect activities that shape their habitats and influence their distributions. A small, slowly recovering grizzly population would, however, be unlikely to have major population-level effects in the short term on any of California's native plant species.***

California is a hotspot of plant diversity, with hundreds of rare and/or endemic species occurring across the state's varied climates and landscapes. Brown bears interact with native plants directly by consuming them and indirectly through the bears' various activities described above. Many California plant taxa evolved to take advantage of soil conditions created by the behaviors of now-absent megafauna, including digging and bioturbation, wallowing, compression, and erosion [48]. The decline of some native plant species in California may be related to the losses of these megafaunal ecosystem engineers and the related proliferation of smaller digging and burrowing animals, as well as land management changes, such as periods of intensive grazing, which have altered soil processes [49]. Because grizzly bears have the capacity to function as bioturbation agents, recovering grizzly bears could help restore some of California's rare, endemic, and endangered native plants over time as populations grow. Grizzly bear seed dispersal, physical impacts on vegetation, and other compounding effects could, over time, influence community dynamics, though understanding these effects would require further research, including modeling, field observations, and controlled experiments [50].

Plant species make up the majority of most brown bears' diets [25], [31]. California contains an impressive abundance and diversity of these potential food groups. In Chapter 4, we discuss the importace of food availability and distribution in California for supporting a viable grizzly population and highlight related future research needs on this topic. Here, we offer an

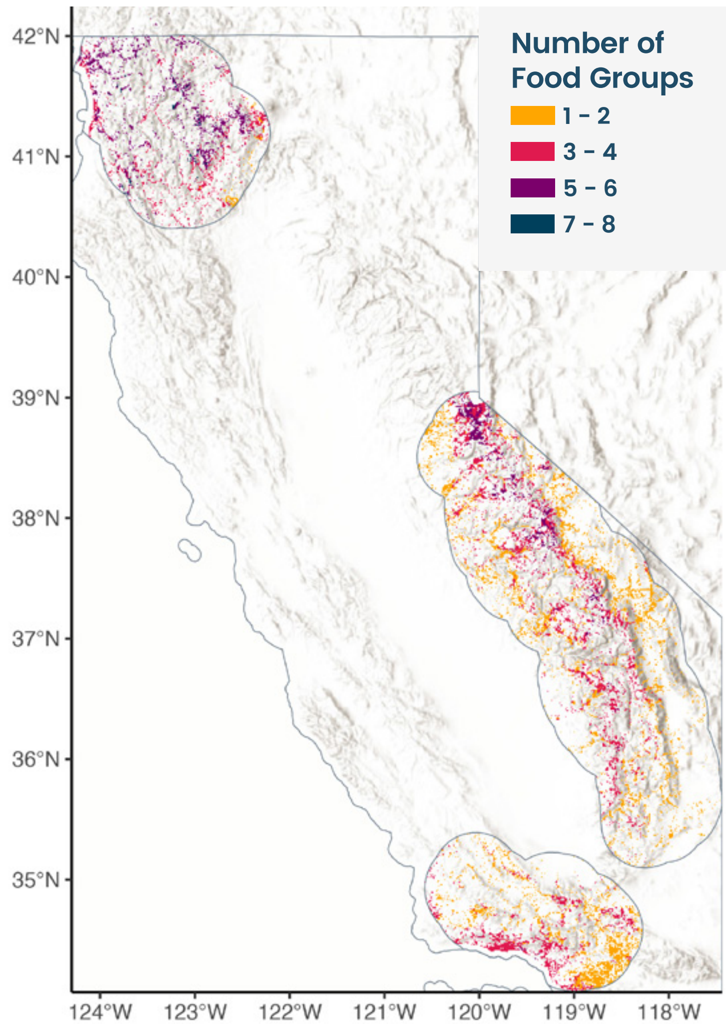


**Figure 5.2.** Hotspot map of modeled key potential grizzly bear food distribution within potential core recovery areas (described in Chapter 3). Orange and pink shading represents lower numbers of modeled food groups, whereas purple and blue shading represents higher numbers. For more information on the methods used to produce this map, see Appendix 5.1.

initial description of the kinds of foods, mostly plants, that grizzly bears might consume in the state, depending on their location, the time of year, and longer-term ecological changes. We began this research by mapping the distribution of some sample plant food groups across the potential core recovery areas and their buffer zones (defined in Chapter 3). To map the distribution of these sample plants, we used current black bear diets in California, historical observations of grizzly diets in California [26], and brown bear diets from other regions [25], [51], [52]. Some key plant groups include the genera *Rubus*, *Vaccinium*, *Allium*, *Camassia*, *Quercus*, *Prunus*, *Carex*, and *Avena*, as well as the species whitebark pine (*Pinus albicaulis*). In addition to plants, we included cutworm moths (of the family Noctuidae), which roost in alpine talus fields [25], [53], as well as Columbian black-tailed deer (*Odocoileus hemionus columbianus*) and other mule deer (*Odocoileus hemionus*). These food groups do not encompass the entire menu of potential grizzly bear foods in California, but they do reflect the broad distribution of foods that would likely contribute to grizzly diets in California. Additional fieldwork could build on and complement the map presented in Figure 5.2 [54]. Technical methods for food item selection and distribution modeling are presented in Appendix 5.1.

## 3 How might grizzly bears affect other California wildlife species?

***Grizzly bears may influence multiple animal species through a variety of direct and indirect interactions, including habitat modification, predation, competition, and changes in space use and movement. Because brown bears are flexible omnivores with diverse behaviors and diets, however, they are unlikely to cause major changes in the populations of other wildlife species—particularly in the initial decades of a gradual recovery.***

Mule and black-tailed deer are the most common ungulate species in most of California, though their populations have fluctuated over time and in particular regions (e.g., [55]). Statewide, deer increased in California during the 20th century—owing to a combination of regulations, habitat changes, and predator controls—and then declined somewhat before stabilizing in the early 21st century [56]. Elk declined dramatically during the 19th century and were largely restricted to Northern California for most of the 20th century. Over the past 35 years, however, California's elk population has roughly doubled [57]. Elk have been translocated to more areas of California, including central portions of the state, and the California Department of Fish and Wildlife has expanded elk hunting in Northern California [58]. This study's potential core recovery areas in the Northwest Forest region would overlap with this area's growing Roosevelt elk (*Cervus canadensis roosevelti*) population.

Grizzly bears interact with ungulates in several direct and indirect ways. Grizzlies prey on ungulates, particularly newborn individuals [28], [59], scavenge their carcasses, and sometimes steal ungulate carcasses killed by other predators. In part because grizzly bears tend to consume large animals opportunistically, their predation alone is usually insufficient to regulate ungulate populations [27], [30], [60]. Under some conditions, however, brown bear predation may act in combination with healthy populations of other predators (e.g., wolves) to limit ungulate densities [30], [61]. Based on research conducted in Yellowstone, the U.S. National Park Service estimated that in the North Cascades, an initial population of 25 grizzly bears would consume up to 90 elk annually during the first 5 to 10 years of a recovery effort [62]. Grizzlies in higher-elevation areas, where deer tend to be more common than elk, may consume around 2.5 times less animal protein than bears in lower elevations [63].

Beyond direct effects, grizzly bears in California may indirectly affect ungulates by influencing their behavior. The mere presence of brown bears and other large carnivores on a landscape can shape how ungulates use space, exercise vigilance, and feed [64], [65]. Grizzly bears may also influence the behavior of other predators, with potential implications for their ungulate prey. Some researchers have speculated, for example, that stealing the carcasses of animals killed by pumas, wolves, or coyotes, a behavior known as *kleptoparasitism*, may increase predation rates on newborn ungulates [30], [66]. To date, there is no clear evidence of this occurring in areas where these species overlap [67], and one study even found that the presence of brown bears in areas with wolves decreased the wolf kill rate [68].

Grizzly bears may also hunt or scavenge a wide variety of non-ungulate prey species, including rodents (squirrels, chipmunks, prairie dogs [*Cynomys* spp.], gophers, voles, mountain beaver [*Aplodontia rufa*], porcupines, marmots [*Marmota* spp.]), shrews, lagomorphs (rabbits, hares [*Lepus* spp.], pikas [*Ochotona* spp.]), amphibians (frogs and toads), songbirds, waterfowl, freshwater fish, insects, and even other carnivores (coyote, red fox [*Vulpes vulpes*], gray wolf [*Canis lupus*], weasels) [69]. Because bears forage opportunistically, the relative contributions of other animal species to their diet varies according to several factors, such as the season, the habitat, the prey species' behaviors and population densities, and the tastes and habits of the individual bear [70]. While the potential for localized impacts on these animal populations is possible, grizzlies would likely have only minor effects on the populations of other wildlife species over initial decades of recovery effort when the restored population is small (see Chapter 4 for population projections).

California had robust salmon and steelhead (*Oncorhynchus mykiss*) runs well into the early 19th century. Stream modifications and diversions, unregulated industrial fishing, and, beginning around 1870, the construction of some 1400 major dams—all contributed to the destruction of most of California's anadromous fish populations. State and federal agencies are now attempting to restore some anadromous fish populations, including the country's largest-ever multi-dam removal project on the Klamath River, but most of the state's streams remain too impaired to support sustainable salmon runs. The degree to which brown bears affect salmon populations depends on the physical layout of the stream and the density of fish in the run [71]. Predation rates on salmon vary substantially, but we still do not know the extent to which predation by bears may affect salmon populations. In California, as in the North Cascades recovery zone [62], bears from salmon-reliant populations would not be part of the translocated cohort [72]. Because this policy would by no means guarantee that bears would refrain from fishing on restored salmon rivers, monitoring efforts would be needed to study and manage the interactions between recovering grizzlies and recovering salmon over time.

No data is available for brown bears' interactions with condors (*Gymnogyps californianus*) because, for a century, these two species' ranges have not overlapped. Condors and grizzlies probably last crossed paths in the early 1900s in the Southern California mountains. Today, California's condor population—which numbers more than 180 in the wild [73]—lives in portions of this study's potential core grizzly recovery areas in the Transverse Ranges and the Sierra Nevada (Figure 5.3). In 2022, the Yurok Tribe also launched a landmark condor recovery program near the Northwest Forest potential core grizzly recovery area. Condors tend to arrive soon after a carcass becomes available, particularly in areas with sparse vegetation, thus increasing their feeding time. At these sites, they compete for priority and dominance with other scavengers, including coyotes, foxes, golden eagles (*Aquila chrysaetos*), and ravens (*Corvus* spp.). It is possible that grizzlies could eventually take some carcasses that might otherwise be consumed by condors [74], but nobody knows how grizzly bears might behave toward a flock of birds with 10 ft (3 m) wingspans. What we do know is that both of these species once thrived in the same California habitats, and there is little reason to believe that they could not do so again.

Brown bears may prey on other carnivore species, steal other carnivores' kills, and displace them from preferred habitats. Brown bears can displace wolves [75], Eurasian lynx (*Lynx lynx*) [76], pumas [77], and black bears [78] from food or kill sites. They may even displace polar bears in the Arctic, though which of these two species dominates the other may depend on the specifics of the interaction [79]. Several studies show that being displaced by a brown bear affects some carnivores' energetic budgets and movements [29], [75], [76], [77]. In extreme situations, kleptoparasitism could affect the reproduction, survival rates, and ultimately, the population sizes of other carnivores. These impacts would be highly unlikely, however, at the population sizes expected during the early decades of a California grizzly recovery effort (e.g., [62]; see Chapter 3).

Interactions between brown bears and wolves are varied [42], but most are indirect. Brown bears' seasonal patterns of foraging probably dampen their interactions with wolves [29], [80]. Brown bears kleptoparasitize wolf kills [80], but unlike some of the other carnivore species described above, this behavior does not appear to impose a significant energetic toll on wolves [81]. Conflicts between brown bears and wolves over carcasses sometimes take place, but such events are rare, and they typically end in standoffs [81]. Currently, in California, wolves mainly occupy lower-elevation areas in the northeast corner of the state, outside of this study's potential core grizzly recovery areas [82]. In 2024, however, one wolf pack did take up residence in the western foothills of the Sierra Nevada, within a potential recovery area grizzly. Yet evidence from other places where these two species live suggests that they would do so here with few direct or significant impacts on one another [81].

Pumas are one of California's flagship species. They range widely throughout the state and have been a specially-protected nongame species since the passage of Proposition 117 [83], a unique ballot measure passed by California voters in 1990. There are a few documented cases of grizzly bears killing pumas, but the two generally avoid one another, and their main form of interaction, as with wolves, appears to be kleptoparasitism [77], [84]. Pumas range over most of the same areas as black bears and exhibit current habitat use patterns similar to those of historical grizzlies in California (see Chapter 2). Pumas have a much larger range in contemporary California, however, than grizzlies would probably ever have again. As solitary ambush predators, pumas are experts at avoiding interactions with humans and other dominant predators. In areas they share with brown bears, they tend to use more rugged terrain [84] and engage in more elaborate caching strategies to protect their meals [85].

According to the preliminary results of an integrated population model by the California Department of Fish and Wildlife, California may contain as many as 65,000 black bears, more than any other U.S. state except Alaska [86]. If correct, this means that California's black bear population has increased at least sixfold over the past century. There may be several reasons for this dramatic rise, including the translocation of Yosemite black bears to Southern California in the 1930s, the designation of black bears as a regulated game species in 1948, historical and ongoing changes in the state's habitats and land management practices, and shifts in public attitudes and values. The disappearance of other large carnivores—including wolves from the 1920s to 2010s and grizzly bears from the 1920s to today—may also have played a role [87]. The loss of these dominant competitors may, for example, have enabled black bears to move into new areas and kill more newborn ungulates [42], [88]. More research will be required to understand the relative importance of and interaction among these and other potential factors.

In areas where black and brown bears both live, brown bears sometimes prey on and often displace black bears [42]. Yet research suggests that at low to moderate brown bear densities, this competitive exclusion is unlikely to limit black bear populations [78]. In places where both species have large populations, they tend to select for different habitats and adopt disparate activity patterns [89], [90]. An important topic for future research is whether, to what extent, and under what conditions a large black bear population may compete with, and thus hinder, brown bears from successfully reestablishing in California [91].

## Opportunities For Future Research

- Future research could build on the food-group mapping presented in this chapter to focus on the availability of grizzly bear nutrition across California's potential recovery areas, as well as through time under various climate change scenarios.
- Future modeling efforts could better explain the potential impacts of grizzly bears to community dynamics in California based on multiple climate change scenarios and over various time periods—particularly concerning potential effects on other wildlife species of concern within the state (Figure 5.3).
- Collaborative work bringing together ecologists, anthropologists, and other Indigenous scholars and elders could provide a deeper understanding of the complex historical relations between Native people and grizzly bears.

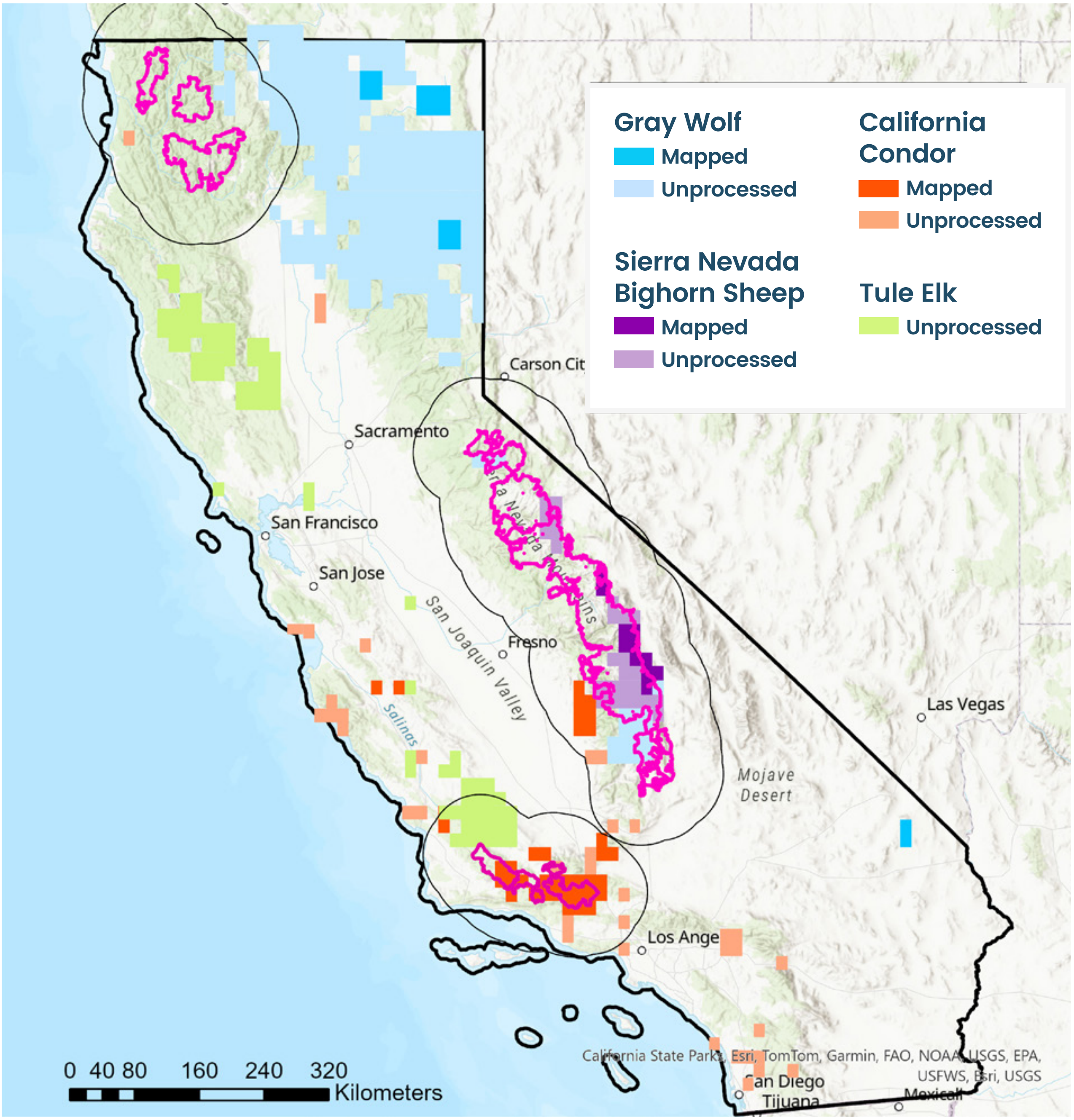


**Figure 5.3.** Overlap of the ranges of four wildlife species of concern in California with the potential core recovery areas described in Chapter 3. The four species of concern are the gray wolf, Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*), California condor, and Tule elk (*Cervus canadensis nannodes*). For species ranges, we consulted the California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB) [92]. These data include observations that are both mapped (evaluated by CNDDB biologists) and unprocessed (not yet confirmed by CNDDB biologists). Potential core grizzly recovery areas are outlined in bright pink, and 50-km buffers are outlined in black.

# Appendix 5.1. Supporting Information

## Section S1. Methods

### Taxa selection

We used a combination of historical records for the California grizzly bear diet [21], black bear diet in California [93], [94], and grizzly bear diet from outside of California to select our focal taxa [25], [52], [95]. Because the diversity of species within each genus is multiple times greater in California than in other grizzly bear ranges, such as the Rockies, we predominantly modeled distribution at the genus level with the exception of whitebark pine (*Pinus albicaulis*), a species of extreme importance for grizzly bears in the Rockies and predicted to be an important food source for California grizzlies [96]. The plant genera we modeled were *Rubus*, *Vaccinium*, *Allium*, *Camassia*, *Quercus*, *Prunus*, *Carex*, and *Avena* (Table S1).

**Table S1.** Plant genera included in the model, with justifications for inclusion.

| Genus | Taxa Native to California | Taxa Naturalized in California | Inclusion Justification |
|---|---|---|---|
| *Allium* | 47 | 0 | Alliums produce large nutrient-dense geophytic bulbs that represent a potential year-round food source for bears |
| *Avena* | 0 | 5 | |
| *Camassia* | 2 | 0 | *Camassia* produce large nutrient-dense geophytic bulbs that represent a potential year-round food source for bears |
| *Carex* | 138 | 6 | *Carex* plants produce nutritious forbs during the green-up season and nutrient-dense seed heads during reproduction |
| *Prunus* | 9 | 11 | |
| *Quercus* | 20 | 0 | Oaks produce large flushes of highly nutritious and calorie-dense acorns, generally during the autumn months [87], [88]. |
| *Rubus* | 10 | 6 | *Rubus* plants produce large flushes of nutrient-dense fruits between spring and fall, depending on the species and climate [89]. They are eaten by black bears frequently in California [84], [90] and grizzly bears outside of the state [20] |
| *Vaccinium* | 9 | 5 | |

In addition to plants, we also modeled the distribution of cutworm moths (of the family Noctuidae). These moths have been shown to be important sources of protein and calories for grizzly bears in the Rockies, especially in high-elevation habitats [25], [53]. Lastly, we included Columbian black-tailed deer (*Odocoileus hemionus columbianus*) and other mule deer (*Odocoileus hemionus*), which are predicted to be one of the main natural mammalian prey for California grizzly bears. We did not include elk (*Cervus canadensis*), as elk populations are generally small where they occur throughout the state and do not occur in large numbers in two-thirds of our study's potential recovery areas.

### iNaturalist and plant data

We exported research-grade iNaturalist data via their web export tool for the state of California when there were fewer than 200,000 occurrences in the dataset. If there were greater than 200,000 occurrences, we exported research-grade observations from the Global Biodiversity Information Facility. After exporting, we combined all plant datasets and cropped the observations to a 50-km buffer around our three potential core recovery areas (Figure 3.1). We then removed any observations (1) of the same species from each genus and (2) located at the same coordinate location. Next, we further narrowed our dataset down to observations that had an estimated positional error of less than 1 km, but we retained those observations that did not list a positional accuracy. We used observations from all years.

### Spatial data

We obtained our spatial covariates using the worldclim function from the geodata package in R [101]. Using these covariates, we downloaded historical climate data from `WorldClim` version 2.1 at a resolution of 30 degree-seconds (~850 m x 850 m) [102]. Variables included in this dataset were: annual mean temperature, mean diurnal range, isothermality, temperature seasonality, max temperature of warmest month, min temperature of coldest month, temperature annual range, mean temperature of wettest quarter, mean temperature of driest quarter, mean temperature of warmest quarter, mean temperature of coldest quarter, annual precipitation, precipitation of wettest month, precipitation of driest month, precipitation seasonality, precipitation of wettest quarter, precipitation of driest quarter, precipitation of warmest quarter, and precipitation of coldest quarter.

### Species distribution modeling

Naturalist data is inherently biased by where people can observe species [103] and often biased by where the species can be observed most easily and where most people are [104]. To account for this bias, we created a sampling effort probability raster from which to draw our pseudo absence points. This raster was created by calculating the inverse distance to roads and trails throughout each study system. Then, for each taxon, we weighted each potential recovery area by the percentage of total observations occurring in that study area. In this way, if one study area had more observations than the others, there would be a higher likelihood of pseudo absence points being drawn from this recovery area. Next, for each taxon, we counted the total number of observations across all potential recovery areas and created an equal number of pseudo absence points using our probability raster. We then extracted raster values for each covariate at all presence and pseudo absence points.

We chose to conduct general linear modeling (GLM) rather than maxent modeling for ease of interpretation. GLMs have been found to demonstrate high predictive performance for species distribution modeling at the trade-off of model specificity [105]. While this trade-off meant there were likely more false negatives in our generated distribution data, our goal was to get a rough and conservative measure of where grizzly bear foods would be found. We then split the data into five folds using the `folds` function from the `predicts` package, which ensures a roughly equal split of presence and absence data in each fold. We put 80% of the data into a training dataset, with the remaining 20% used for testing. Next, we modeled the presence of a taxon against every covariate with a binomial distribution using the training dataset and the `glm` function in R. We used our model to predict species distribution across the entirety of the study areas using the `predict` function from the `predictions` package in R [106].

To test our model, we used the `pa_evaluate` function from the `predicts` package in R, which is specifically designed to evaluate models run on presence/absence data. This analysis allowed us to take the model parameters determined on the training dataset and test their performance on the testing dataset. We recorded the area under the receiver operator curve (AUC), the correlation coefficient (Cor) and corresponding p-value (PCor), and the overall diagnostic power of the model (ODP; Table S3).

Finally, to visualize where multiple food sources would be available for bears, we added all species distribution rasters together and rounded to the nearest whole number.

## Section S2. Results

Overall, 16.86% of the potential recovery areas had at least one of the modeled foods present (Table S2). Across all three study areas, 0.39% had only one food source present in a given location, 1.72% had two foods, 5.41% had three foods, 3.70% had four foods, 2.91% had five foods, 2.3% had six foods, 0.32% had seven foods, 0.08% had eight foods, and 0.018% had nine foods available. Within each of the three study areas, the percentage coverage by at least one food item was 14.71%, 18.16%, and 20.51% in the Northwest Forest, Sierra Nevada, and Transverse Ranges recovery areas, respectively.

**Table S2.** Percentages across and within the study areas covered by food items.

| Number of available foods | All three study areas | Northwest Forest | Sierra Nevada | Transverse Ranges |
|---|---|---|---|---|
| **1** | 0.39% | 0.00% | 0.72% | 0.00% |
| **2** | 1.72% | 0.06% | 2.51% | 1.94% |
| **3** | 5.41% | 0.61% | 6.24% | 10.38% |
| **4** | 3.70% | 1.75% | 4.16% | 5.81% |
| **5** | 2.91% | 4.39% | 2.79% | 2.27% |
| **6** | 2.30% | 6.21% | 1.68% | 0.12% |
| **7** | 0.32% | 1.25% | 0.06% | 0.00% |
| **8** | 0.08% | 0.35% | 0.00% | 0.00% |
| **9** | 0.02% | 0.08% | 0.00% | 0.00% |
| **Total** | 16.86% | 14.71% | 18.16% | 20.51% |

**Table S3.** Model evaluation scores using model parameters determined on 80% of the data and testing on the remaining 20%.

| Taxon | NP | NA | AUC | Cor | PCor | ODP |
|---|---|---|---|---|---|---|
| *Allium* | 434 | 438 | 0.75 | 0.44 | 1.24E-42 | 0.5 |
| *Avena* | 52 | 52 | 0.61 | 0.2 | 0.04 | 0.5 |
| *Camassia* | 11 | 10 | 0.82 | 0.72 | 0.00027 | 0.48 |
| *Carex* | 65 | 63 | 0.75 | 0.43 | 2.92E-07 | 0.49 |
| *Noctuidae* | 373 | 457 | 0.74 | 0.43 | 1.53E-38 | 0.55 |
| *Odocoileus hemionus* | 991 | 1488 | 0.72 | 0.38 | 4.14E-80 | 0.6 |
| *Pinus albicaulis* | 86 | 86 | 0.96 | 0.91 | 2.57E-66 | 0.5 |
| *Prunus* | 355 | 356 | 0.68 | 0.29 | 1.85E-15 | 0.5 |
| *Quercus* | 1404 | 1402 | 0.71 | 0.38 | 3.99E-96 | 0.5 |
| *Rubus* | 390 | 390 | 0.76 | 0.46 | 3.23E-41 | 0.5 |
| *Vaccinium* | 125 | 133 | 0.92 | 0.73 | 9.87E-45 | 0.52 |

*Notes.* SNP = number of presence points. NA = number of absence points. AUC = area under the receiver operator curve. Cor = correlation coefficient. PCor = p-value associated with Cor. ODP = overall diagnostic power.

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Chapter 6

# Public Support

By Alex McInturff*, Christine Wilkinson*, Lara Volski, Ellen M. Pero & Peter S. Alagona

* indicates co-lead authors

California Grizzly Alliance

## Key Points

Building and maintaining high levels of public support will be essential for a successful California grizzly recovery program.

Californians broadly support the idea of recovering grizzlies, but their support is based on limited information, does not refer to a specific proposal, and could change over time.

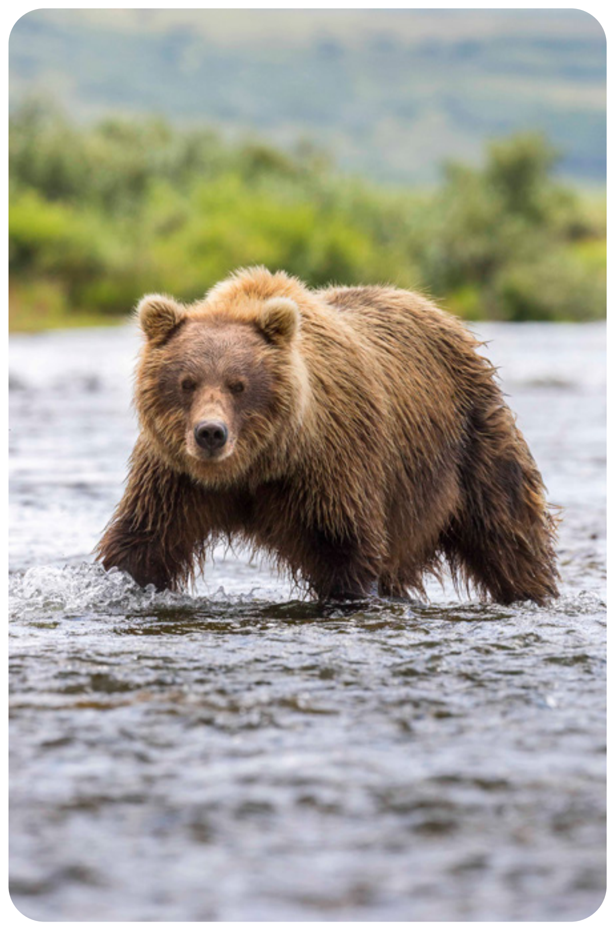
Conflicts with people, as well as outsized perceptions of risk, would reduce public support for a grizzly recovery program. Low public support could limit the bears' ability to move across the landscape and endanger the lives of individual bears.

Maintaining strong public support will require not only implementing targeted coexistence measures, but also cultivating public trust. This means ensuring that people who live near or use potential recovery areas feel heard, consulted, and respected, addressing people's legitimate concerns, engaging in transparent and effective bottom-up and top-down decision-making processes, and building a diverse, broad-based advocacy coalition.

# Introduction

Building and maintaining high levels of public support, both across regional populations and within key local communities, have proven essential for large carnivore reintroduction and recovery efforts around the world [1]. Californians regularly support conservation measures and funding programs, and the state is known as a bastion of mutualist values, emphasizing care for and coexistence with wildlife at increasing levels that exceed those of other western states [2], [3]. Currently, Californians broadly support a grizzly recovery program, but their degree of support could change over time in response to a number of factors. If support were to wane or become politically polarized prior to a reintroduction effort, then the feasibility of such an effort may be called into question [4], as occurred in Washington state in 2019 [5]. If support were to decline after a reintroduction, then California's habitats could become more lethal to grizzly bears. Humans already kill around 80% of the grizzly bears that die each year in the lower 48 U.S. states [6]. Further losses could reduce the viability of a reintroduced grizzly population and jeopardize the success of their recovery program.

Public support may shift over time owing to a number of factors, including both actual conflicts with people and negative or outsized beliefs about the risks of such conflicts. Addressing these potential challenges would require both tangible measures that promote coexistence and less tangible measures that build trust by enabling people to feel heard and respected. Successful efforts to build public support usually combine support for specific coexistence measures with open, transparent, and collaborative bottom-up and top-down community-building and decision-making processes [7], [8]. Evidence suggests that such engagement may be as critical to maximizing the benefits and minimizing the risks of coexistence as practical public safety and conflict prevention measures [9], [10], [11]. (See Chapters 7 and 8 for more details.) Even well-designed and attended processes cannot change broader social circumstances, such as economic changes and declining trust in institutions [12], [13], [14]. Still, effective processes can foster greater trust within communities, and the research that emerges from it can provide managers with crucial information about how best to plan a successful recovery program [15].



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# Questions

## 1 To what extent do Californians support grizzly bear recovery?

***Californians support the idea of recovering grizzlies, but their support is based on limited information, does not refer to a specific proposal, and could change over time. To build and maintain high levels of public support, advocates should engage rural communities, continue to collaborate with California Tribes, and foster positive, proactive conversations among a broad and diverse public.***

In 2019, Hiroyasu et al. surveyed Californians about their knowledge of and potential support for a grizzly recovery program [16]. The authors found that Californians strongly support the idea of recovering grizzlies, but their support is based on limited information, does not refer to a specific proposal, and could change over time. Only a quarter of residents surveyed knew that grizzlies were currently extinct in the state; half said they did not know, and a quarter said they believed grizzlies still lived in California. When informed about the grizzly's present situation, two-thirds of respondents—across both urban and rural areas—supported a recovery effort.

Examples from other states suggest that as specific reintroduction proposals take shape, questions emerge, debates arise, and coalitions form [17], [18], [19]. Public opinion surveys in Washington, for example, found that most residents supported a North Cascades grizzly recovery effort, but members of some rural communities eventually organized in opposition [5]. Some observers believe that a similar process is likely to unfold in California [20]. This hypothesis is plausible but untested. The state's overwhelmingly urban population, strong mutualist value orientations (emphasizing care for and coexistence with wildlife), broad-based support for conservation, and dramatic increases in concern about large carnivores such as pumas suggest that support is likely to be stronger and opposition weaker in California than in other western states. Moreover, the grizzly's status as a state mascot, the rapidly diminishing influence of legacy natural resource industries, and other factors signal that California might see stronger support than other states (see Chapter 8).

Opinions about wildlife conservation in California exhibit an urban-rural divide similar to those seen elsewhere in North America and Europe [21]. The dynamic in California is distinctive, however, because California is the most urban U.S. state by population. More than 94% of Californians live in cities—slightly above the percentage for neighboring Nevada, the second most urban state—and most of these cities are located along the Central and Southern California coasts or in the Great Central Valley [22]. Around three-quarters of Californians live on just 2% of the state's land area, with several other regions of the state having human population densities similar to or below those of the Northern Rockies and North Cascades.

Some rural residents feel that California's urban geography makes it more difficult for their voices to be heard. But in California as elsewhere, rural voices often exert a disproportionate influence over conservation policies. Rural residents who are the most likely to share landscapes with grizzly bears tend to be less supportive of large-carnivore conservation efforts [23], though this varies among individuals, communities, and over time. Earning the trust, engagement, and support of rural residents may, therefore, greatly increase the prospects for a successful grizzly recovery. California conservationists can learn from established programs, such as Montana's Blackfoot Challenge, which has emerged as a powerful model for building trust, collaboration, and support among scientists, officials, wildlife advocates, and community members [7], [8]. Further research on rural California cultures, economies, and identities may also help support recovery efforts by listening to and proactively addressing people's legitimate questions and concerns [10], [11], [12], [14], [15].

Support among California's diverse Native people will be essential for a successful grizzly recovery program. According to the U.S. Census Bureau, in 2020, California had a self-identifying Indigenous population of 762,733, making it the state with the largest number of Native American residents. This figure includes people of diverse heritages from many regions, including both inside and outside of the state, and it is more than double California's estimated human population prior to Spanish colonization, which was as high as 350,000.

California Tribes have long histories and rich cultural traditions related to bears, many of which remain vibrant today [24]. Many members of these Tribes regard bears as a special kind of kin. Some traditions—such as those of the


**Figure 6.1.** Using a range of coexistence tools and approaches can help build and maintain public support, while increasing the likelihood of a successful California grizzly reintroduction and recovery program.

Yurok People, whose homeland is in California's Northwest Forest region—distinguish between the words "human" and "person," which is uncommon in modern English language usage [25]. Human is a narrow term that refers to *Homo sapiens*, whereas a person is a being or entity, human or not, who participates in a community and warrants respect, even when being used as a resource. In this worldview, bears occupy a special place as the nonhuman persons from California that are most similar to us.

Indigenous people are the original stewards of California's environment, the holders of deep knowledge about its animals and nature, and the only humans who have ever lived sustainably in this region. Yet California Tribes have diverse political and economic situations. Most also have a long list of other priorities related to community health, well-being, and economic development, and few have been able to retain large tracts of their ancestral lands [26]. Some tribal members have expressed support for a recovery effort, but views vary and many questions remain [27], [28]. A diversity of tribal viewpoints was reflected at the first "The California Grizzly: A Gathering of Nations" event, attended by around 40 members of more than half a dozen Tribes, hosted by the California Grizzly Alliance and held near Sacramento in October 2024.

Broader political support, in the form of public opinion, can also influence large carnivore conservation efforts. Examples of this support at the ballot box include Proposition 117 [29], California's 1990 measure making pumas a specially-protected species, and Proposition 114 [30], Colorado's 2020 measure to reintroduce wolves in that state. Yet measures such as these only partly reflect the details of the issue itself. In Colorado, Washington, and Idaho, for example, research has shown that support for wolf conservation falls almost entirely along party lines and often follows the urban-rural divide [31], [32]. Grizzly bears tend to attract more support than wolves, as well as less controversy and polarization [33], [34]. A proactive, evidence-based public conversation—along with positive, noncontroversial measures such as the California State Senate's declaration (SR 75 [35]) of 2024 as the "Year of the California Grizzly Bear"—could help increase public awareness and positively frame this issue for diverse audiences.

## 2 Which factors could reduce otherwise high support for grizzly recovery following a reintroduction?

***Conflicts with people, as well as negative or outsized perceptions of risk, would likely reduce support for a grizzly recovery. Addressing these potential challenges would require both practical measures that promote coexistence and broader efforts to build trust by enabling people to feel heard, respected, and part of decision-making processes.***

Conflict with humans is one of the most likely causes of reduced support for reintroduced grizzly bears. Although property damage can erode support, human safety incidents, regardless of their rarity, generate far more concern and even opposition to recovery efforts. In Italy, for example, research showed that a widely reported "bear attack" made a previously supportive public much more skeptical [4]. Established, evidence-based coexistence measures can greatly reduce the likelihood of such incidents and help build trust in local communities. In California, the managers of national parks and other public lands have been working for decades to keep black bears wild and reduce the risk of conflict incidents, but outside of these areas in local communities, support for coexistence has been inconsistent and insufficient (see Chapter 7). Robust, long-term funding for coexistence measures that reduce the risk of conflicts with black bears is important to prepare and ensure public support for a grizzly bear recovery program.

People's perception of risk often diverges from their level of statistical risk. However, perceptions might be even more important than statistics in shaping attitudes and levels of support [36], [37], [38]. Kansky and Knight, for example, found that "intangible costs," including anxieties stemming from elevated risk perceptions, best explained people's attitudes toward wild mammals that had the potential to cause damage [39]. These intangible costs are often rooted in people's values and worldviews rather than in specific incidents or the financial costs and benefits of living with wildlife [40]. Wildlife may also become scapegoats, receiving the blame for larger social problems, economic challenges, or other political frustrations [14], including perceived local interference by agencies and organizations that are believed to represent the interests of city dwellers [41], [42]. Research suggests that people's identities [43] and morals [44], more than conflicts or costs, shape people's attitudes toward animals like bears and wolves.

Previous reintroduction efforts offer lessons about how research can ameliorate negative risk perceptions. Scientists and managers can build trust by genuinely seeking to understand residents' individual perceptions and community values, which in many rural areas have developed over time in response to local social and environmental conditions [45]. Working in communities can also help wildlife advocates develop programs to address local concerns [46]. Qualitative research that enables people's voices to be heard, not just quantified or placated, is especially useful when trying to understand intangible impacts. People often express these impacts not as attitudes and values or costs and benefits, but as stories based on personal and family experiences [47]. Educational programs that draw from this research may improve risk perceptions while building local cultures of bear stewardship [48]. Previous efforts suggest that instilling pride in the reintroduced species among local residents can maintain higher levels of support [49]. Finally, research that identifies current or potential conflict hotspots where support is low and risks are relatively high can help managers and community members implement the most targeted, cost-efficient, and effective coexistence strategies (see Chapter 3) [50], [51].

## 3 How might reduced public support hinder a grizzly recovery effort?

***Reduced levels of support could threaten a grizzly bear reintroduction through the direct killing of bears, and through human behaviors that lower habitat suitability and connectivity, making landscapes less conducive to bears.***

Reduced public support may pose the single greatest potential threat to the feasibility of a grizzly bear reintroduction. Low or wavering public support may lead, both directly and indirectly, to greater numbers of grizzly bear deaths, as it has for several other large carnivores [52]. Legal killings include cases of mistaken identity, for example, when an otherwise law-abiding black bear hunter accidentally kills a protected grizzly bear. "Management killings," when officials euthanize a bear deemed a public nuisance or safety hazard, are permitted in most jurisdictions and are among the most common sources of human-caused grizzly mortality in some areas. The joint record of decision for the North Cascades recovery effort [53], for example, identifies grizzlies in this area under section 10(j) of the Endangered Species Act, allowing for killings of problem bears (see Chapter 9). Low levels of public support will likely lead to greater latitude for management killing and thus reduce the feasibility of meeting recovery goals.

Legal killings also include vehicle collisions with bears where no other traffic laws were broken. In southern British Columbia, vehicle strikes are one of the greatest sources of grizzly mortality, limiting their population sizes [54], [55]. Vehicle strikes would also be one of the greatest concerns for grizzlies in California. Although traffic collisions are usually accidents, they may alter people's perceptions of risk and level of generalized concern, which can affect—both positively and negatively—overall support for a grizzly recovery.

Accidental killings are often a consequence of low or polarized public support. These include unpermitted (nonmanagement) preemptive killings by people worried about the presence of large carnivores, unpermitted retaliatory killings in response to property damage or suspected property damage like the loss of livestock, and malicious killings by individuals who do not want these animals on the landscape or decide to express other frustrations in this way [56], [57]. Grizzly bears are often easily seen even from a distance and, thus, may be relatively vulnerable to malicious shootings compared with some more secretive species. Accidental killings are often causes for serious concern in the western United States and Canada [58]. They can do particular damage during the early phases of a reintroduction and recovery program when a population is small and fragile.

Low public support may also have indirect effects. Ghoddousi et al. described the importance of psychological and social factors, such as fear, in shaping levels of tolerance [59]. Several studies have shown that people's attitudes and values shape the landscape itself, serving as a reasonable predictor of both carnivore movements and conflicts with humans [60], [61], [62]. Sage et al. created a habitat connectivity model that incorporated tolerance for grizzly bears among ranchers in Montana, and the researchers found that low tolerance hindered the ability of bears to move across otherwise suitable habitats and connected landscapes [63]. These observations are difficult to translate directly to California owing to the state's distinctive geography. Unlike the Northern Rockies, where large private ranches and public land grazing allotments are often seamlessly interspersed with public lands, in California, large areas of mostly contiguous suitable habitat are sharply divided from vast areas of intensive agriculture (see Chapters 2 and 3). These disparate geographies may lend themselves to different human-bear interactions, including different geographies of support, tolerance, conflict, and coexistence.

## 4 What can grizzly advocates do to build and sustain public support for a recovery program?

***In addition to targeted strategies for promoting coexistence, many other actions will contribute to maintaining public trust and support, including ensuring that people who live near or use potential recovery areas feel heard and respected, addressing legitimate concerns, engaging in transparent bottom-up and top-down decision-making processes, and building a diverse, broad-based advocacy coalition.***

The research described above suggests that maintaining current high levels of public support will be essential for ensuring the success of a California grizzly recovery program. It also shows that although specific measures that reduce risk and promote coexistence are crucial, other objectives are at least as important for recovery feasibility as mastering bear biology or implementing specific coexistence measures. These other objectives include cultivating public trust, ensuring that people who live near or use potential recovery areas feel heard and respected, addressing legitimate concerns, engaging in transparent decision-making processes with both bottom-up and top-down support, and building a diverse, broad-based advocacy coalition (Figure 6.1). Fundraising to cultivate public support has been an essential element of other large carnivore recovery programs, such as the reintroduction of jaguars (Panthera onca) in the Ibera Wetlands of Argentina, and both private and public entities investment can increase recovery feasibility [64], [65].

Public trust and community engagement are critical for a successful reintroduction [48]. Public trust in government—and other institutions of many kinds—has been declining in the United States for half a century [66], [67]. Within this context, wildlife, especially including endangered species and large carnivores, have often become symbols of larger social tensions [14], [43]. Building support for specific projects in an era of generalized distrust is difficult, but it is not impossible. The U.S. Environmental Protection Agency, for example, has developed best practices for building trust around the management of its toxic Superfund sites [68]. As with pollution cleanup, conservation projects often work best when community engagement is robust and sustained [11], [69], [70]. A sense of *relational* trust, which refers to people's general sense of an agency's capacity, credibility, and transparency, is often more important than their belief in that agency's narrow technical expertise [71]. Efforts to build relational trust often involve cultivating genuine, personal, and collaborative relationships among officials and community members. Connecting recovery programs with a local sense of pride can further complement strong trust-oriented relationships [49]. The co-created knowledge that emerges from these relationships may integrate multiple ways of knowing and emphasize shared values in decision-making.

The planning process may be just as critical for building trust and fostering support as the outcome of a policy. In wildlife management, people are more likely to reject decisions, even if their concerns have been addressed, when they feel these decisions were not reached in an open, transparent, and equitable way [72]. Clearly defining and adhering to key principles, such as fair treatment and meaningful involvement [73], [74], can help ensure that decision-making processes are seen as legitimate [9], [75]. The perception of unjust or opaque processes can reduce community participation and support and diminish relational trust, imperiling grizzly bear recovery [76], [77].

Examples from other states show the value of open, transparent, and equitable processes. Following a wolf reintroduction in Colorado, for example, the state convened a wolf technical working group (TWG) and a stakeholder advisory group (SAG) composed of members representing diverse interests, including ranchers, hunters, and environmentalists. The TWG has made technical and logistical recommendations on conservation and damage prevention, while the SAG serves as an advisory body to Colorado Parks and Wildlife and the Parks and Wildlife Commission. All SAG meetings are open to public observation and comment. Despite the range of perspectives, this group reached a set of consensus recommendations in a 2022 report [78]. While this group continues to navigate the social and political complexities of wolf reintroduction in Colorado, it offers a helpful template for transparent and open engagement. Similar programs are in place in other U.S. states, as well as several Canadian provinces, all of which provide models for planning, collaboration, information gathering, and responding to residents' concerns in ways that build trust and support [7], [8].

Ultimately, both top-down and bottom-up approaches are needed to mitigate risks and build support for carnivore recovery efforts. Public advisory groups and community-led efforts can be powerful ways to foster trust, establish common social norms, develop relationships, and enable diverse groups to cultivate mutual understanding. Working with tribal and community leaders to build credible processes that represent diverse viewpoints, address concerns, and emphasize shared values will also play an important role in building and maintaining broader public support.

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## Opportunities For Future Research

- In-depth, place-based research in communities near potential recovery areas can evaluate current and potential levels of support, as well as the broader social and cultural factors that most influence them.
- Little research examines how levels of support change over time, but a reintroduction offers a critical opportunity to track and understand these changes as discussions continue.
- Further research to map hotspots of conflict, tolerance, and benefits near proposed recovery areas can help inform locally-tailored management plans.
- Research on the most effective communication strategies for various communities can enable managers to reach broad audiences and help diverse Californians better understand the issues involved.
- Previous campaigns—such as the remarkable work using pumas, including the famous Los Angeles resident known as P-22, to support habitat connectivity projects—can provide case studies for the kinds of storytelling and community building needed to develop a broad constituency for grizzly recovery [79].

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Chapter 7

# Human Safety

By Peter S. Alagona

California Grizzly Alliance

## Key Points

Brown bears, including grizzlies, are large, powerful animals that are naturally shy and rarely harm humans. They pose an extremely small statistical risk to human safety compared with a range of other concerns.

In recent years, the populations of both people and bears—including black and grizzly bears—have increased in the American West. But the frequency of serious human safety incidents has not. This divergence is due largely to coexistence measures implemented in parks and on other public lands by wildlife managers, land managers, and advocacy organizations.

Any human safety concerns about grizzlies in California would likely be limited, in the coming decades, to a handful of mountain parks and wilderness areas. Users in these areas should follow guidelines and best practices to further reduce the possibility of a rare physical conflict.

To further enhance human safety, California wildlife and land managers should implement established, evidence-based coexistence measures developed over the past several decades in areas where grizzlies currently live.

To date, California has not invested in a comprehensive, statewide Bear Smart program or other wildlife coexistence program. Doing so would help reduce ongoing challenges with other species, enable greater collaboration, shift the emphasis from response to prevention, aid communities in developing locally tailored programs, and improve prospects for a successful grizzly recovery effort.

# Introduction

Human safety is one of the most common concerns raised in discussions about brown bear conservation and recovery. Brown bears are large, powerful animals that in most places must consume a year's worth of food in around 8 months. They compete for meals, defend their cubs, have a strong sense of personal space, participate in complex social structures, and communicate with other bears in varied and nuanced ways that are easily misinterpreted—or missed entirely—by humans who are not aware of and alert to these behaviors. By the age of 2, brown bears are more than capable of harming an adult human, yet they rarely do so.

This chapter focuses on *human safety concerns*—defined as real or perceived risks to human health—related to a grizzly bear recovery effort in California. It draws from data, lessons, and experiences in regions where brown bears currently live, provides key facts and figures, and distinguishes myth from reality while acknowledging the importance of both in shaping people's attitudes, beliefs, and behaviors. It describes the proximate and contextual factors that influence brown bear-related human safety risks, compares concerns associated with black bears versus brown bears, and identifies measures to minimize risks.

Humans and brown bears encounter one another thousands of times every day throughout the world. This chapter explains that the statistical risk these encounters pose to human life is very small, both in terms of the number of physical conflict incidents and in comparison with a litany of other safety concerns. Yet, like many wildlife species, brown bears warrant caution and respect. Incidents involving brown bears are much rarer than those involving black bears but tend to have higher consequences for the people involved. The risk of an adverse encounter can be further reduced through established, evidence-based management interventions, modest investments, community engagement, and informed personal choices. Precautions that protect both people and grizzly bears will be essential for a successful California recovery effort.

Photo: Tom Fenske - stock.adobe.com

# Questions

## 1 How much of a risk do brown bears pose to human safety?

***Brown bears pose a very small statistical risk to human safety—both in terms of the number of incidents and in comparison with a range of other concerns.***

Many people assume that brown bears are dangerous animals. Statistics do not support the belief that brown bears pose a significant threat to human safety, but the notion that they do probably persists for several reasons. Brown bears are large, powerful animals with striking physical features, including muscular shoulders and long claws adapted mainly for digging. Native peoples developed strategies for living with brown bears long ago, but like many other traditional Indigenous practices, scientists and managers have not generally studied, appreciated, or adopted these approaches. For more than 200 years, since the Lewis and Clark expedition, grizzly bears have been the subject of a perennial stream of misinformation, ramped up in recent years by new forms of social and other viral media. On rare occasions, when brown bears are involved in physical conflicts with people, news outlets often skip the context and use sensationalistic headlines to attract attention, making these incidents seem both more random and more common than they actually are.

Brown bears pose a very small statistical risk to humans, as measured by the number of incidents involved and the number of people affected. The statistical risk is also small compared with a litany of other safety concerns. In the United States, around half of all premature deaths, claiming hundreds of thousands of victims annually, involve preventable causes related to poverty, lifestyle, accidents, substance abuse, and a lack of access to health care [1]. Human fatalities involving wild animals make up a tiny fraction of 1% of these. Of the estimated average of 458 deaths occurring each year due to encounters with wildlife in the United States, almost all—440, or 96%—involve automobile collisions with deer [2]. Venomous arthropods, such as hornets (*Vespa* spp.), bees, and wasps, are a distant secondary cause [3]. Dogs pose far greater dangers to Americans than all wild predators combined. Cattle are responsible for at least 10 times the number of human fatalities—an average of 22 per year in the United States—as all brown, black, and polar bears [4].

In 2019, a large team of researchers [5] conducted a global review of brown bear-related human safety incidents. They found that, between 2000 and 2015, 664 such incidents had occurred—an average of 39.6 per year—across the species' global range in Asia, Europe, and North America. Of these, 85.7% (an average of 33.9) resulted in human injuries, and 14.3% (an average of 5.7) in human fatalities. The summary statistics for fatalities in Europe (1.2 per year) and North America (1.5 per year) were similar.

According to Bombieri et al. [5], human and bear population densities were the most important factors affecting the frequency of human safety incidents. In Canadian provinces, European countries, and U.S. states, higher human and bear population densities tended to increase the likelihood of human-bear encounters, and more encounters usually—but not always, as discussed below—led to more incidents. Romania, which has a relatively high rural human population density and Europe's largest population of brown bears outside Russia, had more than double the number of incidents of any other country. Areas where human and bear densities were lower, such as Canada's Northwest Territories, had few incidents.

It is worth noting that although brown bears pose a tiny statistical threat to humans, the same cannot be said of the threat humans pose to brown bears. Hunting regulations and enforcement vary across the species' range. Brown bear hunting is legal in several European countries, as well as in Canada's Northwest, Nunavut, and Yukon Territories. Alberta banned grizzly hunting in 2006, but between 2013 and 2023, humans in this province are believed to have killed at least 235 grizzly bears, including 57 killed by the agency charged with protecting them [6]. In 2017, First Nations and nongovernmental organizations successfully pushed British Columbia to place a moratorium on brown bear hunting. In 2023, however, hunters across the U.S. border in Alaska killed 737 of the state's roughly 35,000 brown bears [7]. In the lower 48 U.S. states, grizzly bears are protected under the Endangered Species Act (see Chapter 9), but humans still kill 70% to 90% of all the grizzlies that die in a given year [8].

## 2 Have brown bear-related human safety risks changed over time?

***Over the past several decades, the frequency of such incidents has stabilized or even declined in North America despite more people living in closer proximity to more bears.***

Media coverage often implies that human safety risks associated with bears are increasing, but statistics for North America, spanning several decades, do not support this claim [9], [10], [11]. During the early 20th century, when populations of both black and grizzly bears were much lower than today, human fatalities averaged only one or two per decade. Fatalities increased beginning around 1940, decelerated during the 1980s,

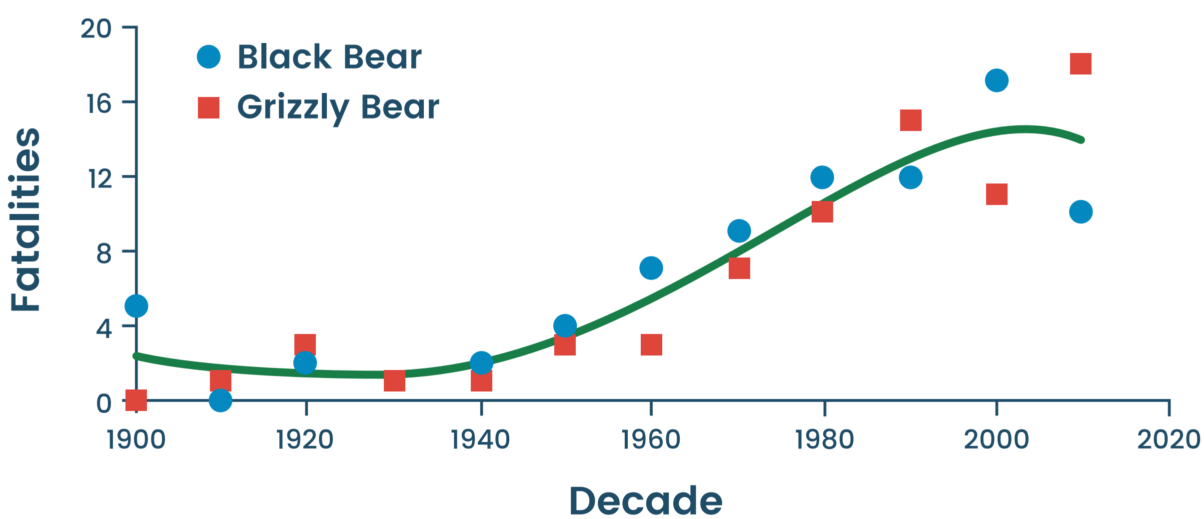


**Figure 7.1.** Human fatalities associated with bears in the United States and Canada, 1900–2020. Redrawn from [11].

and then leveled off by 2000 (Figure 7.1). They have remained stable or declined slightly in the years since, even as the numbers of humans and bears sharing the same landscapes have grown dramatically. This finding is not what one would expect from the work of Bombieri et al., cited above [5], which identified human and bear population densities as the most important factors shaping safety risks.

This leveling or reduction in serious human safety incidents is due mainly to actions taken by managers working in the national parks and on other public lands. Before 1970, the vast majority of bear-related human injuries were minor and involved food-conditioned black bears in national parks and other nearby recreational areas (see Question 4 below). At this time, the small grizzly population in the lower 48 states was also largely limited to a few national parks and wilderness areas. Beginning around 1970, public agencies launched more focused programs to reduce these problems. In Yellowstone, the frequency of bear-related human injuries peaked between 1931 and 1959 at around 63 per million visitors. By 2012, it had plummeted to fewer than 1 per million visitors (Figure 7.2) [12]. The odds of being injured by a grizzly in Yellowstone are now 1 in 1.7 million for backcountry camping and 1 in 27.2 million for all overnight stays.

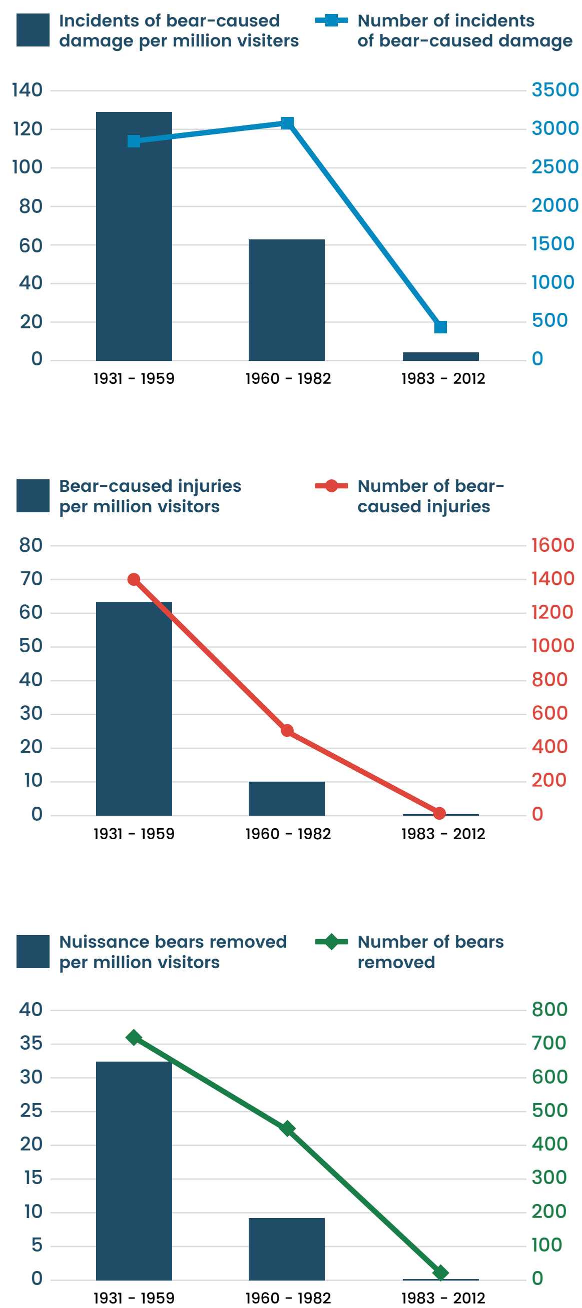


**Figure 7.2.** In Yellowstone National Park, the combined number of black and grizzly bear-related property damage incidents (top), bear-related human injuries (middle), and bear removals (bottom) declined dramatically from 1931 to 2012. Researchers have attributed these trends to several factors, including the removal of artificial feeding sites and stronger regulations and law enforcement involving human food waste and storage. Figure adapted from [12]

## 3 How do proximate factors shape the outcomes of encounters between humans and brown bears?

***Humans and brown bears cross paths thousands of times every day throughout the world, and these encounters rarely result in adverse outcomes. The likelihood that an encounter will lead to a physical conflict depends on the individual bear, the circumstances of the encounter, and the behavior of the person or persons involved.***

Humans and brown bears cross paths thousands of times every day throughout the world, and these encounters rarely result in physical conflicts. Physical conflicts between humans and brown bears almost never result when encounters occur at a distance of at least 100 m, the U.S. National Park Service's (NPS's) minimum recommended viewing range [13]. The risk of an adverse encounter, though small, depends on several factors, including the individual bear, the details of the particular situation, and especially the behavior of the person or persons involved.

All brown bears share a repertoire of typical behaviors, but some populations appear to have distinctive behavioral dispositions. Some researchers have suggested that these population-level variations stem from genetic differences. This hypothesis may be true for some small European populations, such as those in the Apennine Mountains of central Italy and the western Cantabrian Mountains of northern Spain, whose boldest individuals may have been culled during centuries of intensive hunting. Most of the brown bears in these populations seem to be warier than those living elsewhere [14]. Conversely, brown bears living in rich coastal ecosystems supporting dense bear populations, such as those in British Columbia and southern Alaska, appear to be more social than those living mostly solitary lives in sparser habitats [15]. Brown bears that have extensive experience living with other brown bears may also be more likely to tolerate humans in shared settings such as well-managed bear-viewing areas.

Despite these apparent differences, genetics cannot fully explain emergent behavioral qualities, such as shyness or boldness, among intelligent animals with complex social behaviors [16], [17]. Within populations, individual brown bears exhibit a range of personalities. Younger bears and females tend to be relatively social, whereas older male brown bears tend to be far less so. Some individuals also seem to be especially tolerant of humans and thus prone to habituation. Habituated bears that have never learned to associate people with either food or danger may be curious about us but will often show their tolerance by ignoring us. Habituated bears are extremely unlikely to show aggression toward people who respect their personal space, or "overt reaction distance." Grizzly 399 was a famous habituated bear that occasionally wandered through Jackson, Wyoming, had tens of thousands of encounters with people, and gave birth to at least 18 cubs between 2004 and her death in 2024.

When bear encounters result in rare human injuries, the word "attack" is often used to describe them, but like the word "conflict," this is an ambiguous and often unhelpful term. It conjures emotions that can cloud judgment, and it frequently appears in both the popular media and scientific literature to describe a wide variety of incidents that have different contexts, causes, and consequences. Understanding the details of these incidents—including the specific circumstances that made them more likely or led directly to them—is essential to learning from them and thus reducing risks to both humans and bears [18].

Staying safe in grizzly country depends, in part, on people making informed decisions and behaving responsibly. A 2016 study by Penteriani et al. [19], for example, found that in Europe and North America, more than half of all physical altercations between large carnivores and humans involved a risk-enhancing behavior by the person or persons involved. For brown bears, some activities appear to enhance risk more than others. Hunters who move quietly, blend into the environment, chase after wounded animals, and deal with carcasses should announce their presence, carry bear spray, and ideally travel with partners. Trail running at dusk while wearing earbuds tends to deafen people to their surroundings. Backpackers should cook away from their campsites and secure their food. Dogs not specifically trained to work around bears should be leashed or left at home [20]. Wildlife viewers should give all animals a respectful distance. Hiking quietly and alone increases the risk of an unexpected encounter, whereas hiking in a gregarious group of two or more people is an extremely safe and rewarding communal activity throughout all of brown bear country.

## 4 How do preceding events and broader contextual factors shape human encounters with brown bears?

***In addition to the proximate factors discussed above, preceding events and larger contextual factors, both shape the likelihood and outcomes of human encounters with brown bears.***

The research on specific, real-time risk factors cited above offers valuable insights, but it also has limitations. These studies identify proximate factors involved in physical conflicts, but they do not generally explain the events leading up to or broader social and ecological contexts setting the stage for such conflicts. Gaining a fuller understanding of these preceding and contextual factors is important because, although some incidents seem to occur at random or as a direct result of specific human actions, many can also be traced to previous events or larger circumstances that made these incidents much more likely.

When serious human safety incidents involving bears take place, there is usually a backstory: a series of preceding events—often involving the same location, person, or bear—that signaled the need for action but remained inadequately addressed. The most common such scenario involves *food conditioning*, in which bears that gain access to human foods begin to engage in riskier behaviors to gain a food reward. Most brown bears must eat a year's worth of food in around 8 months. Once they access high-quality food that they associate with humans or developed areas, they are usually reluctant to abandon these sources of nutrition. And because bears have intergenerational cultures of learned behavior, they often teach their cubs to do the same.

For decades, the NPS fed or permitted the feeding of both black and brown bears for the viewing enjoyment of tourists. The problems associated with these policies became apparent as early as the 1890s and then escalated over time [21]. By the mid-20th century, parks such as Yellowstone were dealing with hundreds of bear-related conflict incidents each year. The vast majority of these involved property, but many led to the deaths of bears, and some resulted in human injuries.

The most infamous of these episodes took place in Glacier National Park. From the park's establishment in 1910 until 1967, no grizzly bear-related human deaths occurred within its boundaries. Then, on the night of August 12, 1967, bears killed two campers in separate incidents in different locations. Investigations later revealed that years of negligent food and waste handling, which were well-known beforehand to park officials and many visitors, had created an extreme and ultimately tragic safety risk. In the months that followed, the NPS killed several bears, including ones not involved with these incidents, generating further criticism and illustrating the backwardness and futility of its policies at that time. In 2024, California's first-ever human death associated with a black bear involved a different species and location from the Glacier incident, but a similar set of circumstances. This case involved an aggressive, food-conditioned bear, and the failure of officials to respond to what many community members recognized as an increasingly alarming situation [22].

After the Glacier incidents, NPS officials debated how to fix decades of mismanagement. In 1970, however, a series of hasty decisions led to another debacle. Yellowstone officials ignored the advice of biologists Frank and John Craighead and abruptly closed the park's last dump where grizzlies had been permitted to forage. Bears that depended on this food source suffered, and a rash of conflicts ensued. Several starved, died from automobile collisions, or were killed by rangers who feared that the desperate bears had become dangerous. This prompted even wider calls for change. The NPS adopted new policies, and in 1975, the U.S. Fish and Wildlife Service listed grizzlies as threatened under the U.S. Endangered Species Act (see Chapter 9).

In areas with histories of conflict, addressing these problems can be challenging, but doing so delivers considerable benefits. Yosemite and Sequoia-Kings Canyon National Parks have a long history of conflicts involving food-conditioned black bears. By the 1980s and 90s, this situation had become a crisis, with hundreds of incidents annually. Physical harm to humans was rare, but property damage and bear deaths were common. Around 2000, these parks launched a multipronged program involving waste management, education, and law enforcement; they developed new or improved technologies, such as lightweight bear-resistant food canisters for backpackers, and they installed hundreds of metal food storage boxes [23]. This approach proved remarkably effective, reducing the number of incidents within these parks' boundaries by more than 90%. Studies later showed that the parks' bears had shifted back from a diet of artificial junk foods to one of natural foods [24].

Larger geographic contexts, in addition to specific preceding events, also shape the likelihood of a rare physical conflict. Natural wildlife corridors and urban- or agricultural-wildland interfaces tend to see more encounters between people and wild animals in general, including bears [25]. Demographic changes—including rural depopulation in Europe and

Japan, and rural population growth in parts of the American and Canadian Rocky Mountains—shape patterns of recreation, tax revenue, political dynamics, civic leadership, and institutions, as well as material factors including urban development, infrastructure, fire behavior, and livestock husbandry [26], [27]. Climatic and ecological changes that shift the distribution or abundance of bear foods may also influence the likelihood of human-bear encounters [28].

Proximate factors, preceding events, and geographic contexts make for a complex risk equation. It is unclear how these issues, as described in other regions, may affect a grizzly recovery effort in California. Some of California's parks and wilderness areas see intensive recreation, but use tends to be fairly concentrated, and some of the best potential grizzly habitat is in remote areas that see relatively little traffic compared with Glacier, Grand Teton, and Yellowstone National Parks (see Chapter 2). Most rural communities near parks in California are not expected to undergo major demographic changes in the coming decades. Unlike the Northern Rockies, California has not, thus far, seen widespread die-offs among whitebark pines, a key grizzly food in the alpine zone often removed from high-use recreational areas [29]. California's grizzly habitats are divided into large, mostly contiguous protected blocks, reducing the near-term likelihood that grizzlies would wander out of them (see Chapter 3). Coexistence measures already taken for black bears in these parks and wilderness areas will be of tremendous value for grizzlies. Finally, California has the distinct benefits of having ample resources and being able to learn from the successes and failures of previous grizzly conservation efforts.

## 5 How do safety risks associated with brown bears differ from those involving black bears?

***Black and brown bears are similar in many ways, but they tend to have different dispositions that shape their human relations. Brown bears are involved in fewer property-related conflicts than black bears, but physical conflicts with brown bears tend to be more serious than those involving black bears.***

For most of their evolutionary histories, American black bears and brown bears lived in different places and thus were able to occupy similar niches without competing [30]. It is not surprising, therefore, that they are alike in many ways. They have similar physical traits, inhabit many of the same ecosystems, will eat almost all the same foods, and engage in many of the same behaviors, including extended maternal care and hibernation—crucial adaptations that shape their life histories and relations with humans. For these reasons, managers use most of the same precautions, interventions, investments, and other tools for both species. Many of these tools are already in use in California, though they could be applied more widely outside parks and other public lands.

Despite their similarities, black and brown bears differ in at least two important ways that relate to human safety. First, individual members of these two species tend to have different dispositions. Black bears are thought to have evolved mainly in forests and are outstanding climbers. When faced with a threat—such as a pack of dire wolves (*Canis* (*Aenocyon*) *dirus*) during the Pleistocene or a busload of tourists today—they often seek safety in the trees. Grizzly bears evolved in diverse habitats, including forests and woodlands, but also in more open areas, such as tundra, grasslands, and shrublands. Adult brown bears are poor climbers. When faced with threats, they must flee or stand their ground. Also, unlike black bears, brown bears in some areas congregate at rich feeding sites such as salmon streams, where they often jostle for space and resources. Compared with black bears, some brown bears thus engage more in complex social behaviors, including occasional confrontations. These forms of communication rarely harm adult brown bears, but they can be dangerous for humans.

Second, compared with grizzlies, black bears are more likely to use habitats in developed areas. Reasons for this include black bears' superior climbing skills, smaller average body size, higher potential fertility rates, and greater propensity for habituation [31]. Habituated black bears, like habituated grizzlies, may be at a heightened risk of becoming food-conditioned, engaging in conflicts with people, or dying in automobile collisions. Black bears that live in some urban areas die younger on average than those living in nearby wildland areas, but they often reproduce at greater rates, enabling them to maintain relatively high population densities [32].

The differences between these two species have profoundly shaped their populations and conservation status. In the lower 48 U.S. states, grizzly bears are slowly recovering from decades of persecution. Today, there are around 2000 grizzlies living in four states. Black bears also have a long history of persecution, but over the past century, their population has rebounded spectacularly. There are now as many as half a million black bears—about 250 times the number of grizzlies—spread throughout 40 of the lower 48 U.S. states. California has long been the state outside Alaska with the largest population of black bears. In 2024, the California Department of Fish and Wildlife, which for years said that the state had around 35,000 black bears, revealed the preliminary results of an Integrated Population Model, suggesting that the state probably had closer to 65,000 [33].

The differences between black and brown bears shape their human relations in other ways. The vast majority of property-related bear conflict incidents in North America involve food-conditioned black bears. Since 2000, however, a small but growing number of incidents have involved grizzly bears. To the west of Yellowstone National Park in Idaho, for example, the number of grizzly-related property conflicts increased from fewer than five per year most years in the 1990s to 34 in 2020 [34]. Only two of these incidents resulted in human injuries, but this trend suggests that technical and financial support, as well as an adjustment period, may be necessary to ensure human safety and minimize property damage for communities that find themselves living with grizzlies either for the first time or for the first time in a long time.

Photo: Jay Goodrich / @tandemstock

## 6 How can we further reduce the human safety risks of living with brown bears?

***Communities can become "Bear Smart" by working with government agencies, nongovernmental organizations, and other institutions to implement practical, proactive, established, and evidence-based measures that enable residents to enjoy living with bears while protecting their property and themselves.***

Half a century of research, education, innovation, advocacy, policy, and management have shown that humans and bears can coexist with considerable benefits and at low risk. The national parks have made impressive strides, but many communities are still struggling with how best to implement locally appropriate, evidence-based management measures. In areas with ongoing challenges, more leadership, community engagement, and modest additional investments in evidence-based measures would help reduce the risk of both property damage and physical conflicts while protecting bears and other wildlife.

Most successful bear coexistence programs have several features in common. They have the backing of key leaders in government and civil society, use multiple tools and approaches, marshal resources to make targeted investments, commit to long-term work, develop effective educational and outreach programs, and engage local communities to cultivate broad-based support and a common sense of stewardship. These programs seek to cultivate not only tolerance of bears but also a sense of pride in living with them. Both bottom-up efforts at the individual and local community levels and top-down efforts by legislators and managers are often necessary to build the most effective programs. Successful programs usually involve diverse individuals, communities, and institutions, including universities, conservation organizations, zoos and museums, civic groups, and government agencies, as well as Tribes and other Indigenous-led institutions.

Instead of addressing problems after they occur, managers and advocacy groups stress proactive measures to prevent problems before they begin. During the 1990s, Bear Smart programs emerged in British Columbia and then spread to several other regions. Advocates developed and promoted the use of new tools and techniques—from bear-resistant food containers to bear-repellent aerosol sprays—that became key elements of this approach. A trove of information now exists for individuals and communities working to improve their relations with bears. Many of these tools can also help people coexist with a range of other species.

The Bear Smart approach focuses on eight areas to protect wildlife and reduce risk:

### 1 Managing attractive nuisances

Attractive nuisances include food and related preparation, storage, and disposal equipment that may entice bears and lead to conflicts, such as compost piles, carcass dumps, bird feeders, fruit trees, vegetable gardens, beehives, coolers, and barbeques, as well as pets and livestock. In bear country, attractive nuisances should be stored safely or protected when not in use. Such precautions may seem like an inconvenience, but limiting attractive nuisances protects all wildlife, not just bears, and reduces the risk of attracting pests and experiencing property damage.

### ② Waste management

Waste management includes both collection and disposal. Homes and businesses in bear country, particularly those located in wildlife corridors or wildland-urban interfaces, should be provided with wildlife-resistant trash cans or dumpsters and should be required to use them correctly. In areas where this is impractical, homes and businesses should be required to store their trash in a secure location, such as a garage or shed, until the morning of the scheduled pickup. Landfills, transfer stations, recycling centers, and other sorting and disposal sites should be locked or covered whenever possible, secured with electrified fences where necessary, and monitored to ensure that bears and other wildlife cannot access them. Waste management firms must be engaged as partners, using a combination of financial incentives, public support, and regulations.

### ③ Education and outreach

Bear Smart educational efforts are often led by community groups in partnership with schools, zoos, museums, conservation organizations, and local, state, and federal agencies. These efforts may take many forms, including school curricula, signage, public service announcements, radio shows or podcasts, social media campaigns, certification programs, community events, and required online videos for campers and wilderness recreationists seeking reservations or permits. Some groups also distribute collectible items with educational messages, such as playing cards, bookmarks, stickers, and apparel.

### ④ Law enforcement

Passing and enforcing laws is an essential aspect of a carrot-and-stick approach to living with wildlife. Encouraging people to abide by these laws should not, however, be the sole responsibility of the police. Conservation agencies and groups, for example, can provide people with information about local regulations, and wildlife officials can engage local residents and communities to help them comply with laws designed to protect them. Penalties should follow warnings, be applied fairly and consistently, and increase in severity with successive violations. Enforcement should focus both on attractive nuisances and other concerns, such as speeding on rural and park roads near known wildlife corridors.

### ⑤ Open-space management

Managing bear-safe recreational spaces in and around towns involves a combination of education efforts, including signage, the monitoring of bear exclusion zones near schools and other sensitive sites, and vegetation management to ensure that attractants such as berry bushes and fruit trees do not lure bears into populated areas. Open space also provides excellent opportunities to engage the public through trailhead tabling, community events, and volunteer projects.

### ⑥ Community planning

Most community-level planning exercises do not include wildlife-specific elements. Increasingly, however, cities and especially counties are considering wildlife in their parks, flood control, transportation, and other planning elements. This work includes community-based mapping efforts to identify key bear habitats and infrastructure improvements to promote human safety, including the construction of strategically designed wildlife road crossings that reduce the risk of traffic collisions.

### 7 Management of individual bears

Individual bears, especially those that become food-conditioned, sometimes require management interventions, including hazing, translocation, placement in zoos, or in extreme circumstances, euthanasia. Bears that pose concerns should be closely monitored, and criteria should be clearly developed—based on science, animal welfare, and local community standards—for how officials address various scenarios. Local, state, and federal coordination is often crucial in facilitating effective responses.

### 8 Scientific and community monitoring

Monitoring programs that engage academic researchers, managers, and the public, including children, can be extremely effective not only for learning about and tracking changes in an area's bear population but also for providing an educational intervention that reduces risk and promotes coexistence. These programs can also be a means of increasing public support for conservation.

## Opportunities For Future Research

- Future research could explore Californians' beliefs and concerns about grizzly-related risks, focusing on how these beliefs differ across the state's diverse regions and between California and relevant states.
- Researchers could map potential hotspots of human-grizzly interactions in California to aid managers in prioritizing proactive coexistence efforts.
- Future research could explore potential policy frameworks that would enable California to develop a more effective—and long overdue—statewide wildlife coexistence program.

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Chapter 8

# Economic Effects

By Peter S. Alagona

California Grizzly Alliance

## Key Points

Brown bears have only modest economic effects in most of the communities where they live and on most of the industries with which they share their habitats. The effects they do have are often difficult to measure, unevenly distributed, and involve a range of cultural values that extend beyond economics.

A well-resourced California grizzly recovery program would likely cost less than $3 million per year over the first 10 years, a fraction of 1% of the money California currently spends on fish and wildlife.

Few of California's farms or forest products industries would see any significant impact from a grizzly recovery effort. Grazing operations that use some protected nature reserves and designated wilderness areas would, over time, benefit from adopting more wildlife-friendly coexistence approaches.

A grizzly recovery program could generate tourism revenue for some rural and tribal communities by creating opportunities for well-managed bear-viewing guide businesses like those currently operating in Alaska, British Columbia, and several European countries.

A grizzly recovery program would be unlikely to have a major effect on outdoor recreation in California. A recovery program would, however, benefit from infrastructure upgrades, educational programs, and other public safety and coexistence measures to ensure safe recreation in areas where the bears live.

## Introduction

Brown bears affect economies in varied ways. Media coverage and academic research tend to dwell on the costs of living with brown bears, including management programs and losses of crops and livestock. More holistic studies show that the bears also provide a range of benefits, including ecosystem services and tourism opportunities. Compared with their often direct and obvious costs, however, these benefits tend to be more difficult to measure and more thinly distributed across society, and they encompass a broader range of nonquantifiable social and cultural values [1]. Thus, although brown bears tend to have only modest economic effects—relative to agency budgets, regional economies, and industries—these effects are often complex and variable and may be felt in different ways by different people.

This chapter draws from theories and frameworks used to study the economic impacts of brown bears in diverse regions, as well as relevant contextual data from California and areas where brown bears currently live. A California grizzly recovery program would not have a major economic impact on California's economy as a whole and would be unlikely to do so for any industry. It would, however, come with some costs and benefits for individuals, institutions, and local communities. Government agencies and their nongovernmental partners should work to ensure that any negative impacts do not disproportionately affect specific communities or individuals. The potential economic benefits of living with grizzlies—if properly cultivated, managed, marketed, leveraged, and distributed—can build public support, aid rural and tribal communities, and increase the prospects of a successful recovery program.

Photo: Jason Savage / @tandemstock

# Questions

## 1 How much would a reintroduction and recovery program cost?

***A California grizzly recovery program would likely draw from public and private funds and cost less than $3 million per year over the first decade. This figure equates to around 0.001% of the budget for the State of California and 0.4% of the budget for the California Department of Fish and Wildlife, based on 2024–25 figures. These funds would compensate agency staff and support program needs, including animal transport and welfare, research and monitoring, coexistence and infrastructure, collaborative projects, and grants for tribal stewardship (Figure 8.1).***

We base our estimate of up to $3 million per year for a California grizzly recovery program on the reported budgets of grizzly recovery efforts already underway in other parts of the United States. According to the U.S. Fish and Wildlife Service (USFWS), in 2022, funding for grizzly recovery in the lower 48 U.S. states totaled $1,081,500 [2]. Expenditures included $166,000 for USFWS research and monitoring, $685,000 for interagency management, $194,000 for conflict prevention, and $36,000 to support nongovernmental partners in their collaborative coexistence and outreach efforts. To put these numbers in perspective, the USFWS's entire 2022 budget for recovering grizzly bears—one of America's most iconic and beloved wildlife species—was less than the average sale price of a single-family home in at least four California counties.

The USFWS plans to expand its grizzly bear recovery program in 2025 to include a reintroduction and recovery effort in the North Cascades of Washington state. *The Final Grizzly Bear Restoration Plan/Environmental Impact Statement* for the North Cascades Ecosystem estimates that this effort will cost an additional $733,167 per year [3]. This funding will cover grizzly capture, transport, and release, as well as monitoring, education, sanitation, and other coexistence programs. The North Cascades budget also includes funding for a recovery coordinator, two full-time conflict specialists, and two seasonal monitors. A recovery effort in California would probably be somewhat more expensive owing to California's greater distance from grizzly source populations and a likely desire among Californians for a greater level of public investment.

The USFWS cost estimates do not cover all of the grizzly bear recovery program's needs, particularly those related to protecting habitat and implementing coexistence programs. The U.S. National Park Service (NPS) has taken a lead role in the effort to restore grizzlies in the North Cascades. Since 1970, the NPS has invested in a range of other efforts to educate visitors about

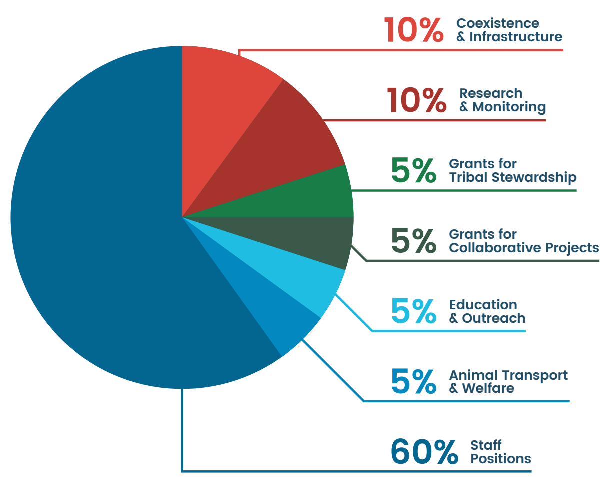


**Figure 8.1.** Spending categories and proportional estimates for a California grizzly recovery program.

grizzlies and promote coexistence with them. In recent years, the NPS has also dedicated more staff time to managing “bear jams,” which take place when visitors stop their vehicles to view bears along roadsides in Yellowstone and Grand Teton National Parks [4].

Most public, nonfederal funds for grizzly recovery come from state governments, including state departments of fish and wildlife, parks and natural resources, and transportation. In 2020, for example, Montana spent $1.44 million on its grizzly bear program [5]. Around 70% of Montana’s expenditures paid for the salaries and benefits of up to 14 full-time employees, while 28% paid for operating costs and 2% for equipment.

The main source of government funding for a California grizzly recovery program would depend on the lead agency. If grizzlies remain listed as federally threatened in the lower 48 states (see Chapter 9), then the USFWS would take the lead with support from the state; if grizzlies are removed from federal Endangered Species Act protections, then either the NPS or, more likely, the State of California would take the lead.

The California Department of Fish and Wildlife (CDFW) is both chronically underfunded and well-positioned, financially, to take on a grizzly recovery effort. To understand this apparent contradiction, it is helpful to consider how state funding for wildlife gets allocated and spent. California has the largest wildlife agency of any state, but its funding varies wildly from year to year. These funding swings are a consequence of the state’s budgetary structure, which produces frequent windfalls and shortfalls due to its heavy reliance on variable revenue from personal income and capital gains taxes. During recent years, the CDFW’s budget has fluctuated from $784 million in 2022–23 to a high of $1.119 billion in 2023–24 (a year during which the department benefited from one-time carryovers and infusions), and then to a low of $682 million during the statewide budget crunch of 2024–25. The CDFW’s 2024–25 budget was 39% lower than the previous year’s budget, but this was still 82% higher than the $126 million budget requested in 2023 by Montana’s Department of Fish, Wildlife, and Parks [6], [7], [8].

Despite its considerable budget, the CDFW is severely under-resourced relative to the demands placed on it. The 2021 *Service Based Budgeting* report found that the CDFW’s public expectations and legal responsibilities have grown dramatically in recent decades, but its budget—which draws from around 60 separate funds, each with its own revenue streams, legal restrictions, and use guidelines—has failed to keep up with the department’s expanding obligations [7]. According to the report, all eight of the CDFW’s “mission-level needs” are underfunded, with the greatest gap, an estimated 74% shortfall, in the crucial area of “species and habitat conservation.”

The *Service Based Budgeting* report provides an important context, but it paints an incomplete picture of California’s investments in species and habitat conservation. In addition to frequent budget swings, California legislators and voters also pass occasional conservation-focused bond measures. These include Propositions 12 and 13 in 2000 [9], [10], which provided $4.1 billion for parks and water conservation; Proposition 84 in 2006 [11], which directed $5.4 billion to parks, water, and other natural resources; and Proposition 4 in 2024 [12], which allocated $10 billion for climate change-related projects, including ecological restoration efforts and nature-based climate solutions. Full funding for the first decade of a California grizzly recovery program, based on the estimate given here, would cost just 0.03% of the funding generated through Proposition 4.

Wildlife in California receives additional financial support from other state and federal agencies. These include the California Department of Parks and Recreation ($873 million budget in 2023–24), which manages the country's largest state park system by the number of units and second largest by area, and the Wildlife Conservation Board ($262 million budget in 2023–24), which allocates funds to purchase lands and waters for recreation and conservation [8]. California also has a robust federal conservation presence, with the nation's second-largest national forest system after Alaska and the greatest number of national parks of any U.S. state, including units located in prime grizzly habitat (see Chapter 2). Most grizzly recovery efforts would take place on these federal lands.

Finally, California has more nongovernmental conservation organizations than any other state, and these groups support a range of relevant projects, including coexistence work in local communities, education, outreach, policy work, legal defense, land acquisitions, and infrastructure improvements. Some of these groups could become partners in a grizzly recovery program. In the Northern Rockies, nongovernmental groups have played crucial roles in protecting habitat corridors and have worked with local communities to implement coexistence projects, such as installing electrified fencing, developing guard dog programs, and transporting cattle carcasses to secure waste disposal facilities. A coalition of nongovernmental organizations has also mobilized to support the recovery effort in the North Cascades.

## 2 How would grizzly bears affect natural resource-dependent industries, including the ranching, agriculture, and forest products sectors?

***Few of California's farms or forest products industries would see any significant impact from a grizzly recovery effort in the coming decades. Some livestock operations that use lands in or near large mountain wilderness areas would, however, benefit over time from adopting proactive approaches that protect bears, reduce the possibility of losses, and promote coexistence.***

California is, by far, the top U.S. state in terms of agricultural revenue, with $51.1 billion in cash receipts in 2021, which is 32.2% more than the second-most productive farming state [13]. In addition to its productivity, California agriculture is known for its diversity. The state's most lucrative farming sector is dairy, but California also leads the United States in many other commodities, including several varieties of fruits, nuts, berries, flowers, grapes, and vegetables. California's top 20 farm commodities accounted for $44.2 billion in cash receipts in 2021, with the additional $6.9 billion coming from about 400 others. These numbers mean not only that California has an enormous agricultural economy but also that its farming and ranching operations take place in diverse climatic and ecological contexts suitable for the production of widely varying products across the state's diverse geographic regions (Figure 8.2).

A California grizzly recovery effort would have little impact on crops. A recovery effort would start with a small number of bears, grow slowly over time (see Chapter 3), and focus on large blocks of protected habitat in national parks, wilderness areas, and other conservation lands. Crops are not grown in these areas. Most of California's protected areas are surrounded by mixed-use buffer zones, which are managed mainly for forest and water conservation, fire protection, recreation, and grazing. Any impacts to row, orchard, or vineyard crops would, therefore, emerge only in places where these products are grown immediately adjacent to protected areas.

Some farms do exist near this study's potential grizzly recovery areas. The Sierra Nevada's western foothills contain extensive berry patches, fruit and nut orchards, and vineyards. In the Transverse Ranges, public lands border citrus groves, avocado orchards, and vineyards. Many of these crops could prove attractive to bears, but the state's experience with black bears suggests that major problems are unlikely. Black bears are several times more numerous than grizzlies will ever be in California, and they are generally more willing than grizzlies to forage in developed areas. Yet they do not appear to pose significant concerns for the state's farmers. For example, the CDFW's 2024 draft *Black Bear Conservation Plan for California* makes only one mention (p. 13), based on "unpublished data," of black bears in relation to crop damage [14]. The draft plan does not identify this as a management issue.

About 33 million acres of California, or around one-third of its area, is covered in diverse forests and woodlands, defined broadly as land with at least 10% tree canopy cover [15]. About 60% of California's forests are publicly

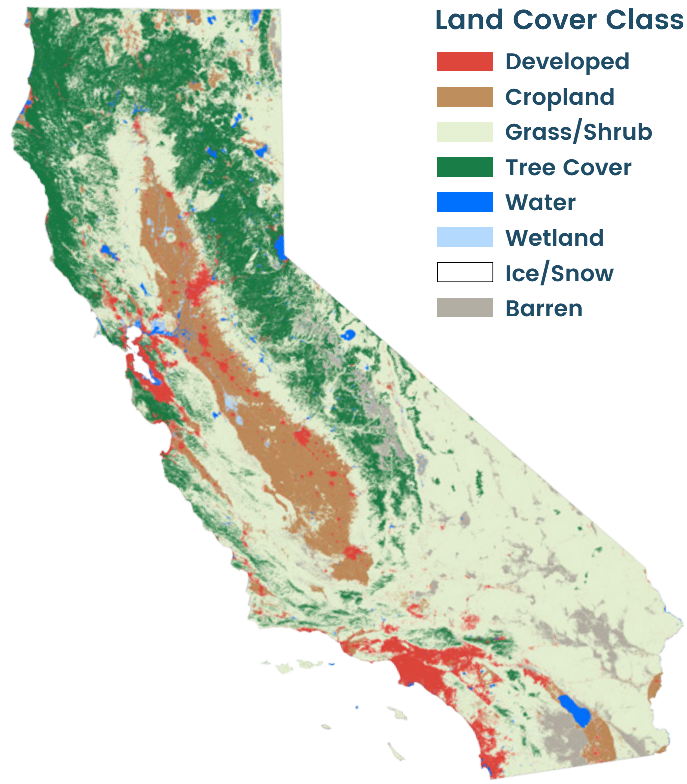


**Figure 8.2.** California land cover, including natural vegetation and agricultural areas.

owned, and around 72% of these publicly owned forestlands are managed by the U.S. Forest Service. Most of the state's remaining harvestable timber exists in a handful of northern counties, including Humboldt, Lassen, Shasta, Siskiyou, and Trinity.

California's timber industry, once a behemoth, has declined dramatically over the past half-century [16]. As late as the 1980s, California loggers harvested 6 billion board feet annually. By 2016, the state produced only around 1.5 billion board feet, a 75% decline. Less than one-tenth of the timber harvested in California today comes from public lands. Prior to 1980, large firms dominated California's timber industry, but most of these have since shut down or left the state. Because a grizzly bear recovery program would focus on national parks and wilderness areas that are already off-limits to timber harvesting, and because any prospect that the bears would expand their range into the mixed-use peripheries of these areas is probably decades away, a grizzly recovery program is unlikely to pose any meaningful impact to California's dwindling timber industry.

Livestock grazing has been an important aspect of California's rural culture and economy since the late 1700s. Compared with a century ago, livestock grazing generates a much smaller proportion of the state's economy, but it still maintains a significant presence on California's public lands. The NPS does not generally allow grazing, but some other agencies and organizations do, including the U.S. Forest Service, U.S. Bureau of Land Management, some land trusts, and some local departments of parks and recreation. Grazing still takes place in some areas protected under the Wilderness Act of 1964 [17], which allows it to continue on most lands that were covered by grazing permits at the time these areas became wilderness [18]. In wilderness and other protected areas where grazing continues, government agencies work with livestock growers to achieve several goals, including producing food, generating revenue, supporting rural livelihoods, complying with state and federal laws, reducing fire risk, managing weeds, protecting water quality, and improving other aspects of land management [19].

In 2024, California was the second-largest wool-growing state, producing 2.3 million lb (1,043,262 kg) annually from 500,000 head [20]. Half a million head of sheep may sound impressive, but it represents an estimated 93% decline since 1880, when the state's sheep industry peaked [21]. Between 1769 and 1880, California's sheep population ballooned from zero to 6.9 million. During the next few decades, however, a series of major social and ecological changes—including the growth of intensive crop agriculture, the adoption of barbed wire to enclose the state's most fertile farmlands, the establishment of new government agencies, the designation of new federal lands, and clashes between Anglo ranchers and Basque shepherds—reduced California's sheep industry by around two-thirds. The state's sheep population hovered between 2 million and 3 million during the first half of the 20th century before beginning its long decline to the present.

Sheep grazing has changed in other ways. During the 20th century, California's sheep growers sought to maximize productivity by removing trees, converting native shrublands to grasslands, and eradicating wild animals considered pests, including bears [22]. Today, many growers use integrated management approaches that seek to limit impacts on sensitive streams and species, reduce erosion, rebuild soil fertility, and control the spread of invasive plants. Many wool growers augment their incomes by leasing their services for fuel reduction projects. Vegetation management using sheep and goats is an increasingly popular fire protection approach, particularly in wildland-urban interfaces [23].

In California, cows outnumber sheep by about 10 to 1. As of 2022, the state contained 5.2 million beef and milk cows [24]. These animals were distributed throughout all of the state's 58 counties, but one of these counties, Tulare, housed one-fifth of the total. Dairy cows made up the largest segment of California's livestock industry, accounting for around $7.5 billion in revenue, while other cows and calves generated about $3.1 billion. Some of these cattle graze on California's public lands. The state's 18 national forests host 515 active grazing allotments [25], and California's Bureau of Land Management lands, which tend to cover more arid areas, host 665 allotments [26].

California has maintained a large cattle industry, even as grazing itself has declined dramatically on both public and private lands (Figure 8.3) [27]. Since 1980, the number of beef cows grazing in California has dropped by a remarkable 43% [28]. This decline is largely due to the industry's shift from extensive grazing operations to intensive dairies and feedlots, but other factors also have contributed. Some formerly grazed areas have been developed for residential, commercial, or other uses. Grazing has also grown increasingly controversial on lands with endangered species, in sensitive arid and alpine habitats, in places with competing recreational uses, and in areas where water quality is a concern. Once relinquished by their permittees, public-land grazing allotments are often retired, though this is not guaranteed in many areas. Land trusts, some of which have acquired former ranches covering tens of thousands of acres, usually permit grazing only in cases where it contributes to fire safety, species conservation, weed control, or other land management goals.

Predators have small impacts on livestock industries as a whole (see Chapter 6), but these impacts may be difficult to absorb for individual growers that have seen their profit margins squeezed by production costs, processors, distributors, and other economic actors and forces. In 2015, a study by the U.S. Department of Agriculture concluded that at least 98% of unwanted cattle deaths were caused by factors other than predators. Respiratory ailments accounted for the largest percentage of losses (23.9% for adult cattle and 26.9% for calves), followed by unknown causes, birth- and rearing-related problems, digestive problems, and old age [31]. Compensation programs for predator-related livestock losses are now available in many states [30]. Losses could be further reduced with additional support from public agencies and nongovernmental organizations, using coexistence approaches developed over the past several decades [32].

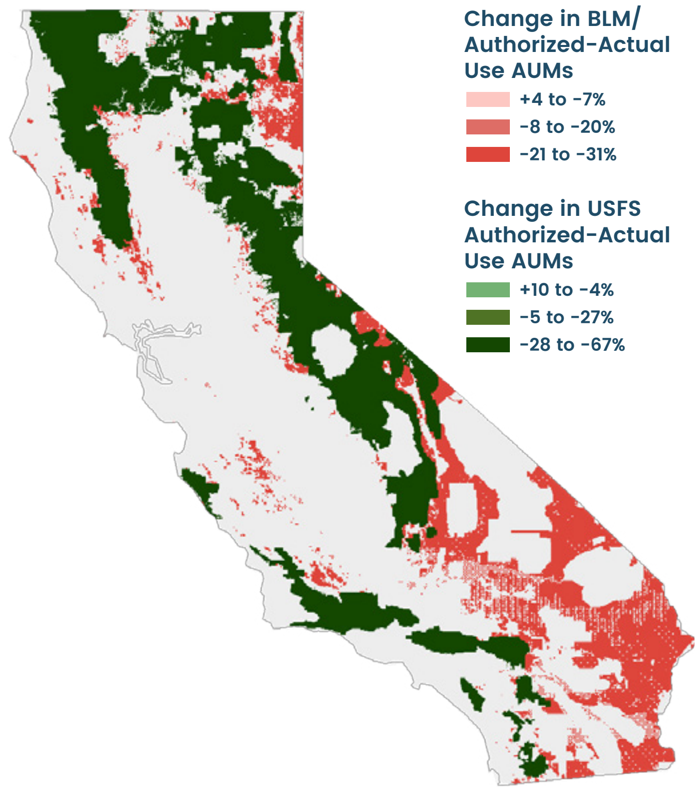


**Figure 8.3.** Decline in cattle grazing, as measured in Animal Unit Months, on public lands in California administered by the U.S. Bureau of Land Management and the U.S. Forest Service. Adapted from [29].

## 3 How would a grizzly recovery effort affect the outdoor recreation industry in California?

***A grizzly recovery program would be unlikely to have a major effect on California's large and diverse outdoor recreation industry, throughout most of the state in the coming decades. A program would, however, benefit from infrastructure upgrades, educational programs, and other public safety and coexistence measures to ensure safe recreation in areas where the bears live.***

California has the United States' largest outdoor recreation industry. According to the Outdoor Industry Association, California's outdoor recreation sector generates $73.8 billion in spending annually, up to one-third more, depending on the data source, than the state's agricultural sector, which generates $51.1 billion [33], [34]. California's outdoor industry produces an estimated $35.2 billion in wages and salaries and directly supports 567,636 jobs. Outdoor recreation takes place in every part of the state and involves a long and growing list of activities. Each year, around 50% of California residents, or more than 19 million people, report participating in some form of outdoor recreation.

Given the scope of these activities and the diversity of areas in which they take place—including cities, deserts, beaches, and waterbodies—a grizzly recovery program would be unlikely to have a major financial impact on California's outdoor recreation industry. This conclusion is true for the vast majority of activities, in the vast majority of areas, and for the foreseeable future, during which time grizzlies would be limited to some of California's most remote nondesert parks and wilderness areas. In the areas where grizzlies live, some management changes and infrastructure upgrades would likely be needed. Most of these changes and upgrades, including signage to reduce speeding on roads and more secure food storage and waste disposal receptacles, would also benefit numerous other wildlife species.

Photo: Ralph Clevenger / @tandemstock

The *Grizzly Bear Restoration Plan/ Environmental Impact Statement* for the North Cascades Ecosystem [3] describes the potential impacts of grizzly recovery efforts on outdoor recreation in northwest Washington state. This document anticipates few significant impacts on recreation, mostly associated not with the bears themselves but rather with helicopter flights and other management activities that could briefly reduce the area's sense of wilderness solitude. It also points to positive recreational and educational impacts from the restoration of the North Cascades Ecosystem.

During the North Cascades Plan/Statement public comment period, a coalition of climbers, paddlers, and cyclists—many of whom supported grizzly recovery—raised questions about potential road, trail, and area closures and the process by which such decisions would be made [35]. Because such closures are among the most controversial wildlife management measures, agencies tend to use them sparingly, temporarily, and only in areas identified as crucial for bear conservation or public safety [36]. Between 2013 and 2022, Yellowstone National Park imposed an average of 20 grizzly-related closures annually, spanning from a few hours to a few months, with most lasting between 3 and 14 days [2]. At Glacier National Park, in 2022, there were two instances in which the NPS restricted front-country campgrounds to hard-sided camping, meaning by camper van instead of soft-sided tent. Glacier also had 18 temporary, grizzly-related trail closures, and two backcountry campground closures. (Unlike in the High Sierra, where dispersed backcountry camping is the norm, hikers on many of Glacier's established trails camp in designated sites.) In Canada, agencies such as Alberta Parks have managed temporary closures by engaging with local communities, creating forums for public input, and providing up-to-date and easy-to-access information on use restrictions and bear activity. A similar Polar Bear Alert Program exists in Churchill, Manitoba.

## 4 How might a grizzly recovery effort affect tourism and tourism-dependent communities in California?

***A grizzly recovery program will have no effect on the vast majority of places and activities that make up California's enormous tourism industry. Bear-related tourism itself is, however, a fast-growing pastime that holds significant economic potential for rural communities and Tribes located near grizzly recovery areas.***

California has the United States' largest tourism sector, generating a record $150.4 billion in spending in 2023 and employing an estimated 1.15 million people [37]. (Calculations of tourism revenue vary in their methodologies but generally include outdoor recreation and wildlife viewing only when such activities involve long-distance or overnight travel.) The presence of grizzly bears is unlikely to deter visitors to California, but it has the potential to attract a small number that otherwise might not come to the state and produce revenue from many more, including in-state travelers.

Brown bears can benefit local economies both directly and indirectly. Until a few decades ago, brown bears contributed to local economies mainly through hunting. In areas with hunting seasons, including parts of Alaska and Canada, brown bears attract hunters who purchase licenses, pay for lodging, food, and transportation, and hire outfitters to organize and lead their trips. In California, reintroduced grizzlies would be a protected species and thus not hunted (see Chapter 9).

Hunting is not as lucrative as other forms of bear-related tourism in many areas where both take place. For example, a study conducted in British Columbia's Great Bear Rainforest prior to that province's 2017 grizzly bear hunting moratorium found that bear viewing generated $16.6 million annually while hunting generated just $120,500, or less than 1% of all bear-related tourism revenue [38]. This finding corroborates studies from other regions, which revealed that wildlife viewing and other “nonconsumptive” forms of nature-based tourism tend to attract more people and produce more revenue than hunting [39]. In many such places, a growing number of businesses are offering tourism experiences focused solely or mainly on wildlife viewing, with brown bears being the most sought-after and highly-valued species [40].

In the United States, wildlife watching is a robust industry that, according to the USFWS, generates more than $250 billion in expenditures on travel, equipment, and other purchases, contributes to more than 2.7 million jobs, and produces labor income exceeding $168.6 billion annually [41]. At least 45% of the U.S. population participates in some form of wildlife viewing. About half of these people, or around 75 million Americans, travel away from their homes to observe wildlife. Wildlife viewing is particularly popular among Americans 65 years of age and older, and it has been made easier by increasingly powerful and affordable technologies, such as improved optical and camera equipment, which enable people to experience wildlife in a safer, less disruptive, and more vivid way.

Tourism in natural and protected areas is a large and growing industry. It overlaps with wildlife viewing—in terms of the priorities and activities of the participants—and generates hundreds of billions of additional dollars annually [41], [42]. Protected areas draw tourists for many reasons, including outdoor sports such as hiking and biking, but visitors often cite wildlife viewing as their top reason for visiting or as an essential part of a nature-based tourism experience. In 2023, for example, Yellowstone and Grand Teton National Parks logged 7.9 million visits, about 13.5 times the resident population of Wyoming, generating an estimated $1.2 billion in revenue and supporting about 15,000 jobs [43]. Tourists in these parks identify hiking and wildlife viewing as their two top reasons for visiting [44].

Over the past 2 decades, bear-viewing-focused tourism has grown rapidly, as measured in participants and revenue, in some areas doubling year-over-year. In North America and Europe, tourists are willing to pay more to see brown bears and express greater satisfaction after seeing them than they express for any other species [45]. The amount of economic activity associated with bear viewing depends on many factors, including the method used to measure it, but studies using different approaches have arrived at similarly impressive figures. In 2020, a year when COVID-19 concerns and restrictions reduced tourist visits to Alaska by 82%, bear-viewing tourism at Katmai National Park alone still produced $79 million for gateway communities such as Homer, created or sustained 975 jobs, and produced more than $37 million in labor income [46], [47].

Bear viewing takes many forms, occurs in diverse geographic contexts, and is subject to various regulations, oversight, community standards, and business practices. In some parts of Europe, where traditional rural livelihoods have dwindled but brown bears have persisted or begun to recover, bear viewing supports jobs including guiding, gear sales, hospitality, and food service. Several European countries, from Slovenia to Finland, permit the use of bait to attract bears. In Bulgaria’s Rhodope Mountains, bear viewing is administered by village-level hunting clubs, which use corn as bait and refurbished Soviet-era bunkers as viewing blinds. In Spain’s Cantabrian Mountains, viewing occurs mainly along roadsides, where tourists search for bears foraging on distant slopes. At sites such as the McNeill River State Game Sanctuary and Refuge in Alaska, agencies have installed boardwalks and platforms to enable better viewing and to keep humans and bears at a safe distance from one another [48]. In Katmai National Park, viewing occurs both at the highly developed Brooks Falls salmon fishing site and in undeveloped coastal areas accessible by boats and bush planes.

Despite the variety of bear-viewing contexts and approaches, these sites have proven remarkably safe for humans. A 2017 study surveyed 235 bear-viewing sites and found reports of only three bear-related public safety incidents, none of which occurred as a direct consequence of the viewing activities themselves [40]. There are probably several reasons why bear-viewing sites are so safe. They tend to be subject to safety regulations, are overseen by professional guides or other local stewards, and follow established and consistent practices. Also, bears often become accustomed or habituated to seeing humans without associating them with food or danger. In the 21st century, trained guides whose livelihoods depend on safety, and for whom a single bad internet review can cost them their business, tend to pay close attention to the welfare of humans and nonhumans alike.

The rapid growth of this sector has, however, raised questions about its impacts on the bears themselves [45], [48]. Current research is investigating how viewing affects bears, including the consequences of artificial feeding, the physiological stress bears may experience around people, how human presence affects bear foraging, and the risks to individual bears, such as the potential for an increased incidence of automobile strikes. A better understanding of how bears experience being watched by humans can aid managers and businesses in creating safer and lower-impact viewing experiences.

In California, bear viewing is unlikely to ever reach the scale of bird or whale watching, in part because grizzlies in California would be unlikely to congregate in large numbers at highly visible feeding sites, as they do along some of Alaska's famous salmon streams. Grizzly viewing in California would probably look more like it does in northern Spain than in southern Alaska, with rangers and guides sharing real-time information about safe places to view bears from a distance. A well-regulated, professional, and education-oriented bear-viewing industry could offer considerable opportunities for communities near potential grizzly recovery areas and has the potential to contribute to both rural economies and grizzly reintroduction.

## Opportunities For Future Research

- Future research could seek to better quantify, using more thorough and holistic methods, the potential costs and benefits of grizzly reintroduction and recovery in California.
- Researchers could seek to identify communities where costs and benefits would be most likely to emerge and recommend policies to reduce costs while increasing benefits.
- Future work could focus on identifying places in California where bears are most likely to overlap with livestock or crops and develop recommendations for coexistence measures in these areas.
- Scientists and managers could use lessons from bear-related tourism in other regions to develop policies and best practices for California.

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Chapter 9

# The Legal Framework for Grizzly Reintroduction

By Brendan Cummings

California Grizzly Alliance

## Key Points

The ESA currently bans, with limited exceptions, the "taking" of any grizzly bears in the lower 48 U.S. states, and prohibits federal agencies from jeopardizing bears or adversely modifying their habitats.

All grizzly bears in the lower 48 states are listed as a Threatened species under the federal Endangered Species Act (ESA). The U.S. Fish and Wildlife Service (USFWS) has argued that its current recovery plan, limited to six recovery zones in the Northern Rockies and North Cascades, fulfills its statutory obligations under the ESA without the need for additional recovery efforts.

In January 2025, the USFWS proposed reclassifying areas where grizzlies currently live or are likely to appear in the future as a single Distinct Population Segment (DPS). If finalized, this proposal would exclude other areas in the species' historical range, including California, from ESA protections.

If all grizzlies in the lower 48 states remain federally listed, then a California recovery effort, like the one planned for the North Cascades in 2025, would likely fall under the ESA's section 10(j) provision for experimental populations.

If grizzlies in the lower 48 states are delisted from the ESA, or otherwise reclassified to exclude states where they do not currently live, then California would have to take the lead in its own recovery efforts. Nothing in state law would prevent grizzlies from being reintroduced or listed as endangered in California before or after a reintroduction.

Whether or not grizzlies remain listed throughout the lower 48 states, a California grizzly recovery effort would likely involve a collaboration among state and federal agencies—including the USFWS, National Park Service (NPS), and California Department of Fish and Wildlife (CDFW)—as well as California Tribes.

# Introduction

Reintroducing grizzly bears to California will necessarily have to be done in accordance with federal and state laws and regulations. The laws that apply will depend on multiple factors, including which entity leads the effort (e.g., federal agency, state agency, and/or Tribe); where the reintroduction occurs (e.g., National Park Service [NPS] or other federal lands, state lands, tribal lands, or private lands); where the bears come from (e.g., Montana, British Columbia); whether the grizzly remains listed under the federal Endangered Species Act (ESA) [1]; and whether new federal or state laws or regulations are passed that are specifically tailored to grizzly reintroduction in the state.

This chapter addresses key questions regarding the current regulatory framework covering grizzly bears in the lower 48 states generally and California specifically, as well as the procedural and substantive laws and regulations that would apply to the reintroduction of grizzlies to the state. It is important to note that while some variables are relatively fixed over the next decade (e.g., bears are unlikely to reach California on their own), others—primarily the specter of grizzly bears losing federal ESA protections—create significant uncertainty over the legal framework that will apply at the time of an actual reintroduction.

Before addressing the central legal questions surrounding a grizzly bear reintroduction effort, we offer a note on terminology: Aside from direct quotations, where capitalization was left unchanged, the capitalized term Threatened refers to a species listed as such under the federal ESA, whereas the lowercase term threatened refers to a species on the state-level list under the California Endangered Species Act (CESA). Similarly, the capitalized term Endangered applies to the federal ESA, whereas the lowercase term endangered pertains to CESA. In short, capitalization signals federal-level status, and lowercase signals state-level status.

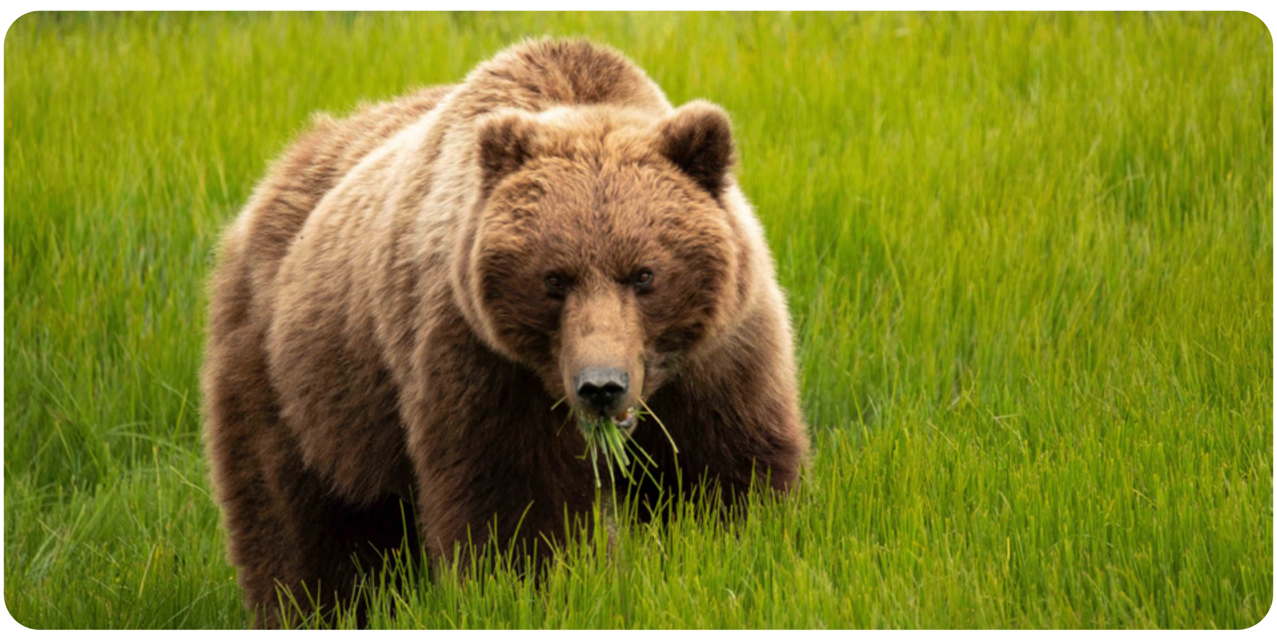

Photo: Danita Delimont - stock.adobe.com

# Questions

## 1 What is the current ESA listing status of grizzly bears in the United States and California?

***All grizzly bears in the lower 48 states are currently protected as Threatened under the U.S. Endangered Species Act.***

Grizzly bears in the lower 48 states were protected as Threatened under the ESA [1] by the U.S. Fish and Wildlife Service (USFWS) in 1975 [2], and notwithstanding multiple legal and legislative attempts to change or remove that protection, they are (as of early 2025) still protected as such [3].

For a species to receive the protections of the ESA, it must first be added to a regulatory list as Threatened or Endangered pursuant to section 4 of the statute [4]. The listing or delisting of a species can occur based on the USFWS's independent discretion or in response to a petition to list or delist. Such decisions must be made on certain timeframes and according to the best available scientific information [4]. Under the ESA, a "species" includes not just biological species and subspecies but also any "distinct population segment" (DPS) of any vertebrate species [5]. Lower-48 bears are listed as a single DPS, but for decades, the question of whether the lower-48 DPS can be subdivided into smaller DPSs warranting either more protection (uplisted to Endangered) or less (delisted) has been the central focus of petitions and litigation regarding the species.

At the time of listing in 1975, lower-48 grizzlies occurred in five states (Montana, Idaho, Wyoming, Washington, and Colorado) and occupied about 2% of their historical range. They had a population of fewer than 800 bears, down from an estimated 50,000 bears in 1800, including as many as 10,000 in what is now California. Five decades later, about 2000 animals are estimated to occupy 6% of their range, but they now only occur in four states, with the last known bear in Colorado shot in 1979 [6].

In its 1975 Threatened finding, the USFWS found that the bear's range had been reduced to isolated areas with limited connectivity and genetic interchange. Moreover, increasing roads for timber harvesting and trails for outdoor recreation were leading to increased conflict with humans and the consequent killing of bears. The killing of grizzlies for actual or perceived predation on livestock was also highlighted as a threat [2]. Today, these same impacts, along with the additional threats stemming from climate change, remain the focus of conservation concern for the species [7].

In the 1975 listing rule, the USFWS identified three "ecosystems" where the majority of bears were still present: the Selway-Bitterroot Ecosystem (now the Bitterroot Ecosystem [BE]); the Bob Marshall Ecosystem (now the Northern Continental Divide Ecosystem [NCDE]); and the Yellowstone Ecosystem (now the Greater Yellowstone Ecosystem [GYE]) [2]. Three additional ecosystems—the North Cascades (NCE), Selkirk (SE), and Cabinet-Yaak (CYE)—have subsequently been recognized by the USFWS for management and recovery planning purposes [8]. These six ecosystems, now called "recovery zones," have also become the basis for proposed DPSs that could be uplisted or delisted [7].

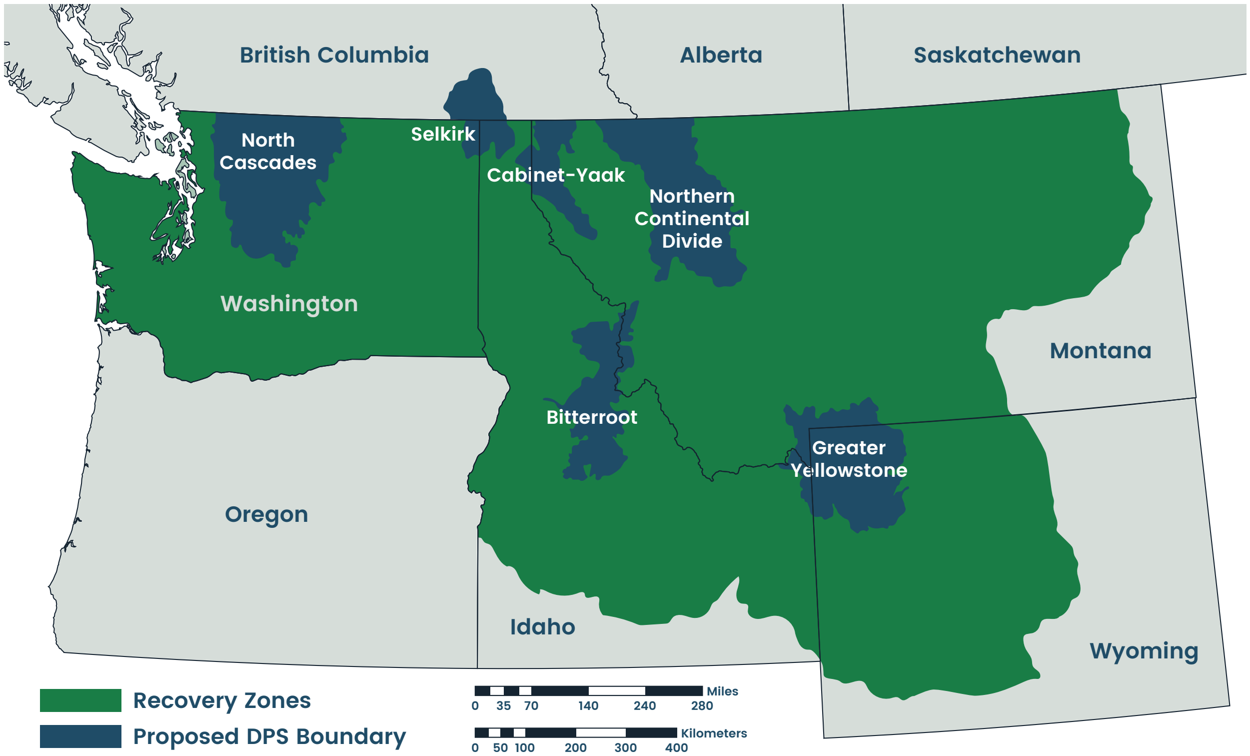


**Figure 9.1.** A map of the lower-48 grizzly bear DPS boundary, as proposed by the USFWS, overlaid on the current recovery zones. Reproduced from [14].

Since 1990, the USFWS has received over a dozen petitions seeking the uplisting or delisting of grizzly DPSs. While the USFWS initially found Endangered status for NCE and CYE bears warranted (and was forced to do the same by courts for SE bears), the agency never actually uplisted any of these populations [7]. However, the agency has deployed the DPS policy to advance delisting efforts for the bears in the GYE and NCDE.

In 2007 and again in 2017, the USFWS issued final rules to designate GYE bears as a DPS and delist them under the ESA [9], [10]. In both cases, the delistings were overturned by the courts, and the lower-48 DPS was reinstated [11], [12]. In the first case, the USFWS failed to account for the impacts of climate change on the bear's whitebark pine food source. The USFWS's second attempt was overturned on the grounds that it was improper to delist a DPS without examining what effect such delisting would have on the remainder of the listed entity (i.e., all other lower-48 bears). The court also found that the USFWS's claim that there were no genetic health concerns for GYE bears was not supported by the science presented in the record.

In 2021 and 2022, Wyoming, Montana, and Idaho filed petitions seeking the delisting of GYE, NCDE, and all lower-48 bears, respectively [13]. In January 2025, the USFWS rejected all three petitions while proposing to reclassify the current lower-48 listing as a new DPS that encompasses the six recovery zones and adjacent areas the bears might occupy in the future [14]. If this proposed rule is finalized, areas outside of this new DPS, including

California and Colorado, would no longer be listed under the ESA (Figure 9.1).

While the ESA, as well as a court order, require the USFWS to finalize or withdraw the new proposed rule by the end of January 2026, given the recent change in administration, it is unlikely to be finalized as proposed. A withdrawal of or significant change to the proposal would likely be litigated by conservation groups, while a finalization of it would be challenged by states and other opponents of continued listing. Additionally, the "not warranted" finding on the delisting petitions from Wyoming, Montana, and Idaho are almost certain to be challenged over the course of 2025 by those states, as well as other entities seeking grizzly delisting. Moreover, legislation to delist some or all grizzly populations has been introduced in Congress.

In sum, whether California remains within the boundaries of a listed grizzly DPS will be determined by rulemakings, litigation, and/or legislation that will play out over the course of 2025 and 2026.

## 2 What protections do grizzly bears receive under the ESA?

***The U.S. Endangered Species Act protects grizzly bears from harmful federal actions as well as any unauthorized activities that would harm or kill an individual bear.***

The two main protective provisions of the ESA are section 7 [15], dealing with interagency consultation, and section 9 [16], dealing with prohibited activities. Section 7 applies only to federal agencies, while section 9 applies to "any person," which includes states, corporations, and individuals.

Section 7(a)(2) has been recognized by the courts as "the heart of the ESA" and is, for most species, the most consequential portion of the statute [15], [17]. This provision requires each federal agency, in consultation with the USFWS, to ensure that any proposed action is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of their critical habitat. Since the 1975 listing of the lower-48 grizzly bears, hundreds of section 7 consultations have been carried out between the USFWS and other agencies regarding logging, roadbuilding, livestock grazing, and other types of projects impacting the bear.

Section 9 [16] prohibits the import, export, and take of any Endangered species of animal, as well as the violation of any section 4(d) regulations for any Threatened species of animal. The term "take" is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" [5], with "harm" and "harass" having their own definitions that can encompass impacts on habitat [18]. Otherwise-prohibited take can be authorized via either section 7 or section 10 if it is "incidental to otherwise lawful activity," while intentional take, as well as other acts prohibited by section 9 (e.g., import/export), can only be authorized via section 10 or, for Threatened species such as the grizzly, via a section 4(d) rule [4].

In 1975, the USFWS issued regulations under section 4(d) governing take of grizzlies [19]. These regulations generally tracked the default section 9 prohibitions on the import, commercial export, commercial transportation, sale, or take of individual animals, and the possession and other activities with unlawfully taken animals. The regulations also allowed for certain exceptions from these prohibitions, including for federal and state employees to pursue, capture, collect, and import grizzly bears. The regulations also allowed bears to be taken in self-defense, to defend others, or to remove grizzly bears threatening human safety or livestock, so long as certain conditions were met. Most controversially, the regulations allowed for sport hunting in portions of the NCDE in northwestern Montana [2].

In 1986, the USFWS amended the rule to extend the federal and state employee exemptions to tribal authorities and to adjust the sport-hunting season [20]. The sport-hunting regulation was successfully challenged on the grounds that hunting was inconsistent with the ESA's definition of "conservation" [21]. The USFWS subsequently rescinded the sport-hunting portion of the regulations [8], and the 4(d) rule has remained essentially the same ever since [19].

In January 2025, as part of its proposed reconfiguration of the lower-48 grizzly DPS, the USFWS also proposed amendments to the 4(d) rule [14]. These amendments would allow the killing of bears by livestock operators on private land and public lands outside of recovery zones and loosen the requirements for killing bears involved in "conflicts." The USFWS also indicated it was considering expanding the exemptions to cover unintentional take from the hunting and trapping of other species, as well as from sport hunting of grizzlies themselves [14]. As with the proposed changes to the lower-48 DPS, it remains to be seen if this rule will be finalized.

## 3 How would grizzlies in California be protected under the ESA?

***Under the current lower-48 listing, any grizzly that makes it to California on its own would receive the same protections as other lower-48 bears. Any bears reintroduced to California would be designated an experimental population and receive reduced protections. If the proposed changes to the lower-48 DPS are finalized, however, neither a naturally dispersing nor reintroduced bear in California would be subject to ESA protections.***

Assuming the current lower-48 listing of grizzlies remains unchanged, if a grizzly bear reached California on its own, it would receive the same protections as all other lower-48 bears not part of an experimental population (i.e., all bears other than those that may be reintroduced into the NCE and BE). Such an occurrence is highly unlikely in the near term (see Chapter 3). Consequently (and assuming lower-48 bears remain listed as Threatened), bears reintroduced to California would be managed as an experimental population.

Section 10(j) of the ESA allows the USFWS to designate certain populations of listed species that are released into the wild as "experimental." This designation can only be applied when the population is reintroduced outside the species' current range [22].

Under section 10(j), an experimental population is treated as a Threatened species regardless of whether it is designated Endangered elsewhere in its range. Given all lower-48 grizzlies are listed as Threatened, the designation as "experimental" alone does not necessarily lower the protections applicable to grizzlies. However, the USFWS must also determine whether that population is "essential" to the continued existence of the species. Virtually every 10(j) population ever designated by the USFWS has been declared to be nonessential. For the purposes of section 7, nonessential populations located outside National Wildlife Refuge or NPS lands are treated as if they are proposed for listing [22]. Consequently, outside these lands, the formal consultation required by section 7(a)(2) would not apply.

In the 50 years since the original listing of lower-48 grizzlies, the USFWS has designated two experimental populations for reintroduction (in the BE in 2000 and NCE in 2024 [19]), but for various reasons related to state or local opposition, or the change in federal administration, the agency has yet to reintroduce any bears onto the landscape.

The recent NCE 10(j) rule [23] may serve as a model for what a 10(j) rule for grizzlies in California might contain. The rule divides the population into three management areas, with different management prescriptions in each. Management Area A, where regulatory protections are greatest, covers the actual NCE recovery zone. Federal lands south and east of Management Area A are in Management Area B, a zone with intermediate protections. Management Area C covers most of the rest of the state. Notably, state and private lands in the NCE recovery zone, notwithstanding their important location, are treated as part of Management Area C, where regulatory protections are weakest [19].

In Management Area A, the rule is similar to the lower-48 grizzly 4(d) rule, with additional preemptive relocation allowed to prevent imminent conflict or habituation. In Area B, rather than any lethal removal having to be done by federal, state, or tribal agents, the USFWS can authorize individuals to kill bears if livestock depredation is confirmed. In Area C, the USFWS can give preemptive authority to kill bears when deemed necessary to protect property, and any individual can kill a bear in the act of attacking livestock or working dogs on private land [19]. Additionally, in contrast to the lower-48 4(d) rule, the regulation exempts virtually all incidental take of grizzly bears, such as what might occur from logging, the use of off-highway vehicles, or other activities that harm, harass, or kill bears [19].

While the North Cascades reintroduction project is undoubtedly an important step in grizzly bear recovery, given it took 3 decades from first proposal to final authorization (and as of early 2025, no bears have yet been released), it also demonstrates the challenges and compromises any reintroduction project will likely face elsewhere in the species' historic range, including in California.

If the USFWS's January 2025 proposed lower-48 DPS rule is finalized as proposed (an unlikely proposition given the recent change in federal administration), any bear leaving the DPS boundary would lose ESA protections. Moreover, given California would not be a part of the listed entity, no 10(j) rule would be required to carry out a reintroduction in the state.

## 4 How does the USFWS treat California grizzly recovery under the ESA?

***The U.S. Fish and Wildlife Service's current official position is that lower-48 grizzlies can be declared "recovered" and delisted without ever restoring bears to California.***

The USFWS has repeatedly rejected grizzly recovery in California for both legal and factual reasons. The USFWS's current position is that reintroducing grizzlies into California or other areas of their historic range is not necessary to achieve recovery of lower-48 bears:

> *[T]here is no obligation to recover species throughout all suitable habitat and/or historical range. It is the Service's position that recovering grizzly bears in the current six ecosystems will meet our obligation under the Act, and that additional areas, such as the San Juan Mountains* and other mountain ranges in the west *[emphasis added], are not needed to meet recovery under the Act (Declaration of Dr. Jennifer Fortin-Noreus, Document 66-1 in [24]).*

The USFWS reiterated this position in its January 2025 proposed DPS rule, stating that its "approach to grizzly bear recovery under the Act is focused on, and will continue to be focused on, the current six ecosystems, and additional areas, such as the San Juan Mountains and other mountain ranges in the West, are not needed to recover the species" [14].

Legally, this position is at odds with court decisions holding that a species must be listed "if there are major geographical areas in which it is no longer viable but once was" [25].

The USFWS position regarding recovery is also at odds with the agency's past positions. Since the 1993 Recovery Plan, the USFWS has raised the possibility of grizzly bear recovery being undertaken outside of the six ecosystems. In its 2011 "5-year" review of the status of lower-48 grizzly bears, the USFWS explicitly called for the study of whether California and other parts of the grizzly's historic range should be considered for recovery:

> *In accordance with the 1993 Recovery Plan, other areas throughout the historic range of the grizzly bear in the lower 48 States should be evaluated to determine their habitat suitability for grizzly bear recovery .... [and USFWS should] conduct evaluations of habitat suitability for currently unoccupied, historic habitat in Colorado, New Mexico, Arizona, Utah,* California *[emphasis added], Nevada, Oregon, and southern Washington (mountain ranges in the western U.S.). [26]*

One decade later, in response to petitions and litigation, the agency attempted such an evaluation. In March 2021, the USFWS released an updated "5-year" review, finding the lower-48 DPS of grizzlies continued to warrant protection as Threatened [6]. While the 5-year review only looked at the status of the species in the six recognized ecosystems or recovery zones, the underlying Species Status Assessment [7] contained a short discussion, along with an appendix, looking at "habitat security" in the Sierra Nevada of California and the San Juan Mountains of Colorado.

The evaluation acknowledged that the "largest area of secure core habitat within grizzly bear historic range outside of the six ecosystems is the Sierra Nevada Mountain Range in California." Also, the agency acknowledged that the Sierra is larger than the CYE and SE recovery zones and that it "could be" large enough to support a grizzly population.

In ultimately dismissing the utility of the area for recovery, the USFWS focused on the fact that natural recolonization was unlikely, as would be any male dispersal that could augment the genetics of a reintroduced population. The USFWS acknowledged that while a "population could be established through reintroduction," the area was not "large enough to contain sufficient numbers of bears to maintain long-term fitness, and ongoing translocations would likely be needed to ensure long-term genetic health." The agency did not appear to calculate how many bears the Sierra Nevada could support. The USFWS concluded that the Sierra Nevada would not "meet the objective of a self-sustaining population" [7].

This requirement of natural connectivity for the Sierra Nevada to be considered a recovery area contrasts with the USFWS's 2007 delisting decision for the GYE, which relied upon active translocation of bears to maintain genetic health. When its subsequent 2017 delisting decision was struck down for not including such active measures to ensure genetic health, the USFWS responded in 2024 by authorizing the translocation of male bears from the NCDE to the GYE as part of its recovery strategy [27]. If the occasional translocation of bears to maintain genetic health is an acceptable recovery strategy for GYE bears, there is no reason it could not also be applied to a reintroduced California population. As such, the USFWS has identified no insurmountable obstacles to grizzly reintroduction in California.

Given the USFWS has stated that lower-48 grizzly bears can be declared recovered and delisted based solely upon recovery of the six populations addressed in the 1993 Recovery Plan, it is unlikely that the USFWS will embark upon a restoration effort for grizzlies in the Sierra Nevada or elsewhere in California as part of its lower-48 recovery strategy. In the absence of USFWS leadership on such an undertaking, any reintroduction will almost certainly be led by the state and/or Tribes.

Photo: Nicki Geigert / @tandemstock

## 5 What kind of environmental review would be required for a federally-led reintroduction?

***A federal grizzly reintroduction program would likely require the preparation of an Environmental Impact Statement under the National Environmental Policy Act.***

Any grizzly reintroduction program in California that involves the active participation of a federal agency will require compliance with the environmental review procedures of the National Environmental Policy Act (NEPA) [28]. Assuming bears remain listed, the USFWS would likely be the lead or joint-lead agency for NEPA purposes, as the USFWS would issue any necessary permits and likely promulgate a 10(j) rule for the reintroduced population. Regardless of listing status, if reintroduction will occur on national park lands, the NPS will likely be the lead or joint-lead agency under NEPA.

NEPA requires that all federal agencies must prepare an Environmental Impact Statement (EIS) for all "major federal actions significantly affecting the quality of the human environment" [29], [30]. An EIS must provide a detailed statement of the environmental impacts of the proposed action, as well as the alternatives to the proposed action.

The NEPA process for a proposed action generally starts with the publication of a notice in the Federal Register announcing the intent to carry out the action and soliciting comments on the scope of the environmental review (the "scoping" process). Assuming the agency moves forward with the action, it then prepares and releases for public comment a Draft Environmental Impact Statement (DEIS), which examines the impacts of the proposed action and various alternatives to it. A Final Environmental Impact Statement (FEIS) follows, incorporating and responding to any public comments and indicating the agency's planned course of action. The agency then issues a Record of Decision (ROD), marking the culmination of the agency's NEPA process. At this point, the agency is free to move forward with the action [30], [31], [32]. A NEPA process is generally expected to take no longer than 2 years but often takes far longer.

The North Cascades Grizzly Restoration project, undertaken by the USFWS and NPS acting as joint-lead agencies under NEPA, provides a close analogue of what a NEPA process for California grizzly restoration could look like. Although the USFWS first embraced grizzly reintroduction into the NCE in 1991 and subsequently made it part of the official recovery strategy in 1997, the actual effort underwent various fits and starts and cancellations before the current program officially restarted with a scoping notice by the USFWS and NPS in November 2022 [33]. A DEIS was released on September 28, 2023, followed

Photo: Jay Goodrich / @tandemstock

by an FEIS on March 21, 2024, and an ROD authorizing reintroduction on April 23, 2024.

The NCE reintroduction project simultaneously demonstrates two points: First, if there is opposition or a lack of agency commitment, the environmental review process for a bear reintroduction can drag on for decades. This time frame proved true for the NCE project when measured from 1991, 1997, or even 2014, when the first NEPA process was launched.

Second, the environmental review process can move expeditiously when political obstacles have been overcome. The NCE process took only 18 months from the 2022 scoping notice to the 2024 ROD.

In California, assuming the NPS and/or USFWS are involved and supportive, compliance with NEPA's EIS requirements should not be an obstacle or source of major delay to reintroducing grizzlies into the state.

## 6 How would grizzlies be managed under California law?

***Grizzlies reintroduced to California would be managed by the California Department of Fish and Wildlife under grizzly-specific legislation or the California Endangered Species Act.***

The State of California will play an indispensable role in any reintroduction program for the grizzly, regardless of the federal listing status of the species.

In California, the management of wildlife is primarily governed by the California legislature, the California Fish and Game Commission (FGC), and the California Department of Fish and Wildlife (CDFW). The legislature adopts and amends laws, codified primarily in the California Fish and Game Code (F&G Code), and approves a budget for activities carried out by state agencies. The FGC was created by the state constitution and was delegated "the power to regulate the taking or possession of birds, mammals, fish, amphibians, and reptiles" [34]. CDFW is an agency created by the legislature to administer and enforce the F&G Code, as well as any regulations promulgated thereunder [35]. While each of these entities has the independent ability to authorize the reintroduction of grizzles to California, as a practical matter, grizzly reintroduction is unlikely to occur unless sanctioned by all three entities.

The legislature has only enacted two currently operative provisions specific to grizzlies. In 1953, the legislature officially adopted the current design of the Bear Flag with reference to a grizzly bear [36] while also declaring that same year that "[T]he state animal is the California Grizzly Bear (*Ursus Californicus*)" [37]. The F&G Code itself makes no mention of the word "grizzly" or "grizzlies," and its genus name "Ursus" appears only once in a section specific to American black bears (*Ursus americanus*) [38].

Any state legislation calling for, authorizing, and/or funding a grizzly reintroduction program would likely provide specific criteria regarding the protection and management regime the reintroduced population would receive. However, in scenarios without specific authorizing legislation for reintroduction (or in the improbable scenario of individual grizzly bears making the long-distance dispersal journey to California on their own), CDFW or the FGC could—and almost certainly would—readily promulgate regulations specifically tailored to grizzly bears. Such regulations would most likely be issued pursuant to CESA [39].

## 7 Could grizzlies be protected under CESA?

***The history, purposes, statutory language, and court rulings all support the conclusion that grizzlies could be protected under the California Endangered Species Act.***

The grizzly bear is not currently listed under CESA. Whether or not a species fully extirpated from California, such as the grizzly, can be listed under CESA prior to reintroduction will likely be contested. However, the policies and purposes of CESA, as well as past precedent, support the eligibility of grizzlies for such a listing.

California courts have repeatedly held that CESA is to be interpreted "liberally" consistent with the statutory purposes and intent of the legislature:

> *We begin with the basic premise that laws providing for the conservation of natural resources such as the CESA are of great remedial and public importance and thus should be* construed liberally*. Within the* CESA *itself,* the Legislature has expressed the objects to be achieved and the evils to be remedied*. The* evils to be remedied include the extinction of certain species *of fish, wildlife, and plants, and the danger or threat of extinction of other species of fish, wildlife, and plants. The* objects to be achieved include the conservation*, protection,* restoration*, and enhancement of any endangered species or any threatened species [emphasis added]. ([40] cleaned up and citing [41] and [42])*

Given CESA was enacted not only to protect against the danger of extinction but also to remedy the fact that some species have already been rendered extinct from California by "restoring" them to the state, it follows that an extirpated species can be listed under CESA.

Moreover, "conservation" is defined under CESA to include "propagation, live trapping, and transplantation," measures clearly applicable to extirpated species such as the grizzly [43].

Past practice under CESA also demonstrates that listings of extirpated species have precedent. For example, the bull trout (*Salvelinus confluentus*) was extirpated from California in 1975 but was still subsequently listed as endangered under CESA in 1980. Similarly, the wolverine (*Gulo gulo*) was listed in 1971 under the precursor to CESA and remains listed as threatened even though the species was likely extirpated from the state in the 1920s. Listing an extirpated—but not biologically extinct—species such as the grizzly bear is consistent with the policy and past practice of CESA.

Many of the issues involving extirpated species and CESA played out before the FGC, CDFW, and the courts in the context of the 2014 endangered listing of the gray wolf (*Canis lupus*). Gray wolves were extirpated from California in the 1920s. In December 2011, an individual radio-collared male wolf entered California from Oregon and passed back and forth between the two states several times over the subsequent years. In response to a petition seeking the listing of wolves as an endangered species under CESA, the FGC ultimately voted to list them as such in June 2014 [44].

The livestock industry challenged the listing, arguing that the wolf was not "native" to California and that a breeding population was necessary for a listing. The California Superior Court rejected these arguments, both of which are relevant to grizzlies [45].

The core of the livestock industry's "native" species argument was that the gray wolf that arrived in California was a different subspecies than those that originally roamed the state. The trial court sided with the FGC, stating "the commission is not limited to protecting only a subspecies, but may protect a native species." Consequently, this case explicitly refutes any potential argument that the "extinction" of the putative subspecies *Ursus arctos californicus* would preclude CESA listing and/or the reintroduction of grizzlies because the reintroduced bears would not be "native" to California.

As to the question of whether a breeding population is necessary for CESA listing, the FGC and CDFW have explicitly concluded that it is not [46]. As it did with the "native" species claim, the California Superior Court adopted the FGC's argument and upheld the FGC's determination to list the wolf against this challenge, "given the remedial nature of CESA, and the importance to construe its provisions liberally."

Of course, the gray wolf and the grizzly situations have significant differences. The wolf had at least an intermittent presence in the state of at least one individual at the time of listing, along with the expectation of a breeding pack forming in the state (an expectation that proved correct). In contrast, grizzly bears will not likely be present in the wild in California until and unless there is an active reintroduction effort. Nevertheless, this factual distinction between wolves and grizzlies does not change the underlying legal framework. In sum, the FGC could list grizzlies in California under CESA prior to their reintroduction. Such action would be consistent with the policies and purposes of CESA and would not be unprecedented.

## 8 What CESA protections and exemptions would apply to grizzlies?

***CESA provides strong protections against the killing of listed species, while exemptions provide for the import, possession, and other measures that would accompany any recovery efforts.***

If grizzlies are listed under CESA, they would be subject to the statute's prohibition on unpermitted take, as well as on import and possession [47]. Like the ESA, CESA has exceptions and permit processes authorizing otherwise prohibited activities.

Under CESA, CDFW can authorize "individuals, public agencies, universities, zoological gardens, and scientific or educational institutions, to import, export, take, or possess" any CESA-listed species for "scientific, educational, or management purposes" via permits or memorandums of understanding [48]. All the necessary steps for reintroduction could be readily authorized through this section. CDFW can also issue permits for take that is "incidental to otherwise lawful activity" [48]. Such permits might be necessary for activities with the potential to take grizzlies, such as road construction, forestry activities, and other habitat-altering activities in the range of the reintroduced bears.

There are also provisions of CESA that deal explicitly with reintroduced populations. If the USFWS issues an enhancement of survival permit pursuant to section 10 of the ESA "in order to establish or maintain an experimental population," and if CDFW finds the permit will further the conservation of the species, no further authorizations are needed under CESA for such activities [47]. Similarly, for any ESA-listed experimental population with an applicable 10(j) rule, if CDFW finds the 10(j) rule will further the conservation of the species and contains measures to avoid and minimize the impacts of any incidental taking, no further authorization or approval is needed under CESA for any such incidental taking that may occur [47].

Lastly, CESA expresses an "intent of the Legislature" that "before the introduction of an experimental population … onto land or into waters of this state, the department should undertake appropriate public outreach, including public meetings, in an effort to inform the public about the proposed introduction of the experimental population and its potential effects, if any, on ongoing human activities" [47]. Public engagement of this sort, in addition to being mandated under California law, is regarded as an essential best practice for species reintroductions (see Chapters 6, 7, and 10).

## 9 What requirements of the California Environmental Quality Act would apply to a grizzly reintroduction?

***A grizzly reintroduction would likely either require the preparation of an Environmental Impact Report or be done under a California Environmental Quality Act exemption for recovery actions.***

A state-led grizzly reintroduction project would either require compliance with the California Environmental Quality Act (CEQA) [49] or fall within a statutory exemption from CEQA. CEQA generally requires agencies to prepare an Environmental Impact Report (EIR) for every project that may have significant environmental effects [50], [51].

Similar to NEPA's EIS requirement, an EIR process starts with a Notice of Preparation (NOP, equivalent to NEPA scoping), followed by a Draft EIR and a Final EIR, all of which are subject to public comment [51]. Upon approval, a Notice of Determination (NOD, equivalent to NEPA's ROD) is filed with the state Office of Planning and Research [52]. Unlike NEPA, where decisions can generally be challenged within 6 years of the ROD, any legal challenge under CEQA generally must be brought within 30 days of the filing of the NOD [52].

When a project requires review under both NEPA and CEQA due to the involvement of federal and state agencies, both NEPA and CEQA allow such review to be carried out through the preparation of a combined EIS/EIR [53], [54].

CEQA also provides for the certification of certain state agency regulatory programs in which the regulatory processes of those agencies are generally deemed equivalent to CESA [50]. Actions taken pursuant to such programs may undergo a different process than preparing an EIR, but their analysis must still meet the substantive standards of CEQA. The regulatory program of the FGC and certain programs of the CDFW have been so certified [55].

In 2021, California enacted the Statutory Exemption for Restoration Projects (SERP), providing an exemption from CEQA for a "project to conserve, restore, protect, or enhance, and assist in the recovery of California native fish and wildlife, and the habitat upon which they depend" [50]. An eligible project must result "in long-term net benefits to climate resiliency, biodiversity, and sensitive species recovery" [50].

A CDFW-led and/or FGC-led grizzly reintroduction program carried out without federal involvement (i.e., if grizzlies are delisted) could likely be implemented via a SERP and/or under the agencies' certified regulatory programs. If done jointly with a federal agency, then the most likely scenario for CEQA compliance would be via a combined EIS/EIR process. Regardless of the scenario, the environmental review process could be completed within 2 years of its start.

## 10 What laws govern tribal involvement in grizzly reintroduction?

***Grizzly reintroduction would trigger tribal consultation provisions for federal and state agencies and would likely be done in cooperation with participating Tribes.***

Tribes will likely play a significant role in any effort to reintroduce grizzly bears to California. On one end of a continuum of levels of involvement, a Tribe can be the lead or co-lead carrying out the reintroduction. Such was the case for the Yurok Tribe with the Northern California Condor Restoration Program [56]. Alternatively, a Tribe can be a potentially affected party that federal or state agencies consult pursuant to applicable laws and policies.

If a Tribe is a lead or co-lead on a grizzly reintroduction project (and lower-48 bears remain listed in a manner that includes California), the process would likely start with a memorandum of agreement reached between the Tribe, the USFWS, and any other participating federal or state agencies. The USFWS would almost certainly only proceed with reintroduction via the establishment of a nonessential experimental population pursuant to an ESA 10(j) rule issued by the USFWS. The USFWS and/or a land management agency such as the NPS would likely be the lead agency for NEPA purposes, and the process would be similar to that for the NCE reintroduction program.

Regardless of whether a Tribe actively participates in the reintroduction program, the USFWS (and the NPS) would have to comply with multiple laws relating to tribal consultation. By way of example, for the final NCE 10(j) rule, the USFWS cited the following obligations:

> *In accordance with the President's memorandum of April 29, 1994 (Government-to-Government Relations with Native American Tribal Governments;* 59 FR 22951), E.O. 13175 *(Consultation and Coordination with Indian Tribal Governments), and the Department of the Interior's manual at* 512 DM 2, *we readily acknowledge our responsibility to communicate meaningfully with federally recognized Tribes on a government-to-government basis. In accordance with Secretary's Order* 3206 *of June* 5, 1997 *(American Indian Tribal Rights, Federal–Tribal Trust Responsibilities, and the Endangered Species Act), we readily acknowledge our responsibilities to work directly with Tribes in developing programs for healthy ecosystems, to acknowledge that Tribal lands are not subject to the same controls as Federal public lands, to remain sensitive to Indian culture, and to make information available to Tribes.* [23]

The USFWS then went on to list the various contacts it made with Tribes over the course of the rule development [23]. California law contains similar consultation requirements, with, among others, 2011's Executive Order B-10-11 [57] directing state agencies to establish tribal liaisons and consult with Tribes on policies that affect them and 2015’s Assembly Bill 52 [58] requiring notification and consultation with Tribes on CEQA projects.

While Tribes generally have to comply with federal laws such as the ESA, section 12300 of the F&G Code generally exempts tribal members on reservation lands from almost all aspects of the F&G Code. Consequently, in the absence of federal listing, if grizzlies were introduced onto tribal lands or dispersed onto such lands, tribal regulation of wildlife rather than state law could govern how grizzlies were managed.

In sum, while consultation and some other requirements of federal and state laws are unique in their application to Tribes, any grizzly reintroduction program will be carried out in consultation with affected Tribes and, ideally, with the active participation and leadership of those Tribes.

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[4] 6 U.S.C. §§ 1533.

[5] 16 U.S.C. § 1532(16).

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[35] F&G Code § 700. 1957.

[36] Government Code § 420. 1943. [Bear Flag.]

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[38] F&G Code § 3960(a)(2). 1957.

[39] California Endangered Species Act, F&G Code §§ 2050 et seq. 1984.

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[41] F&G Code §§ 2051. 1957.

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Chapter 10

# Logistics and Monitoring

By Ellen M. Pero, Alex McInturff & Peter S. Alagona

California Grizzly Alliance

## Key Points

Brown bear translocation practice has improved dramatically over the past 40 years. Brown bears can now be moved safely and successfully using established best practices.

Trained experts should handle captured bears and move them efficiently to their new locations in safe, climate-controlled containers. Current guidelines favor hard releases in which bears are immediately set free at their destination without a restrained adjustment period.

Source populations should be chosen based on their size, location, and genetic relatedness to bears that once lived in the recovery area, as well as the similarity of the habitats in the source and destination locations and regulatory and permitting issues. Potential source populations for a California recovery program in the United States include the Northern Continental Divide and Greater Yellowstone Ecosystems. British Columbia also has robust potential source populations.

Only wild bears without conflict histories are considered suitable candidates to join founder populations in a reintroduction program. Founder populations should be skewed toward adolescent females, which have the greatest reproductive potential and are mostly likely to remain near their release sites.

Logistical, political, and ecological constraints may influence translocation decisions, including which bears are chosen and where they are released.

Effective monitoring is essential for tracking species reintroductions and recoveries. Monitoring results can increase basic understanding, track key trends, identify challenges for human-bear relations, build public trust and support, and inform adaptive management through structured decision-making processes.

# Introduction

Planning to capture, transport, and release large, long-lived, intelligent, and wide-ranging animals such as grizzly bears involves a number of complex considerations [1]. How many animals should be captured and moved? Where should they come from? Should wild or captive stocks be used? Should animals be drawn from one or more source populations [2]? How can risks to individual animals be reduced? How can animals be encouraged to remain near their release sites? How can public concerns be addressed [3]? How should crucial decisions be made? And who should be responsible for making them? This chapter describes the state of knowledge for translocating brown bears. It also discusses how these considerations may apply to a California grizzly reintroduction and recovery program—while recognizing that any such effort would likely encounter uncertainties requiring effective, real-time, and context-dependent decision-making.

Prior to the 1980s, moving brown bears was a high-risk activity with a low probability of success. Since then, however, translocation techniques for brown bears (Figure 10.1) and other large carnivores have improved dramatically, demonstrating that effective planning, monitoring, and community engagement, along with flexible, transparent, and effective decision-making processes, can greatly increase the chances of success [3], [4]. Translocation practice has been described from reviews of previous bear restoration efforts [5], [6], [7], ongoing restoration planning efforts [8], and translocations of bears for the purposes of addressing local conflicts [9], [10]. Thanks to some of these efforts, translocated brown bears now live in the Cabinet-Yaak Ecosystem of northwest Montana [11], [12], the Autonomous Province of Trento in Italy [13], [14], and the French Pyrenees [15], [16]. Additional translocation projects are now being planned for the North Cascades in Washington state and the nearby Okanagan region of British Columbia. Based on these combined experiences, scientists and managers continue to refine a series of best practices for translocating brown bears.

**Figure 10.1.** Release of a translocated of a grizzly bear. Reproduced from [17].

# Questions

## 1 Can brown bears be moved safely and successfully?

***Brown bear translocation practice has improved dramatically over the past 40 years. Trained experts using established best practices can now move brown bears safely and successfully.***

There is a long history of people moving bears from one place to another. In 1933, not long after grizzlies went extinct in California, U.S. National Park Service and U.S. Forest Service officials moved 27 black bears from Yosemite to the mountains north of Los Angeles [5]. Many of Southern California's black bears today descend from this translocated population. Since the middle of the 20th century, nearly 1000 additional black bears have been translocated as part of around a dozen conservation efforts across the United States [3].

Brown bears have been moved less frequently than black bears. Between the 1930s and 2022, in the United States and Europe, only around 65 brown bear individuals are known to have been translocated as part of restoration efforts (Table 10.1) [3]. Additional conservation translocations are now being planned to Washington's North Cascades and the nearby Okanagan region of southern British Columbia. In addition to translocations to establish populations at recovery sites, other brown bears have been translocated to address local conflicts, providing further experiences on which to base future reintroduction efforts [9], [10].

Historically, many such translocations were poorly planned, executed, documented, or monitored, limiting our ability to assess their outcomes and learn from their successes and failures [18]. Many of these efforts did not even define their goals or how to measure success. Recently, however, the science and practice of species reintroductions has advanced significantly, becoming an established subfield of wildlife conservation with a growing list of publications, best practices, and success stories (e.g., [19]).

Prior to 1983, no documented examples of brown bear translocations succeeded in augmenting or reestablishing populations. During the 4 decades since then, 5 out of 6 documented brown bear conservation translocations have partially or fully succeeded in achieving their stated goals [3] (Table 10.1). Across these efforts, and many large carnivore translocations more generally, increasing success is in part due to changing social factors in the release area (see Chapters 6, 7 and 8 for further discussion) [3], [4], [20].

**Table 10.1**

Compiled brown bear translocation events as part of restoration efforts, with their locations, years, number of translocated individuals, and outcomes. Adapted from [3].

| Study area | Country | Years | n individuals | Outcome |
|---|---|---|---|---|
| Adamello Brenta Nature Park | Italy | 1999–2002 | 10 | Success |
| Bialowieza Forest | Poland | 1937–1938 | 10 | Failure |
| Cabinet Mountains | USA | 1990–1994 | 4 | Partial |
| Cabinet Mountains* | USA | 2005–2022 | 18 | Partial |
| Central Finland | Finland | 1982–1993 | 5 | Success |
| Central Pyrenees | France/Spain | 1996–1997 | 3 | Partial |
| Central Pyrenees | France/Spain | 2006, 2016 | 6 | Success |
| Limestone Alps | Austria | 1989–1993 | 3 | Failure |
| Adamello Brenta Nature Park | Italy | 1959 | 2 | Failure |
| Adamello Brenta Nature Park | Italy | 1969, 1974 | 4 | Failure |
| Adamello Brenta Nature Park | Italy | 1999–2002 | 10 | Success |

*Later translocations in the Cabinet Mountains of Montana, USA, represent additions to the list compiled by [3]. The source for these additions is [12].

## 2 What are the best practices for capturing, transporting, and releasing grizzly bears?

***Best practices for translocating grizzly bears include capturing wild bears using remote drug delivery systems or culvert traps, following established veterinary guidelines for carefully handling and immobilizing bears, taking measures to reduce stress, moving bears expeditiously to their destinations, and then releasing them quickly to reduce their captivity period and potential for interactions with people.***

Managers consider several factors when identifying source populations and individuals from which to recruit a founder population for a reintroduction program. Some of the earliest known brown bear translocations in Europe are believed to have failed in part because they used captive-raised bears [7]. Captive-raised individuals are no longer considered for such projects [5]. This means that in virtually all cases, brown bear conservation translocations begin, after a planning process, with the capture of wild bears that have been identified as good candidates to participate in a founder population.

Independent subadult females, generally between 2 and 5 years old, are among the most demographically important members of a population, based on their lifetime reproductive potential [8], [21]. Among brown bears, adolescent females also have the highest rates of *site fidelity*, meaning that they are most likely to remain near the location of their release [12]. The literature thus recommends that founder populations be heavily weighted toward wild-born subadult females [8], [21]. Brown bears with histories of conflict, such as property damage, do not appear to be more likely than others to repeat similar behaviors in their new locations or attempt to return to their places of origin [9], [10]. Out of an abundance of caution, however, individual brown bears that have conflict histories are not typically considered candidates for conservation translocations [6], [8], [22].

Recommendations vary as to the best timing of brown bear captures and releases [6]. Brown bears are not captured and moved during their winter hibernation period. In Alberta, translocating brown bears with conflict histories during the spring or summer succeeded more often than in the fall [10]. Autumn releases are, however, thought to encourage nearby denning and long-term site fidelity. Releasing a bear into an area during the height of its greatest food-producing season may also encourage site fidelity. This hypothesis is a potential future research topic for California, which has seasonal patterns of plant and animal productivity that differ from those in the Northern Rockies. Planning for these factors is one thing, but executing plans often depends on the bears themselves. The actual timing of translocation may depend on the managers' ability to capture suitable individuals from the source population.

Best practices for proper grizzly bear capture, handling, immobilization, transport, and release have developed over several decades [23], [24], [25], [26], [27]. During the period that these standards have been mostly in place, translocated brown bears have suffered few injuries [12]. Because most experts agree that shorter captivity periods are better, they place an emphasis on both safety and efficiency. Bears may be captured and immobilized using tranquilizing drug delivery systems from the air (e.g., helicopter), ground, or remotely fired from culvert traps [6]. Given the sometimes challenging logistics of capturing and transporting bears in remote areas, a combination of trucks and helicopters may be used to facilitate capture and transport [8]. All guidelines recommend that trained and experienced personnel oversee grizzly bear translocations from start to finish.

Causing stress to animals is an unavoidable aspect of wildlife translocations [28], [29]. It is impossible to avoid stress altogether, but it is possible to minimize it [27]. Carefully identifying and targeting animals most appropriate for transfer reduces the chance of capturing a poor candidate. Some guidelines advise that bears be confined for fewer than 24 hours, that they fully recover from anesthetic effects before being moved, and that they be provided with water when necessary [25]. Immobilized bears should be examined and have their vital signs monitored. Enclosed climate-controlled containers limit stress on bears during transport [6]. Any move of a grizzly bear from an existing population to California would involve many hours of travel, but this is not an insurmountable barrier. Brown bears that were moved by truck transport from Slovenia to France traveled more than 1500 km over 21 to 24 hours [30]. The distance between the Greater Yellowstone Ecosystem (GYE) and Sequoia National Park, for comparison, is around 1700 km and takes about 17 hours by road.

Once released, bears may experience the additional stress of encountering a new environment [29]. Brown bears have been transported successfully into areas quite unlike their places of origin [9], [31]. However, because brown bears are intelligent, long-lived animals with local cultures and learned behaviors [32], it is best to release them into sites similar to their previous ranges or at least into places with abundant local foods that overlap with those found in their source location [6], [8]. For some wildlife species, experts recommend a soft release, in which an animal is placed in an enclosed area for an initial period to discourage it from abandoning the site [33]. In contrast, for brown bears, most experts recommend a hard release, in which an animal is moved quickly and set free immediately without an initial adjustment period. The rationale for this approach is to minimize interactions with humans, which, for bears, may ultimately be more problematic than being released into an unfamiliar but wild and remote area [6], [8].

Even with a hard release, managers may provide supplementary foods or temporarily alter the local habitat in the release area to provide a nutritional boost and encourage site fidelity during the initial post-translocation period [6], [33]. Such measures have been widely used for several wildlife species, including California condors, elk [34], and raptors [35]. Food supplementation is also common for brown bears in Europe [36], though the costs and benefits of such strategies appear to depend on the method and context of their usage. Some experts have expressed concern that even temporary access to artificial food may disrupt long-term bear behavior, ecology, competition, and dispersal [37]. Other evidence, however, suggests that under certain circumstances, artificial foods may reduce bear movements, resulting in smaller home ranges and encouraging site fidelity of individuals [38].

One of the most important decisions for conservation translocations is where to release an animal. The first step in identifying a release site is to determine whether the factors that drove the species out are still present [2], [39], [40]. In California, particularly in national parks and remote wilderness areas, grizzlies would not encounter the kind of unrestricted persecution that drove their decline more than a century ago (see Chapter 1). A release site should also be of sufficient size to meet the bears' habitat requirements (see Chapters 2 and 3) [41], [42], and have adequate resources to meet all of the bears' needs over the seasons and throughout their various life history stages [43]. These resources include adequate nutrition, cover, a low-elevation spring range, denning sites, water sources, some degree of remoteness from humans, and resilient ecosystems.

Food may be the single most critical habitat component for a release site [7]. Maximizing the overlap between available food resources in the source and release areas may discourage site abandonment and reduce the chances of conflicts with people [6], [8]. An important research need for California is gaining a better understanding of the distribution and abundance of grizzly foods around potential release sites. Another important quality of a potential release site is its location relative to human activities. Additional research may focus on the specifics of recreation and other uses near proposed release sites, including the potential for conflicts or accidents. Given these concerns, an ideal release site may be in a diverse, mid-elevation forested area at the end of a long restricted access route, such as a fire road, that is already closed to recreational use and surrounded by large blocks of high-quality protected habitat (see Chapters 3, 6, and 7).

## 3 Where would translocated grizzlies come from?

***Source populations would be chosen based on their size, location, and genetic relatedness to bears that once lived in the recovery area, as well as the similarity of the habitats in the source and destination locations and regulatory and permitting issues. Potential source populations for a California recovery program from within the United States include the Northern Continental Divide and Greater Yellowstone Ecosystems. In Canada, British Columbia has robust potential source populations.***

Several factors would inform the selection of source populations from which to draw individual bears for translocation. The source population should be close enough so as not to require too long of a capture and transport journey. It should be robust enough to "spare" a small number of individuals without affecting its viability [1]. And it should occupy an area as ecologically similar as possible to the translocated individuals' ultimate destination [6], [31]. The need for site similarity presents an interesting potential research topic for California, which, like the North Cascades, contains some key habitat elements that differ from those in the Northern Rockies.

Likely sources for a grizzly founder population include areas in North America with bears that are geographically proximate and genetically similar to those that once inhabited California. Options include the Northern Continental Divide Ecosystem (NCDE) and the GYE, which together span the states of Montana, Idaho, and Wyoming. These two populations have grizzlies that are genetically indistinguishable from the bears that once inhabited California [44]. Together, the NCDE and GYE populations have roughly doubled in size over the past half-century since being listed as threatened under the U.S. Endangered Species Act, and they now number close to 2000 individuals. The NCDE and GYE do not have "extra" bears, but if these populations continue to increase, moving a small number from these areas would be unlikely to have a significant impact on their populations [8].

Grizzlies living in the southern interior of Canada are part of the same clade (IV), or genetic lineage, as those that once lived in California and currently inhabit the Northern Rockies. Bears would not likely come from Alberta because since 2010, the grizzlies there have been listed as threatened under provincial law. British Columbia is believed to have around 15,000 grizzly bears, up to 20 times more than Alberta, and could potentially serve as a robust international source. There is a strong precedent of the United States and Canada cooperating for wildlife recovery projects [12], [45]. Within Canada, efforts are currently underway to plan for the translocation of grizzly bears from central British Columbia to the Okanagan and North Cascades regions along the United States-Canada border.

While brown bears in small populations are not known to suffer from genetic problems as severely as some other species (e.g., the Florida panther [*Puma concolor coryi*]), sourcing grizzly bears from more than one region could have modest benefits associated with greater genetic diversity [8], [46], as well as minimizing impacts on U.S. source populations. The choice of sources may ultimately depend less on genetics than on logistics, such as licensing and permit requirements (see Chapter 9) and the ability to safely and efficiently identify and capture candidate individuals.

## 4 How would decisions be made during the reintroduction and recovery process?

***Logistical, political, and ecological constraints may influence translocation decisions, including such key questions as which bears are chosen and where they are released. Many decisions may thus vary by year and benefit from monitoring, structured decision-making (Figure 10.2), and adaptive management to respond to dynamic circumstances.***

The science and practice of species reintroductions has advanced considerably in recent years, but many choices still depend on the particular circumstances. Logistical, political, and ecological considerations may all influence important decisions. Key details, like how many bears get moved from a particular sex and age class, may depend in part on chance factors, such as which individuals from a source population are willing to enter a baited culvert trap. Managers can, to some extent, plan for these complexities and uncertainties (e.g., [8] Figure 10.3), and they may even incorporate related variables into their models [48] (see Chapter 4). Regulatory approvals that depend on political support also involve some uncertainty and, despite much planning, may require considerable flexibility (see Chapter 9). Wolf recovery efforts in Colorado, for example, have required officials to make decisions that vary by the year according to the availability of source populations and the dynamics of interstate and international coordination [49].

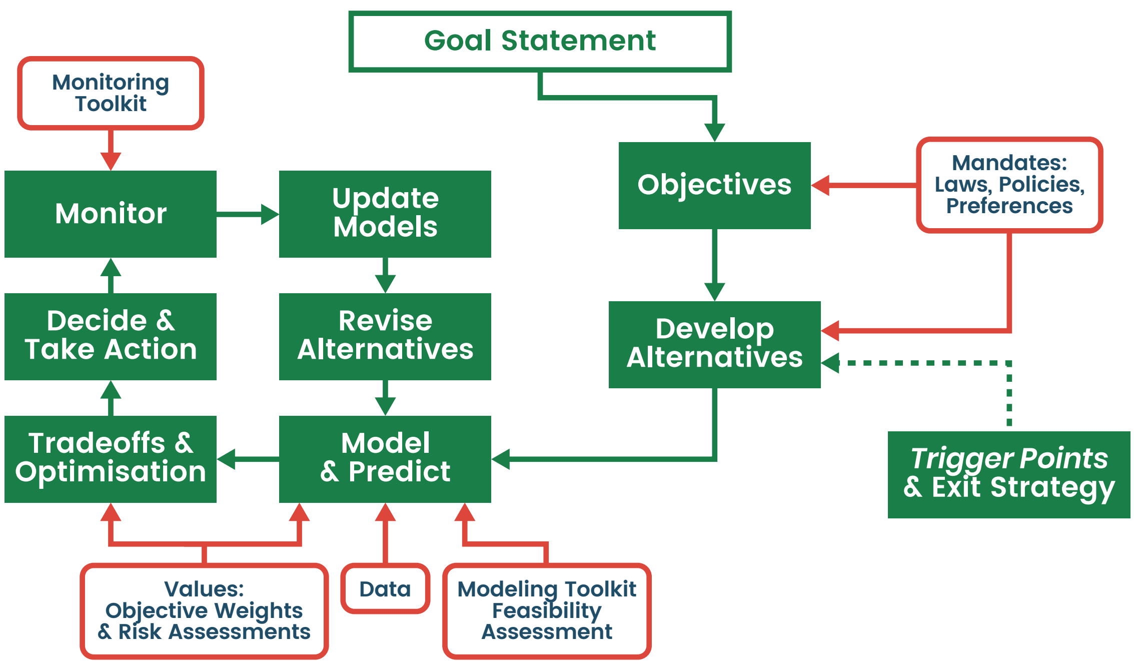


**Figure 10.2.** Flowchart of the structured decision-making and adaptive management process for conservation translocations, including adaptive management practices of monitoring, updating models, and revising decisions. Adapted from [47] to include the identification of decision-making trigger points alongside the establishment of an exit strategy. We refer readers to [47] for further information on the structured decision-making process and its application to the practice of conservation translocation.

The recovery strategy for California grizzlies may change over time as managers learn and improve their practices. Monitoring and adaptive management are cornerstones of contemporary wildlife conservation, especially for projects such as species reintroductions, which involve high levels of uncertainty [50], [51]. *Adaptive management* refers to an approach to learning by doing in which policy and management prescriptions are treated as working hypotheses, and management actions are considered tests of these hypotheses [52]. For adaptive management to work, interventions must be designed in a way that allows managers to learn from them, monitored in a way that facilitates rigorous analysis, and made flexible enough to allow for regular policy adjustments (Figure 10.2). Adaptive management may be either built into translocation plans from the very outset [8] or added to management plans during subsequent stages of a recovery effort [14].

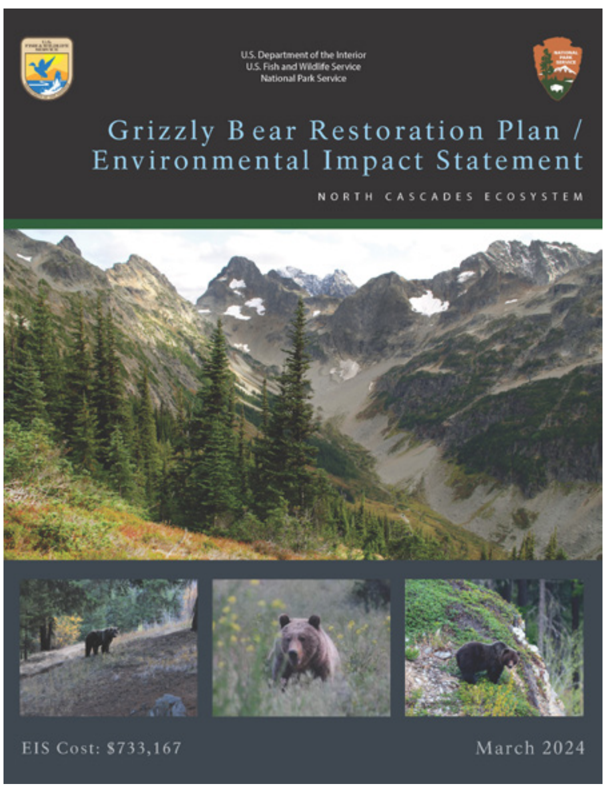


**Figure 10.3.** The restoration plan [8] for grizzlies in the North Cascades Ecosystem by the U.S. Fish and Wildlife Service and the National Park Service.

Learning is an important step, but implementing changes, even when supported by robust evidence, can be extremely difficult. Effective, transparent, and inclusive processes can greatly improve how decisions are made and implemented. For this reason, managers are increasingly adopting *structured decision-making* for complex recovery projects that involve multiple phases, scenarios, and objectives [53], [54]. The International Union for the Conservation of Nature, for example, draws on structured decision-making processes for its conservation translocation guidelines [2] and workshop materials (see iucn-ctsg.org/training; Figure 10.4). Such processes require managers to identify recovery objectives [18], [50], [55], use clear criteria to measure progress toward these objectives, and establish thresholds or trigger points [56] that signal the need for action—for example, gathering additional information or changing course regarding previously planned interventions (Figure 10.2). Common large carnivore reintroduction and recovery objectives include ensuring population persistence and human safety while minimizing the project cost and harm to individual animals. Structured decision-making processes require institutions with sufficient funding and support (see Chapter 8), flexibility for managers to use monitoring data for real-time decisions, and mechanisms for ensuring decision-maker accountability [57]. This is a difficult balance to achieve, but working toward it is essential because institutions and decision-making structures can make or break even the best-planned reintroduction and recovery efforts [58].

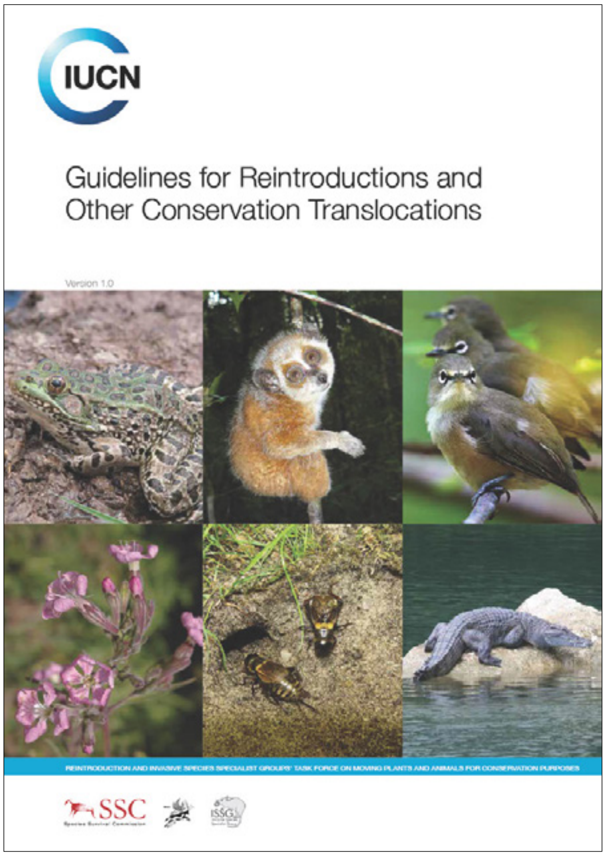


**Figure 10.4.** Cover of the reintroduction and translocation guidelines from the International Union for the Conservation of Nature [2].

Ultimately, an agency, committee, team, or official must have the authority to make decisions about management actions. If grizzly bears remain listed as threatened under the U.S Endangered Species Act throughout the lower 48 states, then decision-making must occur within the context of federal protection (see Chapter 9) and may involve establishing an operating team to make real-time decisions in a timely manner amidst multiagency efforts [59]. If grizzlies are removed from the federal list, then California and Tribes will likely have considerably more latitude to pursue their own management plans and recovery efforts. Recovery teams, whether at the state or federal level, often include members from agencies, universities, nongovernmental organizations, and other civic and academic groups with expertise in disciplines including various fields of biology, ecology, land management, wildlife coexistence, and veterinary science (e.g., [60]).

Reintroductions most often lead to successful recoveries when decisions receive ongoing support from key civic groups [61] that can help with exchanging information, making collaborative decisions, and delegating responsibilities [62]. Community meetings, focus groups, and advisory committees are increasingly used in wildlife recovery efforts and have been used previously for translocation efforts and other conservation initiatives involving grizzly bears (e.g., the North Cascades


**Figure 10.5.** Social media advertisement for the U.S. National Park Service in-person public scoping meetings for grizzly bear restoration in the North Cascades Ecosystem. Reproduced from an October 30, 2023 post on Facebook by the regional conservation group Conservation Northwest.

Subcommittee of the Interagency Grizzly Bear Committee [63] and the National Park Service public scoping meetings [64] Figure 10.5).

See Chapters 6 and 7 for further details on community engagement.

## 5 How would a California grizzly recovery program be monitored?

***Effective monitoring is essential for tracking species reintroductions and recoveries. Monitoring results can increase fundamental understanding, track key trends, identify challenges for human-bear relations, build public trust and support, and inform adaptive management through structured decision-making processes.***

Despite a historical lack of emphasis, scientists and managers now consider rigorous and effective monitoring essential for translocation projects [2], [39]. Given the many uncertainties associated with moving animals into landscapes from which they have long been absent, monitoring is necessary to inform decision-making (Figure 10.2), increase knowledge, reduce uncertainty, identify data gaps, and contribute to the growing body of knowledge on species reintroductions [55], [65]. A well-planned monitoring program directs managers to articulate clear goals, measure and report on their progress, and make timely decisions based on current information.

A comprehensive monitoring program for California grizzlies may include the following components:

Targeted monitoring of habitat use by GPS-tracked or camera-trapped bears can improve models of grizzly habitat suitability and needs in California [66]. The assessment of habitat suitability described in Chapter 2 and predicted habitat use described in Chapter 3 draw from data collected on grizzly bears' habitat use in other places. Monitoring the habitat use of grizzly bears following their release in California would enable researchers to update these models with place-specific data, thus improving our understanding of how grizzly bears may use the state's landscape and how their movements may change over time (e.g., [67]). This knowledge would then aid the design of adaptive plans, such as prioritizing high-quality but insufficiently conserved California habitats for greater protection.

Demographic monitoring can help scientists and managers understand specific events and short-term trends, as well as longer-term patterns of population change (e.g., [12]). Tools such as GPS trackers, camera traps, and DNA sampling by collecting hair or scats at bait stations can provide valuable information, including demographic rates, whether males and females have overlapping ranges and may reproduce, how related the bears are in a given area, and the overall genetic diversity in and across populations [12], [46]. These data can improve population viability models and contribute to decision-making [48], [50] by identifying thresholds for management actions, such as translocating additional individuals [52], [68].

Reintroduction projects have rarely monitored the effects of recovering populations on other species or entire ecosystems, but this is an important emerging priority, particularly for large carnivores and other potential keystone species or ecosystem engineers (see Chapter 5) [3], [69], [70]. Reintroductions share many features with Before-After-Control-

Impact experiments (BACI; [71]), which offer opportunities for learning by measuring changes in baseline conditions over time (e.g., [72]. For example, tracking grizzly diets [73] would provide novel information on how grizzlies use California's unique vegetation. Monitoring community-level responses may be captured using repeat photography (e.g., [74]), plant sampling (e.g., [75]), or more direct monitoring of space use by grizzlies and other species with which they share their habitats (e.g., [76]). Because a recovering grizzly population in California would likely be small and grow slowly, monitoring methods must have sufficient sensitivity to capture subtle or local effects and must be of adequate duration to capture changes over time (e.g., [72]).

Monitoring for species reintroductions typically has focused on biological metrics, but social factors also commonly pose challenges to such efforts [77]. Monitoring human-bear relations would prove useful for informing decisions about where to conduct future releases and focus coexistence efforts (e.g., [78], [79]). In the GYE, for example, monitoring human and grizzly space use helped managers better identify needs for management interventions, such as temporary area closures (see Chapters 7 and 8) [80], [81]. Surveys of human perceptions in and around grizzly bear recovery areas can also inform community engagement efforts. Repeated citizen surveys in northeast Italy's Trentino region allowed managers to better understand shifts in local support and respond by developing alternative options for managing conflicts [14], [20].

Transparency is a crucial aspect of a comprehensive monitoring program. Making data available to researchers, local community members, and other concerned citizens can help keep the public engaged and improve collaborative decision-making [62]. This is particularly important for large carnivores, where trust is indispensable for maintaining public support [82], [83]. Another proven method to increase both transparency and engagement is to sponsor community science programs that enable the public to contribute to research. The North Bay Bear Collaborative north of San Francisco, for example, has developed community-based programs to document black bear behavior and ecology by collecting and preserving bear scats, which can then be used in laboratory research.

California Tribes could play a central role in monitoring and public engagement. The Karuk Tribe in upper Northern California, for example, has led restoration efforts of forestlands, including traditional burning practices, to recover elk populations while promoting traditional ecological knowledge and practices [84], [85]. In the past, Tribes have often been excluded from decision-making processes related to endangered species, including grizzly bears [86]. A monitoring plan that prioritizes tribal leadership, sovereignty, and resilience can help raise awareness of these painful histories while promoting healing through capacity building and economic development [87].

## Opportunities For Future Research

- Future research could seek to better understand the diversity, distribution, and seasonal abundance of bear foods in California's potential recovery areas, particularly near proposed release sites, to assist in siting decisions.
- Future research may study the potential for human-bear interactions around potential release sites based on patterns of land use, access, and recreation. This work could help identify the best sites and help implement proactive measures to avoid potential conflicts during the early stages of a reintroduction and recovery effort.
- Lessons learned from other ongoing and planned brown bear conservation translocations, including in the North Cascades, could help inform decision-making for a future California reintroduction and recovery effort.

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# Conclusion

In 1942, Aldo Leopold, considered by many to be the founder of American wildlife management, chided his colleagues for the way they had treated grizzly bears. “There seems to be a tacit assumption,” Leopold wrote, “that if grizzlies survive in Canada and Alaska, that’s good enough. It is not good enough for me… relegating grizzlies to Alaska is about like relegating happiness to heaven: one may never get there” [1].

Over the past half-century, grizzly scientists, managers, and other advocates have worked tirelessly on the bears’ behalf. Grizzlies are no longer in imminent danger of going extinct in the lower 48 states, but their population remains greatly diminished, at only around 4% of its pre-European level. The current recovery program, for all its accomplishments, does not ensure the long-term survival of the bears. Nor is it conceived, designed, or equipped to achieve a meaningful recovery south of the Canadian border. Achieving such a recovery will require a more ambitious vision. This vision, to paraphrase Leopold, should not relegate grizzlies to a few cold and remote places, but rather seek to recover them wherever feasible throughout their historical range.

This feasibility study builds on nearly a decade of research conducted through the California Grizzly Research Network and California Grizzly Alliance. This work began with questions, not conclusions, and sought to develop a strong foundation of evidence from multiple disciplines and perspectives. Much remains to be done. At each stage along the way, however, the lessons we learned pointed to a clear and consistent conclusion: California (the place) likely contains plenty of habitat for a sustainable population of grizzly bears. The question is whether Californians (the people) will embrace such a bold and visionary project.

When grizzlies disappeared from California, the state lost not just a mascot or a resource but also an ecosystem engineer, a historical icon, a connection to place, and a source of wisdom, humility, and inspiration. Some Native Californians also feel they lost a relative. Answers to the questions of when, where, and how to recover grizzlies must be based on sound science of the kind presented in this Feasibility Study. But any answer to the question of why the bears should be brought back must reckon with more than facts and theories. It must describe the kind of world we all want to live in and the kind of future we hope to build in it. The most important habitat for grizzlies, as people who have dedicated their lives to studying and protecting the bears often say, is not in some dataset, scientific report, or computer model. It’s not even in the forests and mountains. It’s in people’s hearts.

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