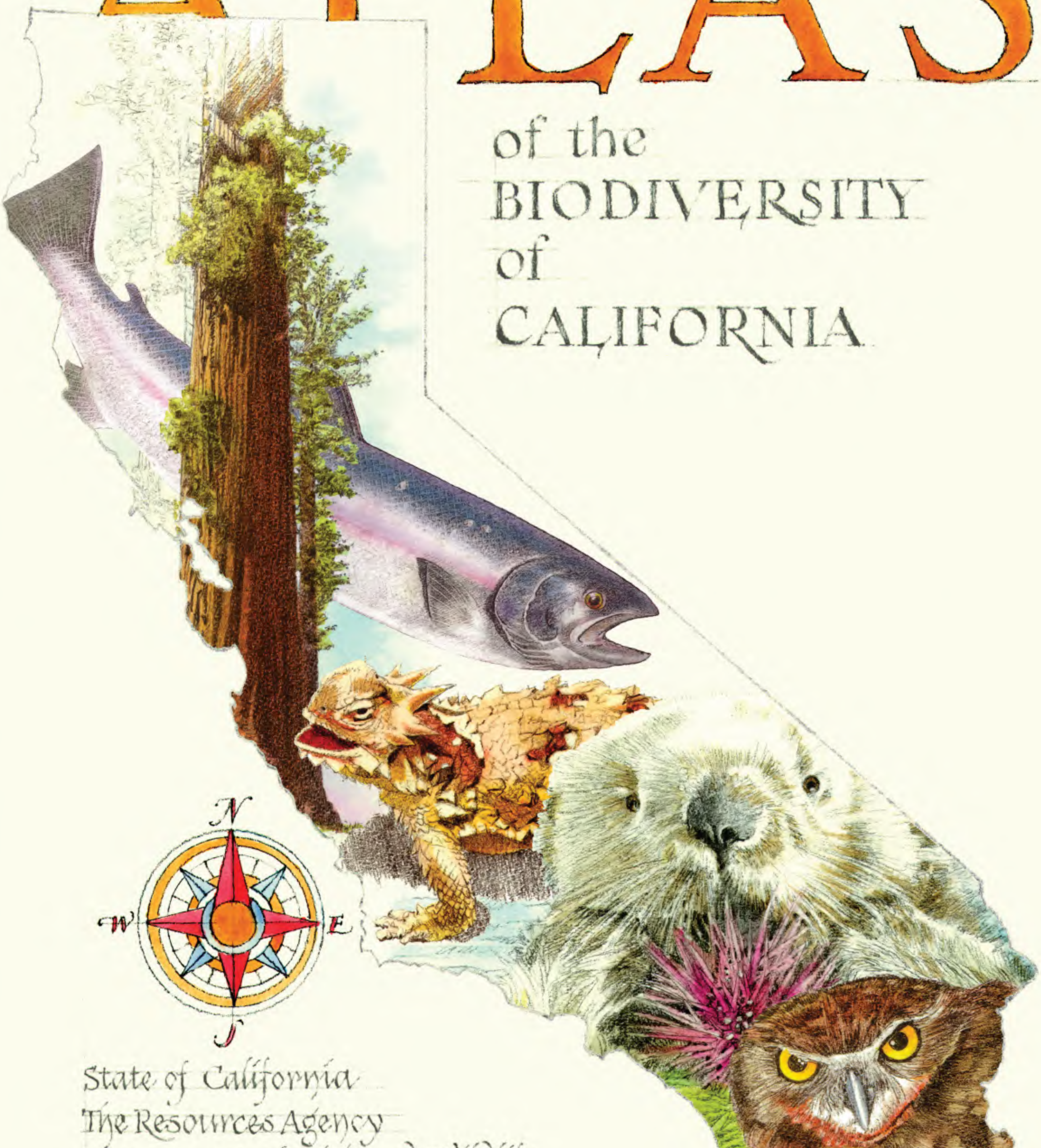
SECOND EDITION

ATLAS of the BIODIVERSITY of CALIFORNIA



State of California
The Resources Agency
Department of Fish and Wildlife

Atlas of the Biodiversity of California

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The Natural Resources Agency
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CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE

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Message from the Director

The Department of Fish and Wildlife is proud to present this second edition of the Atlas of the Biodiversity of California, featuring updated maps that reflect changes to our understanding of the natural world and the impacts humans are having upon it.

A map is a slice of distilled wisdom, and each tells part of a larger story. This atlas is meant to point toward truths, to whet an appetite for learning, and to inspire the people of California to preserve our biodiversity for posterity.

The California of today was built over millions of years. It was shaped by collisions of land masses, shifts in climate, and the adaptations of organisms across geologic time. From the misty glades of redwood forests to fleeting explosions of desert wildflowers, from alpine waterfalls to the gentle meanderings of the Delta—the natural landscape of California has many different faces. This land has never remained still. Mountains move at barely perceptible speeds. Species are ever evolving and migrating. Humans are relative newcomers, yet virtually all of California's habitats have been impacted by human activity. Now human influence has dramatically altered the pace of environmental change.

We humans, at once both wise and foolish, find ourselves bearing a staggering responsibility. We must learn while making mistakes. Future generations will inherit our role as the stewards of this earth. Let's make sure we pass along a world that still makes a child's eyes grow wide with wonder.

When times look dire, if you start to feel all is lost, simply stop. Broaden your gaze. Lay your hands on the soil. Listen. This world is buzzing with beauty. California's future is contingent on how we collectively understand, engage with, feel about, and care for this great natural world described in the second edition of the atlas. May it help you and all of us on our journey.

Charlton H. Bonham

Director, California Department of Fish and Wildlife

Acknowledgments

We gratefully acknowledge the many individuals who helped make this second edition of the Atlas of the Biodiversity of California a reality. Governor Edmund G. Brown provided the impetus to undertake this update by launching the Biodiversity Initiative in the fall of 2018. Drawing from this inspiration, staff of the California Department of Fish and Wildlife began to assemble the maps and stories that make up this atlas. We thank the authors and mappers, all experts in their fields, for the time and care they extended to this project. We are additionally grateful to the many researchers who shared their data models with us and to all the persons who regularly contribute their observations of rare plants and animals to the California Natural Diversity Database. Without these contributions the richness maps would not have been possible. Staff of the California Department of Fish and Wildlife, California Department of Conservation, and others listed below present this atlas in hope of inspiring Californians to take action to conserve the state's extraordinary biodiversity.

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About the Artist

In Memoriam

1936 – 2011

Dugald Stermer, a native Californian who graduated with an art degree from UCLA, worked in advertising before accepting the position as Art Director for the politically influential Ramparts Magazine (1964–1970). His illustrations and designs have appeared in numerous books, magazines, and posters, covering topics from political commentary to rare plants and animals to the design of the 1984 Olympic Medals. In 1986, when asked by then Judge William Newsom, Dugald produced illustrations for the Mountain Lion Foundation that helped to secure the lion's protection in California. A distinguished professor at the California College of the Arts for over 20 years, he became the Chair of the Illustration Department in 1994. He was commissioned by the U.S. State Department to design and illustrate their 2009 Earth Day Poster. Among his many endeavors "to change the world for the better," he counseled substance abusers and ex-convicts for over 30 years at the San Francisco based Delancey Street Foundation (where he also had his office). Dugald is the author of four books: *Vanishing Creatures*, *Vanishing Flora*, *Birds & Bees*, and *The Art of Revolution*. He was also nationally known for having the largest collection of left-handed vintage Martin guitars and for his collection of Tom Mix memorabilia.

- Chris Stermer, Wildlife Biologist, California Department of Fish and Wildlife

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A Definition of Biodiversity

LA GRACIOSA THISTLE

A Definition of Biodiversity

Biodiversity may be defined on many different levels. For a regional landscape or an entire state, it is the diversity of species, habitats, and vegetation types. For a habitat or vegetation type, it is the diversity of life forms within it. For a species, it is the genetic variation within a population or among populations.

California is truly a special place, known for its great variety of plants and animals. The state is home to some of the nation's most unique and highly threatened species (see map at right) and is one of the 35 biodiversity "hotspots" recognized worldwide (Mittermeier et al. 2004, Zachos and Habel 2010). Compared to other states, California has both the highest total number of species and the highest number of endemic species—those that occur nowhere else (Stein 2002).

This variety of life, or biodiversity, can be explained by our unique geography, climate, and geologic history. Where else can you find the highest point and the lowest point in the contiguous United States? Mount Whitney (14,494 feet) and Badwater, Death Valley (282 feet below sea level) are within 80 miles of each other, and both are only 200 miles from the Pacific Ocean, where a diverse marine landscape exists just offshore. California's high mountain ranges and deserts have kept native animals and plants relatively isolated from the rest of the continent. The warm summers and mild winters of California's rare Mediterranean climate also make the habitats different from those in other parts of the country. Then there is the sheer size of the state; California is more than 100 million acres in area and over 1,000 miles north to south. Add these factors together and you have one of the planet's richest places for plant and animal diversity. California's natural heritage embodies the very definition of biodiversity.

Because California is also a great place for human life, it is home to the largest population of people in the country. The human demands for the land, water, and natural resources that make life so abundant in California present the greatest threats to its unique plants and animals. California is second in the nation in number of rare species within a state, with over one third of its species identified as at risk. California also ranks third in the number of species that have been lost forever (Stein 2002). Our challenge is to meet the needs of society while maintaining the state's remarkable biodiversity for future generations.

For the purposes of this atlas, we are examining biodiversity on a statewide level. Updated from the 2003 edition, this atlas presents a summary of the best available information we have to date on species, habitats, and vegetation types at that level. A complete analysis of biodiversity would include many additional groups of living things for which we lack statewide data. This would include fungi, lichens, most non-vascular plants, such as mosses, and more. For animals, this would include most invertebrates, such as mollusks, insects, spiders, and crustaceans, and other marine life that reside in the waters off California's coast. Nevertheless, we can still identify places on the landscape where biodiversity appears to be unusually high.

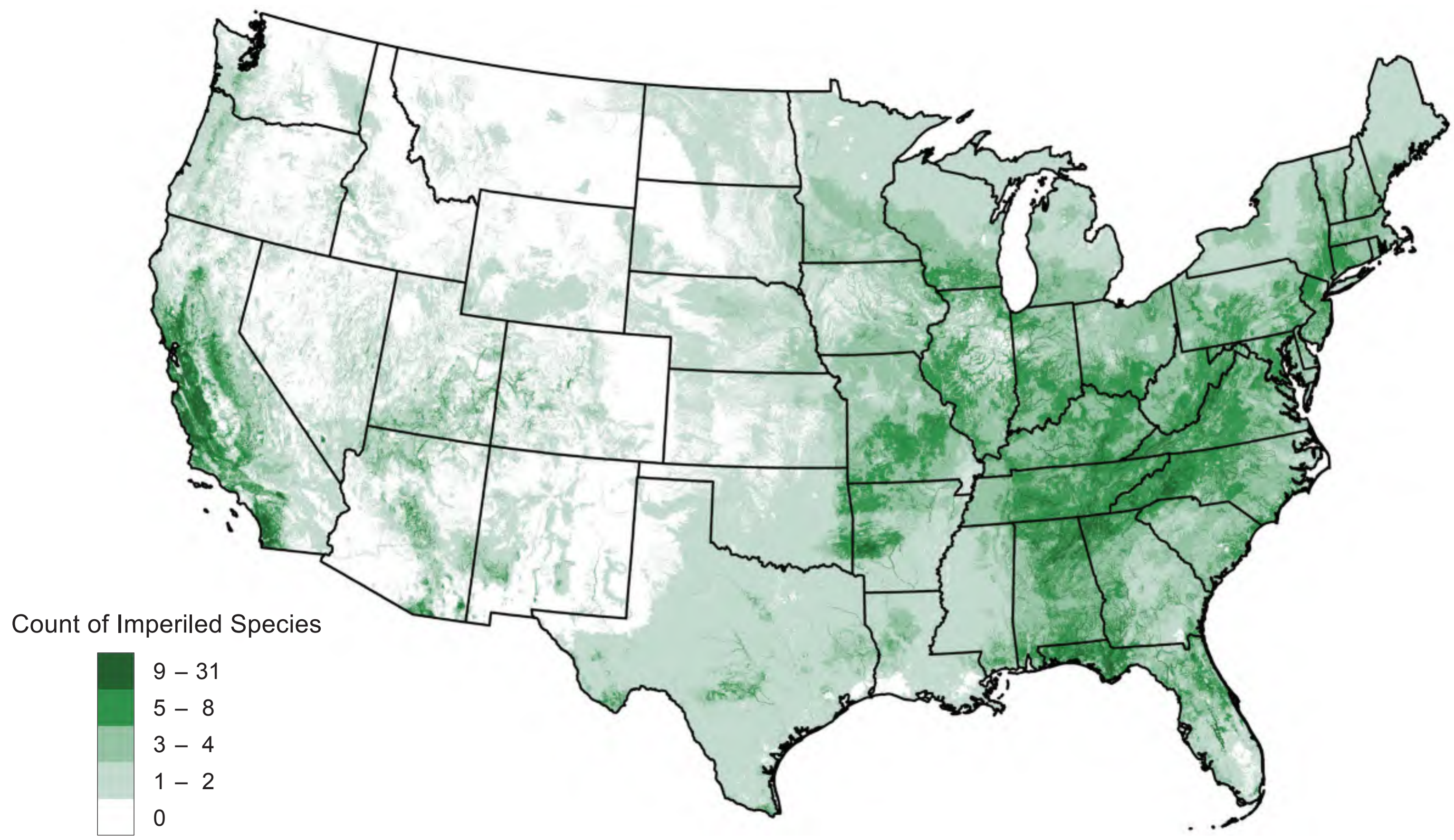
Biodiversity Analysis Main Components

Richness — a measure of diversity. The total number of plant taxa, animal species, or vegetation types in a given area. Note that this is the number of species or taxa, rather than the number of individuals. An area high in bird richness, for example, supports many different species of birds. The density of birds is not necessarily higher here than in other areas of the state.

Rarity — a measure of sensitivity. Used for those taxa that have special status due to very limited distribution, low population levels, or immediate threat, such as habitat conversion. An area high in rarity has many taxa that meet this definition.

Endemism — a measure of natural distribution. Used for those taxa that are found only in one specific area, such as one region or the state itself. A region of high endemism has many taxa restricted to it.

Note: "taxa" refers to organisms at different levels of biological classification, including species, subspecies, varieties, and evolutionarily significant units.



Richness of Imperiled Species in the United States

Numbers of species in the lower 48 United States that are protected by the Endangered Species Act and/or considered to be in danger of extinction. Adapted from NatureServe's Map of Biodiversity Importance Project (NatureServe 2019).

Biodiversity Rank	Diversity	Rarity/Risk	Endemism	Extinction
1	***California***	Hawaii	***California***	Hawaii
2	Texas	***California***	Hawaii	Alabama
3	Arizona	Nevada	Texas	***California***
4	New Mexico	Alabama	Florida	Texas
5	Alabama	Utah	Utah	Georgia

Source: Adapted from *States of the Union: Ranking America's Biodiversity* (Stein 2002).

Note: Based on analysis of over 21,000 species in the United States.

Richness in California	Number of California Native Species (Taxa)	Percent of U.S. total Species (Taxa) in California	Number of California Endemic Species (Taxa)	Number of California Special Status Taxa
Vascular Plants	5332 (6578)	32 (35) %	1315 (2309)	2351
Amphibian	68 (73)	22 (20) %	32 (36)	49
Reptile	99 (115)	29 (19) %	11 (16)	45
Bird	402 (456)	50 (44) %	2 (18)	157
Mammal	196 (313)	45 (32) %	17 (82)	143
Freshwater Fish	70 (105)	8 (10) %	19 (44)	97

Sources: NatureServe (2020a), Jepson Flora Project (2020a), Baldwin et al. (2012), California Department of Fish and Wildlife (2020a).

Note: Species and taxa counts include extinct taxa and fluctuate between authoritative sources over time due to ongoing changes in recognized taxonomy, newly described taxa, and conservation status. For this reason, numbers mentioned in later chapters may not agree with this table.

An Introduction to the Atlas

What's New in the Second Edition

The second edition of the Atlas of the Biodiversity of California has been updated with all new maps since the first edition was published in 2003. They were created using the latest mapping techniques and are based on a greatly expanded database of species locations and habitat information. The map colors have been chosen for easier interpretation by persons with color vision deficiency. The text in each chapter has been updated by experts in the field to contain the most current information available. The revised edition also includes expanded content on marine biodiversity, a new chapter on climate change, and updates on methods of conserving California's biodiversity.

The maps of taxonomic richness and rarity look slightly different than those in the first edition, reflecting improvements in available biodiversity data. The taxonomic richness maps are based on predictive habitat models that are more detailed than the species range data used previously. The vegetation maps and predictive habitat models reflect millions of additional acres of vegetation that have been mapped according to the Survey of California Vegetation fine-scale mapping standards. The rarity and endemism maps incorporate more than twice the number of CNDDB occurrences, as well as additional data gathered from BIOS and other partner datasets. The CNDDB and BIOS data systems are described below.

Organization of the Atlas

The data in the atlas are presented in five major sections. The first section, "A Remarkable Geography," showcases geographic data such as climate, geology, and vegetation that underlie California's extraordinary biodiversity. "Measures of Biodiversity" displays maps of richness, rarity, and endemism for major taxonomic groups such as plants, mammals, and invertebrates. "Examples of Biodiversity" presents iconic or unique habitats and species from across the state. "Threats to Biodiversity" outlines human-driven threats to biodiversity, including population growth and climate change. Finally, the last section, "Conserving Biodiversity," describes some of the efforts to protect California's natural heritage, such as conservation planning and habitat restoration.

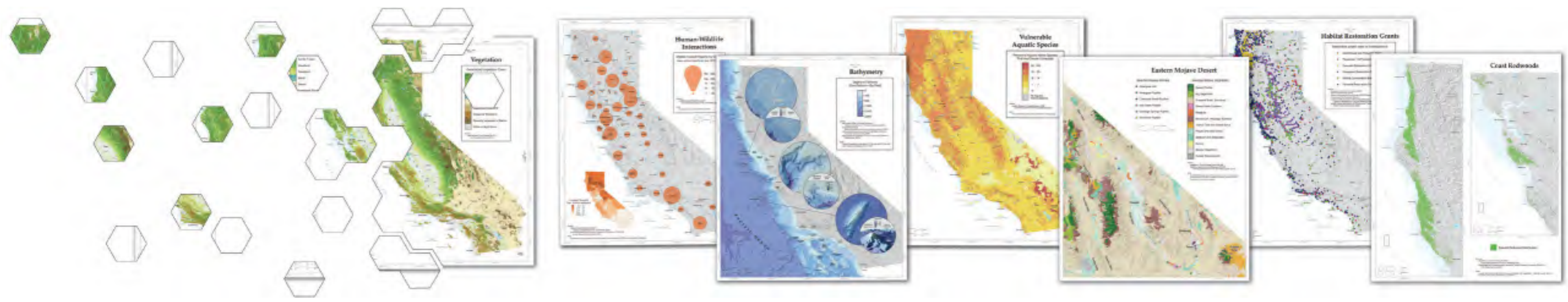
The symbols and data sources common to all of the maps in this atlas are presented on page 8. A glossary of biological, geographical, and management terms begins on page 103.

Gathering the Data

All maps in the atlas present the most comprehensive statewide or regional datasets available for the topics chosen. The data were primarily assembled from California Department of Fish and Wildlife (Department or CDFW) programs that map and track biodiversity data, as described below. The digital datasets used to create many of the maps in this book are available on the Department's BIOS website and are updated regularly to reflect the most recent information for California. Although the maps depict the entire state of California, many parts of the state have not been surveyed at this time; only the data collected in surveyed areas are represented on the maps. To some extent the topics chosen, particularly those featured in "Examples of Biodiversity," reflect what datasets are available. Unless otherwise specified, the maps in the atlas show present-day biodiversity in California and are not based on historical information.

Biogeographic Information and Observation System — a library of spatial datasets

The Biogeographic Information and Observation System (**BIOS**) is a system designed by the Department to manage and visualize biogeographic data for California. It currently includes a library of almost 2,500 spatial datasets providing information on California's flora, fauna, and natural resources, such as species ranges, distributions, and survey detection locations. BIOS houses datasets developed by Department scientists and staff, as well as data shared by partner agencies and researchers, and makes this information publicly available for online viewing and



downloading. The dataset number listed on the map sources in this book (i.e., *Vegetation - Sonoma County [ds2691]*) corresponds to the BIOS dataset number.

The Survey of California Vegetation
— fine-scale vegetation maps for California

The Survey of California Vegetation (**SCV**) sets standards for vegetation surveying, classification, and mapping in California. By following these standards, vegetation maps of different parts of the state, produced by various agencies or other groups, can be combined seamlessly. To date, 52 million acres of vegetation have been mapped or are being mapped according to SCV fine-scale mapping standards. These maps can be viewed and downloaded from BIOS; the *Vegetation (MCV / NVCS) Mapping Projects – California [ds515]* dataset (CDFW 2020) lists the mapping projects that are completed or in progress at the current time. The SCV conforms to the National Vegetation Classification Standard (USNVC 2019), so that California's vegetation classification nests within the national system.

California Wildlife Habitat Relationships
— a database of wildlife information

The California Wildlife Habitat Relationships (**CWHR**) system (CDFW 2014) includes several components—current range maps, habitat suitability models, and life history information—that describe all regularly occurring terrestrial vertebrates in California. The range maps represent the typical geographic extent of each species. The habitat suitability models predict the habitats (vegetation types, cover, special habitat features, etc.) that a species is likely to use for breeding, feeding, and resting. These models are combined with vegetation maps to create the CWHR predictive habitat maps, pinpointing where species are most likely to be found within their ranges. CWHR has been used for several large wildlife resource conservation efforts, including the California Wildlife Action Plan, and is used to predict wildlife response to changes in habitat condition.

California Natural Diversity Database
— an inventory of California's rare species

The California Natural Diversity Database (**CNDDB**) is a statewide inventory of the locations, called occurrences, and status of the state's rarest plant and animal species. The CNDDB is California's natural heritage program and is a member of the NatureServe Network, an international network of over 100 similar programs throughout the western hemisphere. Maps representing high priority special status plants and animals, including vertebrates and invertebrates, were created using occurrence data from the CNDDB (CDFW 2020b). The CNDDB has mapped over 96,000 locations for more than 3,000 of California's rarest and most imperiled species.

Areas of Conservation Emphasis
— a source for biodiversity maps

The Areas of Conservation Emphasis (**ACE**) project combines species and habitat data from BIOS, CNDDB, CWHR, and the SCV to develop maps of biodiversity for California, such as the amphibian, reptile, bird, mammal, plant, and invertebrate richness and rarity maps shown in this atlas. ACE was designed primarily to provide a set of information-rich maps to those working in the field of biodiversity and species conservation, but it is also available to any member of the public with an interest in understanding the most current data concerning California's biodiversity. In addition to maps of species diversity, ACE also develops maps of significant habitats, habitat connectivity, and climate resilience.

ACE has two principal map types: terrestrial and aquatic. Terrestrial maps summarize land-based biodiversity data using a 2.5-square-mile hexagon grid. Aquatic analyses concern fish and aquatic-obligate species such as waterfowl, many amphibians, river otters, pond turtles, and other species for which surface water is an essential habitat component. These are summarized by watershed, as described below.

Creating the Maps

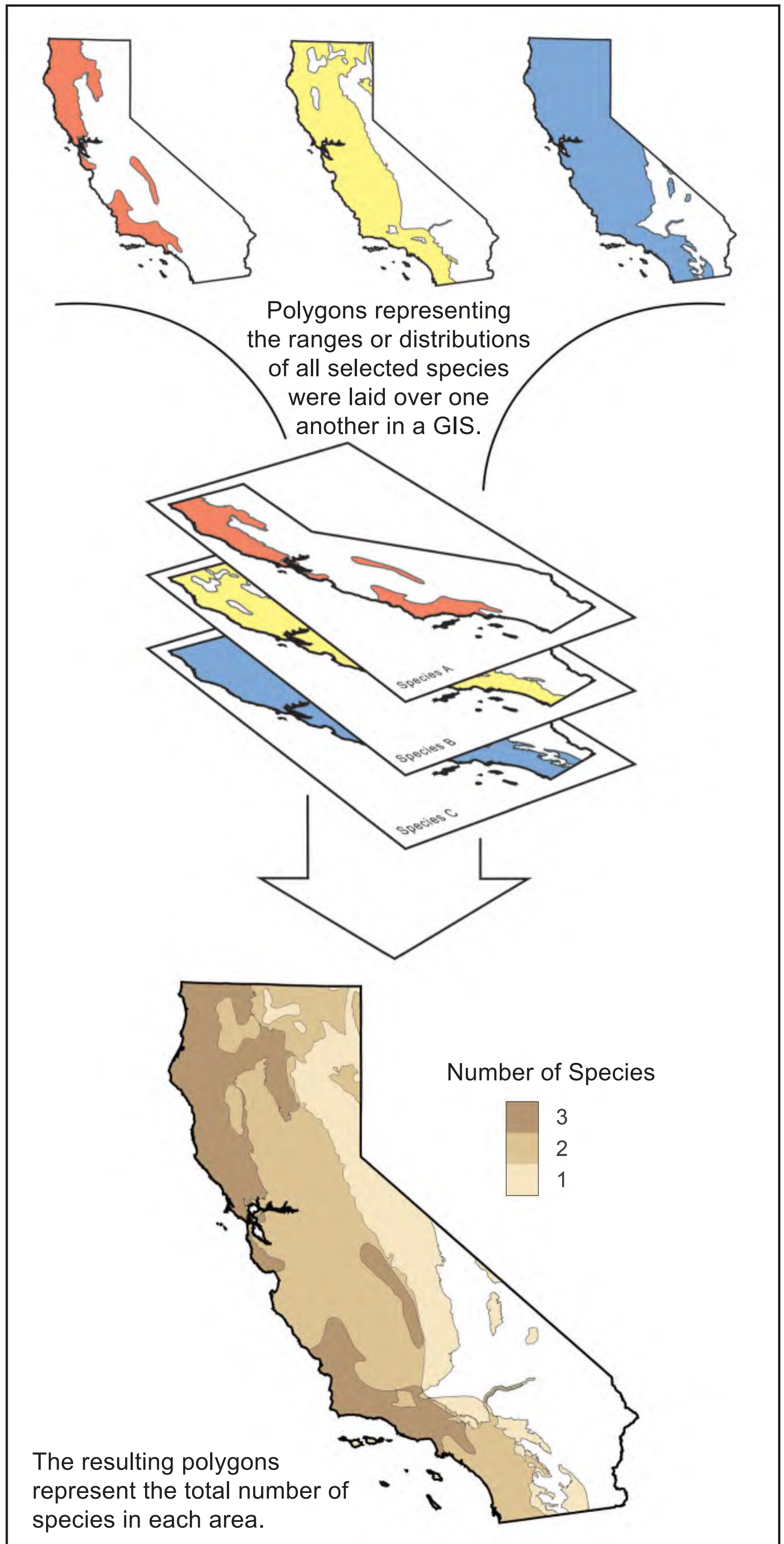
All of the maps in this atlas were created using a geographic information system (GIS). A GIS is a digital system for recording, creating, and analyzing spatial information about the world. A GIS is an excellent tool for representing the complexity of the real world because it can easily combine multiple layers of information in various ways to conduct analyses and create maps.

ACE-derived Maps

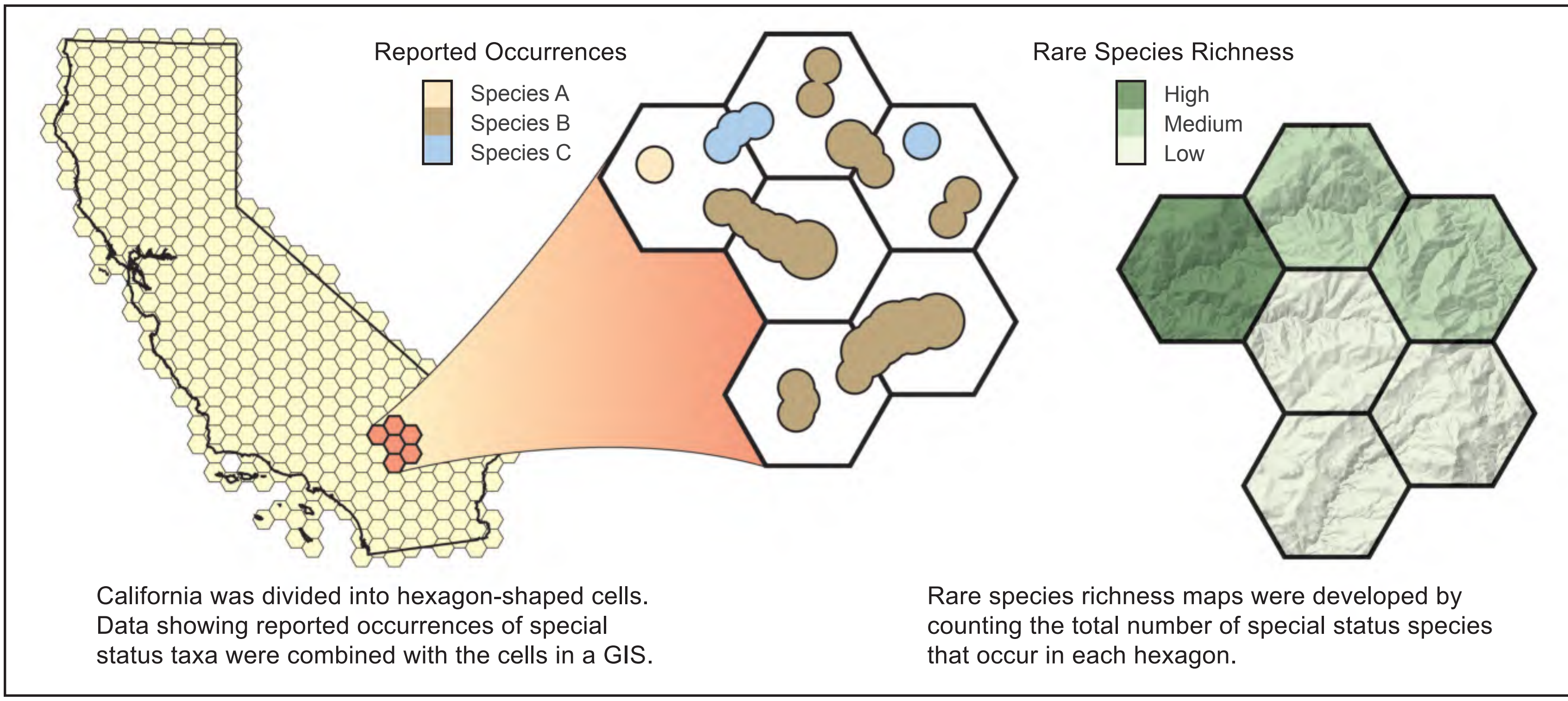
All of the ACE-derived maps represent patterns of biodiversity across the state, analyzed either by hexagon or watershed. Terrestrial ACE data are analyzed in a regular grid of 2.5-square-mile hexagons that is drawn over the entire state. Aquatic data are summarized to watersheds at the HUC12 level, rather than hexagons. Unlike the regular terrestrial hexagon grid, watersheds are defined by contours in the landscape, forming natural bowls which catch and direct water to low areas in the topography, forming ponds or streams. Because they are defined by landscape form, watersheds are variable in size and shape. The watersheds shown in these maps average 40 square miles in size but may exceed 400 square miles.

The ACE maps summarize data on species and habitats within each hexagon or watershed. For example, terrestrial ACE richness maps superimpose CWHR predictive habitat maps over the ACE hexagon grid and summarize them to reflect the total number of species that potentially occurs there (see the figure at right). Similarly, rare species occurrence information is summarized by hexagon to generate the rare species richness maps, as shown in the figure on the opposite page. Irreplaceability maps are also based on occurrence data, but they use a rarity-weighted index. Each species or subspecies is assigned a value that is inversely proportional to the number of cells in which it is found. The weighted values are then summed for each cell.

Except where noted, the legend categories were created by looking for natural breaks in the distribution of hexagon scores. On several maps, however, the data is displayed using quantiles, where each legend category contains an equal number of units. Richness and rarity maps in the "Measures of Biodiversity" section include data for native taxa only. The native richness maps for all animals are presented at the species level, except maps of climate vulnerable taxa, which include subspecies. Rarity richness maps consider taxa at both full and subspecies levels. Some maps include



How Species Richness Maps Were Created

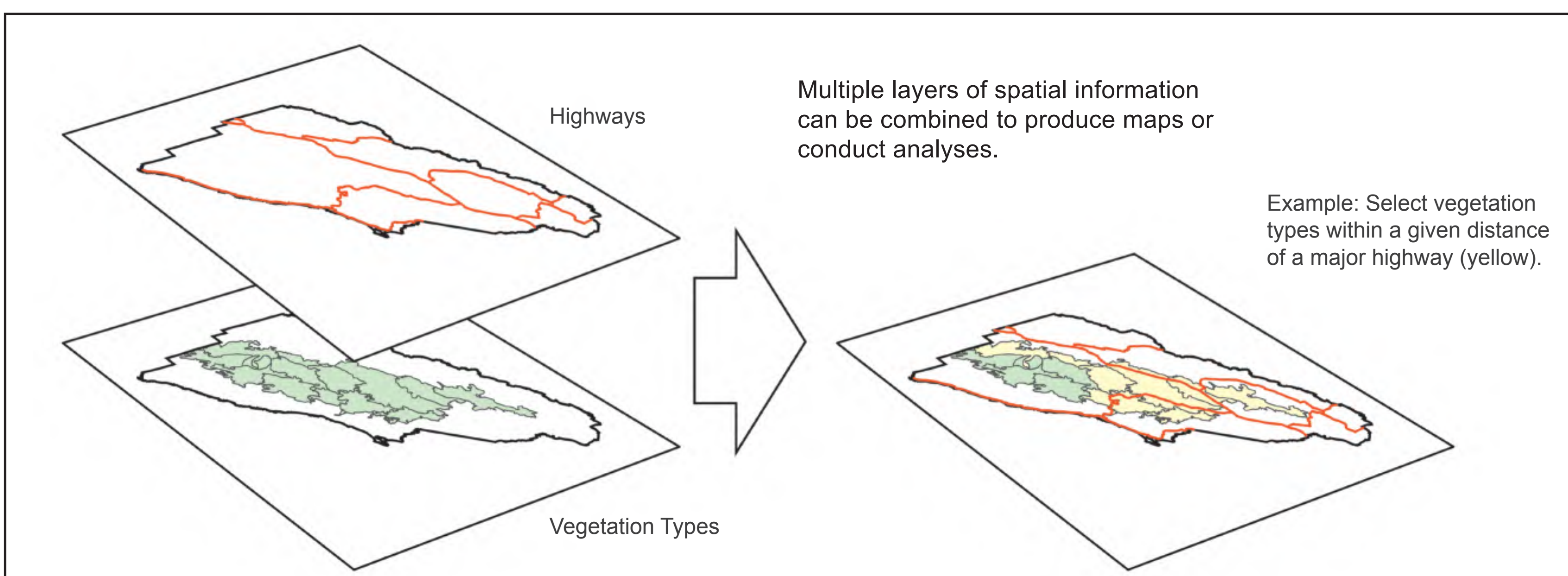


How Rare Species Richness Maps Were Created

ecoregional boundaries as defined by U.S. Department of Agriculture (USDA) sections (USFS 2010). Note that the Central Valley, which includes both the Sacramento and San Joaquin valleys, is called the Great Valley Ecoregion on these maps.

Other Maps

The remainder of the maps in the atlas were created by overlaying data from one or more sources onto a single map. The figure below shows how highways and vegetation types can be displayed on the same map. The resulting map shows where the vegetation types and highways are in relation to each other, and can be used to assess which vegetation types are within a given distance of a highway. Overlaying data layers allows the visualization of the spatial distribution and relationships among multiple sources of information.



Creating Maps by Overlaying Layers

About the Maps

Map Symbols

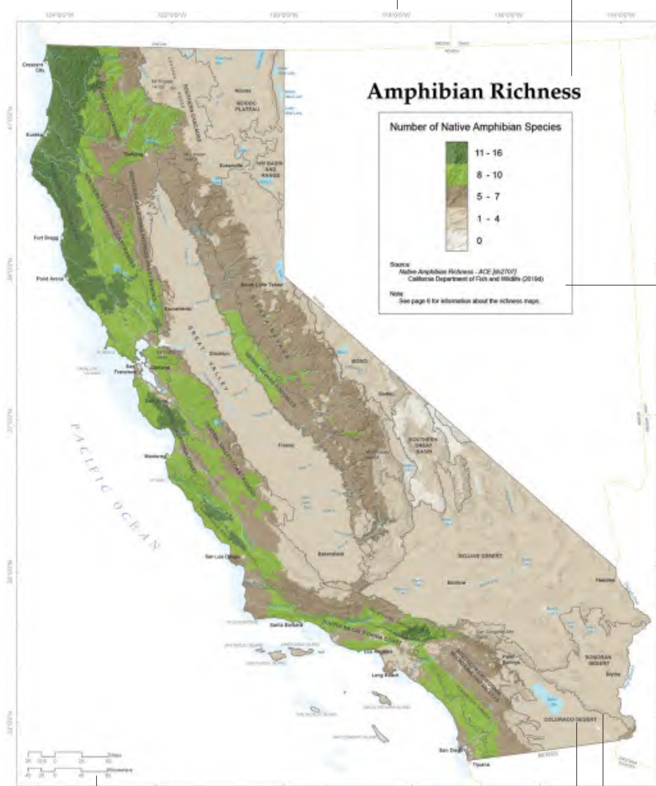
These map symbols appear on most of the maps in this atlas. Unique symbolism is explained in the legend for each map.

- OREGON / CALIFORNIA — State Boundary
- Regional Boundary
- Ridgecrest — City or Town
- Lake
- Rogers L. (dry) — Seasonal or Dry Lake
- Buena Vista Lake Bed — Historical Lakebed
- Bathymetry
- Merced R. — River or Stream
- FARALLON ISLANDS — Small Islands
- Cordell Bank — Marine Feature
- Mt Lassen 10457 — Mountain Peak

Notes on reading the maps

Longitude tic marks on top and bottom neatlines count from east to west.

Legend describes the information specific to each map.



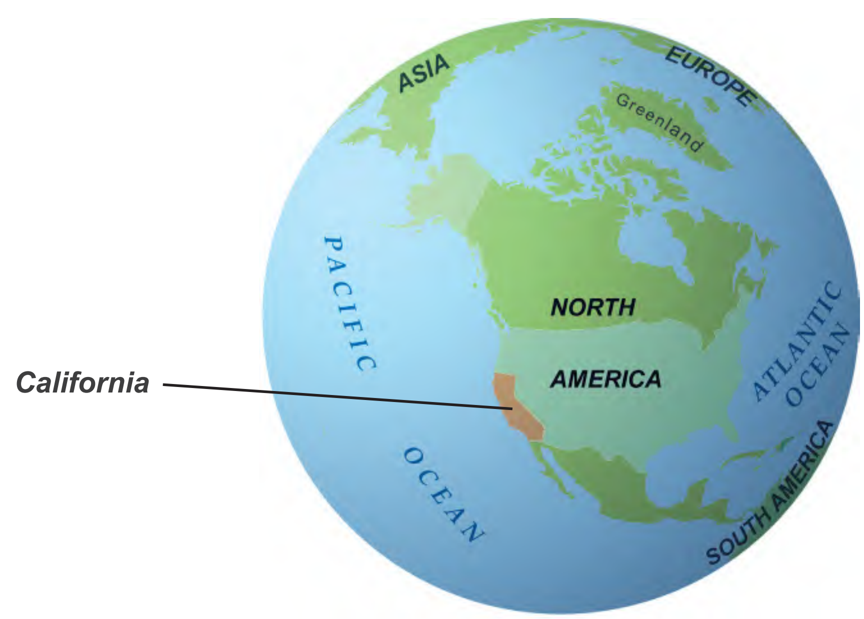
Sources listed here are unique to this map.

Latitude tic marks on left and right neatlines count from south to north.

Scale bar shows both miles and kilometers.

Regional names and boundaries help to orient the reader.

Where in the world is California?



Base Map Data Sources

Each atlas map includes "base map" reference layers that show geographic context without distracting from a map's subject matter. Here are base map data sources common to many of the maps:

<u>United States Geological Survey</u>

- State Boundaries
- Cities, Place Names
- Hydrography (lakes, rivers, coastline)
- Digital Elevation Model (hillshade, shaded relief)

<u>National Oceanic and Atmospheric Administration</u>

- Bathymetry
- Marine Place Names

<u>Esri</u>

- State and International Boundaries
- U.S. Highways (TomTom North America, Inc.)

<u>California State Lands Commission</u>

- Coastline and Islands

<u>United States Forest Service</u>

- Ecological Subregions for the State of California

Map Projection

Most of the maps use a map projection called "California Albers," which was developed in the early 1990s by the GIS staff at the Stephen P. Teale Data Center (State of California). This projection was selected because it does a relatively good job of depicting California on a flat surface. The parameters of this projection are listed below.

Projection Name: California Albers

Type: Albers Equal Area Conic

Datum: North American Datum 1983 (NAD 83)

Spheroid: Geodetic Reference System 1980 (GRS 80)

Parameters:

Units:	Meters
False Northing:	-4000000 meters
Central Meridian:	-120 00 00 (longitude)
Standard Parallels:	34 00 00 (latitude)
	40 30 00 (latitude)
Latitude of Origin:	00 00 00 (Equator)

Notes on Species Names

Names of vascular plants are from The Jepson Flora Project (Jepson 2020a). Names of amphibians and reptiles are generally those adopted by the Center for North American Herpetology and the Society for the Study of Amphibians and Reptiles Names Database (Crother 2017). Names of birds are those published by the California Bird Records Committee and the American Ornithologists' Union Committee on Classification and Nomenclature (Chessar et al. 2019). Mammal names are from the *Revised Checklist of North American Mammals North of Mexico* (Bradley et al. 2014) except where more recent taxonomic changes have been published. Names of fishes are generally those published by the American Fisheries Society's *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* (Nelson et al. 2004) or *Inland Fishes of California* (Moyle 2002). For terrestrial and marine invertebrate animals, we adopted the names used by NatureServe, whose references by taxonomic group are listed at www.natureserve.org. The standard reference for marine algae used here is *Marine Algae of California* (Abbott and Hollenberg 1976). We have adopted the scientific convention for capitalization of the official common names according to the current standard for each taxon group. For example, for plants and mammals only proper names are capitalized, while all names of fish, amphibians, reptiles, and birds are capitalized.

Photographs

Photographs are credited with the photographers' names and, if appropriate, their organizations. Photographs without credits were obtained from open source websites.

A Remarkable Geography

To explain California's biodiversity, we must first look at its geography, the basic physical systems that shape California. California is roughly 164,000 square miles in size with 840 miles of coastline. The size and interplay of active physical systems within California has resulted in a landscape of extremely varied geography: the highest and lowest elevations of the contiguous United States are both found in California. We can explain much about the biodiversity of the state by looking at its topography, geology, soils, climate, bathymetry, and ocean currents.

Climate and Topography

California is one of the few places where five major climate types occur in close proximity. Here, the Desert, Cool Interior, Highland, and Steppe climates border a region of Mediterranean climate (see the map on page 15). Perhaps the only other place like California is central Chile, where this convergence is made even more extreme by the dramatic Andean topography.

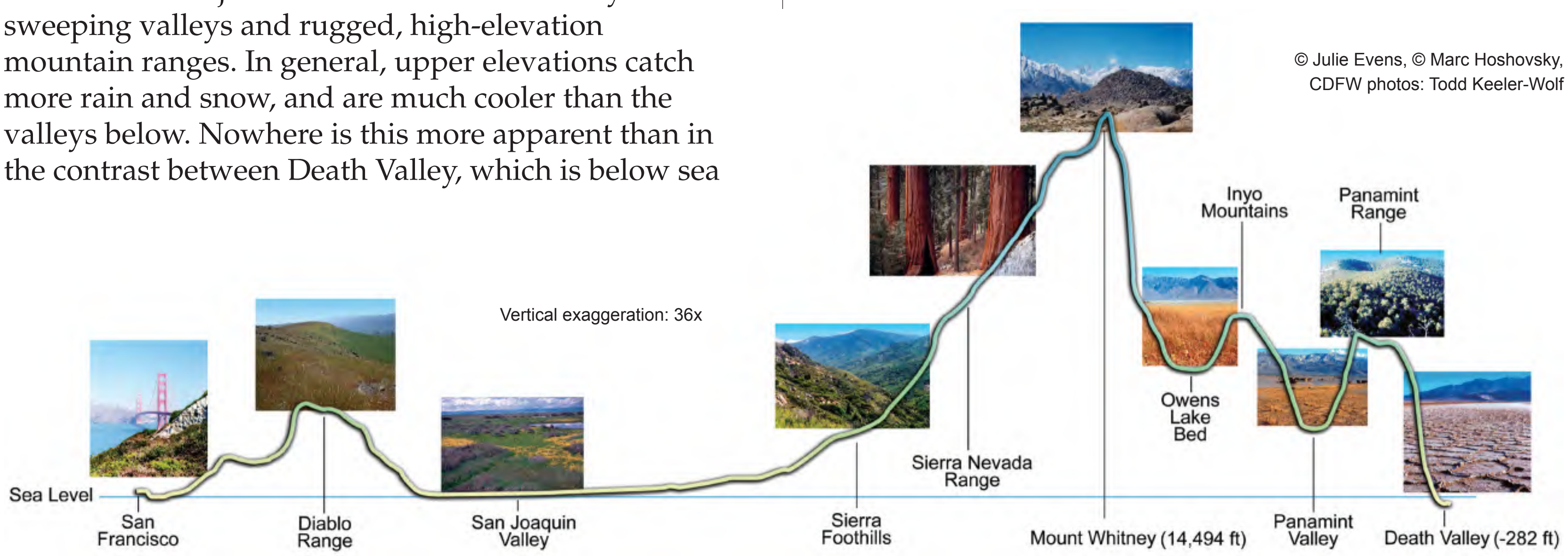
As climates go, the Mediterranean climate is rare. Outside of the Mediterranean Sea region, it is limited to five locations: two in Australia, one in South Africa, one in Chile, and one in California.

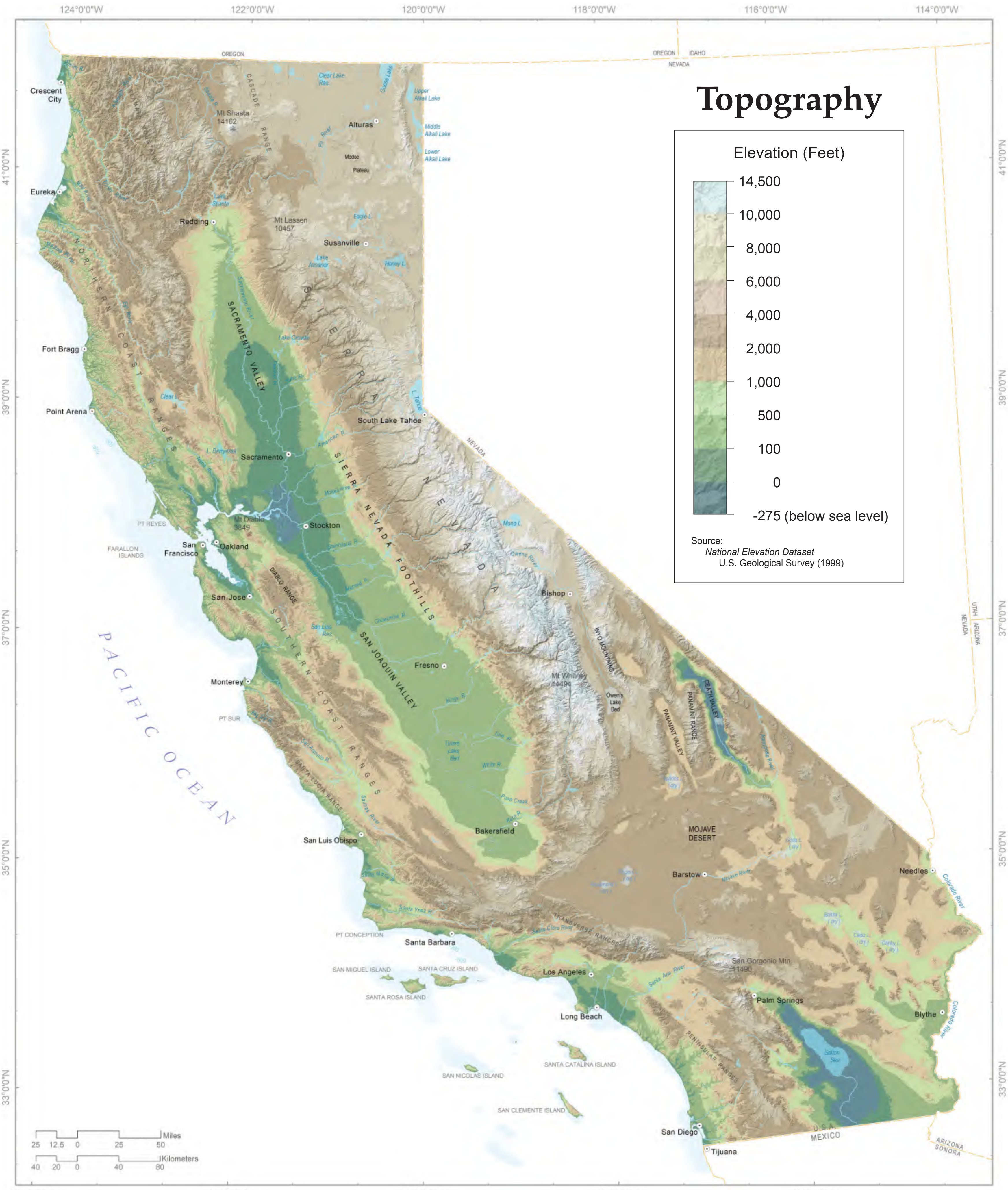
In California, the Mediterranean climate has two main variations. One is the temperate climate found along the coast and the western slope of the Sierra Nevada. Summer fog is frequent along the immediate coast due to the influence of the Pacific Ocean. The second variation is an interior valley version with hotter summers and cooler winters. With both types, most of the precipitation falls in winter—not summer—which is unusual for much of the world, where the opposite is true.

The mild temperatures and winter rain of the Mediterranean climate support some of the highest species richness in the state. Interestingly, however, California's Desert climates rival the Mediterranean for plant and animal species richness. For California's deserts, topography comes into play along with climate. The Mojave Desert is characterized by sweeping valleys and rugged, high-elevation mountain ranges. In general, upper elevations catch more rain and snow, and are much cooler than the valleys below. Nowhere is this more apparent than in the contrast between Death Valley, which is below sea level, and the Panamint Range, with peaks as high as 10,000 feet above sea level. In Death Valley, plants and animals may bake in 115 degree summer heat while 12 miles away and 2 miles up, cool breezes blow through the dark green needles of bristlecone pine (*Pinus longaeva*) and the delicate leaves of mountain maple (*Acer glabrum*). California's Steppe climate of the San Joaquin Valley is hot like a desert but averages enough moisture to support grasslands and other vegetation not commonly found in the desert.

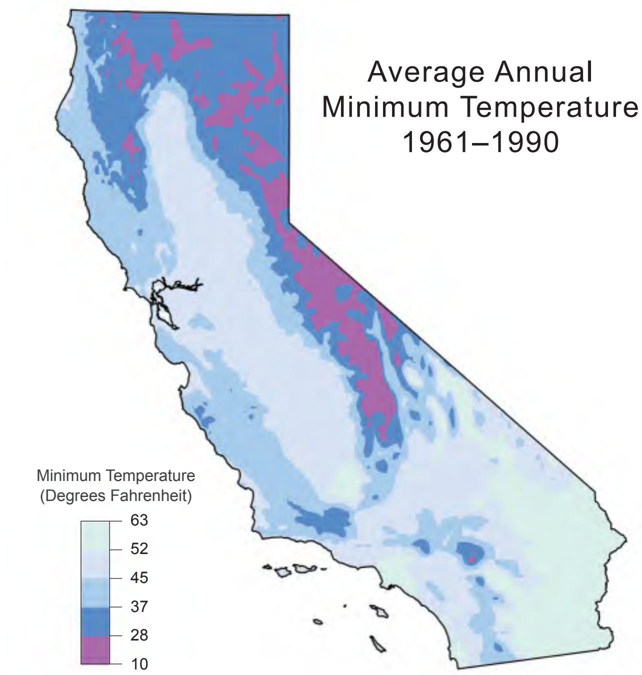
California's higher elevations, such as those found on the Modoc Plateau and in the Sierra Nevada, generally have two major climate types: a Cool Interior climate and a Highland climate. In these areas, the conditions that determine most other climates (latitude, prevailing winds, and temperature) are strongly modified by elevation, slope, and aspect. Aspect, or the direction a slope faces, is very important. South-facing slopes catch the sun's rays and heat, making them warmer and drier, while shaded north-facing slopes are cooler and wetter. West-facing slopes tend to catch more precipitation from storms moving inland from the Pacific Ocean. The result is vegetation diversity—even on a single mountain. For example, a ridge may have oaks and open grass areas on one side and a dense canopy of fir or pine trees on the other.

Plants and animals have evolved to thrive in the varied conditions created by the interplay of climate and topography in California.

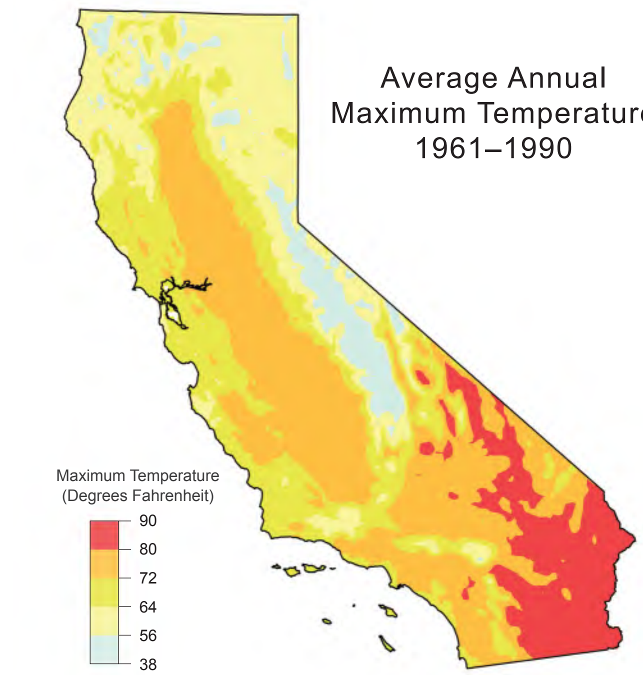



Topography
Elevation (Feet)
14,500
10,000
8,000
6,000
4,000
2,000
1,000
500
100
0
-275 (below sea level)
Source:
National Elevation Dataset
U.S. Geological Survey (1999)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
SONORA
U.S.A.
MEXICO
PACIFIC OCEAN
Crescent City
Mt Shasta 14162
Alturas
Eureka
Redding
Mt Lassen 10457
Susanville
Fort Bragg
SACRAMENTO VALLEY
SIERRA NEVADA
Point Arena
South Lake Tahoe
Sacramento
SIERRA NEVADA FOOTHILLS
PT REYES
Mt Diablo 3849
Stockton
FARALLON ISLANDS
San Francisco
Oakland
DIABLO RANGE
San Jose
Bishop
SAN JOAQUIN VALLEY
Fresno
Monterey
INYO MOUNTAINS
Mt Whitney 14496
Owen's Lake Bed
DEATH VALLEY
PANAMINT RANGE
PANAMINT VALLEY
PT SUR
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
SANTA LUCIA RANGE
San Luis Obispo
Bakersfield
MOJAVE DESERT
Barstow
Needles
Colorado River
PT CONCEPTION
Santa Barbara
TRANSVERSE RANGES
San Gorgonio Mtn 11490
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
Los Angeles
Palm Springs
Long Beach
Blythe
PENINSULAR RANGES
Salton Sea
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
San Diego
Tijuana
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

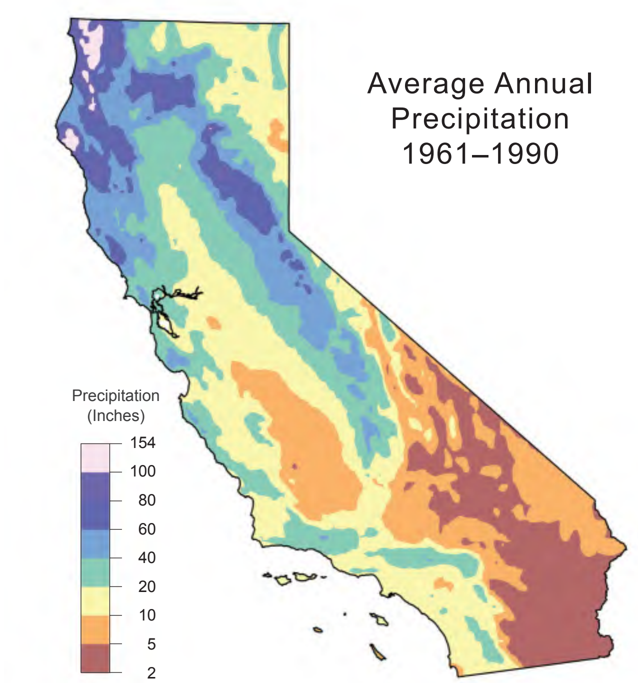
The combination of temperature and precipitation strongly influences the distribution of species across the state. Some species have evolved physical traits or behaviors that allow them to survive the climatic extremes they encounter. For example, desert-adapted mammals may deal with high temperature by having larger ears to cool their bodies or by spending most of their day underground. These adaptations can lead to speciation and contribute to the incredible biodiversity in California.



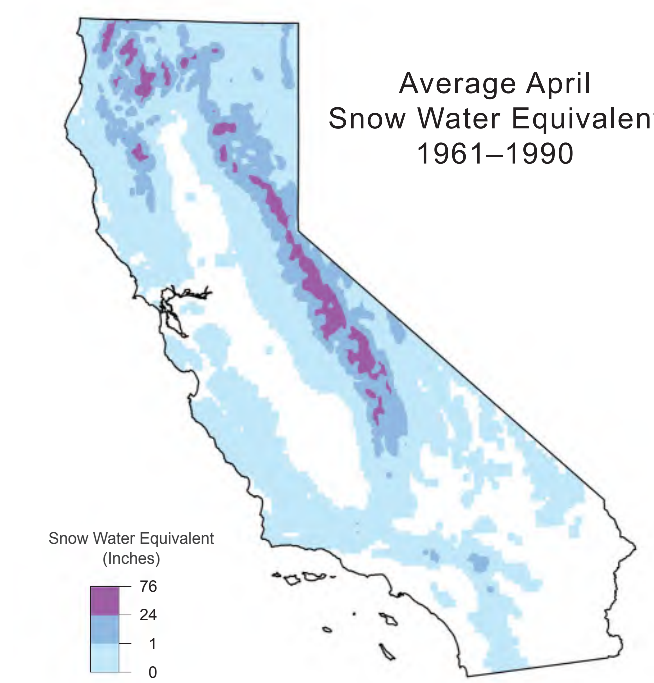
Source:
Annual Average Minimum Temperature, Historical Baseline (1961–1990)
Pierce et al. (2018)



Source:
Annual Average Maximum Temperature, Historical Baseline (1961–1990)
Pierce et al. (2018)



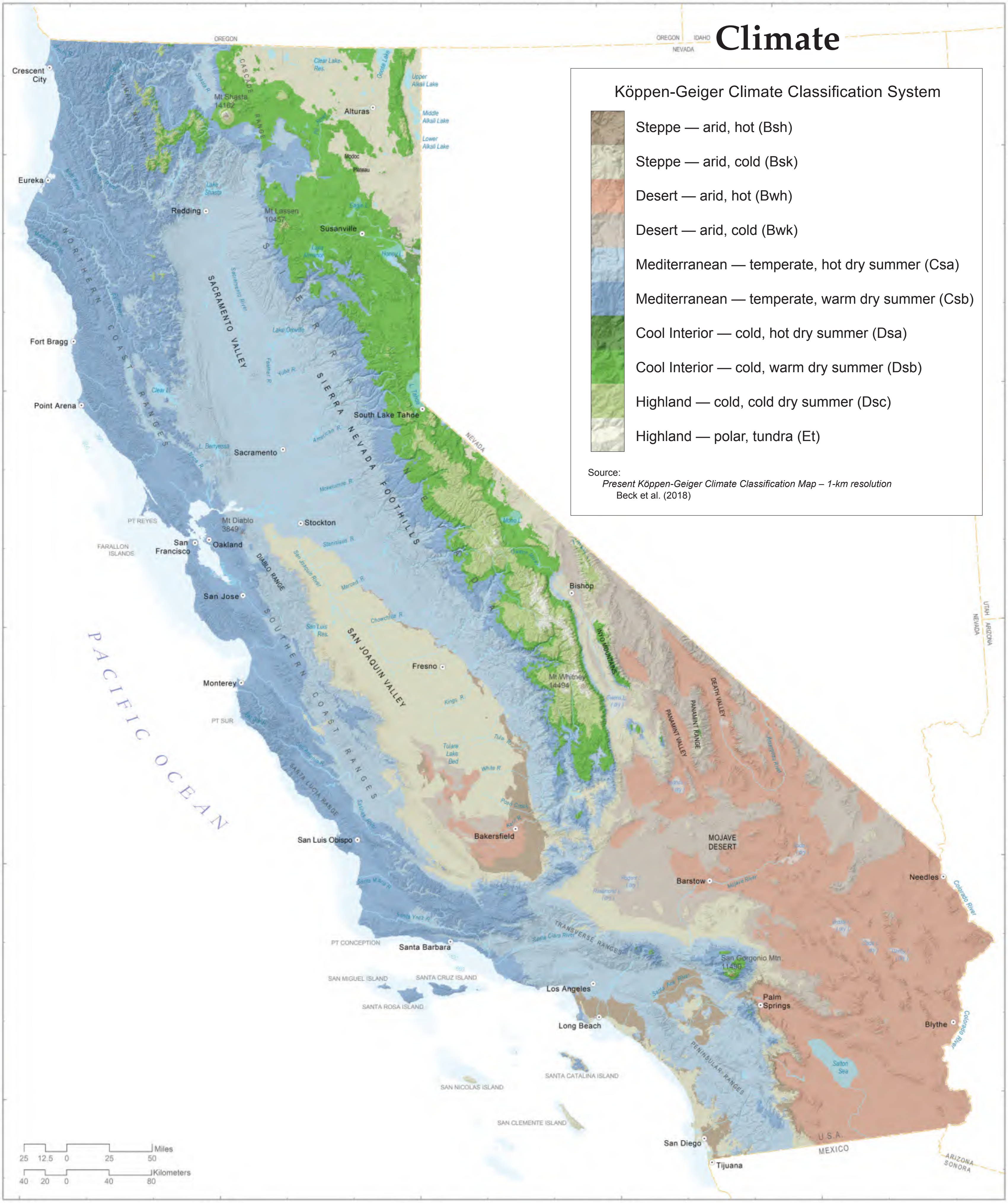
Source:
Annual Average Precipitation, Historical Baseline (1961–1990)
Pierce et al. (2018)



Source:
April Average Snow Water Equivalent, Historical Baseline (1961–1990)
Cal-Adapt (2020a)

Precipitation that accumulates in snowpacks during the winter provides much of the state's water in late spring and summer when it is hotter and drier. The Sierra Nevada snowpack alone is the source of more than one third of California's water supply. Snow water equivalent is the measurement of how much water would be released if the snowpack melted.

Climate


Köppen-Geiger Climate Classification System
Steppe — arid, hot (Bsh)
Steppe — arid, cold (Bsk)
Desert — arid, hot (Bwh)
Desert — arid, cold (Bwk)
Mediterranean — temperate, hot dry summer (Csa)
Mediterranean — temperate, warm dry summer (Csb)
Cool Interior — cold, hot dry summer (Dsa)
Cool Interior — cold, warm dry summer (Dsb)
Highland — cold, cold dry summer (Dsc)
Highland — polar, tundra (Et)
Source:
Present Köppen-Geiger Climate Classification Map – 1-km resolution
Beck et al. (2018)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
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MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
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Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
Sacramento
South Lake Tahoe
Stockton
San Francisco
Oakland
Mt Diablo 3849
San Jose
Monterey
Fresno
Bishop
Mt Whitney 14494
San Luis Obispo
Bakersfield
Santa Barbara
Los Angeles
Long Beach
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Palm Springs
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San Gorgonio Mtn 11490
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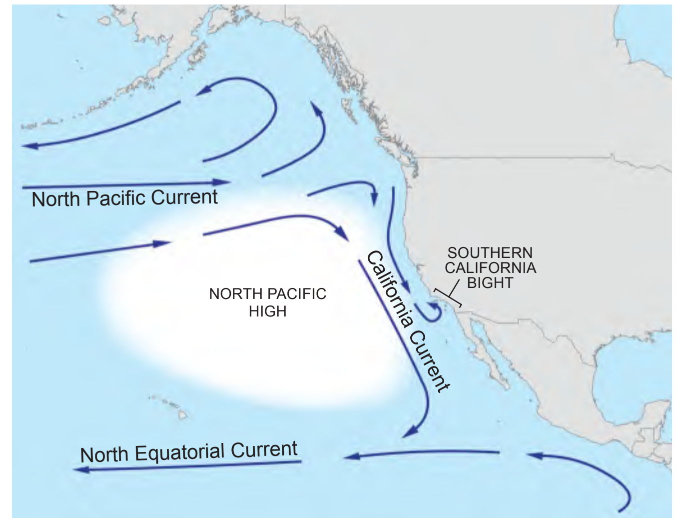
SAN JOAQUIN VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
DIABLO RANGE
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
CASCADE RANGE
INYO MOUNTAINS
DEATH VALLEY
PANAMINT RANGE
PANAMINT VALLEY
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Colorado River
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Sea Currents and Temperatures



Northeastern Pacific Currents and High Pressure System
CDFW Graphic: Annie Chang

The California Current System is located off the U.S. West Coast. A key component of this system, the California Current, brings cool waters south from British Columbia, Canada to the Baja California Peninsula, Mexico. Off Southern California, part of the California Current branches off and curls northeast to become the Southern California Eddy.

Conditions within the California Current System are highly dynamic due to various oceanic responses to large-scale atmospheric drivers, such as winds associated with atmospheric pressure systems, and to local perturbations, such as storms. One useful indicator of these changing ocean conditions is sea surface temperature (SST) as captured from satellite imagery. To highlight changes, anomalies between annual SST values and long-term average temperatures are determined and mapped.

The North Pacific High, a large atmospheric high-pressure system, occurs west of the North American continent. It moves northward in the summer and southward in the winter. It is strongest in the summer and its southward-blowing winds drive the surface waters of the California Current away from the coast. The surface waters are replaced by deeper, colder, nutrient-rich waters in a process called upwelling. These nutrients support high productivity, from abundant phytoplankton to great numbers of fish, marine mammals, and sea birds.

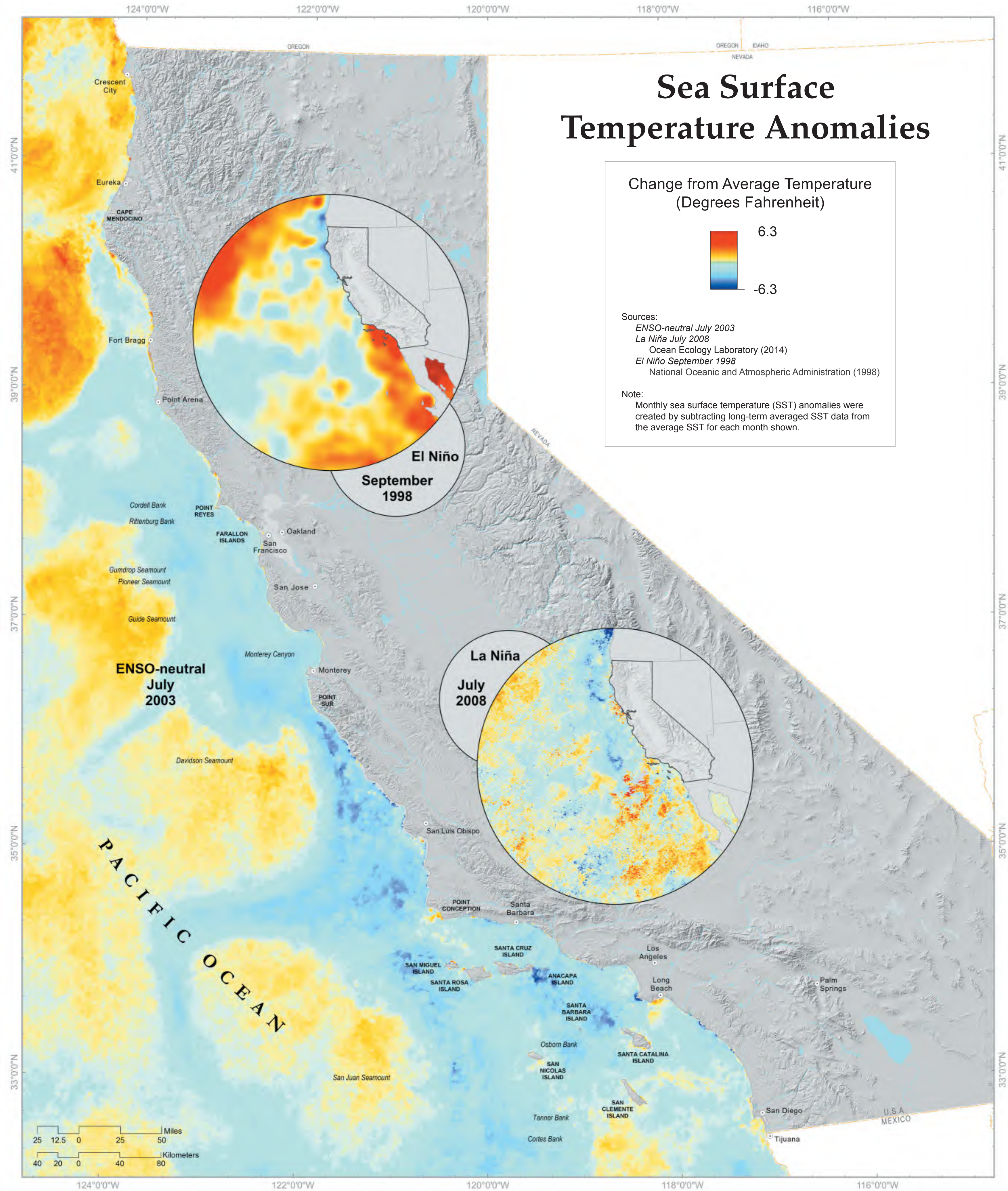
The timing and intensity of upwelling varies along the coast. North of Cape Mendocino, upwelling-favorable winds primarily occur in the summer, while between Cape Mendocino and Point Conception they occur from spring through early fall. Upwelling-favorable winds can be present throughout the year in Southern California, but the region is shadowed from the stronger winds so upwelling is weak. Throughout California, local perturbations such as storms and other changes in the weather can lead to relaxation of favorable winds, reducing upwelling, or even reversal of winds, resulting in local downwelling.

One large-scale atmospheric-oceanic pattern that affects ocean conditions is the El Niño Southern Oscillation (ENSO). The map shows the SST anomalies for July 2003 during an ENSO-neutral state. In this state, the trade winds blow westward across the equatorial Pacific from high pressure in the east to low pressure in the west. When this pressure gradient decreases, the trade winds relax and, through various ocean processes, waters in the eastern equatorial Pacific warm. Along the California coast, upwelling-favorable winds are reduced with the associated weakening of the North Pacific High. Productivity drops as available nutrients decline. These are the conditions observed during an El Niño. Over a period of months, warm waters from the south typically move north into the Southern California Bight and, in the case of very strong El Niños, may move into the Central California region (see El Niño inset). El Niños occur every three to eight years and last from 12 to 18 months, after which conditions may return to an ENSO-neutral state or move into a La Niña.

During a La Niña, the opposite happens (see La Niña inset); the trade winds strengthen and waters in the eastern equatorial Pacific cool. The North Pacific High also strengthens, resulting in enhanced upwelling and, at times, increased productivity along the California coast.

Point Conception is a biogeographical boundary between the colder waters off Central California and the warmer waters to the south. The transition zone between these two regions is an area of high diversity. During El Niños, species from more subtropical waters may move into Southern California waters while some species from Southern California may move north along the California coast. Recruitment for species that favor warm waters also may increase. During La Niñas, opposite trends in movement and recruitment may occur.

Sea Surface Temperature Anomalies

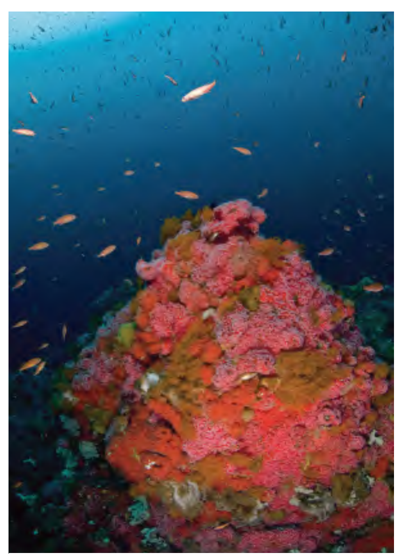


Bathymetry

Gorgonians, also called sea fans, are attached to rocky reefs off Santa Catalina Island. CDFW photo: Dianna Porzio

As mountains and valleys define the diverse topography of California, seamounts, banks, submarine canyons, and a narrow continental shelf define its coastal bathymetry. Bathymetry is the measure and study of water depth. This bathymetry map illustrates many fascinating ocean features in remarkable detail.

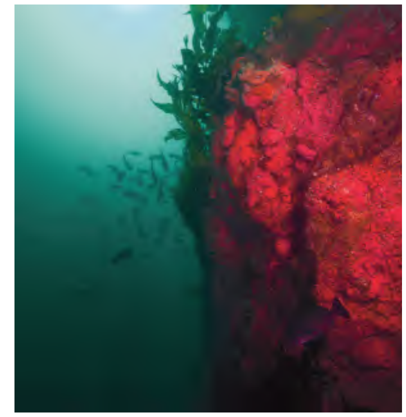
Seamounts are underwater geologic formations abruptly rising from the seafloor and are typically formed by volcanic activity. They are made of hard, rocky material, provide structure for various forms of marine life to grow on, and are considered biologically diverse hot spots. In Central California, the Davidson Seamount occupies an area 8 miles wide by 26 miles long and rises over 6,500 feet tall, yet its peak remains over 4,000 feet below the sea surface.



Abundant assemblage of invertebrates at Cranes Point in Cordell Bank
Photo: Joe Hoyt, NOAA CBNMS

In contrast to seamounts, banks form where the seafloor has been elevated above the continental shelf due to the movement of tectonic plates. Banks are biologically diverse because they provide solid structure among the soft sediments that characterize the continental shelf. Cold, nutrient-rich water flows up their steep slopes, creating conditions that are ideal for benthic organisms, including sponges and corals. Cordell Bank is located 22 miles offshore Point Reyes. It occupies an area 4 miles wide by 7 miles long, is 400 feet tall, and its peak is 115 feet below the ocean surface.

Submarine canyons are deep valleys relative to their immediate surroundings. They can form due to underwater landslides and intense currents, starting as underwater gullies and scarps, then subsequently deepening into canyons. Evidence of this canyon erosion is seen perpendicular to the shoreline up and down the California coast. Prominent examples exist below Cape Mendocino and along the Big Sur Coast (just below Point Sur). The state's largest and most dramatic example is the Monterey Submarine Canyon.

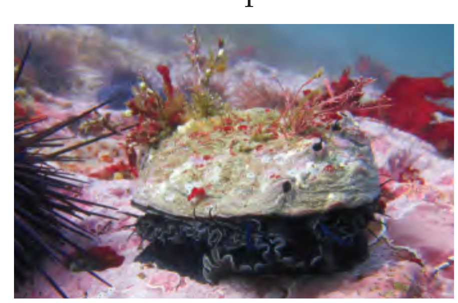


Dali's Wall offshore Pebble Beach characterizes the geologic formations found in the Monterey Area.
Photo: Chad King, NOAA MBNMS

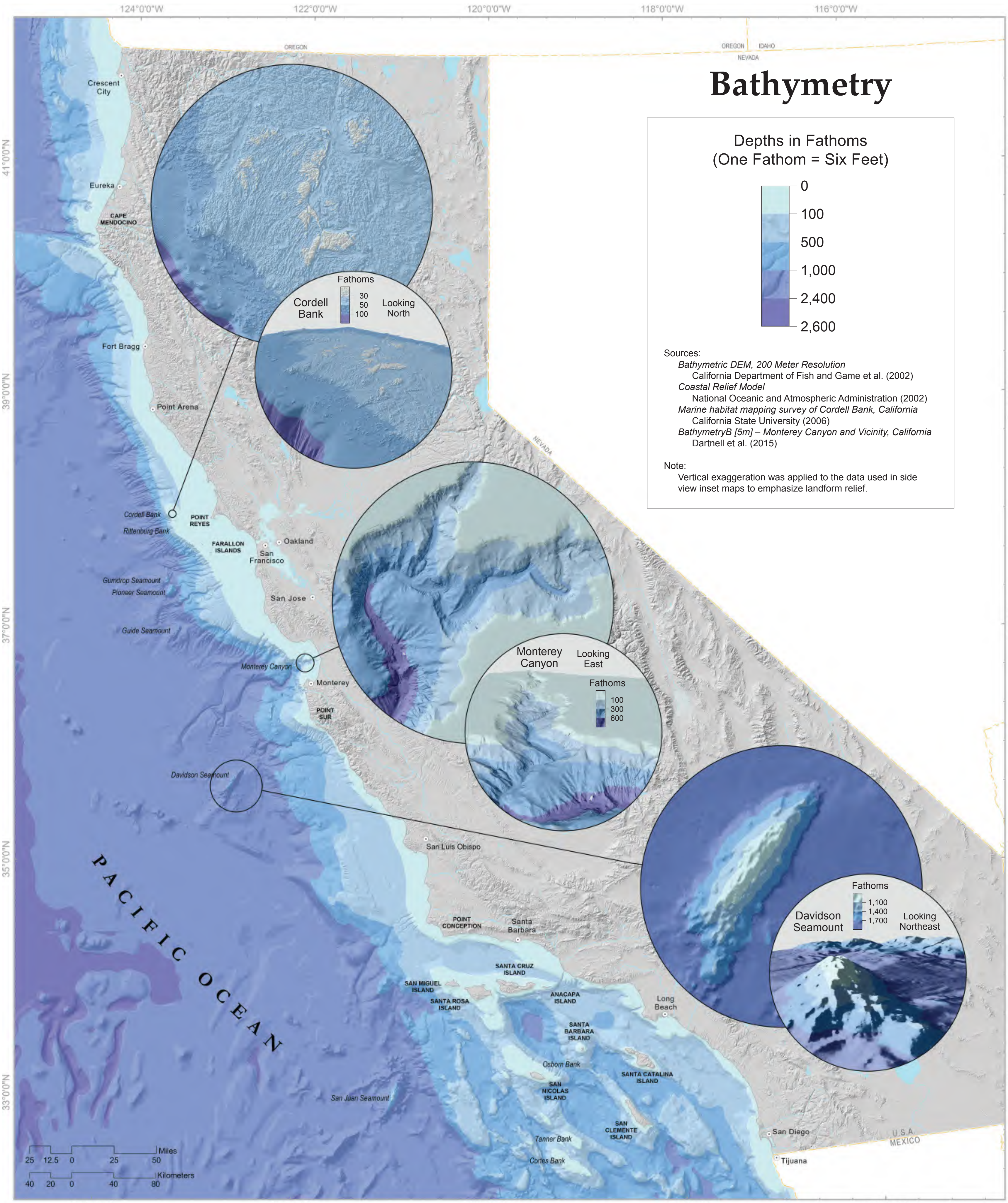
Beginning immediately at the shoreline of Moss Landing, it meanders over 100 miles out to sea to a maximum depth over 13,200 feet; this size rivals that of the Grand Canyon. Monterey Bay's distinctive symmetrical mapping profile is the result of this canyon's erosion over time.

The seafloor can also be categorized in terms of its composition, or habitat type. Rocky reefs, boulders, gravel, soft and coarse sediments, silts, clay, and mud are some of the diverse habitats found on California's geologically complex seafloor. In estuaries such as Humboldt Bay (near Eureka), the seabed composition is dominated by soft muds, sands, silts, and clays, and this environment is a nursery to a variety of marine life. In coastal environments around Big Sur, the seabed composition is a mix of coarse and fine sands, rocky reefs, and boulders. These environments are host to iconic marine life including kelp, rockfish, urchins, otters, and abalone.

Bathymetry plays an important role in ocean current dynamics because the structure of the seafloor and its interaction with offshore winds dictate the directional paths of currents. These currents provide necessary nutrient-rich waters to organisms and can create biodiversity hot spots, as seen on seamounts and banks. Bathymetry also impacts various abiotic conditions (temperature, acidity, oxygen concentration) that drive species composition offshore California. Understanding the ocean bathymetry of California is important for understanding biological processes and marine ecosystems.



California's iconic Red Abalone (*Haliotis rufescens*) is typically associated with hard surface and kelp.
CDFW photo: Athena Maguire



Bathymetry
Depths in Fathoms
(One Fathom = Six Feet)
0
100
500
1,000
2,400
2,600
Sources:
Bathymetric DEM, 200 Meter Resolution
California Department of Fish and Game et al. (2002)
Coastal Relief Model
National Oceanic and Atmospheric Administration (2002)
Marine habitat mapping survey of Cordell Bank, California
California State University (2006)
BathymetryB [5m] – Monterey Canyon and Vicinity, California
Dartnell et al. (2015)
Note:
Vertical exaggeration was applied to the data used in side view inset maps to emphasize landform relief.
Cordell Bank
Fathoms
30
50
100
Looking North
Monterey Canyon
Looking East
Fathoms
100
300
600
Davidson Seamount
Fathoms
1,100
1,400
1,700
Looking Northeast
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
U.S.A.
MEXICO
Crescent City
Eureka
CAPE MENDOCINO
Fort Bragg
Point Arena
Cordell Bank
Rittenburg Bank
POINT REYES
FARALLON ISLANDS
Oakland
San Francisco
San Jose
Gumdrop Seamount
Pioneer Seamount
Guide Seamount
Monterey Canyon
Monterey
POINT SUR
Davidson Seamount
San Luis Obispo
PACIFIC OCEAN
POINT CONCEPTION
Santa Barbara
SANTA CRUZ ISLAND
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
ANACAPA ISLAND
SANTA BARBARA ISLAND
Long Beach
Osborn Bank
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
San Juan Seamount
SAN CLEMENTE ISLAND
Tanner Bank
Cortes Bank
San Diego
Tijuana
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Geology and Soils

At Wilder Ranch State Park near Santa Cruz, marine terraces formed by wave-cut platforms and sea cliffs represent ancient shorelines that have been uplifted due to relatively slow-moving tectonic activity over time. In the background, another, even older terrace is visible along the horizon. These terraces may vanish over time as sea level rises, unless they are thrust upward by a powerful earthquake. For more information see *Wilder Ranch State Park* (CGS 2015b). Photo: Mike Fuller, California Geological Survey

The broad range of California's elevations and landscape features is a result of an active continental margin where tectonic plates shift the earth's crust. For over a billion years, tectonic processes have layered and altered geologic terrains to shape the present landscapes. Compressional, extensional, and translational faults create the mountains, valleys, and displaced features seen throughout California today.

Movement along faults not only displaces rock units across California over time but also provides planes of weakness in the ground that can act as conduits for root systems and can redirect or impede groundwater flow. This has occurred in the Colorado Desert at the Thousand Palms Oasis, where palm trees grow along a fault line that traps groundwater near the surface. In Northern California, coastal soils form on marine terraces that have been uplifted due to faulting, such as those at Wilder Ranch State Park. The result is referred to as an "ecological staircase," where each step up in elevation reflects longer periods of weathering and soil development. These soils are nutrient-poor, highly acidic, and offer low levels of oxygen, which may result in stunted vegetation called pygmy forests (Schulz et al. 2018).

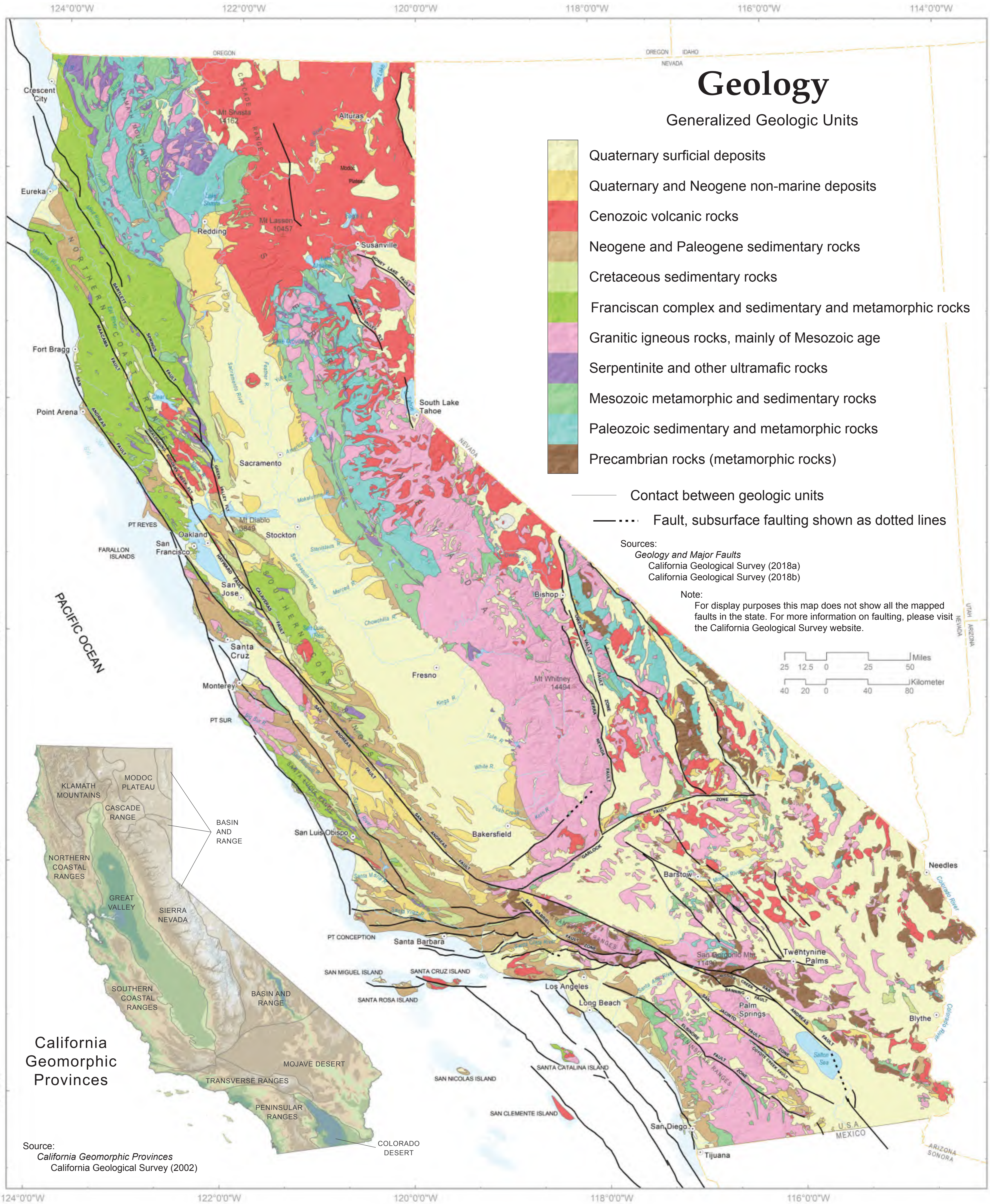
The Thousand Palms Oasis in the Coachella Valley Preserve is located within the San Andreas fault zone. The linear alignment of vegetation that extends beyond the Thousand Palms Canyon Road indicates the surface trace of the fault. Groundwater is redirected to the surface, providing palm trees with an adequate water supply. Photo: National Agriculture Imagery Program (2018), U.S. Department of Agriculture

Rocks are described and mapped based on mineralogy and the way in which the they are formed; they are broadly classified as igneous, metamorphic, and sedimentary. Igneous rocks are formed by rapid cooling of lava flows or pyroclastic explosions and ash falls, or by slower cooling of underground magma. Sedimentary rocks are developed by weathering and erosion of existing rocks and soil, forming deposits such as limestone, shale, sandstone, and conglomerate. When sedimentary or igneous rocks are subjected to high temperatures, pressures, and chemical reactions, they alter to become what are called metamorphic rocks, as found in the Franciscan Complex. The distribution of rock types across California is shown on the geologic map on the right.

Young surficial sediments that have not lithified (solidified into rocks) are mapped as Quaternary deposits. These include alluvium, desert sands, coastal estuary deposits, and beach deposits. As rocks and surficial sediment weather and erode, they break down to form soils with mineral characteristics derived from their parent material. Soils that remain on the landscape for thousands of years develop distinct layers called soil horizons.

California's diverse terrain can be grouped into 12 geomorphic provinces based on landforms and geologic history, as shown in the map inset (CGS 2002). The physical characteristics of each province influence the regional climate which in turn affects the soil development process. These intertwined factors are responsible for the wide variety of habitats that support species throughout California (CGS 2015a, CGS 2020). For example, the Sierra Nevada Province is home to 50 percent of the plant species and 60 percent of the animal species in the state (CWWR 1996).

(continued)


Geology
Generalized Geologic Units
Quaternary surficial deposits
Quaternary and Neogene non-marine deposits
Cenozoic volcanic rocks
Neogene and Paleogene sedimentary rocks
Cretaceous sedimentary rocks
Franciscan complex and sedimentary and metamorphic rocks
Granitic igneous rocks, mainly of Mesozoic age
Serpentinite and other ultramafic rocks
Mesozoic metamorphic and sedimentary rocks
Paleozoic sedimentary and metamorphic rocks
Precambrian rocks (metamorphic rocks)
Contact between geologic units
Fault, subsurface faulting shown as dotted lines
Sources:
Geology and Major Faults
California Geological Survey (2018a)
California Geological Survey (2018b)
Note:
For display purposes this map does not show all the mapped faults in the state. For more information on faulting, please visit the California Geological Survey website.
25 12.5 0 25 50 Miles
40 20 0 40 80 Kilometer
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
U.S.A.
MEXICO
ARIZONA SONORA
PACIFIC OCEAN
Crescent City
Eureka
Fort Bragg
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Redding
Alturas
Susanville
Mt Shasta 14162
Mt Lassen 10457
South Lake Tahoe
Sacramento
Stockton
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PT REYES
FARALLON ISLANDS
San Francisco
Oakland
San Jose
Santa Cruz
Monterey
PT SUR
Fresno
Bishop
Mt Whitney 14494
Bakersfield
San Luis Obispo
Barstow
Needles
PT CONCEPTION
Santa Barbara
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
Los Angeles
Long Beach
San Gorgonio Mtn
Twentynine Palms
Palm Springs
Blythe
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
San Diego
Tijuana
KLAMATH MOUNTAINS
MODOC PLATEAU
CASCADE RANGE
BASIN AND RANGE
NORTHERN COASTAL RANGES
GREAT VALLEY
SIERRA NEVADA
SOUTHERN COASTAL RANGES
BASIN AND RANGE
MOJAVE DESERT
TRANSVERSE RANGES
PENINSULAR RANGES
COLORADO DESERT
California Geomorphic Provinces
Source:
California Geomorphic Provinces
California Geological Survey (2002)

Geology and Soils

(Continued from page 20)

Habitats and ecosystems rely on soil to support diverse plants and wildlife. Studies show that soil age, parent material, and soil horizon characteristics affect the sizes, distributions, and physiological responses of plants. Chemical and mechanical weathering of parent material determines the nutrients available in the soil and gives distinct characteristics to the soil horizons (Birkeland 1999). For example, granitic rocks erode to form sandy soils, while fine-grained sedimentary shale deposits erode to form clay-rich soils. Grain size contributes to the ability of water to move through the soil to underlying layers; fine-grained soils retain water, and coarse-grained soils drain rapidly. With time and landscape stability, soil development processes lead toward finer-grained soils with more distinct soil horizons.

An active wind-blown sand sheet encroaches upon the creosote bush at left, Chuckwalla Valley, Mojave Desert.
Photo: Jeremy Lancaster, California Geological Survey

Deserts are dominated by active alluvial surfaces and dunes with geologically young, well-drained sands having little to no soil horizons. Within the Mojave and Colorado deserts, soil age affects the size and density of creosote bush (*Larrea tridentata*). Younger, well-drained sands allow deep roots and robust growth in *Larrea*, whereas older soils limit root growth and size. Lizards, tortoises, and kangaroo rats often seek refuge beneath this shrub and it is a dominant food source for desert woodrats (Marshall 1995).

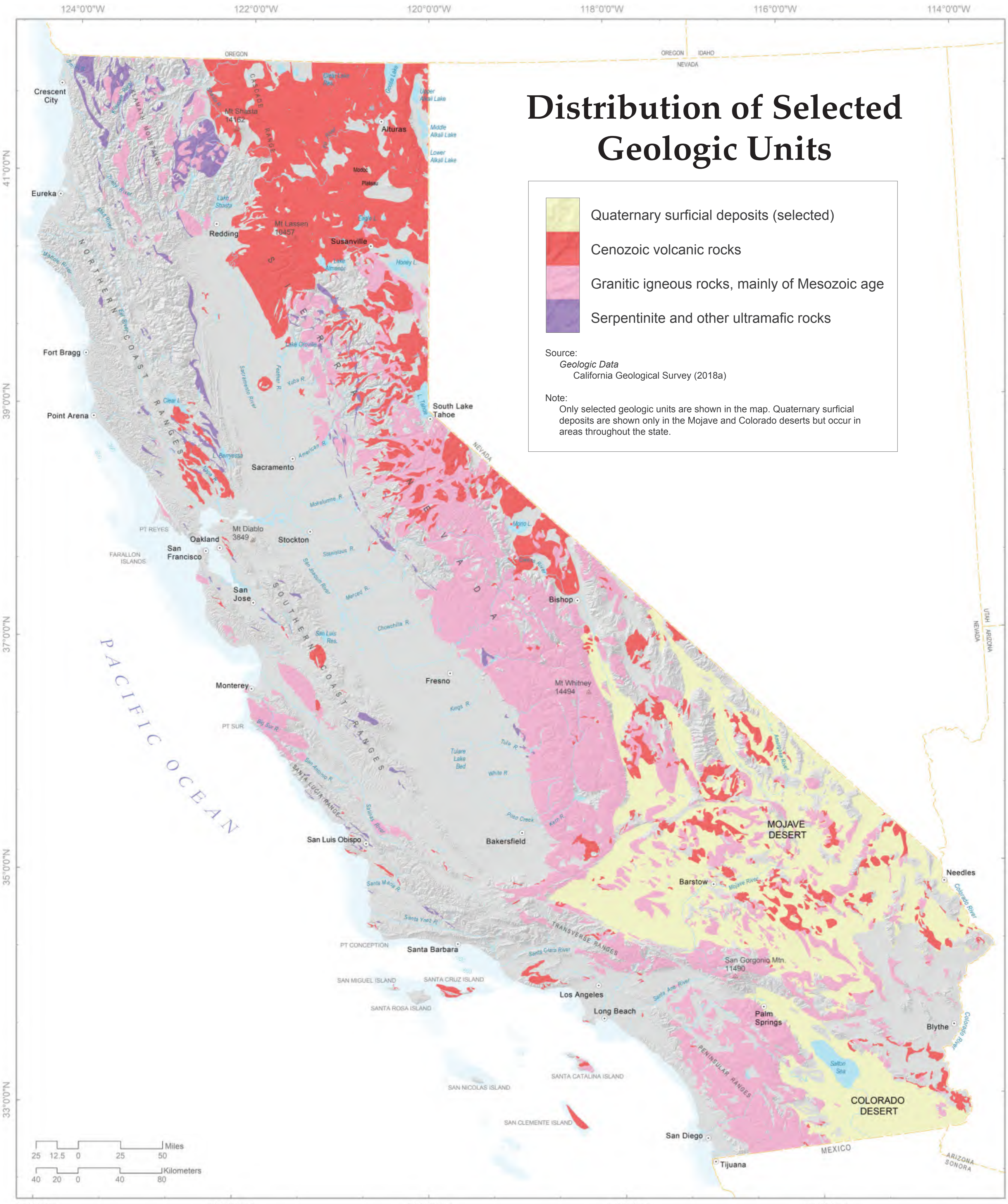
Ultramafic rocks weather into "serpentine" soils that are rich in asbestos, magnesium, nickel, chromium, and other heavy metals but low in nitrogen. This chemical composition can alter cell membranes and reduce root growth, resulting in stunted plants as observed in Jeffrey pine trees (*Pinus jeffreyi*) in the Klamath Mountains. Some adaptive plants thrive in the nitrogen-poor soils, however. The rare carnivorous California pitcher plant (*Darlingtonia californica*), found in serpentine wetlands, catches and decomposes insects to obtain its nitrogen (USFS 2020).

Darlingtonia californica has adapted to serpentine soils by trapping and decomposing insects to obtain nutrients.
Photo: Barry Rice

Where igneous deposits are resistant to erosion, rocky landscapes with little soil are common. In Northern California the whitebark pine (*Pinus albicaulis*) flourishes in coarse granite, basalt, and glacial deposits (Tilley et al. 2011). The giant sequoia (*Sequoiadendron giganteum*) requires moistures and temperatures occurring within 4,600- to 7,100-foot elevations on the western slope of the Sierra Nevada, where coarse soils are derived from granitic and glacial parent material (Weatherspoon 1990, Habeck 1992).

The map on the opposite page shows the locations of serpentine, volcanic, and igneous geologic units that represent the parent materials for serpentine and granitic soils discussed above. The desert soils can be seen on the map as Quaternary surficial deposits in the Mojave and Colorado deserts.

Sequoiadendron giganteum are the largest trees in the world.
Photo: National Park Service


Distribution of Selected Geologic Units
Quaternary surficial deposits (selected)
Cenozoic volcanic rocks
Granitic igneous rocks, mainly of Mesozoic age
Serpentinite and other ultramafic rocks
Source:
Geologic Data
California Geological Survey (2018a)
Note:
Only selected geologic units are shown in the map. Quaternary surficial deposits are shown only in the Mojave and Colorado deserts but occur in areas throughout the state.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
Crescent City
Eureka
Redding
Alturas
Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Oakland
San Francisco
Mt Diablo 3849
Stockton
San Jose
Bishop
Monterey
Fresno
Mt Whitney 14494
PACIFIC OCEAN
San Luis Obispo
Bakersfield
MOJAVE DESERT
Barstow
Needles
Santa Barbara
San Gorgonio Mtn. 11490
Los Angeles
Long Beach
Palm Springs
Blythe
COLORADO DESERT
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
SIERRA NEVADA
TRANSVERSE RANGES
PENINSULAR RANGES
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Geography and Vegetation

The relationship between California's geography and its wealth of biodiversity is reflected in its vegetation. Vegetation may be defined as a patchwork of plant species arrayed across the landscape. It includes a variety of life forms such as trees, shrubs, grasses, forbs, and mosses. These life forms are distributed in different combinations and patterns in response to variations in the physical environment, such as climate and geology.

Tall conical spires of Santa Lucia fir (*Abies bracteata*) rise above the rounded crowns of canyon live oak (*Quercus chrysolepis*) on the precipitous misty slopes of Cone Peak in Monterey County. These fir woodlands are completely restricted to the steeper, fire-protected slopes of the Santa Lucia Mountains of California's Central Coast.
Photo © Todd Keeler-Wolf

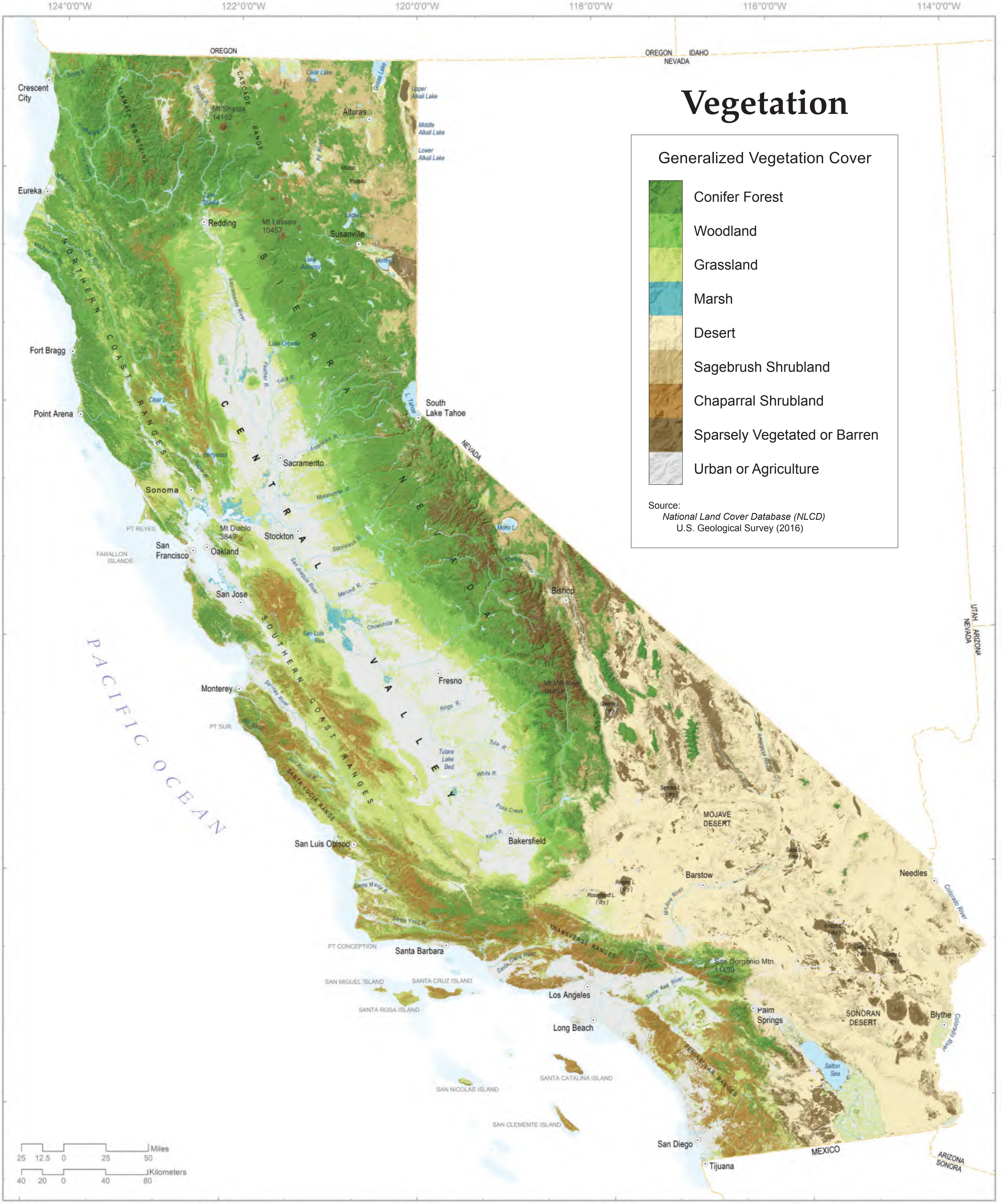
The broad patterns of vegetation in California relate most clearly to the combination of temperature and moisture, which is, in turn, strongly influenced by the state's varied topography (see "Climate and Topography"). These patterns are clearly shown in the map on the facing page. The most extreme climates—the coldest alpine heights of the Sierra Nevada and the driest desert sand dunes—are sparsely vegetated. The cooler and wetter climates, including the North Coast and the mountain ranges, are forested with coniferous trees. The hotter and drier Mojave and Sonoran deserts are covered with desert scrub characterized by small-leaved shrubs and cacti. Areas of intermediate temperature and moisture are carpeted with woodlands, grasslands, chaparral, and coastal scrub. These are found in the Coast Ranges and foothills of the Sierra Nevada, in the valleys and on the edges of the Central Valley, and along the Southern Coast.

A stand of The Cedars manzanita (*Arctostaphylos bakeri* ssp. *sublaevis*), a rare vegetation type forming only on steep serpentine soils at The Cedars, Sonoma County
Photo © Todd Keeler-Wolf

Other important factors that influence vegetation, such as soil fertility and depth, are determined by topography and geology. Within a general area climatically suitable for woodlands, we may see chaparral on shallower, steeper, and rockier soils; grasslands on deeper and less steep clay-rich soils; and woodlands on intermediate soils of gentle and moderate slope. The substrate on which vegetation grows may affect the species composition. For example, vegetation on soils derived from serpentine, our state rock, may often be chaparral, but it will be less dense and composed of very different species than adjacent chaparral on soils derived from non-serpentine rock. These fine-scale patterns are difficult to see on the statewide map at right. An example of a detailed vegetation map is provided in the Mojave Desert chapter.

California's unusual summer-dry Mediterranean climate is another important geographic factor, producing many types of vegetation that are unique to the state. These include drought-deciduous shrublands, where the plants are green in the winter but leafless during the hot dry summer months, and vernal pools, full of showy annual flowers in the spring but completely dried up in the summer.

Coast redwood (*Sequoia sempervirens*) forest, North Coast
Photo © Marc Hoshovsky

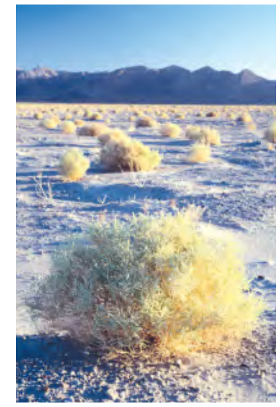

Vegetation
Generalized Vegetation Cover
Conifer Forest
Woodland
Grassland
Marsh
Desert
Sagebrush Shrubland
Chaparral Shrubland
Sparsely Vegetated or Barren
Urban or Agriculture
Source:
National Land Cover Database (NLCD)
U.S. Geological Survey (2016)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
OREGON
IDAHO
NEVADA
NEVADA
UTAH
ARIZONA
ARIZONA
SONORA
MEXICO
Crescent City
Eureka
Redding
Alturas
Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Sonoma
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Bishop
Fresno
Monterey
PT REYES
FARALLON ISLANDS
PT SUR
PACIFIC OCEAN
San Luis Obispo
Bakersfield
MOJAVE DESERT
Barstow
Needles
PT CONCEPTION
Santa Barbara
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
Los Angeles
Long Beach
San Gorgonio Mtn. 11490
Palm Springs
SONORAN DESERT
Blythe
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
San Diego
Tijuana
KLAMATH MOUNTAINS
CASCADE RANGE
NORTHERN COAST RANGES
SIERRA NEVADA
CENTRAL VALLEY
SOUTHERN COAST RANGES
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Measures of Biodiversity

Areas of high richness, rarity, and endemism are found in every region of California. Even within a taxonomic group, such as plants or mammals, one region may support the highest total richness of species because of its climate and resulting vegetation. Another may support the highest concentrations of special status taxa or endemics because of its rare local geology or its geographic isolation. Each region is unique in its contribution to the biodiversity of California.

Vegetation Types

Coast sagebrush (*Artemisia californica*) Alliance,
Garrapata State Park, Central Coast
CDFW photo: Todd Keeler-Wolf



Allscale (*Atriplex polycarpa*)
Alliance, Mojave Desert
CDFW photo: Todd Keeler-Wolf

The patterns across the land that all of us see—forests, woodlands, meadows, chaparral, and grasslands—are made of different vegetation types. They are defined by their dominant or characteristic plant species, which are strongly influenced by non-living components such as soil, geology, climate, or topography. Vegetation patterns thus reveal the direct impact of the physical environment on the biological diversity of the landscape.

Vegetation types vary widely across California's diverse climate zones, as one might expect. However, even very local variations in the landscape produce distinct variations in the vegetation. A north-facing slope that is in the shade much of the year is very different in terms of moisture, temperature, and wind exposure than an immediately adjacent south-facing slope (see Fremont Peak photo below).

The difference between the exposures on the south-facing (left) and north-facing (right) slopes on Fremont Peak in Monterey County enables a seasonal annual grassland to grow on the drier, warmer south slope while a forest of oaks grows on the shady north slope, where conditions are predictably cool and moist.
CDFW photo: Todd Keeler-Wolf

The Department's Vegetation Classification and Mapping Program (VegCAMP), along with many partners, is in the process of defining and mapping the vegetation throughout California. The map at right shows the number of vegetation types currently known in different areas of the state. High topographic and soil diversity in the Sierra Nevada, Coast, and Peninsular Ranges results in high vegetation type richness, as shown. Although we have not yet thoroughly sampled and mapped the entire state, we expect that the North Coast and Klamath Mountains will be among the most diverse areas for vegetation types, due to the complex geology and topography of these ranges. Because animal species are very often associated with specific vegetation types, these maps are useful tools for species conservation and management.

California boasts a wealth of vegetation types. The California Department of Fish and Wildlife currently lists over 2,000 distinct plant associations (CDFW 2019b). This is about 25 percent of the current number of plant associations in the entire United States National Vegetation Classification Hierarchy (USNVC 2018). Nearly 30 percent of the vegetation types found in California are found *only* in California. Ensuring the conservation of each of these types will help maintain California's unique biodiversity.

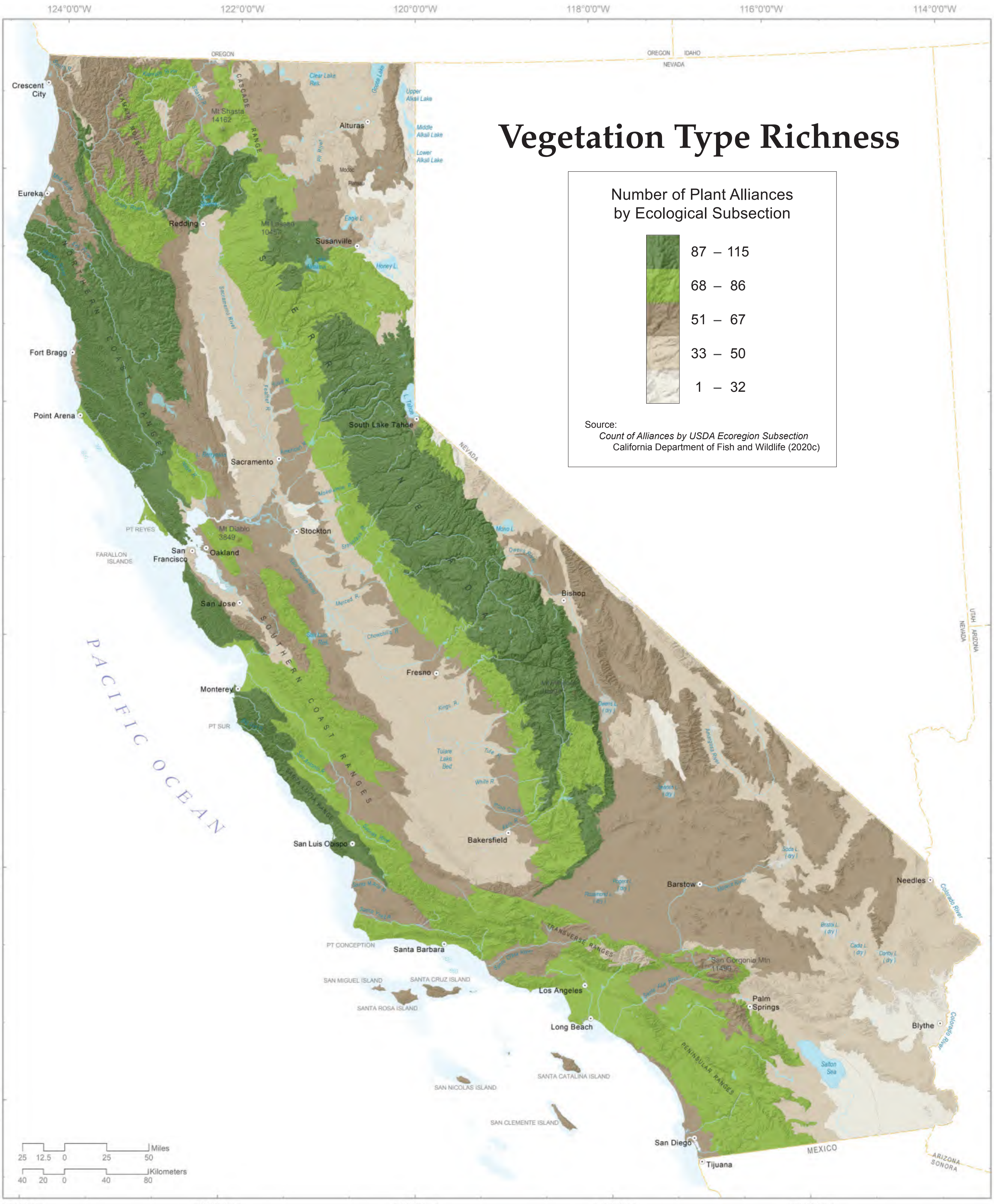
How Vegetation Types are Classified in California

Vegetation types can be organized hierarchically, using concepts such as forest, woodland, shrubland, and grassland at the coarser levels and specific types of forest, woodland, shrubland, and grassland—each defined by characteristic species of plants—at the finer levels.

Quantitative sampling enables the definition of these finer levels. A plant alliance is generally based upon the dominant plant species in the uppermost or dominant layer of vegetation. A plant association is defined by the most characteristic species associated with a plant alliance. Many plant associations may be nested within a single plant alliance just like many species may be nested within a single genus.

Each defined vegetation type is ratified by a national panel of ecologists in much the same way as a new species is named and validated. California's classification system for vegetation is maintained by VegCAMP and the California Native Plant Society's Vegetation Program. It is documented in the Manual of California Vegetation (CNPS 2020a) and conforms to the USNVC.

Vegetation Type Richness



Plants

California contains some of the highest plant diversity in the world. It leads the nation in numbers of native plants. The latest figures indicate California has over 6,500 native plant taxa, including species, subspecies, and varieties. This represents over 25 percent of the total number of plant taxa in the United States. In addition, California has a large number of endemics with over 2,300 endemic plant taxa; this represents over one third of its native flora (Jepson 2020b, NatureServe 2020b).

California lady's-slipper (*Cypripedium californicum*)
Photo © Kristi Lazar

Reasons for this plant diversity stem from California's unique combination of Mediterranean climate and topographic, geologic, and soils diversity. In addition, many taxa from the Tertiary Period, such as the giant sequoia (*Sequoiadendron giganteum*), have survived here due to our mild climate. Finally, outbursts of speciation have occurred over geologic time among some groups of plants (Raven and Axelrod 1978). This is perhaps most notable among California's annuals, which are responsible for some of our most beautiful wildflower displays.

Bristlecone pine (*Pinus longaeva*)
Photo © Kristi Lazar

The California plant richness map was created using georeferenced specimen collections from the Consortium of California Herbaria (Baldwin et al. 2017). This dataset includes collection locations for nearly every native plant species in California. These data were combined with models of climate data and landscape intactness to create an overall map of species richness (Kling et al. 2018). Climate models help provide a more complete picture of predicted species locations using ecological and geographic factors. Landscape intactness models account for the lower likelihood of plant species persisting in areas that have been developed or converted to agriculture.

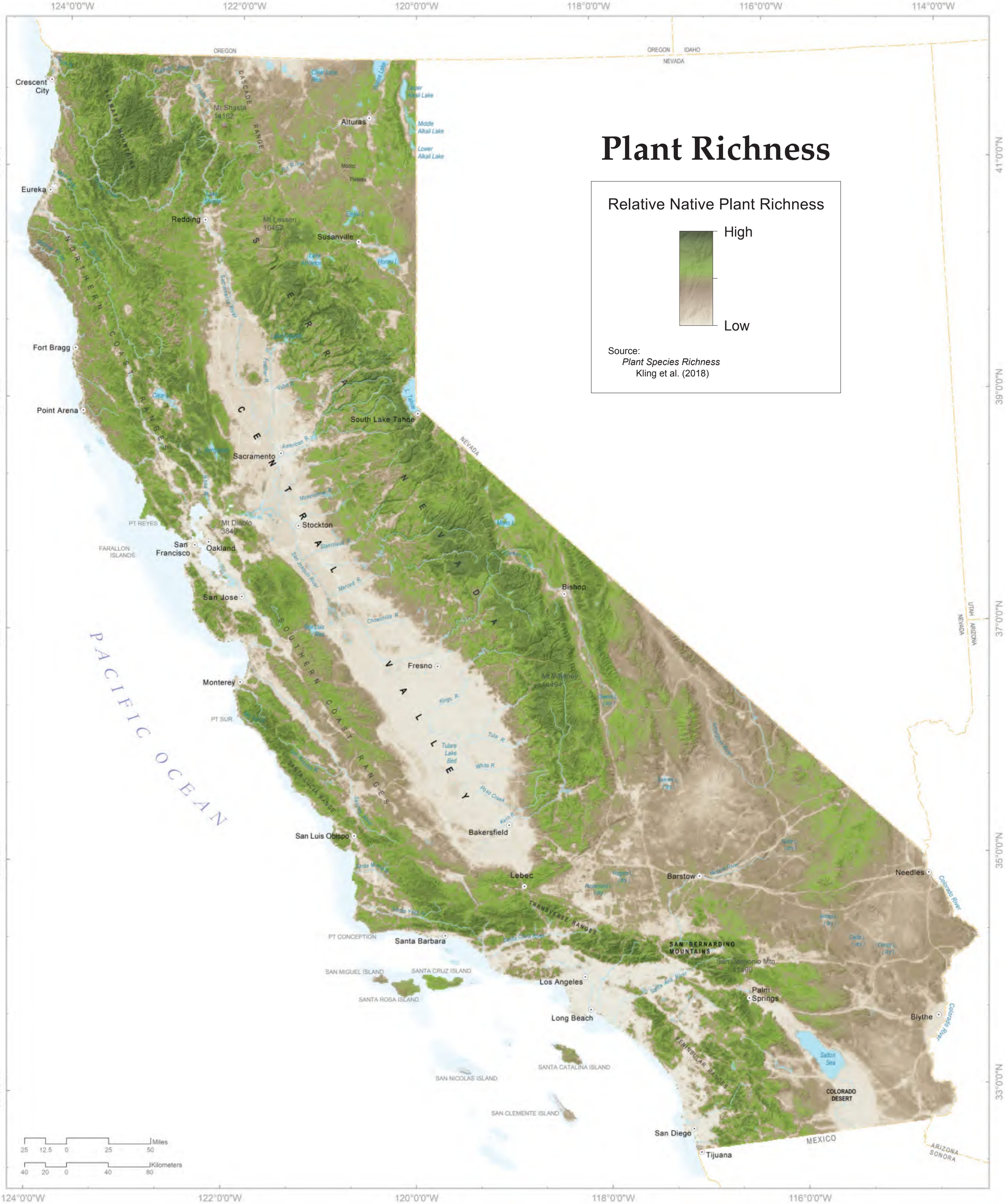
Wildflowers at Tejon Ranch, near Lebec
Photo © Kristi Lazar

This is especially important since over half of the specimens in this dataset were collected prior to 1980, with many of those specimens collected from areas that have subsequently experienced habitat alteration. While areas with high species richness tend to be those that have been mostly untouched by human activities, plant distribution and diversity are still strongly influenced by basic ecological factors.

Vegetation and plant species closely follow shifts in moisture and temperature as produced by topography and accompanying climate. The topographic and moisture gradients in the Sierra Nevada are the most extreme in the state, followed by those in the Klamath Mountains and in the San Bernardino Mountains. Thus, the map at right shows some of the richest plant diversity in the High Sierra Nevada and Klamath Mountains, as well as the Transverse Ranges of Southern California. Excluding urbanized areas, the regions that are lowest in plant richness are the relatively dry and hot Colorado Desert and Central Valley areas.

Engelmann's hedgehog cactus (*Echinocereus engelmannii*)
Photo © Kristi Lazar

Compare this map and the rare plant richness map that follows. Rare plant richness may more closely follow geologic variation than does overall plant richness, and thus the desert mountain ranges, San Bernardino Mountains, and several coastal areas are rare plant hotspots. Also, the high level of rarity in the San Francisco Bay area and along the south coast may reflect the greater level of habitat destruction in those areas than in the Sierra Nevada, where total plant richness is high but rare plant richness is relatively low.



Plant Richness
Relative Native Plant Richness
High
Low
Source:
Plant Species Richness
Kling et al. (2018)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
ARIZONA SONORA
Crescent City
Eureka
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Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Lebec
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
PACIFIC OCEAN
CASCADE RANGE
NORTHERN COAST RANGES
SIERRA NEVADA
CENTRAL VALLEY
SOUTHERN COAST RANGES
TRANSVERSE RANGES
SAN BERNARDINO MOUNTAINS
PENINSULAR RANGES
COLORADO DESERT
San Gorgonio Mtn
Salton Sea
Colorado River
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Special Status Plants

San Francisco lessingia (*Lessingia germanorum*) is an endangered annual plant found on and near remnant sand dunes in San Francisco and San Mateo counties. Photo: Jeb Bjerke

California has over 2,300 special status (rare and at risk) plant taxa, more than any other state in the nation. This number represents about 35 percent of all the native plants in the state. The special status list for California includes plants that are naturally low in numbers due to restricted or specialized habitats arising from California's ecologically diverse landscape. California also has some of the most intense development pressure anywhere in the nation, and many plant taxa have become rare due to human activities.

Agriculture has converted nearly all the land in the Great Valley, which is and was home for many special status vernal pool plants. Residential development, which has historically been concentrated along the coast, has been moving inland and into the Sierra Nevada foothills, threatening hundreds of species. Invasive introduced plants have further displaced the native flora and are a serious threat to many plant populations. (See the "Threats to Biodiversity" section later in this book.) The map on the opposite page shows the known distribution of rare plants in California, highlighting areas where the concentration of special status species is greatest.

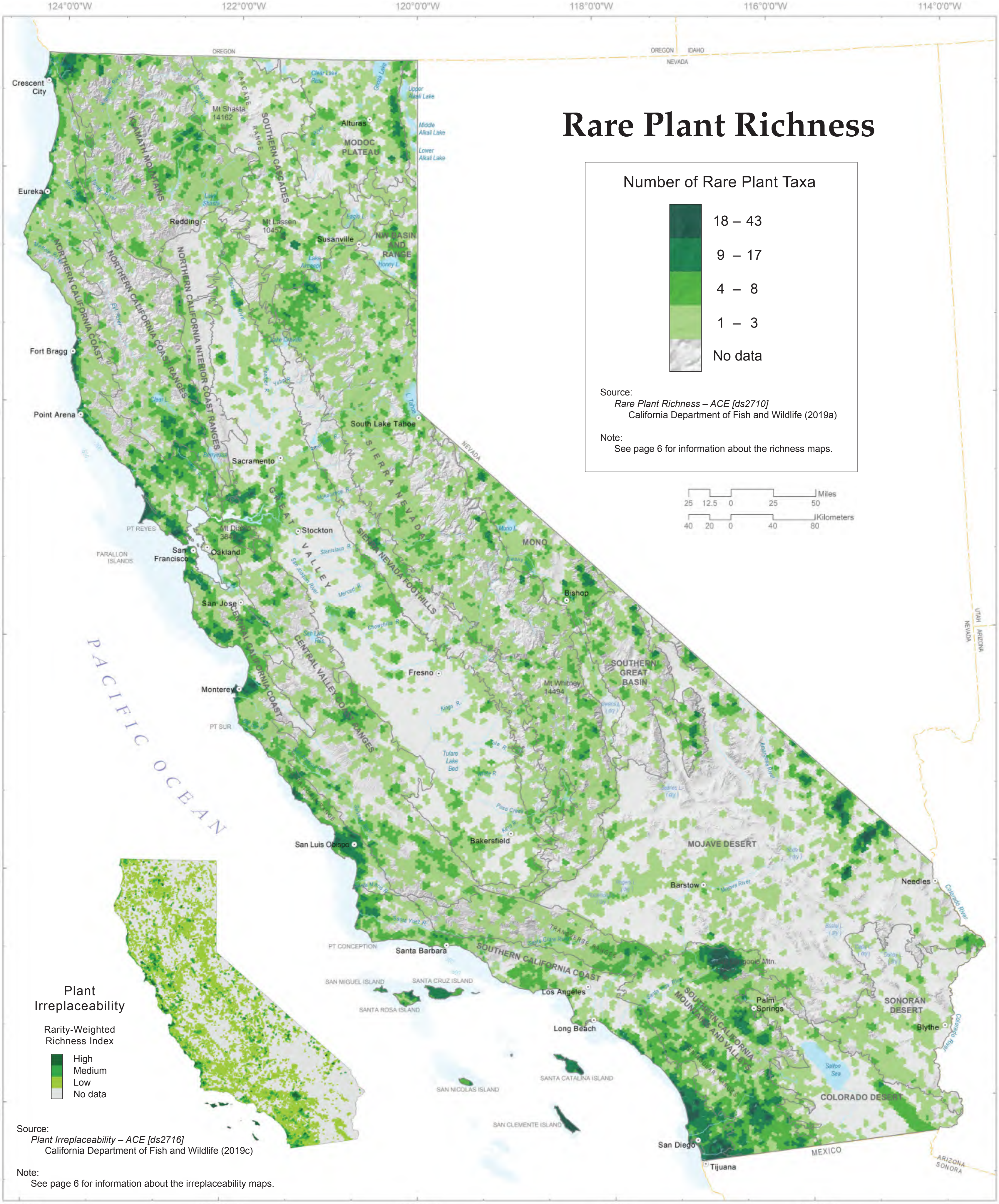
The endangered Loch Lomond button-celery (*Eryngium constancei*) is found only in volcanic ash flow vernal pools in Lake and Sonoma counties. Photo: Jeb Bjerke

California's varied geology and soils help explain why California is so rich in plant species. The table at right lists the numbers of special status plants found on different substrates in California (CDFW 2020q), with serpentine-derived soils taking the lead in special status plant diversity. Serpentine soil, which is high in the heavy metals chromium, cobalt, iron, and nickel, produces an environment that few plants can tolerate. Only a small group of specialized plants has evolved to withstand the harsh conditions of serpentine soil. By doing so, they have escaped strong competition from invasive and introduced plants, which tend to do very poorly on serpentine. Because serpentine outcrops are often discontinuous and separated by non-serpentine expanses, they tend to act like "islands" for native plants. The reduced gene flow means species may evolve independently, leading to greater diversification and potentially more new species.

Rare plants typically have low population numbers and/or highly restricted distributions. They may also possess genetic traits that make them locally adapted to unique habitats. Rare plants that are adapted to habitats that are also rare are especially vulnerable to habitat changes or destruction. The inset map to the right, Plant Irreplaceability, identifies areas of California that contain special status plant species in unique habitats that, if destroyed, could lead to the extinction of that species. Many of the areas of highest irreplaceability (dark green) are found in ecologically diverse areas, are threatened by expanding human populations, or both. Where population density and levels of development are low, such as in the Mojave Desert ecoregion, there appear to be very few "irreplaceable" plant species; however, these are also areas with few thorough botanical surveys, so the number of special status plant taxa may be significantly underestimated.

Substrate Preferences of Special Status Plants
Based on CNPS (2020b)

Substrate and Number of Special Status Plant Taxa			
Serpentine	344	Sandstone	23
Granite	157	Metamorphic	19
Clay	139	Shale	14
Volcanic	138	Acidic	10
Carbonate	132	Peridotite	2
Alkaline	85	Gypsum	2
Gabbro	30		



Rare Plant Richness
Number of Rare Plant Taxa
18 – 43
9 – 17
4 – 8
1 – 3
No data
Source:
Rare Plant Richness – ACE [ds2710]
California Department of Fish and Wildlife (2019a)
Note:
See page 6 for information about the richness maps.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
Palm Springs
Barstow
Needles
Blythe
San Diego
Tijuana
Mt Shasta 14162
Mt Lassen 10457
Mt Diablo 3849
Mt Whitney 14494
MODOC PLATEAU
NW BASIN AND RANGE
KLAMATH MOUNTAINS
SOUTHERN CASCADES
CASCADE RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
SOUTHERN GREAT BASIN
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
MOJAVE DESERT
SOUTHERN CALIFORNIA COAST
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
SONORAN DESERT
COLORADO DESERT
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Plant Irreplaceability
Rarity-Weighted Richness Index
High
Medium
Low
No data
Source:
Plant Irreplaceability – ACE [ds2716]
California Department of Fish and Wildlife (2019c)
Note:
See page 6 for information about the irreplaceability maps.

Amphibians

Juvenile Mount Lyell Salamander (*Hydromantes platycephalus*)
Photo © Ben Witzke

California is home to approximately 70 species of native amphibians and that number continues to grow as advances in genetic testing reveal undiscovered diversity. There are two main characteristics that describe all amphibians: they have scaleless skin that air and water can pass through, and they are ectothermic, using the temperature around them to regulate their body temperature. Most amphibians are active only at night, when humidity is high, or during thick fog or rain. In California, amphibians include salamanders, frogs, and toads. Amphibian species diversity is greatest in the Northern California Coast ecoregion, where rainfall is highest. The "State Amphibian" is the California Red-legged Frog (*Rana draytonii*), which is the largest native frog in California.

California Red-legged Frog (*Rana draytonii*)
Photo © Ben Witzke

The word "amphibian" comes from an ancient Greek word that means "a being with a double life." This refers to the fact that many amphibians have both an aquatic and a terrestrial life stage; however, some species are completely terrestrial. For species with a two-phased life cycle, the first fully aquatic stage is the egg. The second is the larval stage, familiarly known as tadpoles or polliwogs in frogs and toads. Most tadpoles consume algae that grows on rocks or other structures in their aquatic environment. Salamander larvae are carnivorous and they absorb oxygen from the water through external gills that are sometimes very prominent. Like salamander larvae, tadpoles absorb oxygen through gills, but their gills are covered by a membrane and are therefore not visible. After several weeks, months, or even years, larvae and tadpoles undergo a transformation into a new body form that allows them to take advantage of terrestrial food resources, obtain oxygen from the air, and disperse over land to other areas. This transformation is especially useful in seasonal wetlands that dry up in the summer or fall.

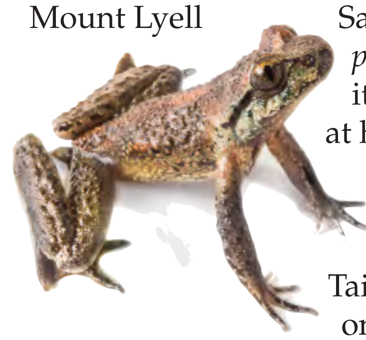
Prominent, feather-like gills of the larval California Newt (*Taricha torosa*)
Photo © Lawrence Erickson

The greatest number of amphibian species is found in the family Plethodontidae, which are the lungless salamanders. They do not have an aquatic phase and they breathe entirely through their skin. While amphibians generally favor wet places, many have special adaptations that allow them to live in hotter, drier areas. For example, the Western Spadefoot (*Spea hammondii*) lives underground in a state of suspended animation for most of the year. After emerging during the rainy season to mate and forage, it buries itself underground using specialized "spades" on its back feet and absorbs needed moisture from the soil.

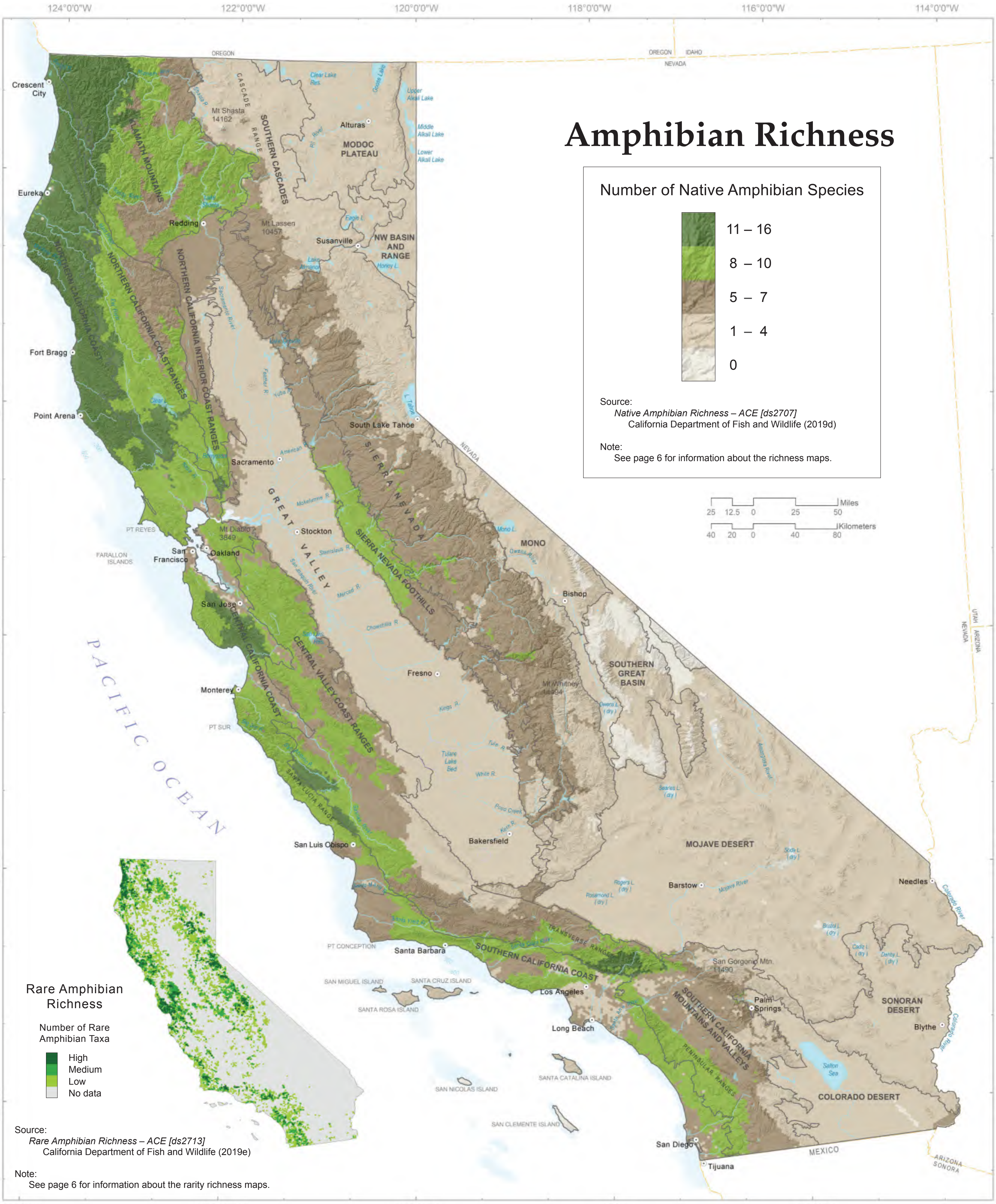
Ensatina (*Ensatina eschscholtzii*) are wide-ranging, variably colored lungless salamanders.
Photo © Ben Witzke

Western Spadefoot (*Spea hammondii*) burrowing in the soil
Photo © Ivan Parr

Amphibians have also evolved special traits to help them survive and reproduce. To avoid predation, some species like newts and toads produce highly poisonous skin secretions. Some species have specialized foraging adaptations such as the Mount Lyell Salamander (*Hydromantes platychephalus*), who can project its chameleon-like tongue at high speed to capture very elusive prey up to one-half its body length away. California is also home to the Coastal Tailed Frog (*Ascaphus truei*), one of only two species of frog with internal fertilization, an adaptation for breeding in fast-running streams.



Male Coastal Tailed Frog (*Ascaphus truei*)
Photo © Ivan Parr



Amphibian Richness
Number of Native Amphibian Species
11 – 16
8 – 10
5 – 7
1 – 4
0
Source:
Native Amphibian Richness – ACE [ds2707]
California Department of Fish and Wildlife (2019d)
Note:
See page 6 for information about the richness maps.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
Rare Amphibian Richness
Number of Rare Amphibian Taxa
High
Medium
Low
No data
Source:
Rare Amphibian Richness – ACE [ds2713]
California Department of Fish and Wildlife (2019e)
Note:
See page 6 for information about the rarity richness maps.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
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OREGON
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Santa Barbara
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SOUTHERN CASCADES
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
SOUTHERN GREAT BASIN
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
SANTA LUCIA RANGE
MOJAVE DESERT
SOUTHERN CALIFORNIA COAST
TRANSVERSE RANGES
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
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SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea

Reptiles

Over 100 species of native reptiles can be found in California. These include the lizards, snakes, turtles, and tortoises that live on the mainland and offshore islands of California, as well as the sea turtles and sea snakes that forage near the coastline. This total continues to increase as new genetic techniques lead to the recognition of additional species. Reptiles can be found virtually everywhere in California, from sea level to over 13,000 feet, occupying every type of habitat, but their diversity is highest in the more arid southern mountains, valleys, and deserts. The "State Terrestrial Reptile" is the Mohave Desert Tortoise (*Gopherus agassizii*) and the "State Marine Reptile" is the Leatherback Sea Turtle (*Dermochelys coriacea*).

Mohave Desert Tortoise (*Gopherus agassizii*)
Photo © Ivan Parr

Reptiles, like amphibians, are ectotherms that cannot regulate their body temperatures internally. They can often be seen in the morning warming up to their optimal body temperature by basking in the sun or on dark-colored surfaces, which readily absorb and maintain heat. Unlike amphibians, reptile skin is covered in coarse, dry scales that are impermeable. Because they do not lose water through their skin, reptiles are able to survive in extremely hot, dry areas.

Reptiles have a broad range of life history traits. For example, Southern Alligator Lizards (*Elgaria multicarinata*) lay eggs, while the closely related Northern Alligator Lizard (*E. coerulea*) gives birth to live young. Some species are highly aquatic like Giant Gartersnakes (*Thamnophis gigas*), while others are sand dune specialists like the Coachella Valley Fringe-toed Lizard (*Uma inornata*). Some are vegetarian like the Common Chuckwalla (*Sauromalus ater*), while others are dietary specialists like Flat-tailed Horned Lizards (*Phrynosoma mcallii*), which eat primarily ants. Still others are generalist predators like the California Kingsnake (*Lampropeltis californiae*), who earned its name by eating not only invertebrates, small mammals, birds, amphibians, and lizards, but also other snakes, even rattlesnakes.

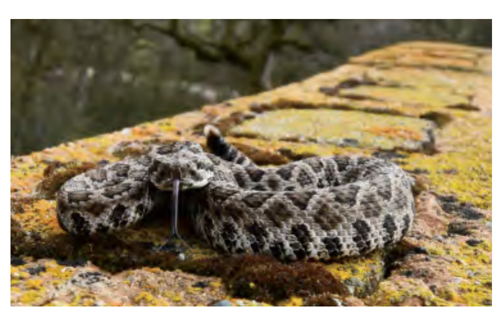
Southern Alligator Lizard (*Elgaria multicarinata*)
Photo © Craig Fischer

Switak's Gecko (*Coleonyx switaki*)
Photo © Jeff Lemm

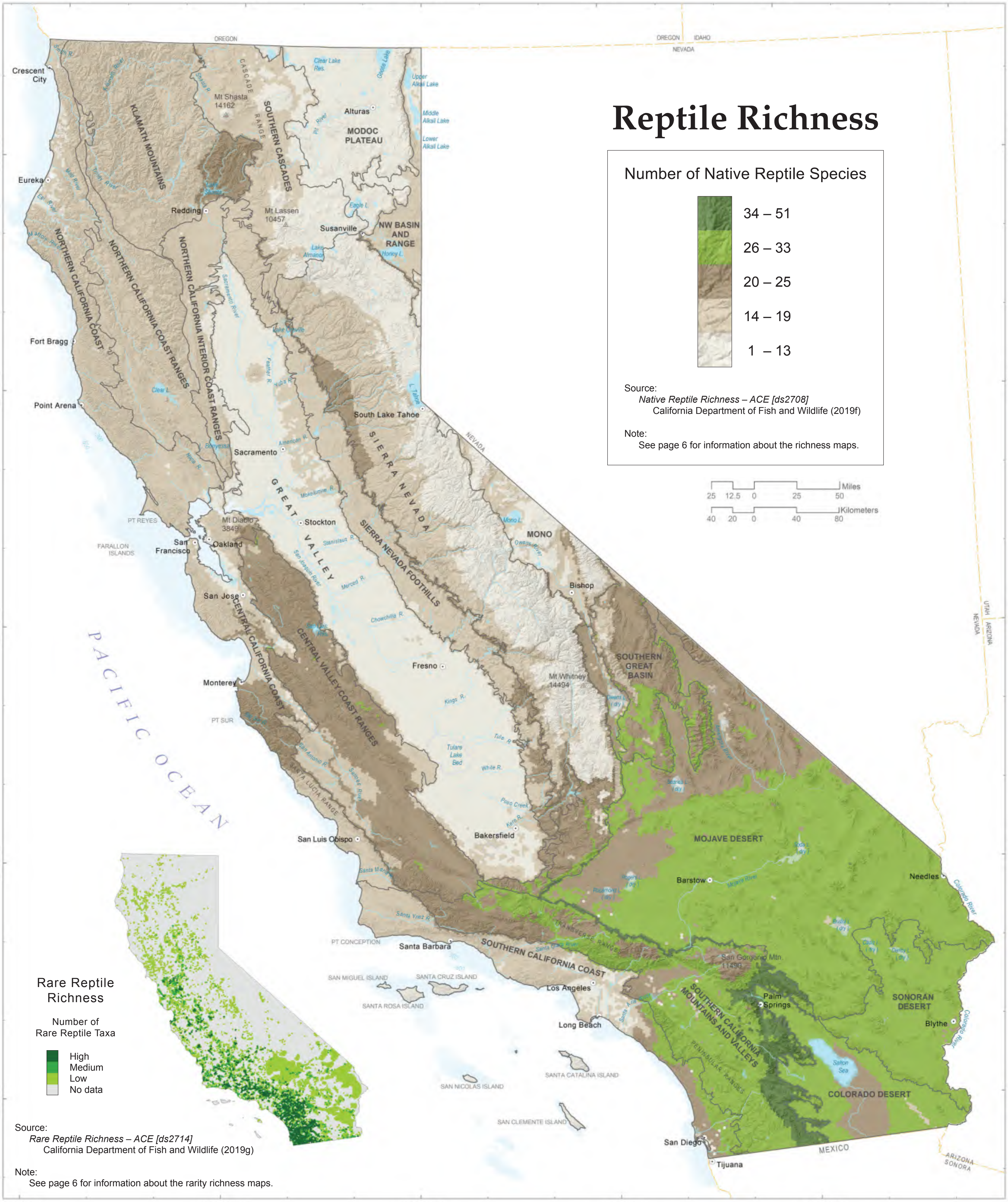
Much of California's remarkable reptile diversity isn't well known by the public. California is home to three species of native boas, snakes that are related to pythons, and three species of native geckos. Five species of legless lizards, who presumably lost their limbs as an adaptation to "swimming" underground in sand and soil, also reside in the state. The only species of venomous lizard in the United States, the enigmatic Gila Monster (*Heloderma suspectum*), lives in our Mojave Desert. The only other venomous reptiles that pose a danger to humans in California are the several species of rattlesnakes that inhabit the state. Rattlesnakes have been feared throughout history due to the serious and sometimes fatal effects of their venom, but that same venom has produced medications that are helping to treat a variety of diseases. Recent research has shed light on little known complex social behaviors some rattlesnakes exhibit, like living in family units and having long-term "friendships" with unrelated individuals.

California Kingsnake (*Lampropeltis californiae*)
Photo © Todd Battey

Rosy Boa (*Lichanura orcutti*)
Photo © Brian Hinds



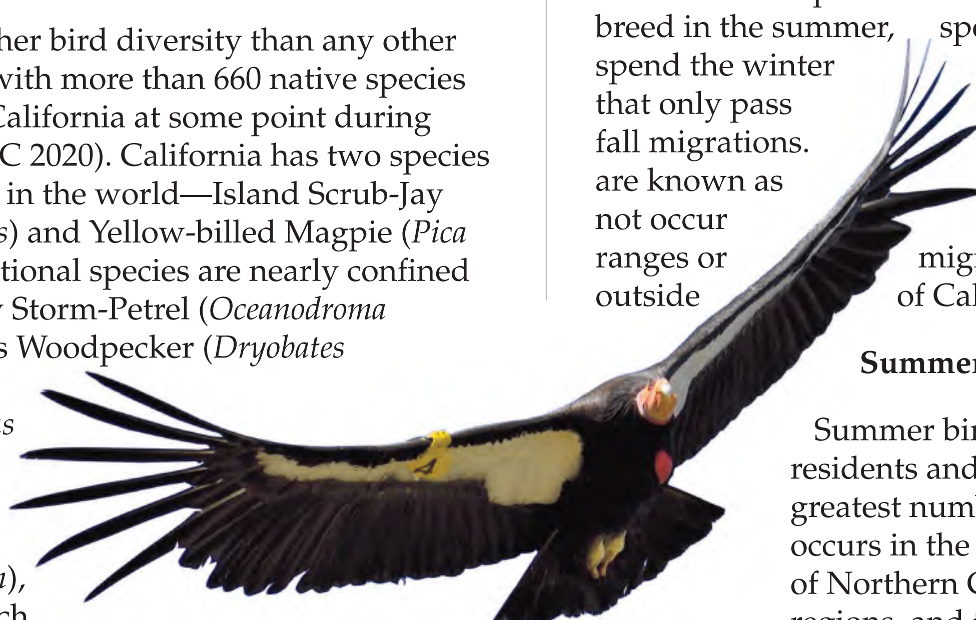
Western Rattlesnake
(*Crotalus oreganus*)
Photo © Eric Stitt


Reptile Richness
Number of Native Reptile Species
34 – 51
26 – 33
20 – 25
14 – 19
1 – 13
Source:
Native Reptile Richness – ACE [ds2708]
California Department of Fish and Wildlife (2019f)
Note:
See page 6 for information about the richness maps.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
Rare Reptile Richness
Number of Rare Reptile Taxa
High
Medium
Low
No data
Source:
Rare Reptile Richness – ACE [ds2714]
California Department of Fish and Wildlife (2019g)
Note:
See page 6 for information about the rarity richness maps.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
KLAMATH MOUNTAINS
SOUTHERN CASCADES
CASCADE RANGE
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
SOUTHERN GREAT BASIN
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
SANTA LUCIA RANGE
MOJAVE DESERT
SOUTHERN CALIFORNIA COAST
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
PENINSULAR RANGES
TRANSVERSE RANGE
SONORAN DESERT
COLORADO DESERT
Crescent City
Eureka
Redding
Mt Shasta 14162
Mt Lassen 10457
Alturas
Susanville
Fort Bragg
Point Arena
Sacramento
South Lake Tahoe
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Mt Whitney 14494
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
Barstow
Needles
San Gorgonio Mtn 11490
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
Salton Sea

Birds

Of all the wild animals inhabiting California, birds are some of the most active and visible. Birds are found everywhere, from the top of Mount Whitney to the bottom of Death Valley, and from the middle of our most populated cities to the most remote wild places. Birds use every available habitat here, including the Pacific Ocean, lakes and rivers, forests and woodlands, grasslands, agricultural lands, and deserts.

California has higher bird diversity than any other state in the nation, with more than 660 native species known to occur in California at some point during their life cycle (CBRC 2020). California has two species found nowhere else in the world—Island Scrub-Jay (*Aphelocoma insularis*) and Yellow-billed Magpie (*Pica nuttalli*). Seven additional species are nearly confined to California—Ashy Storm-Petrel (*Oceanodroma homochroa*), Nuttall's Woodpecker (*Dryobates nuttallii*), Oak Titmouse (*Baeolophus inornatus*), Wrentit (*Chamaea fasciata*), California Thrasher (*Toxostoma redivivum*), Lawrence's Goldfinch (*Spinus lawrencei*), and Tricolored Blackbird (*Agelaius tricolor*). Until its recent release near Arizona's Grand Canyon and to Baja California, California Condor (*Gymnogyps californianus*) was confined to this state. Additionally, there are numerous subspecies found only in California. California's large size, varied topography, mild climate, and habitat diversity are responsible for the state's uniquely rich bird life.


California Condor (*Gymnogyps californianus*)


California Thrasher (*Toxostoma redivivum*)

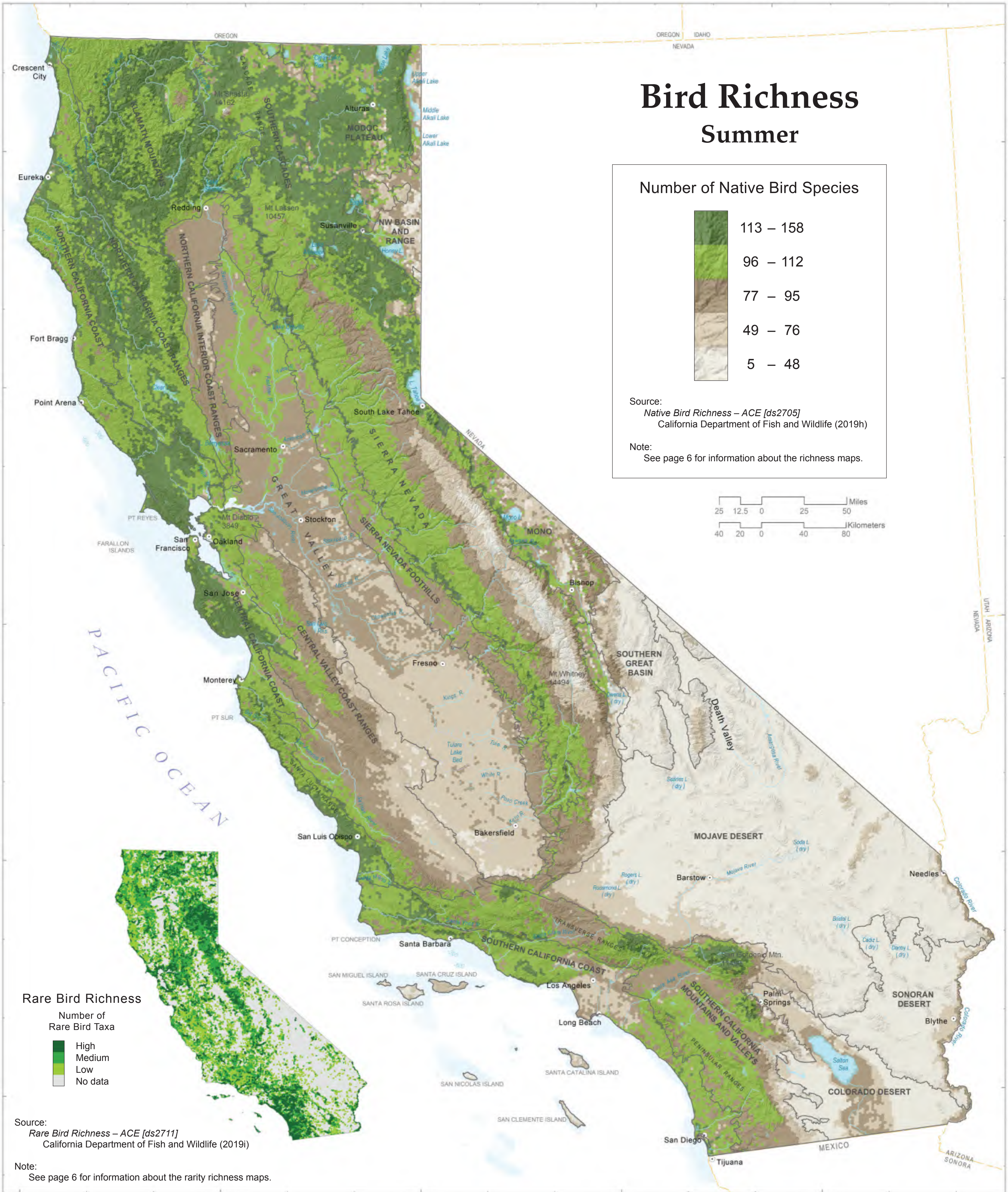
Birds are often categorized by whether they migrate or not. About one quarter of California's native bird species are known as residents because they remain here all year and do not migrate. Between one third and one half of the state's birds are regularly occurring migrants. These include species that migrate to California to breed in the summer, species that migrate to spend the winter in California, and species that only pass through during spring or fall migrations. Finally, about one third are known as vagrants because they do not occur here regularly—their ranges or migratory routes are normally outside of California.


Verdin (*Auriparus flaviceps*)

Summer

Summer bird species richness includes residents and migrant breeders. The greatest number of breeding species occurs in the woodlands and forests of Northern California, the coastal regions, and the Sierra Nevada and other mountains. In areas richest in breeding species, a large proportion of species are migrants. Fewer species breed in the arid desert regions, high elevation mountain zones, and the Great Valley. However, these areas of low species richness are important because they support a high proportion of species with restricted ranges. In the desert regions, these include resident species like Gambel's Quail (*Callipepla gambelii*), Cactus Wren (*Campylorhynchus brunneicapillus*), and Verdin (*Auriparus flaviceps*), and rare migrant breeders like Gray Vireo (*Vireo vicinior*), Bendire's Thrasher (*Toxostoma bendirei*), and Lucy's Warbler (*Leiothlypis luciae*).


Male Tricolored Blackbird (*Agelaius tricolor*) in a triticale grain field
CDFW Photo: Matt Meshriy


Bird Richness
Summer
Number of Native Bird Species
113 – 158
96 – 112
77 – 95
49 – 76
5 – 48
Source:
Native Bird Richness – ACE [ds2705]
California Department of Fish and Wildlife (2019h)
Note:
See page 6 for information about the richness maps.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
Rare Bird Richness
Number of
Rare Bird Taxa
High
Medium
Low
No data
Source:
Rare Bird Richness – ACE [ds2711]
California Department of Fish and Wildlife (2019i)
Note:
See page 6 for information about the rarity richness maps.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
San Diego
Tijuana
Barstow
Needles
Palm Springs
Blythe
KLAMATH MOUNTAINS
SOUTHERN CASCADES
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
SOUTHERN GREAT BASIN
Death Valley
MOJAVE DESERT
SOUTHERN CALIFORNIA COAST
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
SONORAN DESERT
COLORADO DESERT
Mt Shasta 14162
Mt Lassen 10457
Mt Diablo 3849
Mt Whitney 14494
San Gorgonio Mtn.
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Colorado River

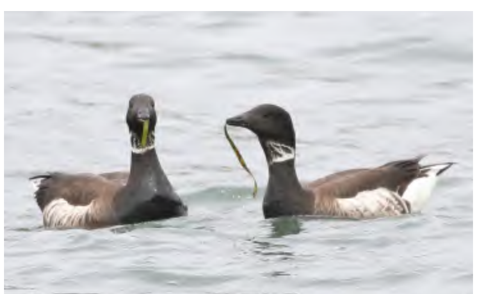
Birds

Snow Geese (*Anser caerulescens*)
Photo © Steve Hampton

(continued from page 38)

Winter

Winter bird species richness includes residents and winter migrants. The pattern for wintering species is dramatically different from that of summer breeding species. Winter species richness is highest in the coastal regions of Central and Southern California, the Great Valley, the foothills of the Sierra Nevada, along the Colorado River, and around the Salton Sea. Species richness in most of the desert regions remains low during winter. In contrast to summer distributions, winter species richness is low in the Sierra Nevada and the mountains of Northern California; this seasonal reduction in species is due to extreme winter weather conditions that drive migrants into areas with milder climates.



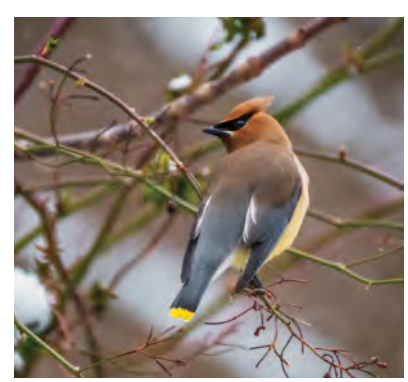
Brant geese (*Branta bernicla*) consuming eel grass
Photo © Steve Hampton

The large number of wintering birds in California includes 40 different species and subspecies of waterfowl, among which are ducks, geese, and swans. About 27 species of waterfowl are found in the Great Valley in winter. Included in these winter visitors are more than 90 percent of the Tule Greater White-fronted Goose (*Anser albifrons elgasi*) and Aleutian Canada Goose (*Branta hutchinsii leucopareia*) populations, and up to 65 percent of the continent's Northern Pintails (*Anas acuta*). Most waterfowl are migratory birds. The migration routes that waterfowl use between breeding and winter areas are aggregated geographically into flyways. North America has four flyways: Pacific, Central, Mississippi, and Atlantic. Most Pacific Flyway waterfowl breed in Canada and Alaska and fly south for the winter to California and Mexico. California provides vital winter habitat for about 60 percent of the waterfowl population in the Pacific Flyway, with the Great Valley ecoregion supporting the greatest concentrations.

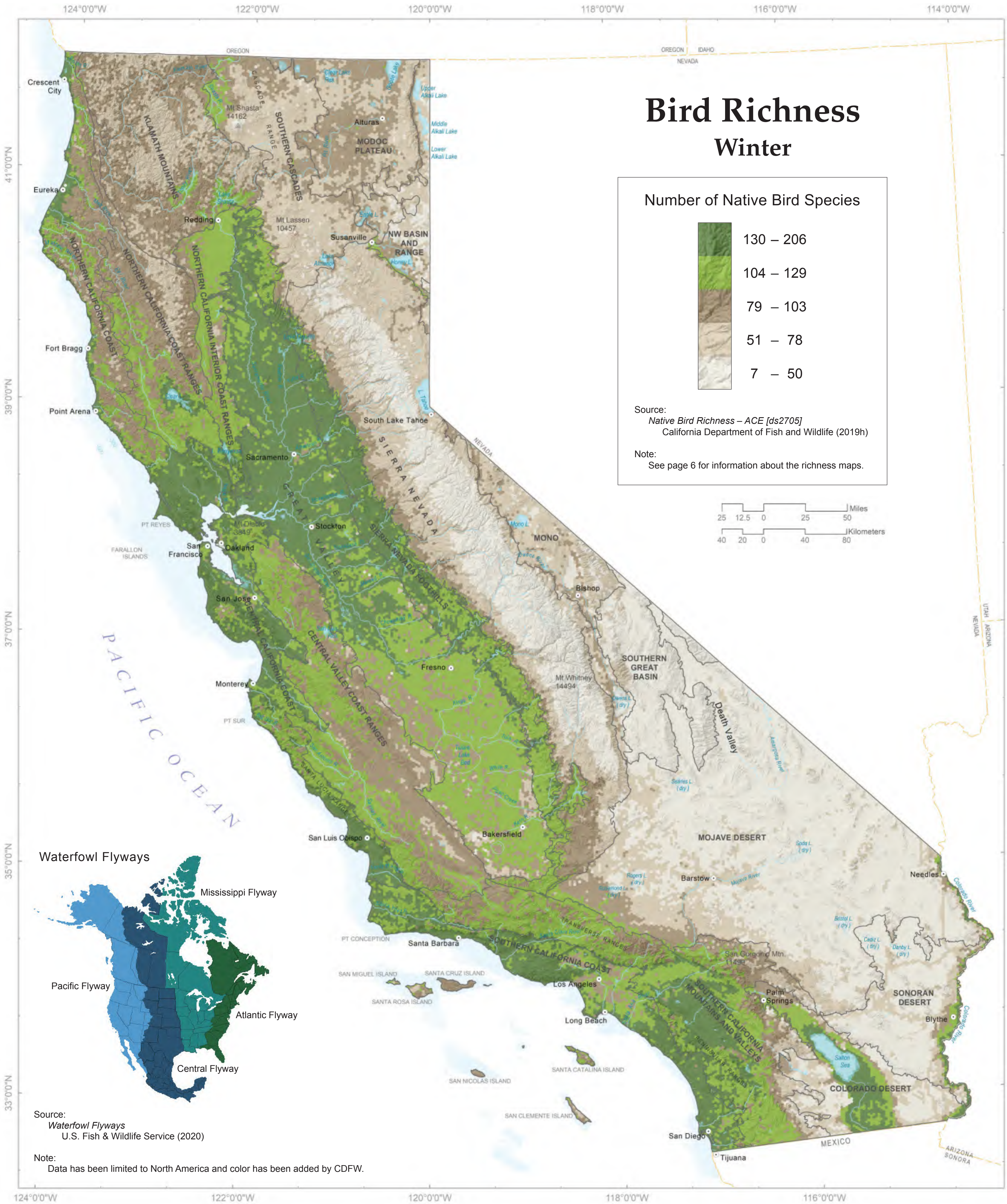
Long-billed Dowitchers (*Limnodromus scolopaceus*)
Photo © Steve Hampton

Sanderling (*Calidris alba*)
Photo © Steve Hampton

Like waterfowl, many other northern breeding birds migrate to California for the winter season. These include shorebirds like Sanderlings (*Calidris alba*), Dunlins (*C. alpina*), and Dowitchers (*Limnodromus spp.*) that use the rich food resources along California's coasts and interior wetlands, marine species in the ocean and estuaries such as loons and grebes, and many landbird species that find ample resources in California's diverse winter habitats.



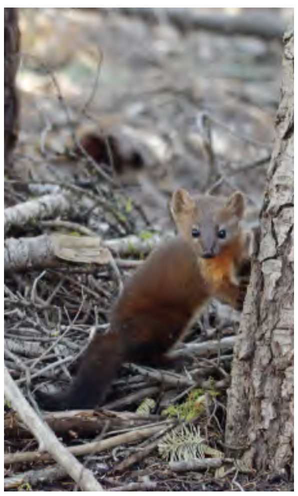
Cedar Waxwing (*Bombycilla cedrorum*)


Bird Richness
Winter
Number of Native Bird Species
130 – 206
104 – 129
79 – 103
51 – 78
7 – 50
Source:
Native Bird Richness – ACE [ds2705]
California Department of Fish and Wildlife (2019h)
Note:
See page 6 for information about the richness maps.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Mt Shasta 14162
Alturas
MODOC PLATEAU
KLAMATH MOUNTAINS
SOUTHERN CASCADES
CASCADE RANGE
Mt Lassen 10457
Susanville
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
GREAT VALLEY
PT REYES
FARALLON ISLANDS
San Francisco
Oakland
Mt Diablo 3849
Stockton
MONO
Bishop
San Jose
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
Monterey
PT SUR
Fresno
Mt Whitney 14494
SOUTHERN GREAT BASIN
Death Valley
San Luis Obispo
Bakersfield
MOJAVE DESERT
Barstow
Needles
PT CONCEPTION
Santa Barbara
SOUTHERN CALIFORNIA COAST
TRANSVERSE RANGES
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
Los Angeles
Long Beach
San Gorgonio Mtn. 11499
Palm Springs
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
SONORAN DESERT
Blythe
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
COLORADO DESERT
Salton Sea
San Diego
Tijuana
Waterfowl Flyways
Mississippi Flyway
Pacific Flyway
Atlantic Flyway
Central Flyway
Source:
Waterfowl Flyways
U.S. Fish & Wildlife Service (2020)
Note:
Data has been limited to North America and color has been added by CDFW.

Mammals

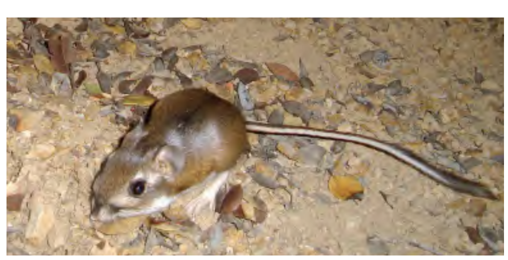
American pika (*Ochotona princeps*). The pika is a relative of rabbits and hares. Climate change is implicated in loss of pikas at many sites in California. Photo © Jen Joynt

The mammals are a highly diverse group of vertebrates sharing an evolutionary lineage that branched off from reptiles about 200 million years ago. Mammals share only three traits that differentiate them from the other vertebrate classes: hair, mammary glands, and the presence of three bones in the inner ear. However, these seemingly incongruous traits bely the fantastic diversity of form displayed by modern mammal species, which range in mass from the tiny Etruscan shrew (*Suncus etruscus*) at 0.06 ounce to the enormous blue whale (*Balaenoptera musculus*) at 209 tons. Mammals around the world also include bats, capable of powered flight, hundreds of species of rodents, a huge variety of carnivores and ungulates, and many other exotic groups, including primates which, of course, includes humans. Here in California, there are 167 species and 421 subspecies of native land mammals, which comprise a significant fraction of the state's wildlife diversity.



Pacific marten (*Martes caurina*). This rare denizen of the North Coast eats a variety of foods, including insects, fruits, and birds, but relies primarily on rodents for its high daily energy needs. Photo © Katie Moriarty

If you ask a person to name a few wild mammal species you'd probably get answers like "deer, bear, fox, rabbit," and so on. These mammals are among the best known because they are relatively large and conspicuous. But most mammals are small-bodied, shy, and retiring—many are active only at night. In fact, by far the greatest diversity within the mammals of California is found in the rodents, with more than 350 species and subspecies. By comparison, there are only 17 species and subspecies of artiodactyls (bighorn sheep, mule deer, elk, and pronghorn). Other groups, such as the carnivores, bats, insectivores (shrews and moles), and lagomorphs (rabbits, hares, and pikas) have intermediate numbers of species.

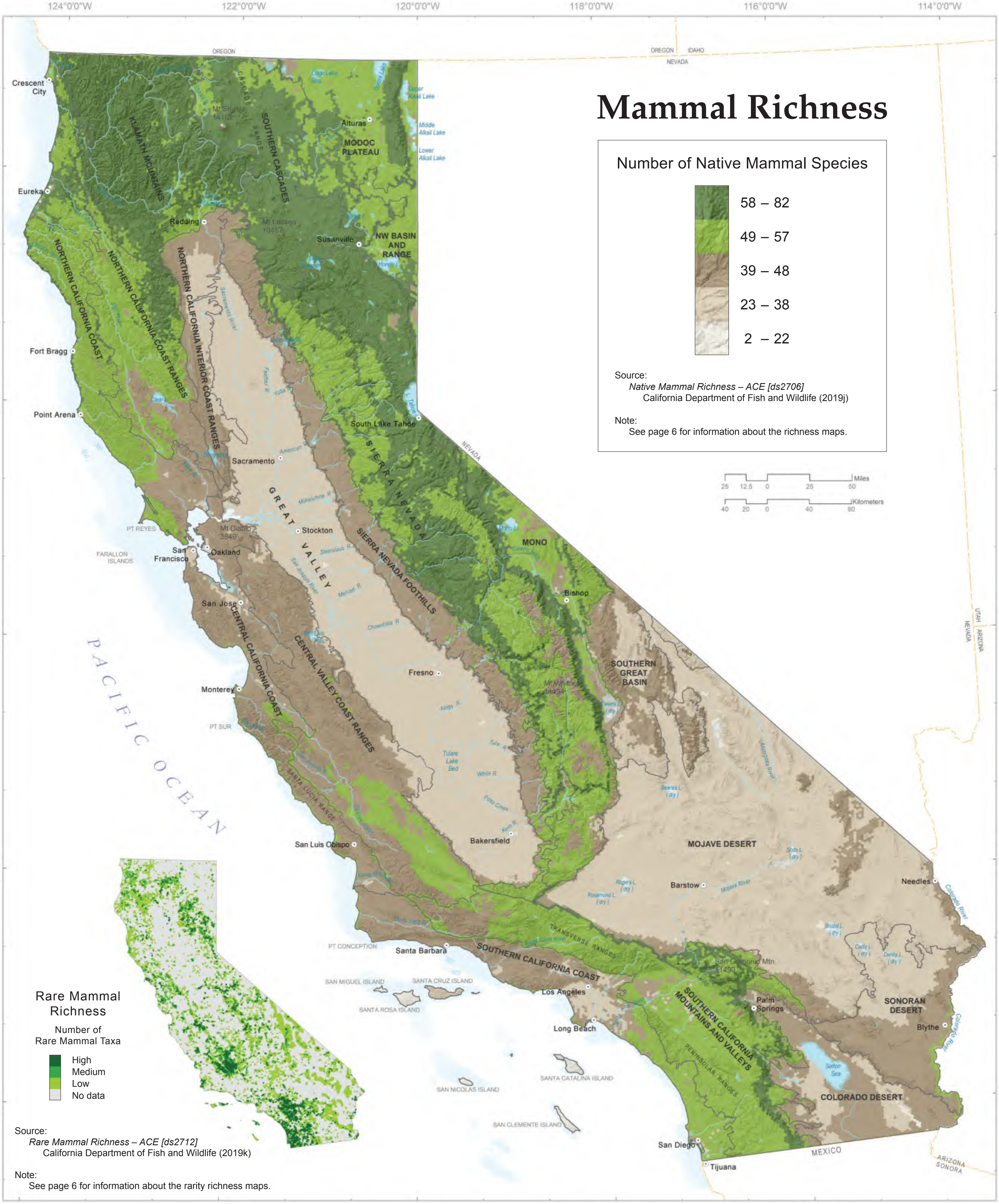


Santa Cruz kangaroo rat (*Dipodmys venustus venustus*). Once common in coastal dune habitats of the Central Coast, this rodent now is only rarely encountered in surveys. Photo © Ken Hickman

Because forested habitats offer many more opportunities for small and medium-sized mammals to make their homes than habitats like grasslands and scrub vegetation, it is not surprising that mammal species richness is high where forest vegetation occurs. This is especially true in the Klamath Mountains, southern Cascades, Sierra Nevada, and other forested areas where rodents such as tree squirrels, chipmunks, woodrats, voles, and porcupines, as well as medium-sized carnivores like spotted and striped skunks, fishers, and martens occur. Rodents also contribute greatly to biodiversity in other vegetation types. For example, many species of pocket mice and kangaroo rats are well adapted to arid climates and contribute to species richness in the Modoc Plateau, Basin and Range, Mono, and Desert Regions of California.

Golden-mantled ground squirrel (*Callospermophilus lateralis*). This beautifully marked medium-sized ground squirrel is common in the Sierra Nevada and southern Cascade ranges of California. Photo © Caitlin Bean

In terms of rare mammals of conservation concern (inset map), the pattern generally follows the overall species richness map but is skewed somewhat to the south. There are more rare mammal species in the Central and Southern Coast Ranges and in the arid valleys and deserts of Southern California than in the comparable northern forests and arid regions. The relative prevalence of rare species in the south is partly due to greater loss of natural habitats to human development there. In addition, the climate in Southern California has become warmer and drier over the past several thousand years, leaving many small mammal species isolated in remnants of their former ranges. The recent acceleration of climate change will most likely increase the conservation risk of many mammals in California in the coming decades.



Mammal Richness
Number of Native Mammal Species
58 – 82
49 – 57
39 – 48
23 – 38
2 – 22
Source:
Native Mammal Richness – ACE [ds2706]
California Department of Fish and Wildlife (2019j)
Note:
See page 6 for information about the richness maps.
Rare Mammal Richness
Number of Rare Mammal Taxa
High
Medium
Low
No data
Source:
Rare Mammal Richness – ACE [ds2712]
California Department of Fish and Wildlife (2019k)
Note:
See page 6 for information about the rarity richness maps.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
Miles
Kilometers
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Fort Bragg
Point Arena
Sacramento
South Lake Tahoe
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
San Diego
Tijuana
Barstow
Needles
Palm Springs
Blythe
KLAMATH MOUNTAINS
SOUTHERN CASCADES
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
SOUTHERN GREAT BASIN
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
MOJAVE DESERT
SOUTHERN CALIFORNIA COAST
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
SONORAN DESERT
COLORADO DESERT
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND

Freshwater Fishes

The endangered Razorback Sucker (*Xyrauchen texanus*) has a distinctive dorsal keel behind the head and lives in the Colorado River. Individuals up to 44 years in age have been found. CDFW photo: Joe Ferreira

The freshwater fishes of California are represented by 69 native resident and anadromous species (Moyle et al. 2015). Resident fishes such as trout, minnows, and chub spend their entire lives in fresh water. Anadromous fishes like salmon and sturgeon spawn in fresh water and migrate to the ocean as juveniles to grow and mature before returning to their home streams.

California Roach (*Lavinia symmetricus*) are stout-bodied, large-eyed minnows under four inches long. While common throughout much of the state, distinct isolated populations are of conservation concern. CDFW photo: Teri Moore

The diversity of California's freshwater fishes reflects the range of aquatic habitat types, from estuaries along the coast to rivers, creeks, and lakes of the valleys and mountains to marshlands and ponds of the desert. With California's habitat diversity, varied topography, and natural variability in annual and seasonal precipitation, native fishes have evolved to adapt to unique hydrologic conditions. Almost two-thirds of the state's 124 recognized unique fish populations are endemic to California.

Owens Pupfish (*Cyprinodon radiosus*) are less than 2.5 inches in length and confined to five populations in the Owens Valley. Males turn bright blue with vertical stripes when breeding. CDFW photo: Joe Ferreira

Native fishes include popular sport fish species like salmon, steelhead, and trout as well as the less familiar species of lamprey, chub, sucker, dace, roach, hitch, stickleback, and pupfish. Non-native fish familiar to anglers, such as catfish, bass, bluegill, crappie, and carp, have been introduced to provide additional fishing opportunities.

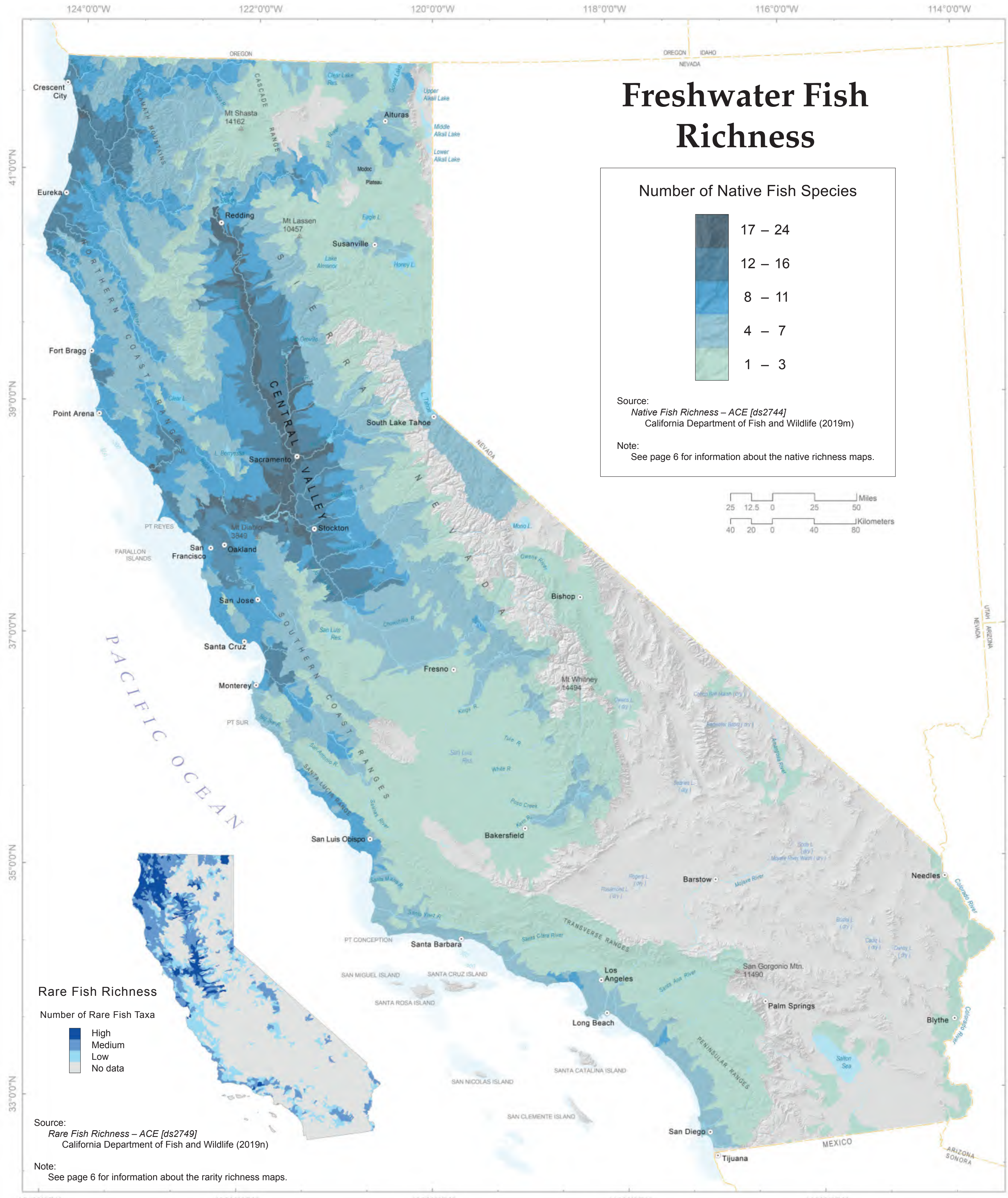
A majority of California's native fishes live in rivers of the Central Valley and North Coast, where water is more abundant. Major rivers of the North Coast include the Smith, Klamath, and Eel rivers, important for many of the state's anadromous species. The major rivers of the Central Valley are the Sacramento and San Joaquin rivers, which collect waters primarily from the western Sierra Nevada and meet in the Bay-Delta area before entering the San Francisco Bay. Almost 30 percent of California's native freshwater fish taxa are found in the Central Valley system of watersheds (Brown and Moyle 2005), including the imperiled Chinook Salmon (*Oncorhynchus tshawytscha*) and Delta Smelt (*Hypomesus transpacificus*). Not surprisingly, many of the state's rare species are found where water is scarcer, such as in small long-isolated marshes of the deserts or areas with high human habitation.

Healthy fish populations require healthy aquatic communities with diverse sources of food and adequate amounts of clean water at the appropriate time of year. Unfortunately, water in California is a very precious commodity for both human consumption and to support our renowned agricultural industry. Most of the rivers of California have been dammed for flood control and water storage or diverted to move water from places of abundance to places of scarcity. This changes the amount and timing of flows and disrupts the natural communities that fish need to thrive. Water quality impacts from urban and agricultural run-off, the presence of exotic competitors, and the impacts of climatic change further threaten fish populations. As a result, over 80 percent of California's native fishes are either imperiled or extinct (Moyle et al. 2015).

Many federal and state regulatory agencies attempt to balance the human and economic benefits provided by the state's water supply with the need to protect California's natural aquatic communities. This will become more challenging as a growing human population adapts to a changing climate.

The Mohave Tui Chub (*Gila bicolor mohavensis*) is the only native fish in the Mojave River basin in San Bernardino County and now exists in its pure form solely in isolated ponds of Soda Springs. CDFW photo: Joe Ferreira

Freshwater Fish Richness



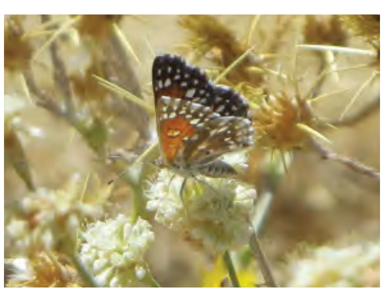
Invertebrates

Vernal pool tadpole shrimp (*Lepidurus packardi*) are endangered crustaceans endemic to California. They play an important role as bioturbators, digging in vernal pool substrates to find food. Photo © Douglas Wirtz

Despite their astounding diversity and the indispensable role they play in nearly every ecosystem on the earth, invertebrates remain one of the least understood groups of organisms. This group includes all animals without backbones and comprises over 90 percent of extant animal species on the earth. Invertebrate taxa include insects, arachnids, mollusks, crustaceans, corals, and worms.

Scientists have documented around 1.3 million invertebrate species worldwide out of an estimated 5 to 30 million. Many undescribed species may go extinct before we can record their existence. This knowledge gap presents a huge challenge for the conservation field, in which invertebrates are consistently underrepresented (Eisenhauer et al. 2019).

The rare invertebrate richness maps on the opposite page show only a very small number of the invertebrate species of the state. The California Department of Fish and Wildlife tracks occurrences of some rare species and those are the numbers reflected here. California's true endemic and overall species richness across all invertebrate groups is among the highest in the United States. For example, though only around 28,000 insect species have been documented in California, total counts are estimated to be closer to 100,000. Approximately 12 percent of these may be endemic (Kimsey 1996, Harrison 2013).



The endangered Lange's metalmark butterfly (*Apodemia mormo langei*) is found only on the remnant Antioch Dunes. It lays its eggs on just one species of host plant, the naked-stemmed buckwheat (*Eriogonum nudum*). CDFW photo: Annie Chang

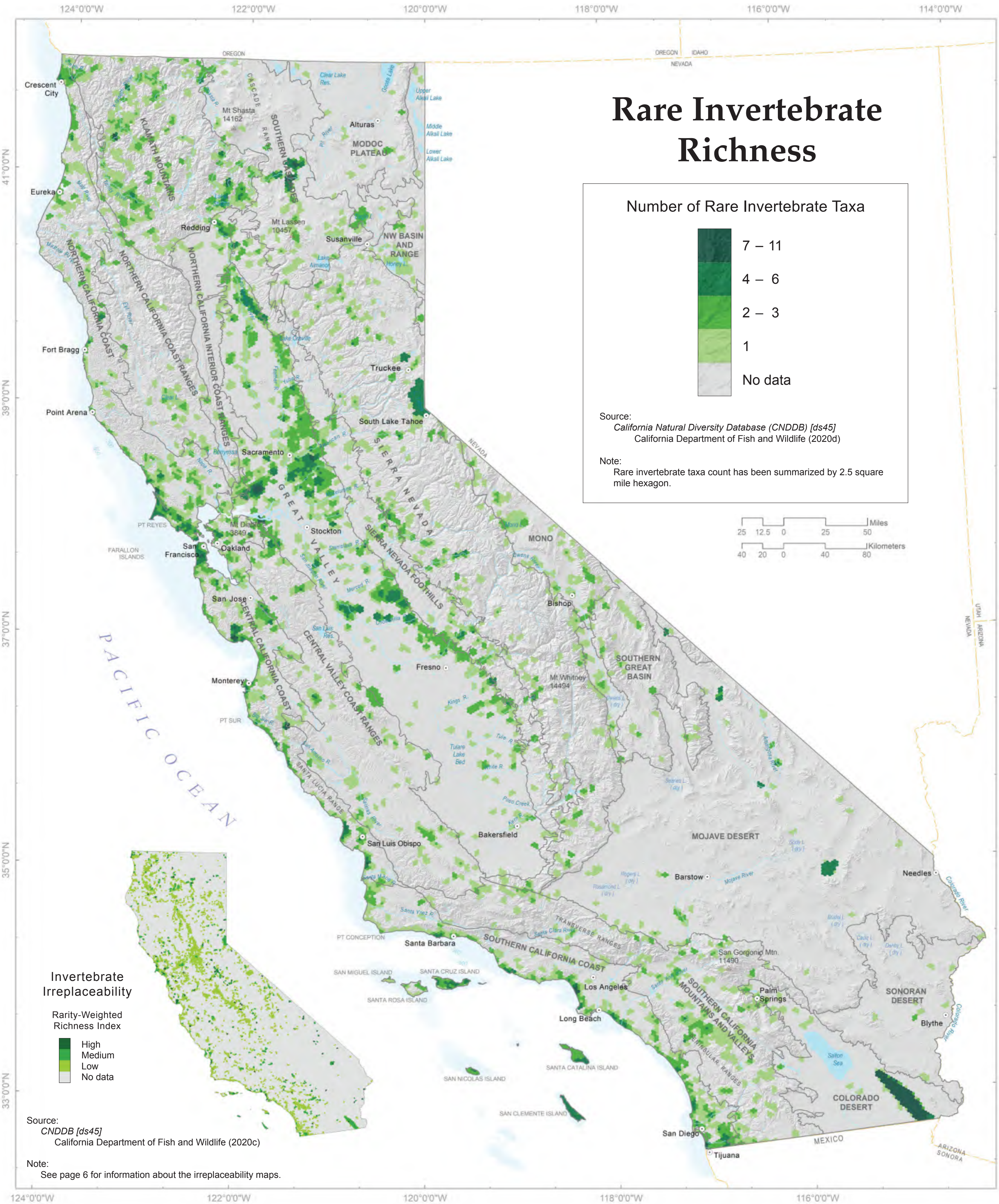
Although these maps represent only a subset of invertebrate species, they reveal important patterns of richness and rarity. For example, a large swath of moderate richness appears in the Great Valley. This is the combined range of several endemic or near-endemic vernal pool branchiopods. Some of these species, including vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*) are federally listed and thus well documented. Many additional vernal pool species, of which over 50 percent may be endemic, are yet to be described (King et al. 1996, Harrison 2013).

Islands of habitat that formed over millennia have produced isolated pockets of invertebrate diversity. The Channel Islands off the Southern California coast are one such hotspot, boasting 80 endemic insects, 20 endemic arachnids (Harrison 2013), and 24 endemic gastropods (Drost et al. 2018). Recent work by specialists nearly doubled the number of endemic Channel Island snails known to science. In the Southern California desert, a recent nine-year study of the Algodones Dunes documented 1,280 insect species, including 79 probable endemics (Kimsey et al. 2017). Because invertebrates are generally difficult to detect and identify, diversity hotspots like these may not be revealed until such exceptional efforts are made.

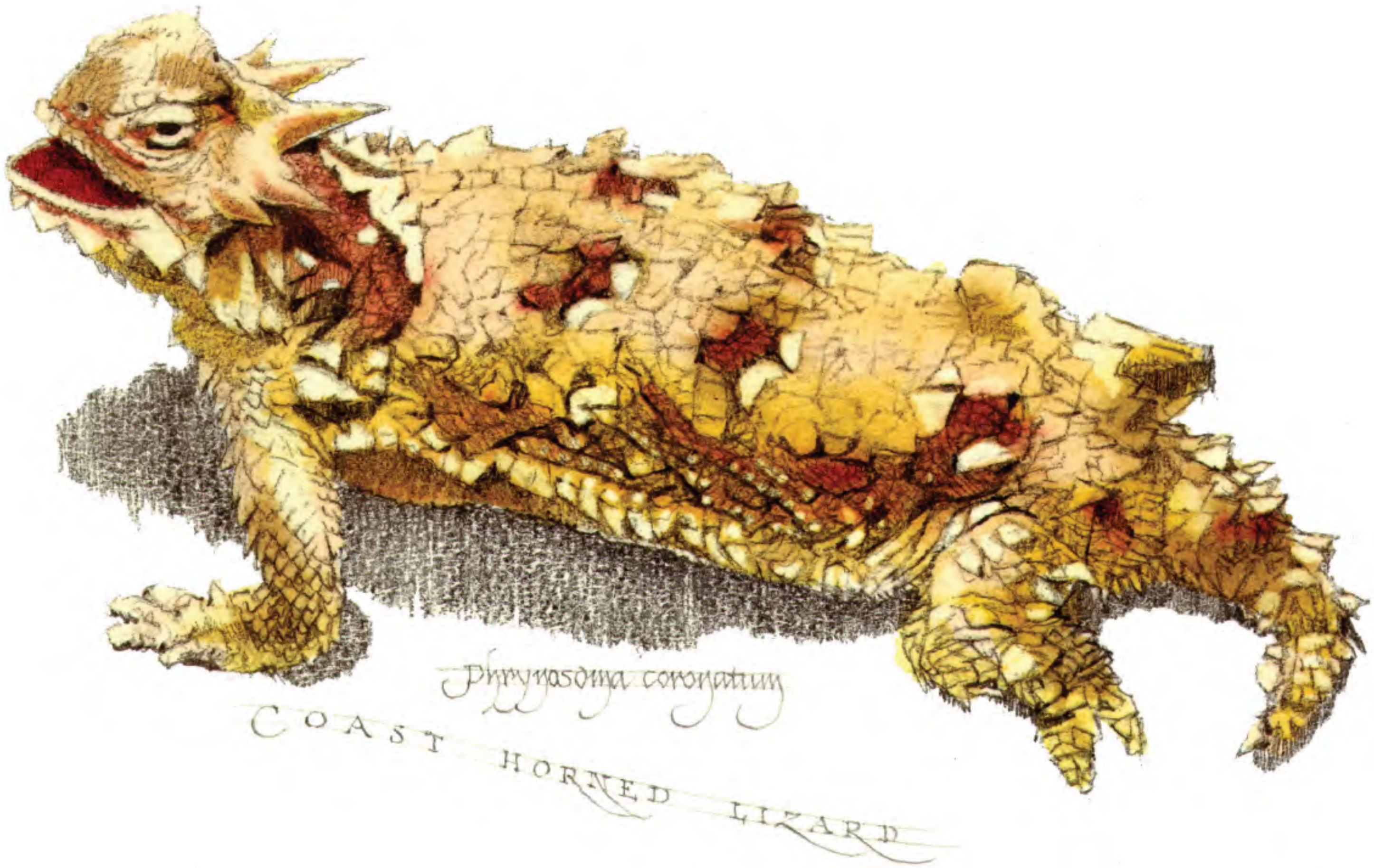
California's diverse landscape contains uncountable unique microhabitats that have given rise to single-site and narrow endemic species. Sheldon's amphipod (*Stygobromus sheldoni*), for example, is a minute, unpigmented crustacean found only in springs of Sagehen Creek, north of Truckee. The Clough Cave harvestman (*Calicina cloughensis*) is known from a single cave in Sequoia National Park. Surrounded by inhospitable desert, the Mohave shoulderband snail (*Helminthoglypta greggi*) survives in the shelter of rocky outcroppings on only a few hills. If a small pile of rocks can harbor a totally unique life form, imagine how many more species await discovery in our great state.

In areas of extensive urban development, formerly common species may now be found only in habitat fragments. On the San Francisco Peninsula, three of eight endemic butterflies have been rendered extinct by development (Shapiro and Manolis 2007). The five surviving butterflies are federally listed as threatened or endangered. Other remnants of native invertebrate diversity include the Tijuana Estuary in San Diego County and Ballona Wetlands in Los Angeles.

Many more invertebrate biologists are needed to assist the dedicated few, as we continue to document and protect hotspots of invertebrate biodiversity and endemism in California before they are lost.


Rare Invertebrate Richness
Number of Rare Invertebrate Taxa
7 – 11
4 – 6
2 – 3
1
No data
Source:
California Natural Diversity Database (CNDDB) [ds45]
California Department of Fish and Wildlife (2020d)
Note:
Rare invertebrate taxa count has been summarized by 2.5 square mile hexagon.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
Invertebrate Irreplaceability
Rarity-Weighted Richness Index
High
Medium
Low
No data
Source:
CNDDB [ds45]
California Department of Fish and Wildlife (2020c)
Note:
See page 6 for information about the irreplaceability maps.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
PACIFIC OCEAN
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
SONORA
MEXICO
Crescent City
Eureka
Fort Bragg
Point Arena
Redding
Mt Shasta 14162
Mt Lassen 10457
Alturas
Susanville
Truckee
South Lake Tahoe
Sacramento
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Mt Whitney 14494
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
San Diego
Tijuana
Barstow
Needles
Palm Springs
Blythe
San Gorgonio Mtn. 11490
KLAMATH MOUNTAINS
SOUTHERN CASCADES
CASCADE RANGE
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
GREAT VALLEY
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
MONO
SOUTHERN GREAT BASIN
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
SANTA LUCIA RANGE
MOJAVE DESERT
TRANSVERSE RANGES
SOUTHERN CALIFORNIA COAST
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
PENINSULAR RANGES
SONORAN DESERT
COLORADO DESERT
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea

Examples of Biodiversity



California supports resources of national and even international significance for biodiversity. From the rich kelp forests off the coast, to the unique populations of fishes in rivers, streams, and mountain lakes, to the isolated pupfishes of the deserts, California's aquatic communities rival some of the most diverse. Yet California is best known for its terrestrial diversity, including iconic coastal redwoods found nowhere else on earth, characteristic oak woodlands of the coastal mountains and Sierra Nevada foothills, and seemingly hostile deserts that support an incredible diversity of life. The Central Valley features sweeping grasslands, colorful flower fields, and one of the most extensive distributions of vernal pools in the world.

Kelp Forests

California's nearshore kelp forests are dominated by two types of brown algae, Giant Kelp (*Macrocystis pyrifera*) and Bull Kelp (*Nereocystis luetkeana*).

Giant Kelp can be found worldwide in nearshore temperate oceans. On the Pacific coast of North America, Giant Kelp ranges from Baja California to southeast Alaska. In its California range, Giant Kelp is most abundant south of San Francisco. A perennial, Giant Kelp individuals can live for up to nine years, although the fronds usually die within nine months.

Giant Kelp forest
Photo: Chad King, MBNMS/NOAA

Bull Kelp resides along the Pacific coasts of North America and Asia. In North America, Bull Kelp ranges from Point Conception north to the Aleutian Islands. Offshore of California, this annual kelp becomes the dominate kelp species north of Santa Cruz County.

Kelp forests play an important ecological role. Marine life take refuge in kelp forests or rely on kelp for food. Marine mammals forage for invertebrates that live in the kelp forest such as crabs, urchins, and abalone (which feed on kelp). Birds hunt fish which in turn feed on invertebrates and kelp in the forest. Even kelp that has perished is utilized, providing food for invertebrates both at sea and on the beach.

Bull Kelp wrack
Photo: Rebecca Flores Miller

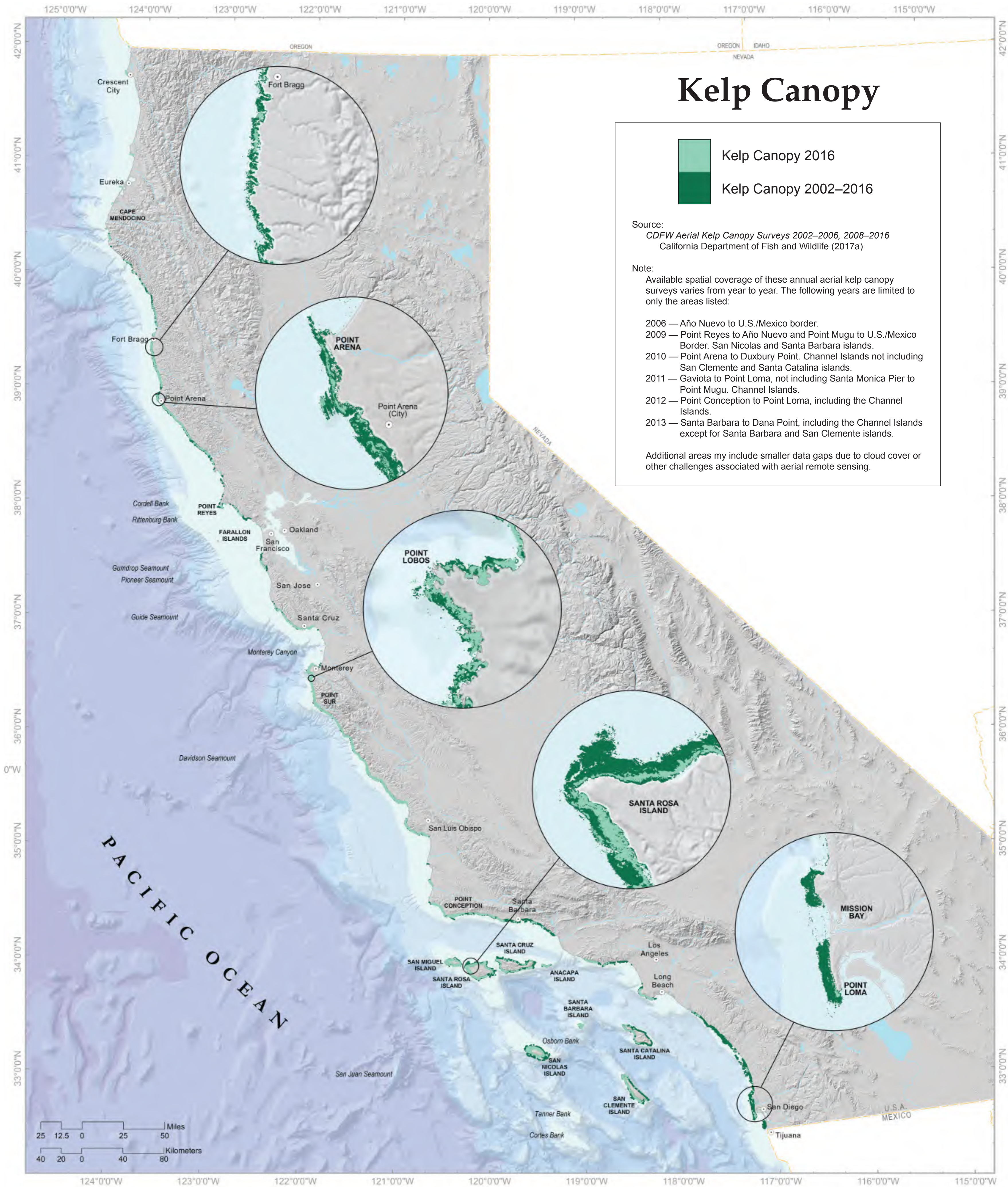
Humans also utilize kelp forests for recreation, including scuba diving, fishing, and the direct harvest of kelp itself. Commercial harvest of Giant Kelp began in the early 1900s to extract acetone and potash to use in explosive manufacturing. Currently, Giant Kelp is harvested to feed cultured abalone while the Bull Kelp harvest is for human food. The kelp fishery is managed by the California Department of Fish and Wildlife under regulations adopted by the California Fish and Game Commission.

Bull Kelp at low tide with Great Blue Heron (*Ardea herodias*)
Photo © Kevin Joe

Ocean conditions naturally ebb and flow over time. Kelp thrives in cool, nutrient-rich water and is reduced by nutrient-poor water and the large ocean swells associated with warm water conditions. Human impacts, including soil erosion, wastewater discharges, power plant warm water outflows, and fishing of urchin predators or competitors, have negatively impacted kelp.

Many of California's kelp forests were greatly reduced in a cascade of events that began in 2013 (Rogers-Bennett and Catton 2019). While researchers examine how these events have shaped marine communities, changing ocean conditions will likely continue to impact kelp forests and complicate conservation efforts. The Department continues to work with partners to adaptively manage kelp forests to protect this important ecosystem.

Low kelp populations, changes in urchin feeding behavior, and urchin population increases can result in the formation of "urchin barrens."
CDFW photo: Paulo Serpa



Kelp Canopy
Kelp Canopy 2016
Kelp Canopy 2002–2016
Source:
CDFW Aerial Kelp Canopy Surveys 2002–2006, 2008–2016
California Department of Fish and Wildlife (2017a)
Note:
Available spatial coverage of these annual aerial kelp canopy surveys varies from year to year. The following years are limited to only the areas listed:
2006 — Año Nuevo to U.S./Mexico border.
2009 — Point Reyes to Año Nuevo and Point Mugu to U.S./Mexico Border. San Nicolas and Santa Barbara islands.
2010 — Point Arena to Duxbury Point. Channel Islands not including San Clemente and Santa Catalina islands.
2011 — Gaviota to Point Loma, not including Santa Monica Pier to Point Mugu. Channel Islands.
2012 — Point Conception to Point Loma, including the Channel Islands.
2013 — Santa Barbara to Dana Point, including the Channel Islands except for Santa Barbara and San Clemente islands.
Additional areas my include smaller data gaps due to cloud cover or other challenges associated with aerial remote sensing.
PACIFIC OCEAN
OREGON
IDAHO
NEVADA
MEXICO
U.S.A.
Crescent City
Eureka
CAPE MENDOCINO
Fort Bragg
Point Arena
POINT ARENA
Point Arena (City)
POINT REYES
FARALLON ISLANDS
Cordell Bank
Rittenburg Bank
San Francisco
Oakland
San Jose
Santa Cruz
Gumdrop Seamount
Pioneer Seamount
Guide Seamount
Monterey Canyon
Monterey
POINT LOBOS
POINT SUR
Davidson Seamount
San Luis Obispo
POINT CONCEPTION
Santa Barbara
SANTA ROSA ISLAND
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
ANACAPA ISLAND
SANTA BARBARA ISLAND
Los Angeles
Long Beach
Osborn Bank
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
San Juan Seamount
Tanner Bank
Cortes Bank
MISSION BAY
POINT LOMA
San Diego
Tijuana
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
125°0'0"W 124°0'0"W 123°0'0"W 122°0'0"W 121°0'0"W 120°0'0"W 119°0'0"W 118°0'0"W 117°0'0"W 116°0'0"W 115°0'0"W
42°0'0"N 41°0'0"N 40°0'0"N 39°0'0"N 38°0'0"N 37°0'0"N 36°0'0"N 35°0'0"N 34°0'0"N 33°0'0"N

Anadromous Fishes

Anadromous fishes are an important biological resource of California. The best known of these are salmon and trout species including Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*), Coastal Rainbow Trout/Steelhead (*O. mykiss irideus*), Coastal Cutthroat Trout (*O. clarkii clarkii*), and the ancient fishes White Sturgeon (*Acipenser transmontanus*) and Green Sturgeon (*A. medirostris*). Other native anadromous fishes include Pacific Lamprey (*Entosphenus tridentata*), Western River Lamprey (*Lampetra ayresii*), Longfin Smelt (*Spirinchus thaleichthys*), Eulachon (*Thaleichthys pacificus*), and Threespine Stickleback (*Gasterosteus aculeatus*). Long before European settlers arrived, some Native American cultures depended upon these abundant resources. Since the 1850s, major commercial and sport fisheries have existed for some of these fish, leading to high public interest in their conservation.


Threespine Stickleback (*Gasterosteus aculeatus*)

Anadromous fishes hatch in freshwater streams and live there for a few weeks to several years before migrating to the ocean. These fishes typically mature in the ocean and then return to their home streams to reproduce. Life spans range from the Threespine Stickleback, at only one year, to the White Sturgeon, with recorded ages over 100 years. Anadromous fishes spawn in streams with rock or gravel bottoms. Most salmonids and lampreys die after spawning, but steelhead and sturgeon may live to repeat the cycle. All California fish species need clean water and temperatures within their tolerance limits. Juveniles need an adequate food supply in the form of detritus, algae, invertebrates, or small fish; suitable spawning and rearing habitat; and cover to protect them from predators.

Eulachon and Coastal Cutthroat Trout are only found along the upper northern coast in California, at the southern end of their range. Coho Salmon, Chinook Salmon, White and Green Sturgeon, and Longfin Smelt migrate from the Pacific Ocean along the coast of California as far south as the San Francisco


Adult White Sturgeon (*Acipenser transmontanus*)
CDFW photo: Mike Healey

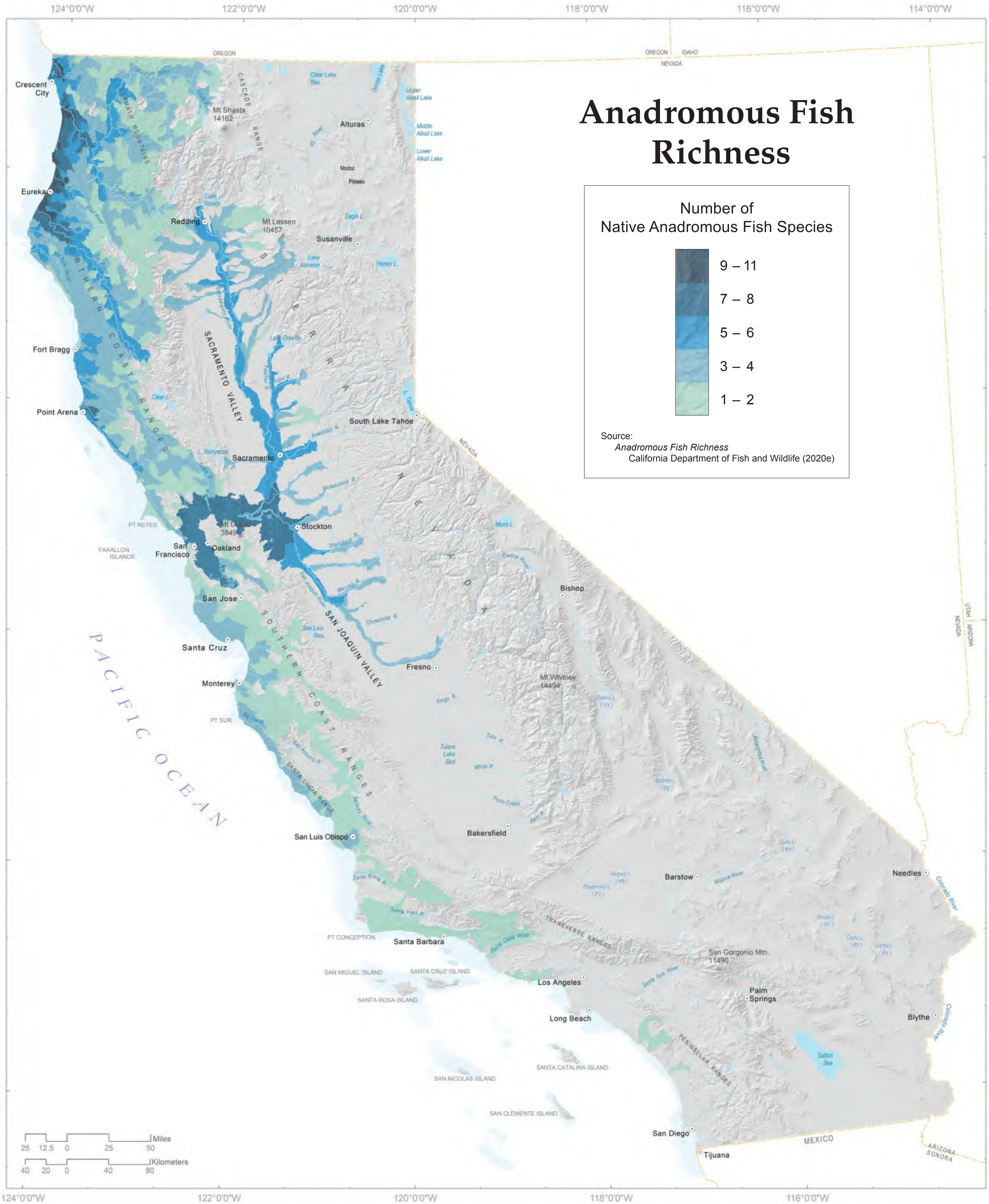
Estuary and the coastal streams around Santa Cruz. Steelhead Trout, Pacific Lamprey, River Lamprey, and Threespine Stickleback are found along the length of coastal California and migrate up many rivers and streams throughout the state. Some anadromous species ranges, like that of Steelhead Trout, extend hundreds of miles inland, using the longer rivers in the Sacramento and San Joaquin valleys for spawning and rearing. The map on the opposite page reflects the various ranges of these fishes.

Since the late 19th century, native fish populations have significantly declined due to overfishing and destruction of habitat. Extensive water and power projects have placed dams on all the major rivers of the state, blocking fish migration. Major water diversions, watershed erosion, and pollution have destroyed or degraded habitat. Even with fish hatcheries, salmon and steelhead numbers have continued to decline and certain major runs have been eliminated or are nearing extinction. Lamprey and sturgeon species have difficulty passing fish ladders designed for salmon, so access to additional historic spawning grounds is blocked (Docker 2015, Moyle 2002).

Maintaining water flows and water quality and continuing to manage fishing activities remain important to the conservation of anadromous species. In the long term, managing genetic diversity is just as important. This includes restoring both the habitat and the local genetic stocks of fish uniquely adapted to occupy that habitat. Small, isolated fish populations must also be protected because they are genetically unique and thus contribute to diversity. Government agencies working cooperatively with private citizens and organizations can help preserve the anadromous fishes of California, contributing to the biodiversity of the state.


Male Chinook Salmon (*Oncorhynchus tshawytscha*) during spawning season

Anadromous Fish Richness



Coast Redwoods

Del Norte Coast Redwoods State Park
Photo: California State Parks, 2020

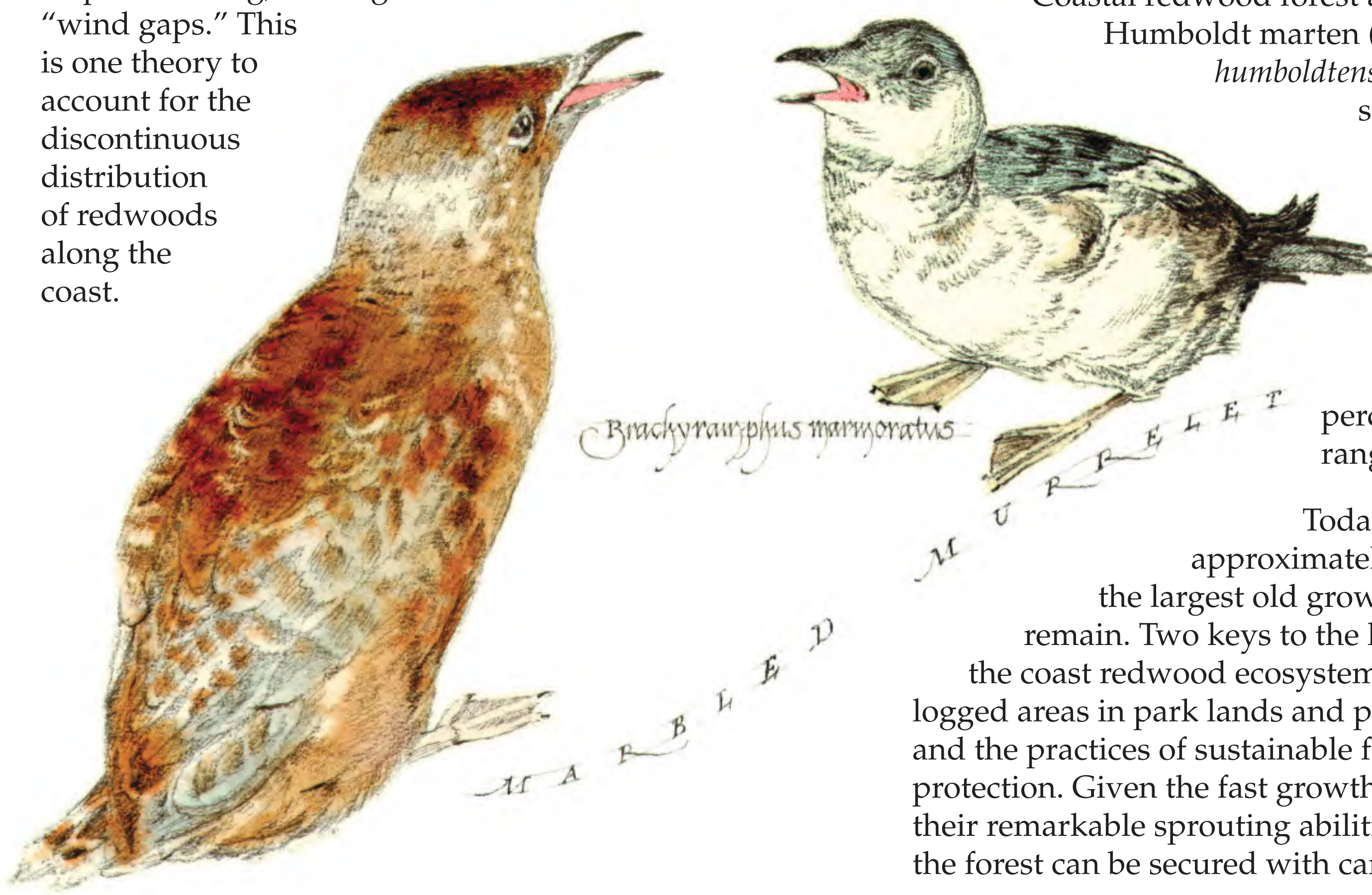
A magnificent contribution to the biodiversity of California is the coast redwood (*Sequoia sempervirens*), known as the world's tallest living tree. Many visitors are awestruck when standing amid old growth giants towering well over 300 feet skyward, with huge bases ranging in diameter from 10 to 25 feet.

Redwoods are remarkably adapted to sprouting new growth after falling, burning, or being cut. Fallen trees even serve as "nursery logs" where seedlings begin their growth in the deep, moist furrows of the long-lasting bark. Redwoods are also extremely long lived. In old growth forests, the average age is about 600 years, with a few trees exceeding 1,500 years.

Coast redwood forest is found only along the coast from southern Oregon to Monterey County. Coastal fog helps provide critical moisture during the drier summer months. Strong winds off major points such as Cape Mendocino and Point Reyes disperse the fog, causing "wind gaps." This is one theory to account for the discontinuous distribution of redwoods along the coast.

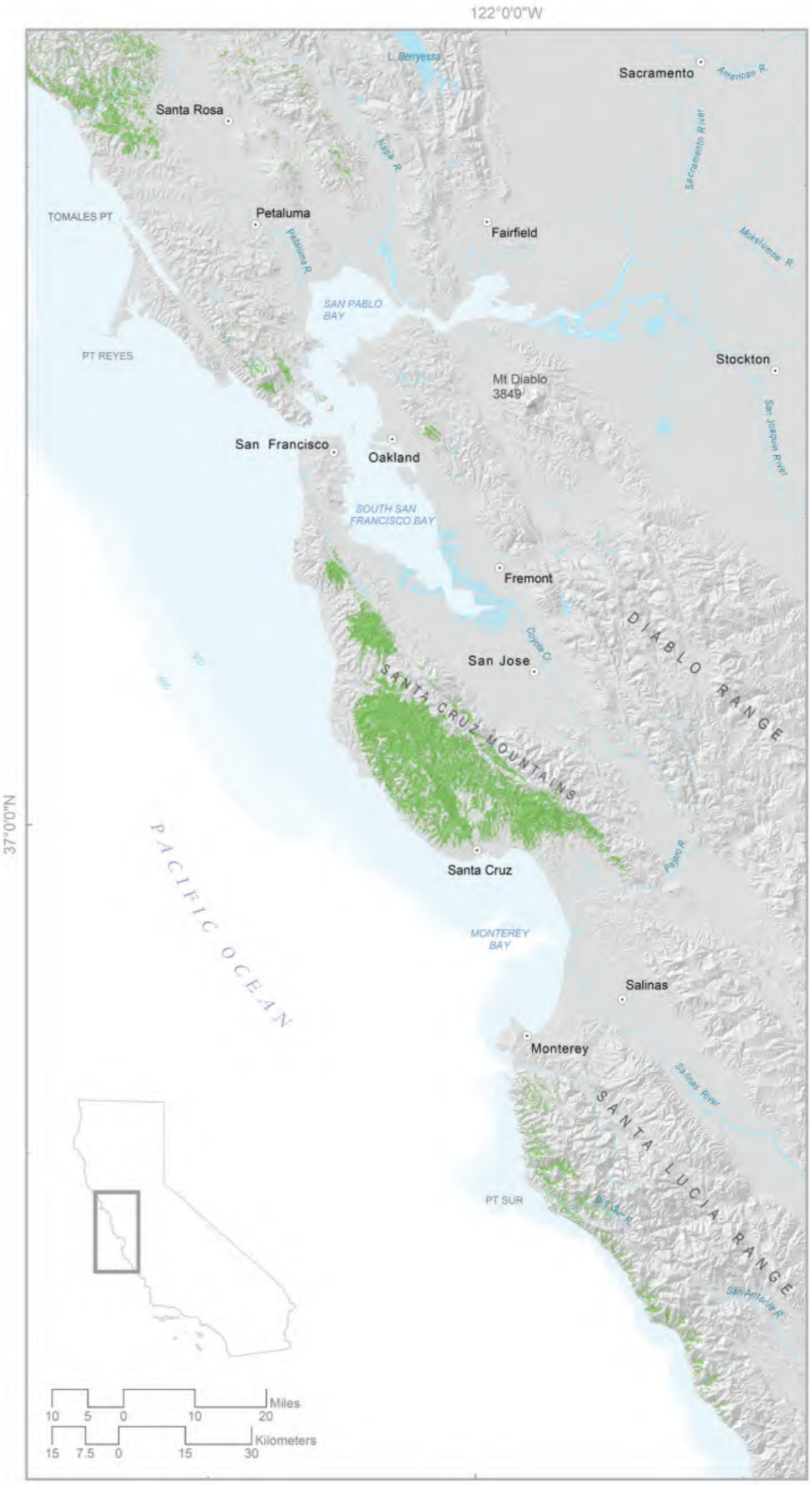
Summer fog is expected to decrease in the future as climate change alters sea surface temperatures (see the Climate Change chapter). This may also impact the distribution of coastal redwood forests.

Some animals occur in higher densities in old growth redwoods than in harvested redwood forests. Examples include Marbled Murrelet (*Brachyramphus marmoratus*), an endangered seabird that nests in redwoods; Southern Torrent Salamander (*Rhyacotriton variegatus*); and Tailed Frog (*Ascaphus truei*). Coastal redwood forest also supports the Humboldt marten (*Martes caurina humboldtensis*). Only two subpopulations of this endangered marten have been observed in the northwest corner of the state, occupying less than seven percent of their historic range within California.



Today, it is estimated that approximately five percent of the largest old growth redwood forests remain. Two keys to the long-term viability of the coast redwood ecosystem are the regrowth of logged areas in park lands and private timber lands, and the practices of sustainable forestry and stream protection. Given the fast growth rate of redwoods and their remarkable sprouting abilities, the biodiversity of the forest can be secured with careful management.

Coast Redwoods



Coastal Redwood Distribution

Sources:
Vegetation – Sonoma County [ds2691]
California Department of Fish and Wildlife (2018a)
Classification and Assessment with Landsat of Visible Ecological Groupings (CALVEG)
U.S. Forest Service (2019)

Note:
Coastal Redwood data for Sonoma County extracted from *Vegetation – Sonoma County*, with the remainder of the state represented by CALVEG.

Oak Woodlands

Valley oak (*Quercus lobata*) woodland with lupines and grasses in Monterey County
Photo © Todd Keeler-Wolf

Oak woodlands are among California's most characteristic wildlife habitats. Scattered oak trees over green or golden brown grass, ranch houses and barns on gently rolling hills, and grazing cattle are typical scenes for many Californians traveling the state's country roads and highways.

Twenty-two species of oaks are found in California (Jepson 2019). They have adapted to fill many niches—from majestic woodlands of widely spreading trees in fertile valleys to tall narrow trees of shady northwestern coastal forests, and from low montane shrubs blanketed by winter snow to highly drought-tolerant shrubs growing adjacent to the hottest and driest of our deserts. Oak-dominated vegetation covers more than eight million acres of the state, ranging in elevation from sea level to over 9,000 feet. Although oaks occupy many important and varied habitats in California, it is our oak woodlands that are iconic.

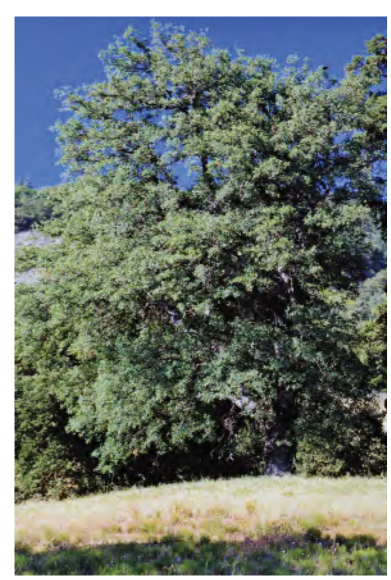
The Acorn Woodpecker (*Melanerpes formicivorus*) derives its name from its acorn collecting habits.
Photo © Timothy Floyd

Woodlands are mostly a mixture of widely spaced trees over grasses and other types of herbaceous vegetation. They are distinguished from forests based on the number of trees and the amount of canopy. Forests are dense, but woodlands have relatively open canopies. The most extensive oak woodlands in California are composed of mixtures of blue oak (*Quercus douglasii*) and interior live oak (*Q. wislizeni*); they occupy the foothills of the Inner Coast Range and the Sierra Nevada. The mixed oak woodlands of the Coast Ranges support among the highest diversity of oaks and resident animals.

California's oak woodlands are home to more than 5,000 species of insects and over 330 species of amphibians, reptiles, birds, and mammals. All oaks produce acorns, often in massive amounts, a rich source of food for many species of animals. Island and California Scrub-Jays (*Aphelocoma insularis*, *A. californica*), the Acorn Woodpecker (*Melanerpes formicivorus*), and other birds depend upon oaks for food. Bears, mule deer, gray squirrels, and other mammals supplement their diets with acorns. Oak woodlands also support more than 1,500 species of plants, nearly 500 of which are rare or of limited distribution.

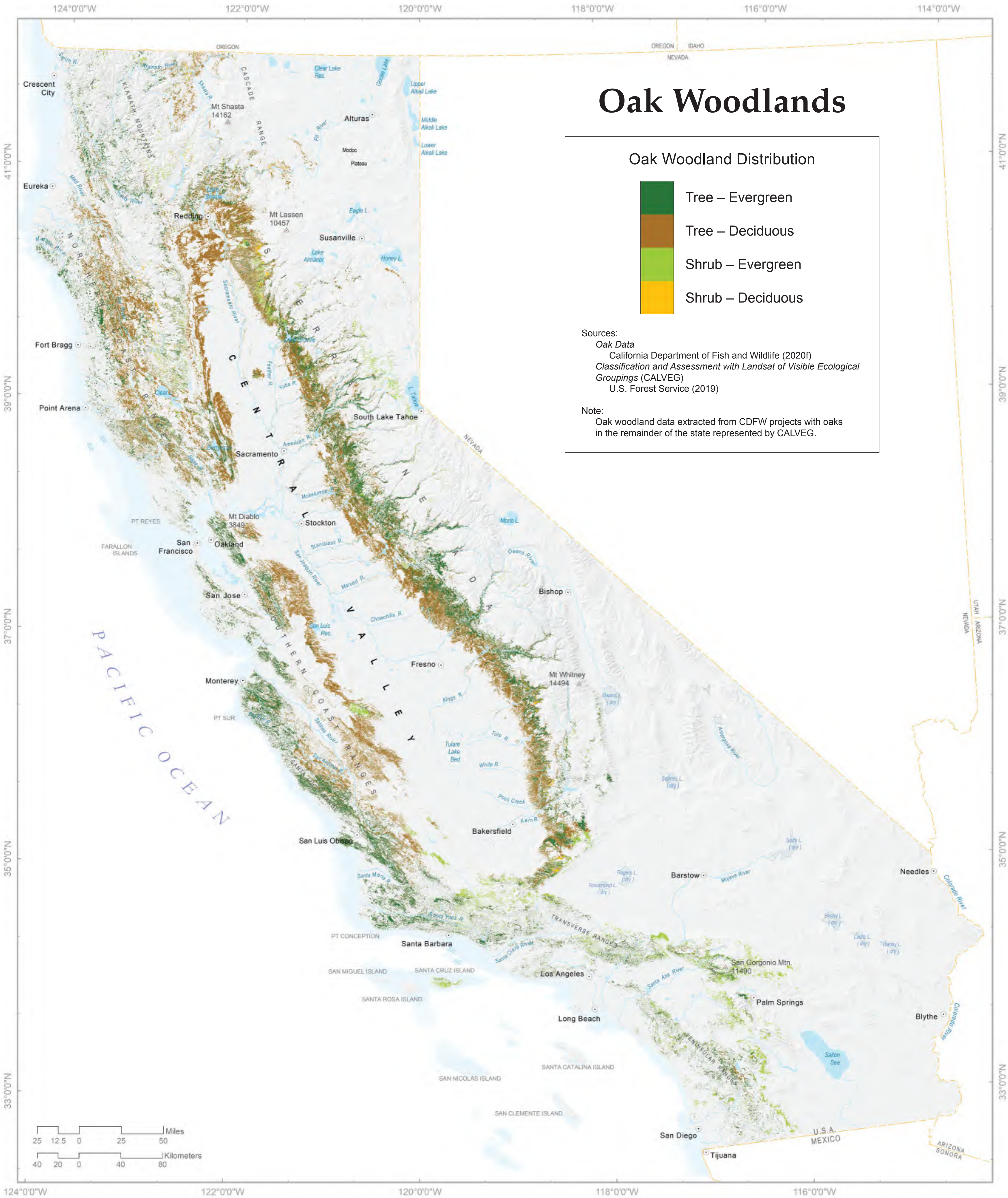
The map on the right shows the ranges of different types of oak-dominated vegetation communities. Iconic winter-deciduous oak woodlands, which drop their leaves in the fall, ring the Central Valley in the low foothills of the Sierra Nevada and Coast Ranges. Evergreen oak trees occupy higher foothills and mountain valleys. Shrub oaks are found adjacent to the deserts and at the highest elevations.

Canyon live oak (*Quercus chrysolepis*) forms a dense woodland on steep slopes above the Yuba River, Placer County.
Photo © Todd Keeler-Wolf



Engelmann oak (*Quercus engelmannii*) from the inland parts of San Diego County and adjacent counties of Southern California
Photo © Todd Keeler-Wolf

Oak Woodlands



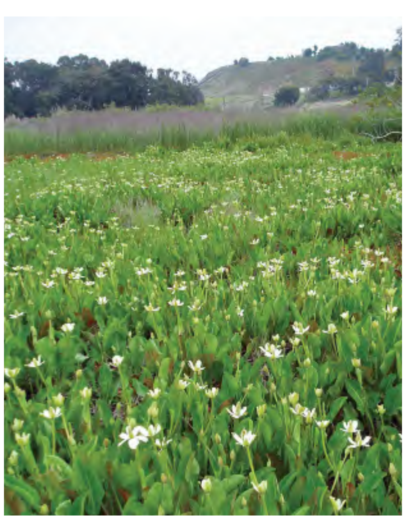
Wetlands and Riparian Habitats

Riparian woodland of California sycamore (*Platanus racemosa*) contrasts with drier upland oak woodland, Arroyo Seco, Santa Lucia Mountains. Photo © Todd Keeler-Wolf

Broadly characterized, California is a dry state. This condition is most noticeable during the seasonal drought of late spring to mid fall when the hills of grass are straw colored and many of the streambeds are without surface water. Notable exceptions to the “summer gold” of the hills and valleys are the riparian zones of the larger streams and rivers and the perennial wetlands associated with springs, lakes, and ponds.

Californian wetlands vary enormously in wetness. Many are flooded throughout the growing season and consist of lush green cattails, tules, and rushes. Others are only seasonally wet (see the Vernal Pools chapter), and some, such as desert playas, are ephemerally watered in rare precipitation events. Some wetlands appear dry but are kept moist below the surface for much of the year by groundwater. California’s riparian forests and thickets are made up of water-dependent alders, cottonwoods, sycamores, and willows. Riparian and wetland habitats are frequently juxtaposed in California.

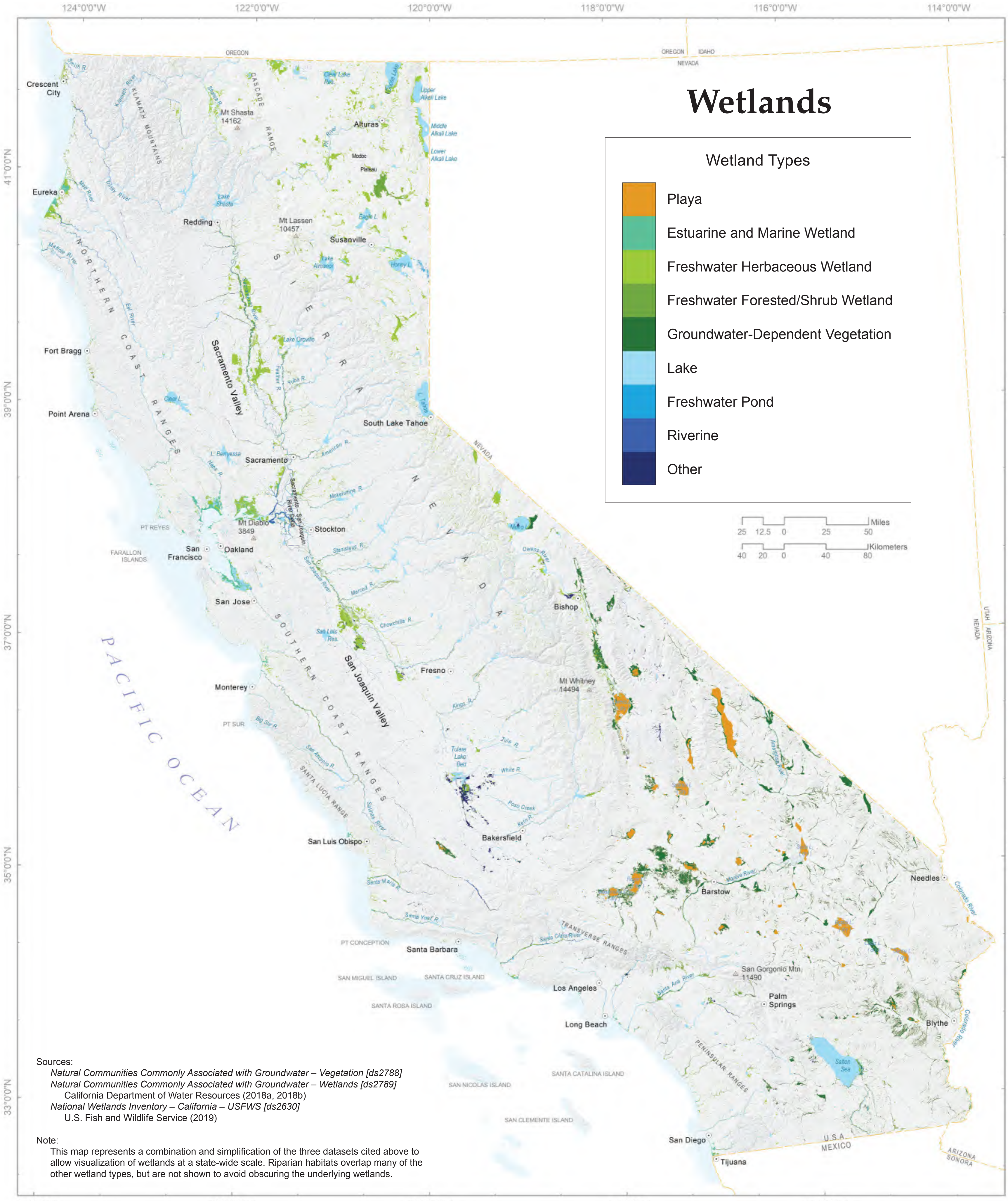
Wetland conditions vary greatly, from chemically harsh springs and ponds of desert basins to lush, flowery alpine meadows and fens. Wetlands of the coastal and interior salt marshes are inhabited by specially adapted plant species that tolerate salts by concentrating them, like pickleweed (*Salicornia pacifica*), or extruding them, like saltgrass (*Distichlis spicata*). Some animal species, such as Ridgeway’s Rail (*Rallus obsoletus*) and the salt-marsh harvest mouse (*Reithrodontomys raviventris*), are only found in these environments. Riparian and wetland vegetation provide a rich source of food for many animal species. Yellow-billed Cuckoo (*Coccyzus americanus*), Least Bell’s Vireo (*Vireo bellii pusillus*), and Willow Flycatcher (*Empidonax traillii*) are among the California birds highly restricted to riparian and freshwater wetland vegetation. The shade cast by riparian vegetation helps maintain cool temperature of streams and rivers, important to the health and productivity of aquatic animals from caddisflies to Chinook Salmon (*Oncorhynchus tshawytscha*). Riparian areas and wetlands also provide buffers to the catastrophic effects of flooding by retaining soil, encouraging the deposition of sediment, forming natural protective levees, and acting as chemical filters.



Yerba mansa (*Anemopsis californica*) at Ballona wetlands, Los Angeles County CDFW Photo: Todd Keeler-Wolf

Our wetlands and riparian habitats are highly limited, as shown on the map, but they are also highly diverse and productive ecosystems. Although the acreage is small, the diversity of species within these habitats is disproportionately high.

As a result of water’s importance to our thirsty society, California’s riparian and wetland vegetation have been decimated. Dams have reduced or eliminated the natural flooding cycles important to the regeneration of many kinds of riparian and wetland plants. Riparian vegetation has been physically removed and replaced by concrete embankments and levees maintained for flood control. Former natural channels have been replaced by tunnels and culverts. Groundwater pumping has reduced or eliminated groundwater-dependent ecosystems. Huge areas of the southern San Joaquin Valley and the Sacramento-San Joaquin River Delta that were once seasonally flooded and covered with a patchwork of tule marshes, swamps, vernal pools, riparian forests, and woodlands are now converted to agriculture. Loss of wetland and riparian habitat since European colonization of California is estimated to be 90 percent.



Sources:
Natural Communities Commonly Associated with Groundwater – Vegetation [ds2788]
Natural Communities Commonly Associated with Groundwater – Wetlands [ds2789]
California Department of Water Resources (2018a, 2018b)
National Wetlands Inventory – California – USFWS [ds2630]
U.S. Fish and Wildlife Service (2019)

Note:
This map represents a combination and simplification of the three datasets cited above to allow visualization of wetlands at a state-wide scale. Riparian habitats overlap many of the other wetland types, but are not shown to avoid obscuring the underlying wetlands.

Vernal Pools

Sonoma sunshine (*Blennosperma bakeri*)
CDFW photo: Annie Chang

Vernal pools are seasonal wetlands that form in depressions in the soil surface. Because these depressions occur over an impermeable soil or rock layer, they hold rainwater longer than the surrounding terrain—long enough for unique plants and animals to thrive there. Vernal pools are known to occur in parts of the world that, like California, have a Mediterranean climate and areas of impermeable subsurface layers. Other parts of the world where vernal pools are known to occur include Chile and Western Australia.

California has one of the most extensive distributions of vernal pools known in the world. They are found throughout the state, from the Modoc Plateau in the northeast to the mesas of the south coast near San Diego. The map at right shows the distribution of vernal pool complexes in California. While vernal pool complexes of the valley and foothill grasslands of Central California are well known, vernal pools are also embedded in a variety of other natural communities, including shrublands and forests. For example, on the Modoc Plateau, the Devil's Garden vernal pool complex is surrounded by sagebrush scrub and juniper woodland. Many San Diego vernal pools are in chamise chaparral and coastal sage scrub habitats (Keeler-Wolf et al. 1998).

Vernal pools support plants and animals adapted to unique living conditions, which range from very wet to very dry each year. In the winter, pools become the watery home of shrimp, toads, and aquatic plants. In the spring, as the water begins to recede, colorful wildflowers bloom in concentric rings and attract ground-dwelling pollinator bees from the uplands nearby. As summer approaches, the pools begin to dry out. Plants tolerant of drier conditions emerge, dried eggs of fairy and tadpole shrimp fall into cracks in the mud, and spadefoot toads take to their burrows to await the next winter rains.

Golden flowers bloom in a vernal pool located at Flying M Ranch in Merced County. Mima mounds can be spotted in the back.
Photo © Kristi Lazar

Del Mar Mesa in San Diego County
CDFW photo: Jason Price

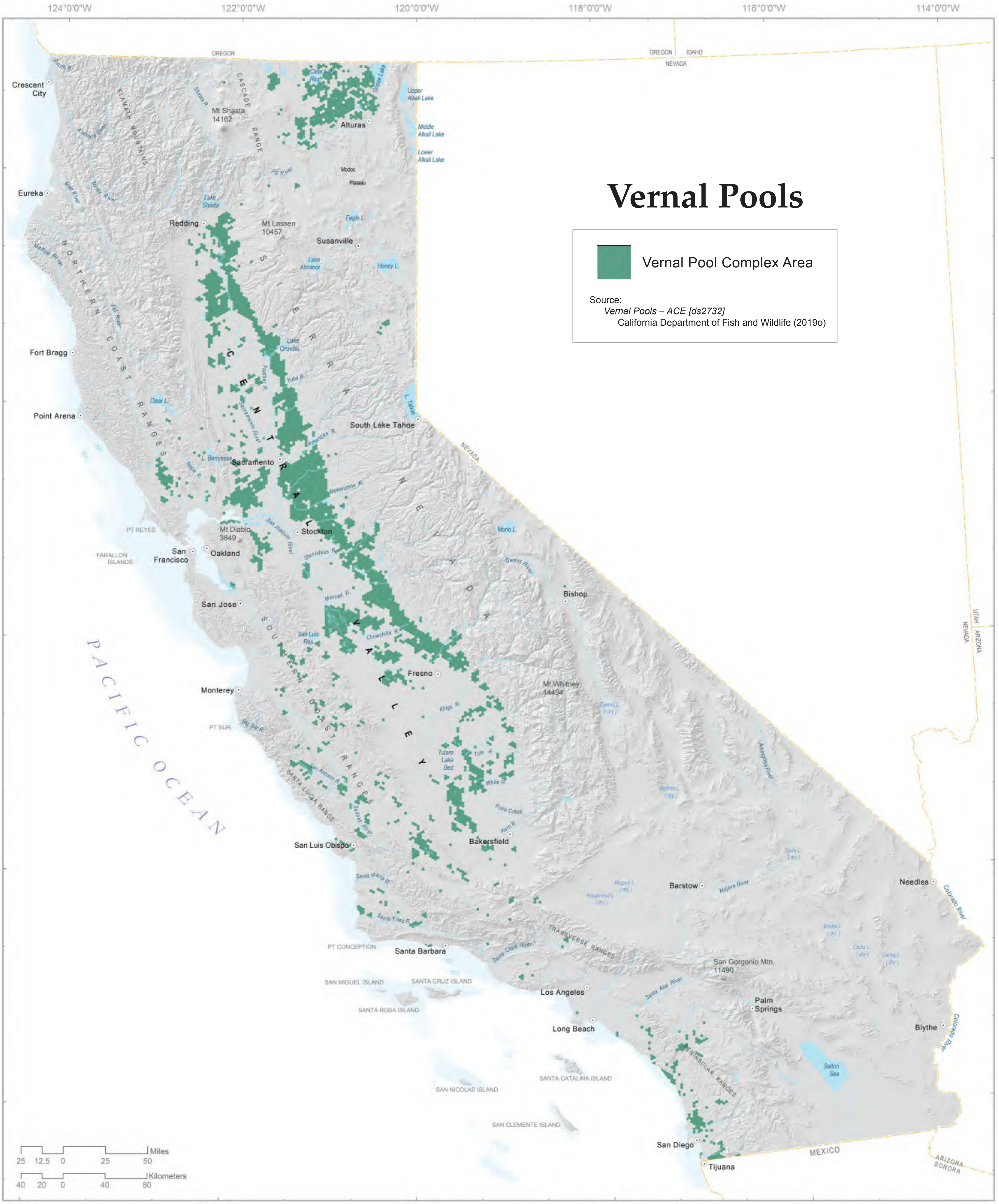
San Diego fairy shrimp (*Branchinecta sandiegonensis*)
Photo: Joanna Gilkeson, USFWS

Many vernal pool plant and animal species are endemic to a local region and are often designated by federal and state government as rare, threatened, or endangered. Typical species include varieties of minty-scented herbs (*Pogogyne* spp.), lemon-scented annual grasses (*Orcuttia* spp.), and delicate fairy shrimp (*Branchinecta* spp.). Another iconic inhabitant is the endangered California tiger salamander (*Ambystoma californiense*).

It is estimated that California's Central Valley alone once had four million acres of vernal pool habitat, which includes the pools themselves and the uplands around them. Today the Central Valley supports just under 770 thousand acres of vernal pool habitat. This loss is largely attributed to urban development and farming, which continue to threaten California's remaining vernal pools.

Otay Mesa mint (*Pogogyne nudiuscula*)
Photo: John Martin, USFWS

Vernal Pools



Trout

California Golden Trout (*Oncorhynchus mykiss aguabonita*) from Big Whitney Meadow shows the characteristic golden yellow body, orange stomach, and red lateral line.
CDFW Photo: Heritage and Wild Trout Program

Coastal Rainbow Trout (*Oncorhynchus mykiss irideus*) from Agua Blanca Creek displays plentiful spots on the body, white edges on the fins, and two eye spots.
CDFW Photo: Heritage and Wild Trout Program

California supports native trout taxa that occupy most cold, clean, freshwater ecosystems across the state. Their ability to adapt to the changes in climate and landscape over California's geologic history has resulted not only in a wide spectrum of trout diversity but one that represents a great range in color and beauty. As California's mountain ranges experienced bouts of uplift, volcanic episodes, and glaciation over time, ancestral trout populations became isolated and cut off from future hybridization (Behnke 1992). This has resulted in distinct groups of trout, representing a minimum of eleven forms that persist today, six of which are endemic to California. These groups include the golden trout of the Kern Plateau, redband trout in remote desert basins of Northern California and the McCloud River, divergent cutthroat trout in the eastern Sierra and in coastal redwood forests, and Coastal Rainbow Trout (*Oncorhynchus mykiss irideus*) that call most of the state's waters their home.

Periodic connection of the Kern River to the Central Valley via Tulare Lake allowed ancient lineages of trout to colonize the Kern River Basin. Subsequent geologic events created physical barriers to upstream fish movement that isolated these populations. Different evolutionary paths ultimately led to three different subspecies: California Golden Trout (*O. m. aguabonita*), Little Kern Golden Trout (*O. m. whitei*), and Kern River Rainbow Trout (*O. m. gilberti*).

Paiute Cutthroat Trout (*Oncorhynchus clarkii seleniris*) from Silver King Creek, showing the nearly spotless body and striking iridescent purplish hue that is characteristic of this trout. This unique species is considered one of the rarest trout in the world.
CDFW Photo: Heritage and Wild Trout Program

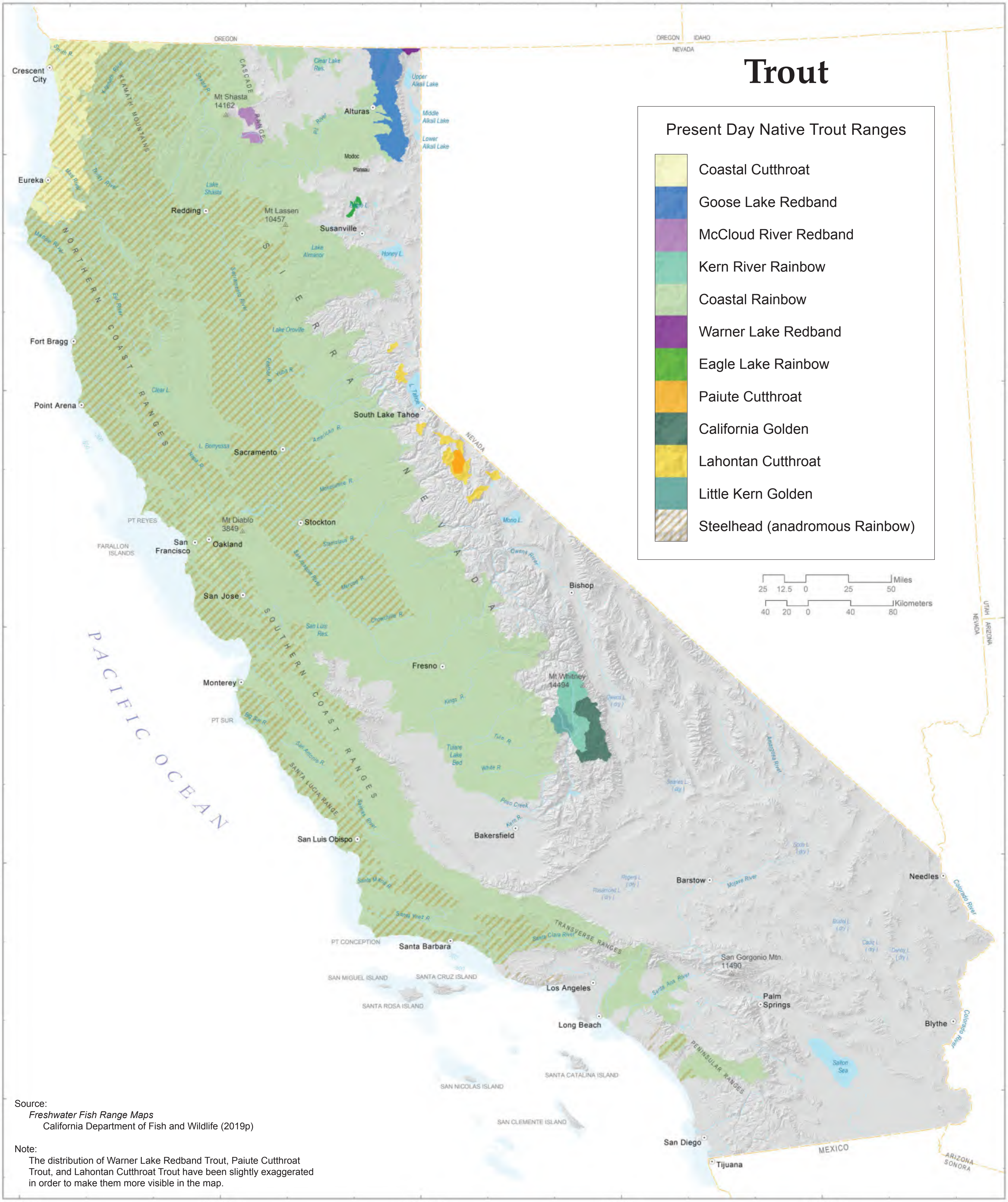
California has three subspecies of cutthroat trout, which are found in two drastically different parts of the state: Coastal Cutthroat Trout (*O. clarkii clarkii*), Lahontan Cutthroat Trout (*O. c. henshawi*), and Paiute Cutthroat Trout (*O. c. seleniris*).

Coastal Cutthroat Trout live with Coastal Rainbow Trout in temperate rainforests, where Chinook and Coho Salmon are an important food source. Lahontan Cutthroat Trout evolved—along with a suite of other native fishes—in the ancient Lahontan basin. Lake Lahontan was a large lake system that covered much of western Nevada and extended into California during the Pleistocene epoch, then contracted following the Ice Age. Lahontan Cutthroat Trout's native waters in California are the Susan, Truckee, Carson, and Walker river drainages. Paiute Cutthroat Trout evolved from the Lahontan Cutthroat Trout in the upper reaches of Silver King Creek in the Carson River watershed.

Lahontan Cutthroat Trout (*Oncorhynchus clarkii henshawi*) from Wolf Creek, has pink and yellow body coloration, large plentiful spots, and distinct parr marks that are characteristic of the fluvial form of this trout.
CDFW Photo: Heritage and Wild Trout Program

Northern California's complex of redband trout showcases a history of isolation due to a reduction of Pleistocene-era waterbodies and geologic events. The McCloud River Redband Trout (*O. m. stonei*) in Northern California are descendants of ancestral redbands that reached the McCloud River through the Sacramento River and were eventually isolated by the development of large waterfalls. Eagle Lake Rainbow Trout (*O. m. aquilarum*) are genetically distinct from Coastal Rainbow Trout and other redband trout of northeastern California. Two additional forms of redband trout occupy desert basins in far northeastern California: Goose Lake Redband Trout (*O. m. ssp.*) and Warner Lakes Redband Trout (*O. m. ssp.*). Understanding of the biodiversity of California's redband trout should improve with more research on these interior trout forms.

For further reading regarding California's native trout, please see California Department of Fish and Wildlife's "An Angler's Guide to the California Heritage Trout Challenge."


Trout
Present Day Native Trout Ranges
Coastal Cutthroat
Goose Lake Redband
McCloud River Redband
Kern River Rainbow
Coastal Rainbow
Warner Lake Redband
Eagle Lake Rainbow
Paiute Cutthroat
California Golden
Lahontan Cutthroat
Little Kern Golden
Steelhead (anadromous Rainbow)
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
Sacramento
South Lake Tahoe
Stockton
San Francisco
Oakland
San Jose
Mt Diablo 3849
Bishop
Fresno
Monterey
Mt Whitney 14494
Bakersfield
San Luis Obispo
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
San Gorgonio Mtn. 11490
Palm Springs
Blythe
San Diego
Tijuana
NORTHERN COAST RANGES
SIERRA NEVADA
SOUTHERN COAST RANGES
TRANSVERSE RANGES
PENINSULAR RANGES
SANTA LUCIA RANGE
KLAMATH MOUNTAINS
CASCADE RANGE
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Source:
Freshwater Fish Range Maps
California Department of Fish and Wildlife (2019p)
Note:
The distribution of Warner Lake Redband Trout, Paiute Cutthroat Trout, and Lahontan Cutthroat Trout have been slightly exaggerated in order to make them more visible in the map.

Mojave Desert


Joshua trees (*Yucca brevifolia*) in Joshua Tree National Park

Although considered the smallest North American desert, the Mojave Desert is the largest in California. It stretches over approximately one fifth of the state and extends into southwestern Utah and northwestern Arizona. The Mojave epitomizes much of what we consider to be the true desert of the American southwest. It is home to such desert icons as the Joshua tree (*Yucca brevifolia*), desert tortoise (*Gopherus agassizii*), desert bighorn sheep (*Ovis canadensis nelsoni*), Death Valley, and the lower reaches of the Grand Canyon of the Colorado River. The Mojave Desert is rich and varied, known for its stark beauty, rugged topography, and high biological diversity. For example, there are an estimated 1,400 native plant taxa in the Mojave Desert region of California, 40 of which are endemic to the state (Baldwin et al. 2002).


Mojave fringe-toed lizard (*Uma scoparia*)
Photo: U.S. National Park Service

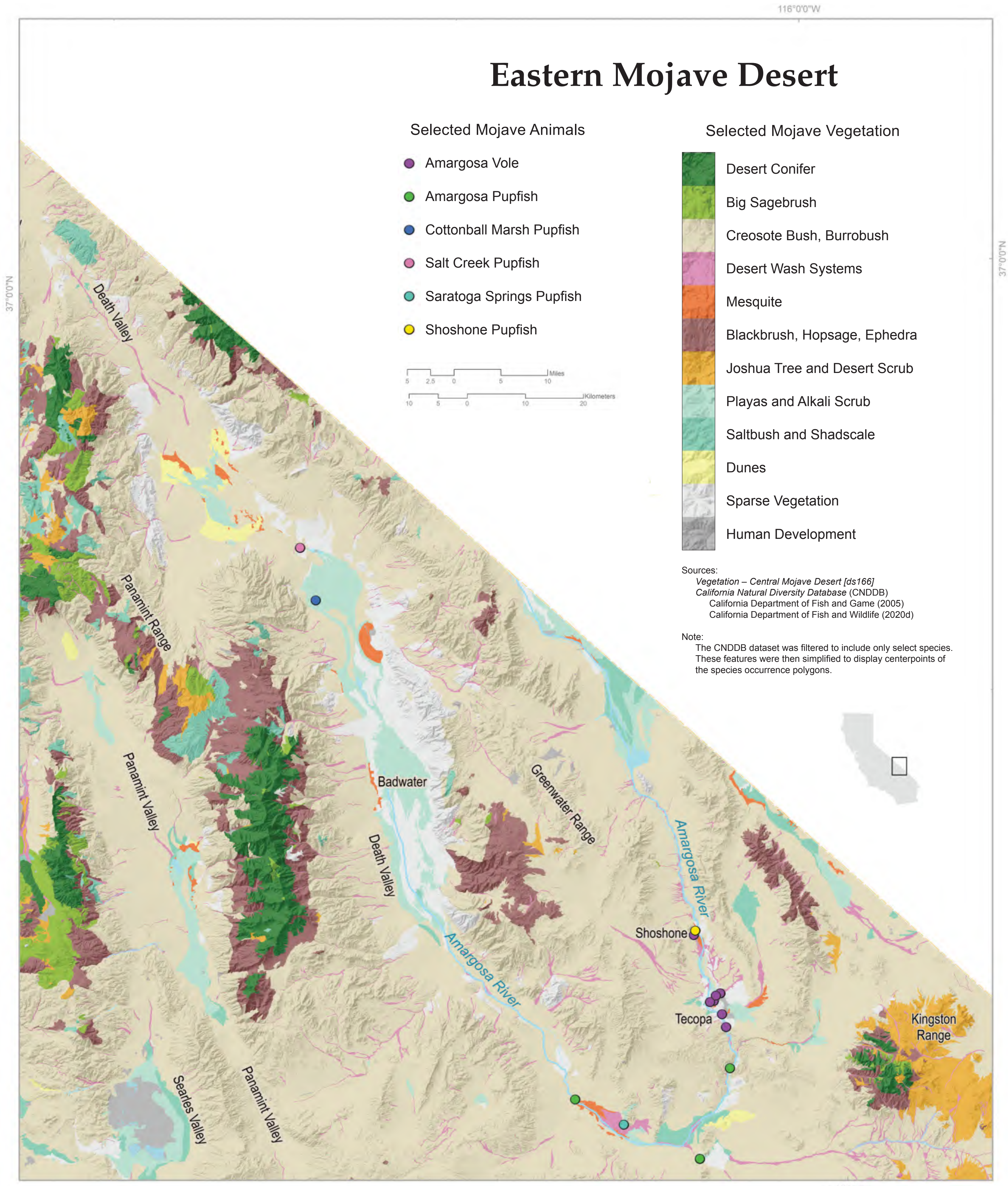
The Mojave is a transitional desert lying midway between the cool Great Basin Desert to the north and the hot Sonoran Desert to the south. Alluvial fans and basins comprise much of the landscape of the Mojave Desert, with silt and sand forming skirts around the mountains and filling much of the basins. The alluvial fans are typically vegetated with creosote bush (*Larrea tridentata*)–burrobush (*Ambrosia dumosa*) scrub. The basins are vegetated with various salt-tolerant species. In some cases, the basins are so salty that no vegetation grows, and only remarkably flat playas and blinding white salt deposits exist. Lava outcroppings and more than a dozen dune systems occur in the Mojave. Many of the dunes are occupied by unusual plant and animal species such as Eureka dune grass (*Swallenia alexandrae*) and the Mojave fringe-toed lizard (*Uma scoparia*). Higher elevations may receive snow in the winter and support singleleaf pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus osteosperma*), with limber pine (*Pinus flexilis*) and bristlecone pine (*Pinus longaeva*) at the highest elevations.

Due to climatic differences, western Mojave habitats differ from those to the east. In the western Mojave, one can find many winter annual herbs such as desert coreopsis (*Coreopsis bigelovii*), goldfields (*Lasthenia californica*), and California poppy (*Eschscholzia californica*). These and many other plants present spectacular wildflower displays in years with ample winter rainfall. The state-threatened and endemic Mohave ground squirrel (*Xerospermophilus mohavensis*) is also found here. To the east, where summer rains frequently occur, certain succulents such as Utah agave (*Agave utahensis*), Spanish bayonet (*Yucca baccata*), Mojave yucca (*Yucca schidigera*), and grasses such as big and little galleta (*Pleuraphis rigida* and *P. jamesii*) are common.

The Amargosa River starts near Beatty, Nevada and flows southerly into California before making a u-turn to terminate in the Badwater Basin of Death Valley (see map). It flows mostly underground, fed by groundwater and springs, but surfaces near the towns of Shoshone and Tecopa. These surface waters and scattered springs represent oases in an otherwise parched landscape. They support a variety of plants and animals, many of which are endemic to the region, including five of California's remaining seven pupfishes (*Cyprinodon* spp.), Amargosa speckled dace (*Rhinichthys osculus nevadensis*), and the endangered Amargosa vole (*Microtus californicus scirpensis*).


Salt Creek pupfish (*Cyprinodon salinus*)
Photo: U.S. National Park Service

Because the Mojave Desert is so close to major metropolitan areas, such as the Los Angeles Basin, and includes several rapidly growing cities, the once wild and unpopulated Mojave is now compromised by the influences of civilization, including recreation and renewable energy development. Careful planning and management will be required to sustain the fascinating and fragile ecosystems of the Mojave Desert.



116°0'0"W
Eastern Mojave Desert
Selected Mojave Animals
Amargosa Vole
Amargosa Pupfish
Cottonball Marsh Pupfish
Salt Creek Pupfish
Saratoga Springs Pupfish
Shoshone Pupfish
Selected Mojave Vegetation
Desert Conifer
Big Sagebrush
Creosote Bush, Burrobush
Desert Wash Systems
Mesquite
Blackbrush, Hopsage, Ephedra
Joshua Tree and Desert Scrub
Playas and Alkali Scrub
Saltbush and Shadscale
Dunes
Sparse Vegetation
Human Development
Miles
5 2.5 0 5 10
Kilometers
10 5 0 10 20
Sources:
Vegetation – Central Mojave Desert [ds166]
California Natural Diversity Database (CNDDB)
California Department of Fish and Game (2005)
California Department of Fish and Wildlife (2020d)
Note:
The CNDDB dataset was filtered to include only select species.
These features were then simplified to display centerpoints of
the species occurrence polygons.
37°0'0"N
37°0'0"N
Death Valley
Panamint Range
Panamint Valley
Badwater
Death Valley
Greenwater Range
Amargosa River
Amargosa River
Shoshone
Tecopa
Kingston Range
Searles Valley
Panamint Valley
116°0'0"W

Central Valley Grassland Habitat

California's Central Valley grasslands are an important part of the state's rich natural heritage. Spanning about 450 miles north to south and connecting the Sierra Nevada with the inner Coast Ranges east to west, the Central Valley is the heart of California and supports grasslands covering almost 20 percent of California's valley land base.

For the Central Valley, the general term "grasslands" describes a mosaic of remnant native and extensive non-native or introduced plant communities. Many early accounts of the California Central Valley describe vast, colorful wildflower fields in the spring turning to dry fields of grasses in late summer (Paddison 1999). Today, Central Valley grasslands are dominated by agricultural lands and introduced species, but still retain some of the herbaceous components that historically defined these systems (Sawyer et al. 2009, Schoenherr 2017). The map to the right shows the extent of current grassland vegetation types and illustrates both the distribution and fragmentation of grasslands in the Central Valley.

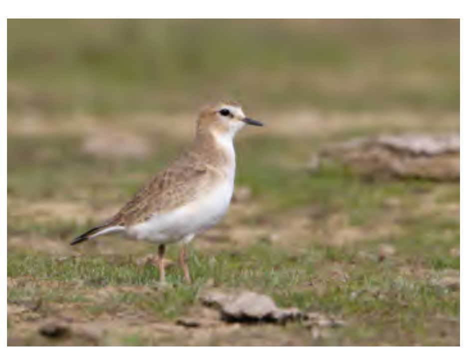
Kern mallow (*Eremalche kernensis*)
CDFW Photo: Kristi Lazar

Despite these changes, Central Valley grasslands continue to host a surprising biodiversity. Thousands of insect species, hundreds of plant species, and dozens of bird, mammal, and reptile species use the remaining prairie as habitat. The unique geography and plant communities of the Central Valley are also a foundation for key ecosystem services that are essential to the human population. Parts of the Central Valley grassland mosaic provide natural water filtration and support native pollinators essential to both agriculture and California's rich native biodiversity, although at a fraction of their historical levels.

The grasslands are home to several special status species. Some threatened or endangered species, like the Blunt-nosed Leopard Lizard (*Gambelia sila*), are highly adapted to the soils and vegetation of the original valley floor and are almost entirely dependent on remaining habitat remnants. Others, like the Mountain Plover (*Charadrius montanus*) and Swainson's Hawk (*Buteo swainsoni*) have adapted to agricultural land uses that in some ways mimic historic Central Valley grassland conditions. Similarly, several endangered plant species like the California jewelflower (*Caulanthus californicus*), Hoover's wooly-star (*Eriastrum hooveri*), and Kern mallow (*Eremalche kernensis*) are part of the once extensive and highly adapted shrub-grassland complex of the southern San Joaquin Valley. About one quarter of all Species of Special Concern (those often most declining or vulnerable) also use Central Valley grasslands as breeding, foraging, or migratory habitat.

Swainson's hawk (*Buteo swainsoni*)

The Central Valley provides an ideal setting for urban, agricultural, and other land uses. As a result, only about 17 percent of the original Central Valley grasslands exist today compared to pre-European settlement times (Schoenherr 2017). This loss, the degradation of remaining native ecosystems, and the intensifying effects of climate change exert pressure on native plant and wildlife populations, driving some to near extinction. However, major habitat restoration and land conservation efforts, either currently underway or completed in the last two decades, provide hope that Central Valley grasslands and the species that depend upon them will be part of California's natural heritage future.



Mountain plover (*Charadrius montanus*)


Central Valley Grassland Habitat
Grasslands
Source:
Vegetation – Great Valley Ecoregion [ds2632]
California Department of Fish and Wildlife (2018b)
Note:
Data has been filtered to include only grassland habitat types.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
39°0'0"N
37°0'0"N
35°0'0"N
Redding
Mt Lassen
10457
Susanville
Eagle L.
Lake Almanor
Honey L.
Fort Bragg
Point Arena
Clear L.
Eel River
Sacramento River
Lake Oroville
Feather R.
Yuba R.
L. Tahoe
South Lake Tahoe
Sacramento
American R.
L. Berryessa
Napa R.
Mokelumne R.
NORTHERN COAST RANGES
SIERRA NEVADA
CENTRAL VALLEY
NEVADA
PT REYES
FARALLON ISLANDS
Mt Diablo
3849
Stockton
San Francisco
Oakland
Stanislaus R.
Mono L.
Owens River
San Joaquin River
Merced R.
Bishop
San Jose
Chowchilla R.
San Luis Res.
SOUTHERN COAST RANGES
Fresno
Monterey
Mt Whitney
14494
Owens L. (dry)
Kings R.
PT SUR
Big Sur R.
Tule R.
Tulare Lake Bed
White R.
San Antonio R.
SANTA LUCIA RANGE
Salinas River
Poso Creek
Kern R.
Bakersfield
San Luis Obispo
PACIFIC OCEAN
Santa Maria R.
Rogers L. (dry)
Rosamond L. (dry)
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Threats to Biodiversity

California's biodiversity faces many pressures. Most are linked to supporting the state's large and growing human population. Threats to biodiversity are mainly due to the direct loss of habitat. In addition, fragmentation of habitat by developed infrastructure obstructs the movement of fish and wildlife and restricts their access to what habitat remains. A burgeoning population also places heightened demands on water, raises pollution, and increases the introduction of invasive plants and animals. Another growing threat to biodiversity comes from the rapidly changing climate, which in California means further reductions in water availability, rising sea levels, and more frequent extreme weather and wildfire events.

Human Population and Land Use

Habitat loss and fragmentation due to human population growth present the greatest problem facing native plants and animals in California. As of January 1, 2020, the state's population was estimated at 39.8 million people (CDOF 2020). The 15 counties bordering the Pacific Ocean account for 54 percent of the population, with 42 percent residing in Los Angeles, Orange, and San Diego counties alone. The nine-county San Francisco Bay Area accounts for almost 20 percent, as shown on the inset map to the right. The state's population will likely increase by approximately 5.2 million and reach 45 million people by 2060 (CDOF 2020). Most of the additional people will concentrate in the South Coast, San Francisco Bay, Central Valley, and inland Southern California areas. However, the rate of growth by county is expected to shift inland. The counties of Merced, Yuba, Placer, Sutter, and Butte are expected to increase over 45 percent during this period.

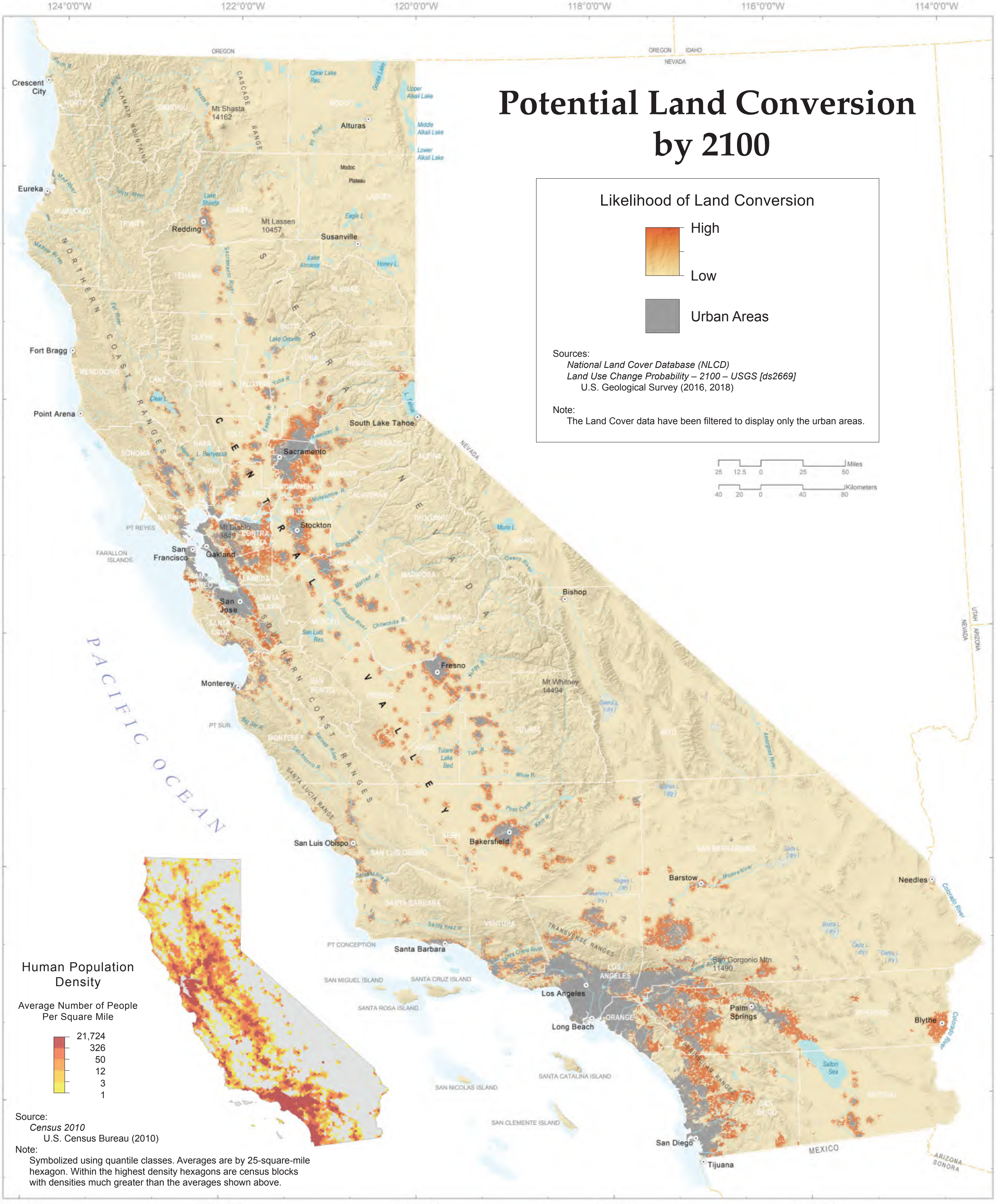
Human population growth creates new demands for housing, roads, jobs, schools, water, energy, and other infrastructure. Expansion of these services converts natural habitat and open space into highly modified landscapes, resulting in the fragmentation of habitat and the loss of native plants and animals.

Existing urban areas typically see the largest population increases in California. Such increases in existing cities generally do not result in great losses of natural habitat acreage. The increases are absorbed through infill projects or expansion along the city edges and the required large-scale infrastructure is usually already in place. However, local endemic species may be greatly affected as their remaining habitat areas are developed or subjected to an increasing human presence. The boundaries where natural areas and built landscapes meet is referred to as the wildland-urban interface. Here species and habitat are subjected to pressures such as disturbance from recreation, fire prevention, pest control, and urban runoff. Many of the state's imperiled species are found in proximity to urban areas, as illustrated in the map on page 3.

It is the rapid population growth in California's more rural areas—the Central Valley, Sierra Nevada foothills, and Southern Coast Ranges—that presents a more troubling trend for native plants and animals. These areas are likely to have housing densities much lower than in the major cities. The combination of high population growth in rural areas and expected low housing densities means that substantially more land presently in natural habitat will be converted to housing. Rural areas generally lack the infrastructure to handle the growth. Consequently, new residential and industrial development requires transportation, water, sewer, and other services to be greatly expanded or newly built, aggravating the impact on habitat. If California stays the course, natural lands are expected to decline at a rate of 54 square miles per year for the remainder of the century. Inland Southern California is projected to show the highest rate of net increase in developed area, followed by counties in coastal Southern California, the Central Valley, and the Bay Area (Sleeter et al. 2017).

The maps in the remainder of this section illustrate the effects humans and infrastructure have on the biodiversity of California.

A highly modified landscape causes fragmentation of the San Elijo Lagoon on the Southern California coast.
CDFW photo: Tim Dillingham


Potential Land Conversion by 2100
Likelihood of Land Conversion
High
Low
Urban Areas
Sources:
National Land Cover Database (NLCD)
Land Use Change Probability – 2100 – USGS [ds2669]
U.S. Geological Survey (2016, 2018)
Note:
The Land Cover data have been filtered to display only the urban areas.
Miles 25 12.5 0 25 50
Kilometers 40 20 0 40 80
Human Population Density
Average Number of People Per Square Mile
21,724
326
50
12
3
1
Source:
Census 2010
U.S. Census Bureau (2010)
Note:
Symbolized using quantile classes. Averages are by 25-square-mile hexagon. Within the highest density hexagons are census blocks with densities much greater than the averages shown above.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
CENTRAL VALLEY
SIERRA NEVADA
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
CASCADE RANGE
KLAMATH MOUNTAINS
TRANSVERSE RANGES
SANTA LUCIA RANGE
PENINSULAR RANGES
Modoc Plateau
Crescent City
Mt Shasta 14162
Alturas
Eureka
Redding
Mt Lassen 10457
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Bishop
Fresno
Monterey
Mt Whitney 14494
San Luis Obispo
Bakersfield
Barstow
Needles
Santa Barbara
San Gorgonio Mtn. 11490
Los Angeles
Long Beach
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Colorado River

Human-Wildlife Conflict

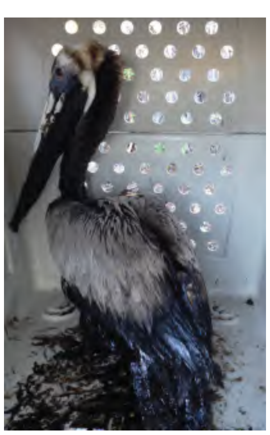
Federally endangered Peninsular bighorn sheep (*Ovis canadensis nelsoni*) graze a golf course adjacent to their natural habitat. Maintained landscapes can provide an attractive year-round food source for wildlife, which can have positive and negative effects for both humans and wildlife.
CDFW photo

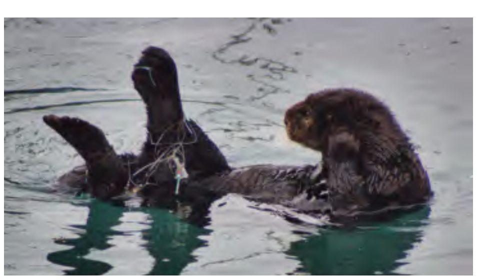
Human interactions with wildlife can occur with a diversity of native species in terrestrial, aquatic, and aerial environments throughout California. These interactions can be positive, like watching a family of bears while walking a wilderness trail during the day. They can be negative, as when the same bears attempt to break into your cabin that night. Human-wildlife conflicts occur when human actions or behaviors have an adverse effect on wildlife or when wildlife behaviors adversely affect humans. Human emotions, attitudes, and values often determine how an interaction is perceived and whether it will end in conflict or coexistence.

Coyotes (*Canis latrans*), called "song dogs" by Native Americans, are intelligent and highly adaptive. With their diverse diet, potential food sources can include unsecured trash or small pets in urban settings.

Competition for limited resources can lead to conflict. Native species are increasingly affected by loss or modification of natural habitat and loss of habitat connectivity due to increased land-use needs for agricultural, economic, and recreational activities (CDFW 2015). Humans can be affected by damage to property or crops, injury to or loss of pets and livestock, actual or perceived threats to human health or public safety, and general "nuisance wildlife" issues.

As a result of conflict, humans have driven some species to extinction, the most significant biological consequence of human interaction with wildlife. One notable example is the loss of our state animal, the California grizzly bear (*Ursus arctos californicus*).





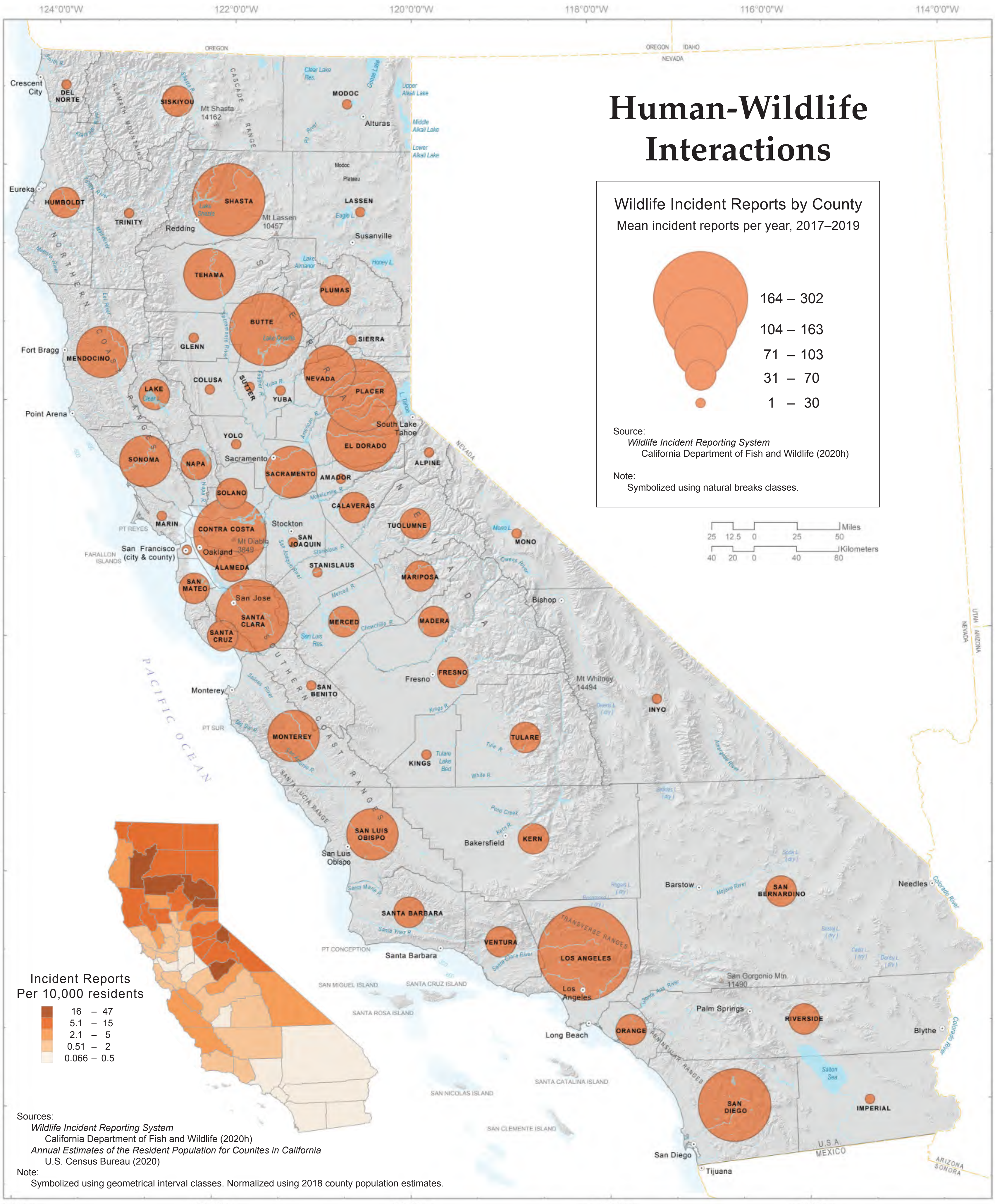
Marine and coastal wildlife, such as pelicans (*Pelicanus* spp.) and sea otters (*Enhydra lutris*), can become entangled in fishing line, imbedded with fish hooks, or exposed to oil spills and pollution. Some fish and wildlife can become too sick or injured to recover.
CDFW photos: Office of Spill Prevention and Response

The frequency and type of reported human-wildlife interactions are highly variable across the state. Conflict hotspots often mirror the human population distribution, as shown on the map to the right. There are a high number of wildlife encounters in cities, where the sheer number of people increases the likelihood of contact with species that have acclimated to the human environment, such as coyotes and turkeys. However, the chance of any individual having a wildlife encounter is greater in rural areas (inset map), where human and domestic animal proximity to natural habitat is greater. A wider variety of animals, including mountain lions and bears, is more commonly encountered in rural areas.

There is a strong drought-associated pattern to reported conflicts with bobcats (*Lynx rufus*). The less rainfall in relation to 30-year annual averages, the greater the frequency of reported incidents.

Managing human-wildlife interactions to reduce conflict becomes more challenging as the human population in the state continues to grow. As California's trustee agency for wildlife resources, the Department takes the lead in helping to resolve reported property damage and human safety issues due to wildlife. The Department provides guidance and online resources on its "Living with Wildlife" website (CDFW 2020g). Diverse species are highlighted there, from black bears and beavers to wild turkeys, with detailed information on their behavior, ecosystem services, and ways to encourage coexistence. How people interact with, perceive, and value wildlife directly inform how conservation and management actions are prioritized to support and sustain biodiversity in California.

Human-Wildlife Interactions

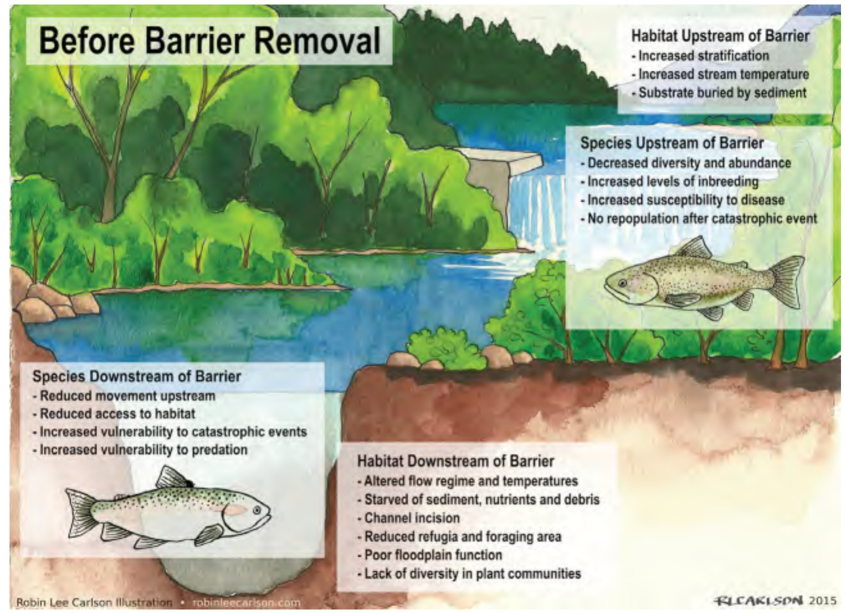


Stream Barriers

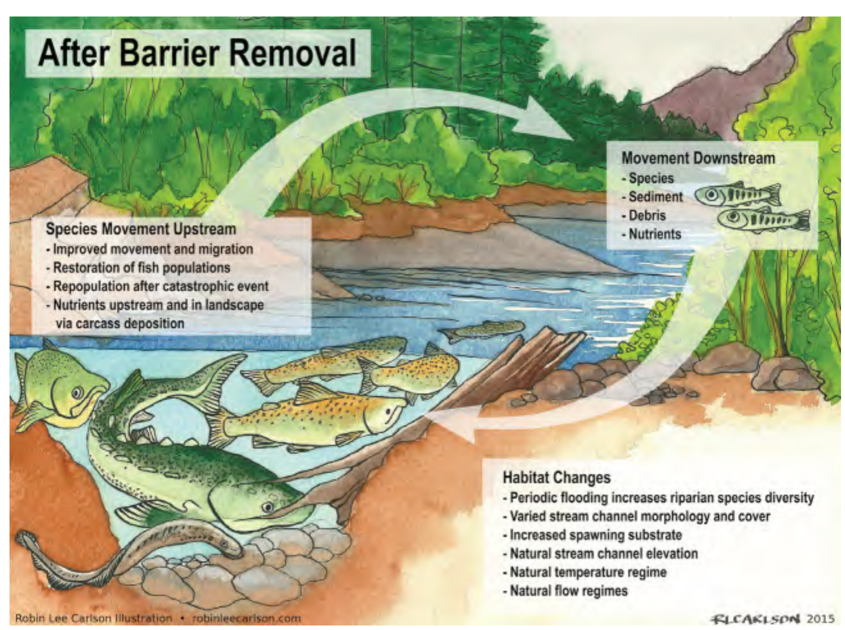
Anadromous fishes like salmon, steelhead, Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*), Pacific Lamprey (*Entosphenus tridentata*), and sturgeon hatch in freshwater rivers and streams, spending their early lives in these systems. Lampreys spend several years in fresh water and make their way to the ocean as adults; the other anadromous fishes migrate to the ocean as juveniles. They feed and grow there, returning as adults to freshwater systems to spawn before dying and completing their life cycles. They require ideal habitat conditions that vary from species to species, but which generally include low-gradient streams for spawning. These habitats were once accessible throughout California but have been partially or fully blocked by human-caused and natural disturbances for at least the last century.

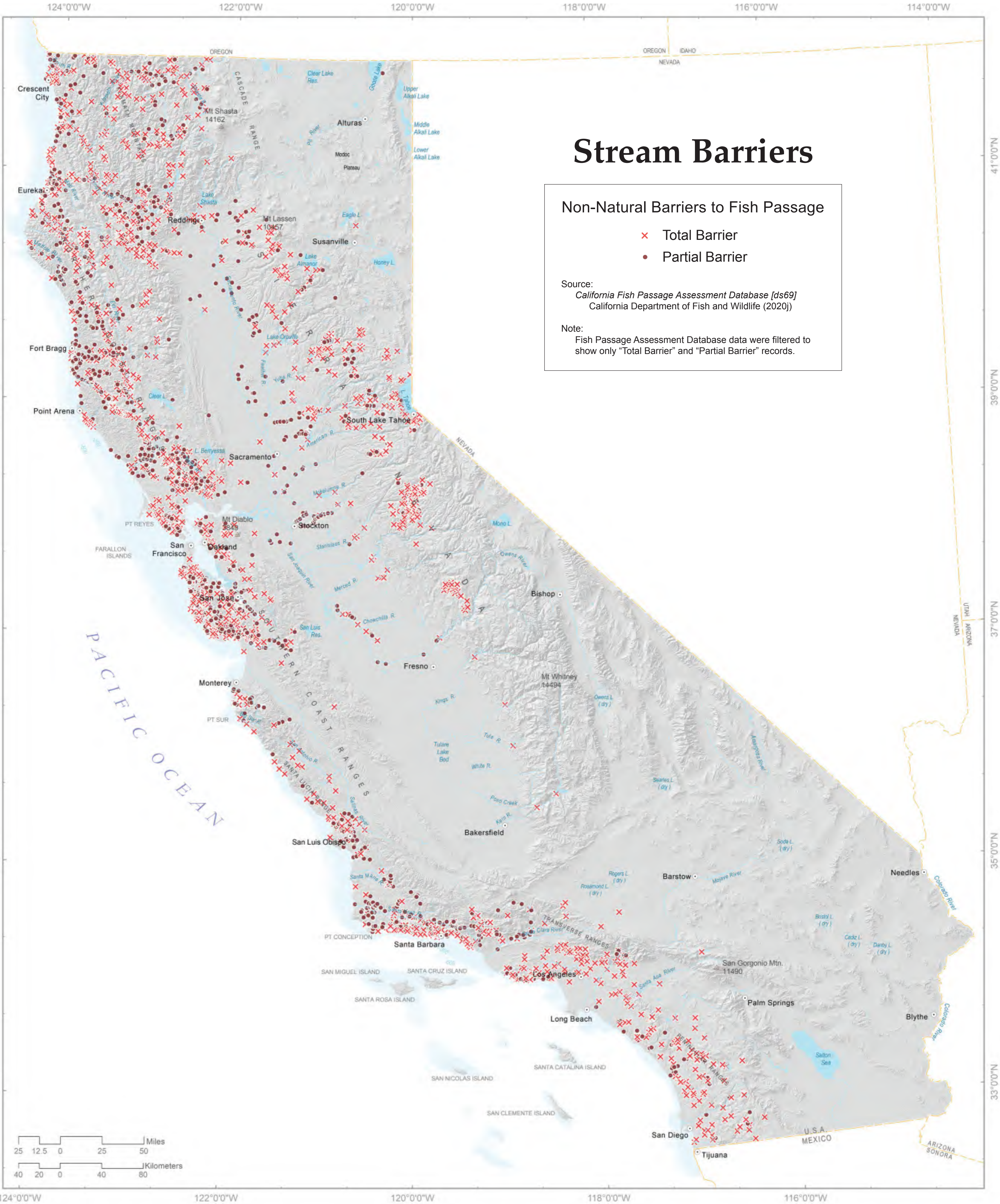
Roads, bridges, and dams were built on public and private lands during the 19th and 20th centuries and water was diverted by various means, creating thousands of barriers that block the passage of anadromous fishes. Consequently, many anadromous fish populations have experienced significant declines and some of these species are now considered threatened or endangered. Man-made barriers include road-stream crossings, irrigation diversions, dams, long concrete channels in urban areas, and many other in-stream structures. Natural barriers include waterfalls, boulders, steep slopes, landslides, logs, and sediment. In some cases, previously installed fish passage structures, such as fish ladders for salmon and steelhead, act as barriers because of poor design or lack of continued maintenance. Some were built without considering the needs of all anadromous fishes and aquatic organisms. These obstacles, especially those created by humans, are one major factor in the decline of anadromous fish populations and represent a continued threat to their survival.

Stream barriers affect adult and juvenile fishes by delaying or preventing upstream migration to spawning habitat and downstream migration to the ocean. Any delays out to the ocean can mean that these fish will not enter the ocean during optimal conditions. Any upstream delays can mean that these fish will either not make it to their spawning grounds in time and will spawn in less than desirable habitat or they will not spawn at all. These barriers impact both adult and juvenile fish by preventing full use of available habitat. Our sport and commercial fisheries depend on these species as a source of income and food; Native American Tribes depend on these species for ceremony and sustenance.



Addressing connectivity has been consistently identified as a high priority, cost-effective approach to protecting and restoring anadromous fish populations. Other habitat restoration activities, like replanting native vegetation to provide shade for juvenile fish, are ineffective if the fish cannot get to the habitat. Reconnecting fragmented habitats and focusing on a multispecies approach that is climate resilient supports both aquatic and terrestrial species migration and is an essential step in species recovery.




Stream Barriers
Non-Natural Barriers to Fish Passage
Total Barrier
Partial Barrier
Source:
California Fish Passage Assessment Database [ds69]
California Department of Fish and Wildlife (2020j)
Note:
Fish Passage Assessment Database data were filtered to show only "Total Barrier" and "Partial Barrier" records.
PACIFIC OCEAN
Crescent City
Eureka
Redding
Fort Bragg
Point Arena
Sacramento
San Francisco
Oakland
San Jose
Stockton
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
San Diego
Tijuana
Barstow
Palm Springs
Needles
Blythe
Susanville
Alturas
South Lake Tahoe
Mt Shasta 14162
Mt Lassen 10457
Mt Diablo 3849
Mt Whitney 14494
San Gorgonio Mtn. 11490
Miles
Kilometers

Aquatic Invasive Species

Quagga mussels attach to the hulls and propellers of recreational watercraft, impairing their operation and potentially moving with them to other waterbodies.
Photo: National Park Service

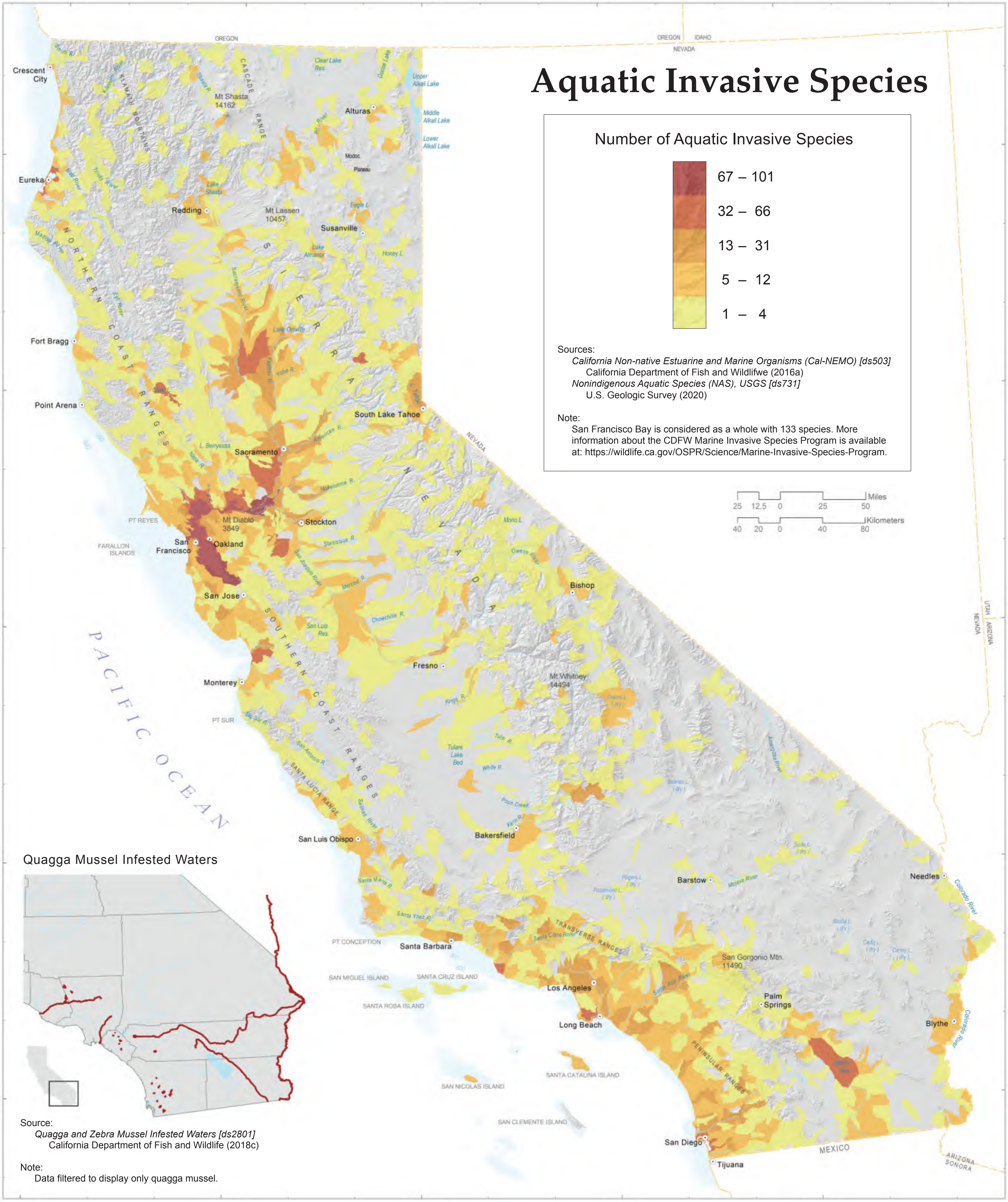
Aquatic invasive species are non-native plants and animals that inhabit aquatic environments all or part of their lives and, when introduced to an area outside of their native range, establish in the new environment and cause harm to the environment, economy, and/or human health. Species that successfully invade new environments can typically tolerate a range of environmental conditions, lack predators in the new environment, and produce numerous offspring that readily disperse. Aquatic invasive species negatively impact California's native and game species by preying upon them; competing with them for food, shelter, and habitat; and possibly introducing and spreading disease. In addition, aquatic invasive species affect the aesthetic and recreational value of the wildlands and waterways throughout the state.

Non-native species introductions can occur naturally, such as when seeds are carried by wind or water, or intentionally or unintentionally by human activity. Until European settlement in the 1700s, California had few non-native species introductions. The earliest transcontinental introductions would have arrived attached to the hulls of ships and carried onboard among the cargo. Over the subsequent 300 years, as human travel and trade has grown and connected distant regions of the world into a global economy, non-native introductions have steadily increased. Today, non-native species are still moved unintentionally on or within commercial ships, on fishing and recreational boats and equipment, and on the vehicles that transport them. As shown on the map, the highest concentrations of invasive species occupy international marine shipping ports, the Sacramento River watershed, and inland lakes. These destinations are frequented by commercial and recreational vessels from around the state, country, and world.

Invasive aquatic plants such as water hyacinth (*Eichhornia crassipes*) form dense blockades of vegetation that alter habitats, impede navigation, clog water intakes, and affect water quality. This waterway was completely blocked by water hyacinth and South American spongeplant (*Limnobium laevigatum*).
Photo: Division of Boating and Waterways, CA State Parks

An example of an aquatic invasive species that was unintentionally introduced to California and has resulted in significant harm to the state is the quagga mussel (*Dreissena rostriformis bugensis*). Quagga mussels are freshwater bivalve mussels native to Ukraine. First detected in California waters in 2007, the quagga mussel arrived in the United States in the late 1980s by way of transoceanic shipping into the Great Lakes. Quagga mussels were likely released in the ballast water of ships. Once established, they spread throughout the vast interconnected waterways surrounding the Great Lakes.

In addition to being carried in water, quagga mussels attach to hard surfaces, such as the exterior hulls of boats, and can survive out of water for days, even weeks, by tightly closing their shells. It is likely that a small boat encrusted with quagga mussels was brought from the Great Lakes area on a trailer across the country to Lake Mead, Nevada, where it was launched, introducing quagga mussels to the West. Like the Great Lakes, Lake Mead possessed habitat suitable for the non-native quagga mussel, and it established and proliferated, producing offspring that were carried downstream in the Colorado River and into California. Their relatively small size (ranging from microscopic to the size of a fingernail) and their ability to survive out of water make quagga mussels well adapted to being inadvertently moved from one waterbody into another, furthering their spread. With a few exceptions, quagga mussels have been contained to the Southern California waterbodies that received mussel-infested water, as shown on the map inset to the right. The managers of these waters, and the boaters that use them, continue to take action to clean, drain, and dry their watercraft when leaving these infested waterbodies and have prevented further unintentional spread.


Aquatic Invasive Species
Number of Aquatic Invasive Species
67 – 101
32 – 66
13 – 31
5 – 12
1 – 4
Sources:
California Non-native Estuarine and Marine Organisms (Cal-NEMO) [ds503]
California Department of Fish and Wildlifwe (2016a)
Nonindigenous Aquatic Species (NAS), USGS [ds731]
U.S. Geologic Survey (2020)
Note:
San Francisco Bay is considered as a whole with 133 species. More information about the CDFW Marine Invasive Species Program is available at: https://wildlife.ca.gov/OSPR/Science/Marine-Invasive-Species-Program.
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
NEVADA
IDAHO
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Mt Shasta 14162
Mt Lassen 10457
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Mt Whitney 14494
Bakersfield
San Luis Obispo
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
San Gorgonio Mtn. 11490
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
CASCADE RANGE
KLAMATH MOUNTAINS
NORTHERN COAST RANGES
SIERRA NEVADA
SOUTHERN COAST RANGES
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
Quagga Mussel Infested Waters
Source:
Quagga and Zebra Mussel Infested Waters [ds2801]
California Department of Fish and Wildlife (2018c)
Note:
Data filtered to display only quagga mussel.

Terrestrial Invasive Species

Terrestrial invasive species are non-native plants and animals that, when introduced to an area outside of their native range, establish in the new environment and cause harm to the environment, economy, and/or human health. Plants are the most common invaders of terrestrial and riparian habitats, with well over 200 species recorded across California's wildlands. The regions of the state most impacted by invasive plants tend to be those areas with the greatest human disturbance due to urbanization, agriculture, and recreation. In addition to plants, numerous non-native insects, birds, mammals, amphibians, and reptiles have become established, negatively impacting California's native species and the habitats upon which they depend.

Like aquatic invasive species, there are a variety of ways terrestrial invasive species may be introduced to an environment. Plants, and particularly their seeds, are readily moved unnoticed on shoelaces, in mud embedded in the treads of tires, in harvested crops, and in an infinite number of other human activities. Because many plants are self-pollinating, it can take just one seed or plant fragment moved to a new location to result in a highly impactful invasion.

Nutria (*Myocastor coypus*) rely on both aquatic and terrestrial environments to feed and shelter. Their large populations, voracious appetite for plants, and ability to modify terrestrial landscapes threatens the state's wildlands and water conveyance systems.

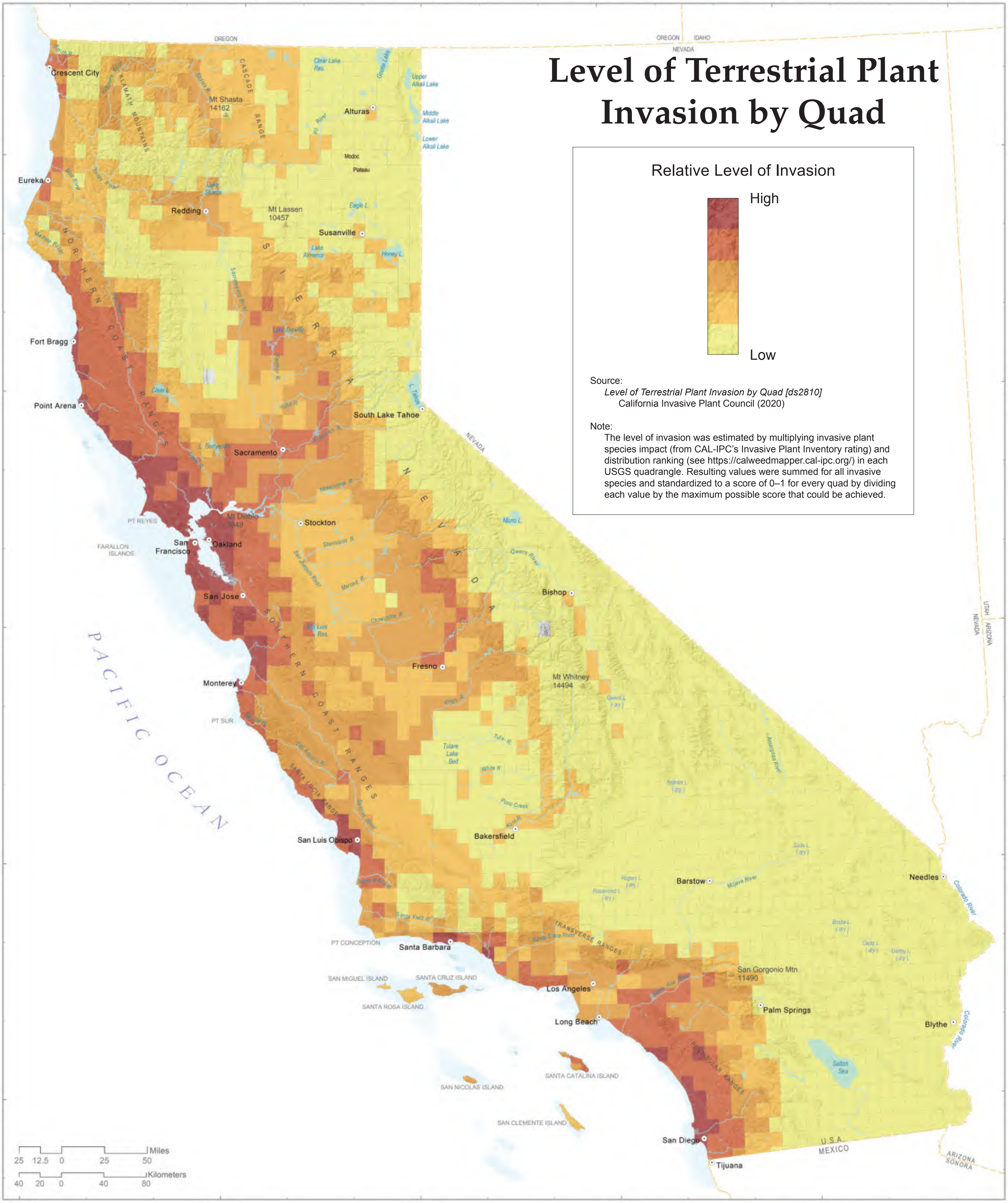
Plants that are invasive in California often have some competitive advantage over our native species. These advantages may include earlier germination time, deeper roots, faster growth, higher seed production, an absence of predators, and the ability to produce chemicals that reduce the success of surrounding flora. This advantage may be very slight, but over time it can result in a significant difference in the relative reproductive success of the non-native species compared to the native species. An example of this is yellow starthistle (*Centaurea solstitialis*), a highly invasive plant estimated to have invaded 10–15 million acres across California. You have probably

Much of California has been invaded by yellow starthistle, a non-native plant whose biology enables it to outcompete natives and dominate landscapes.

encountered this unpleasant invasive in open spaces and along roadsides, as well as in the state's wildlands. Its flower head bears a cluster of very sharp spines that remain well after the bright yellow flowers have withered and the plant has died.

Starthistle originates in an area with a climate that is similar to California's, so it is not surprising that it does well here. But it has a few extra advantages which have enabled it to be wildly successful. Its seeds germinate earlier than many other plant species and, rather than putting its early growth into the development of leaves, it invests in producing a long root. This root allows it to tap into moisture deep in the soil later in the summer, outcompeting shallow-rooted plants for scarce and much needed water late in the growing season. In addition, starthistle produces many seeds, at least 20 to 120 seeds per plant, but sometimes over 100,000 seeds per plant under optimal conditions. A high percentage of its seeds can successfully germinate the following season and a dense starthistle population is very quickly established. Over the span of years, when non-native species repeatedly outcompete the natives and fewer natives successfully reproduce, the native species may be extirpated, resulting in a loss of native biodiversity.

Non-native invasive plants tend to establish and thrive where plant communities and soil have been disturbed. Disturbances are temporary or long-term changes in the environment and can result from many causes including mowing, scraping or tilling the soil, livestock grazing, wildfires, landslides, and flooding. Disturbances create the opportunity for invasive species to establish in an environment, and from there they can spread. The most effective means for preventing the impacts of invasive species is to prevent their introduction and spread, and to minimize environmental disturbances that they can exploit.



Level of Terrestrial Plant Invasion by Quad
Relative Level of Invasion
High
Low
Source:
Level of Terrestrial Plant Invasion by Quad [ds2810]
California Invasive Plant Council (2020)
Note:
The level of invasion was estimated by multiplying invasive plant species impact (from CAL-IPC's Invasive Plant Inventory rating) and distribution ranking (see https://calweedmapper.cal-ipc.org/) in each USGS quadrangle. Resulting values were summed for all invasive species and standardized to a score of 0–1 for every quad by dividing each value by the maximum possible score that could be achieved.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
SONORA
U.S.A.
MEXICO
PACIFIC OCEAN
Crescent City
Mt Shasta 14162
Alturas
Eureka
Redding
Mt Lassen 10457
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Bishop
Monterey
Fresno
Mt Whitney 14494
Bakersfield
San Luis Obispo
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
San Gorgonio Mtn. 11490
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
KLAMATH MOUNTAINS
CASCADE RANGE
NORTHERN COAST RANGES
SIERRA NEVADA
SOUTHERN COAST RANGES
TRANSVERSE RANGES
PENINSULAR RANGES
Modoc Plateau
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Climate Change

Trends

Climate is defined by prevailing weather conditions, typically averaged over at least 30 consecutive years. The earth's climate has changed throughout history, including long periods of warming and cooling. However, the current warming trend is occurring at an unprecedented rate and is largely due to human activity—namely, the release of large volumes of carbon dioxide and other heat-trapping gases into the atmosphere (IPCC 2014).

Over the past several decades, California's climate has been characterized by rising air temperatures and increasingly frequent heat waves, and extreme events such as droughts and heavy storms have become more common. More precipitation has fallen as rain than snow, which has reduced snowpack and dramatically decreased glacier size (CEPA 2018). This has changed the timing and volume of water runoff from upper elevations. For instance, the Sacramento River's peak runoff now occurs almost a month earlier than during the first part of the century. Recent warming has also exacerbated drought conditions, leading to drier vegetation and an increase in area burned by wildfire (Bedsworth et al. 2018).

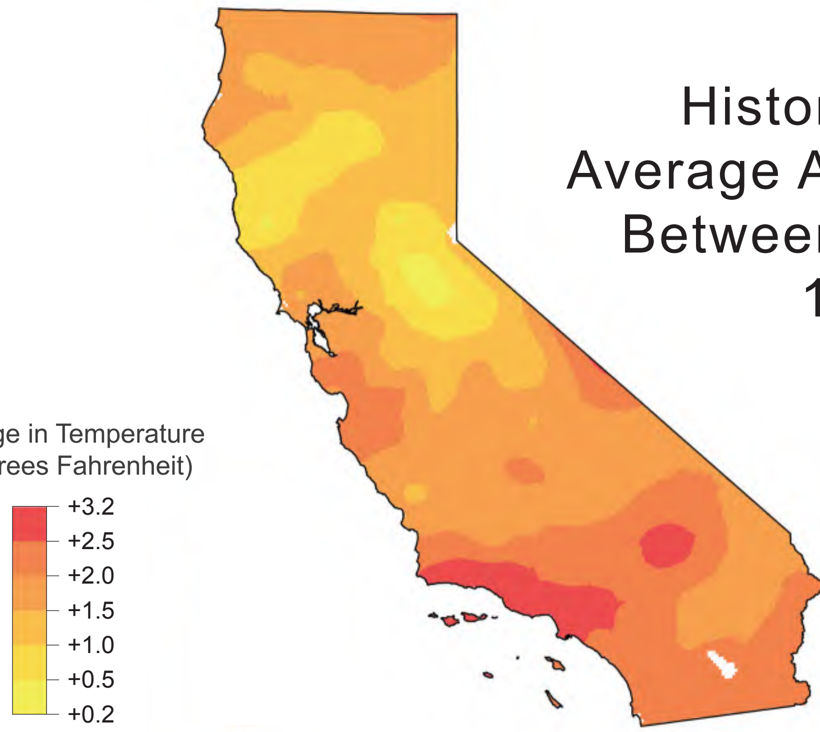
Ocean temperature off the coast of California has risen over the past century and thermal expansion in warming oceans and melting ice sheets and glaciers have contributed to local sea level rise (Sievanen et al. 2018). In addition, the frequency of strong El Niños and extreme ocean heatwaves has increased as the climate has warmed (Oliver et al. 2018). In just the past 40 years, there have been three very strong El Niños and within the past decade, the Northeast Pacific has experienced two extreme marine heatwaves: a multi-year event that extended from fall 2013 through spring 2016 (called The Blob) and a single-year event in 2019 (NOAA 2020).

Over the next several decades, California's average maximum and minimum daily temperatures will continue to increase, snowpack will continue to decline, and wildfire events are expected to increase in frequency with a trend toward more catastrophic, high-intensity fires (see the maps on the following page). Ocean temperatures are expected to rise, important ocean-atmosphere interactions (winds, currents, and coastal upwelling) will likely shift, extreme warm water events will increase, and the ocean's chemistry will change as it absorbs greater amounts of carbon dioxide from the atmosphere (Sievanen et al. 2018). Local sea levels will rise and the resulting inundation in low-lying areas such as around San Francisco Bay will be boosted by increased flooding from extreme storms (Gershunov et al. 2019).

The effects of climate change will not unfold uniformly across the landscape, but will depend on the scale in question (state, region, or locality) and will vary geographically due to differences in topography, elevation, latitude, and proximity to the ocean or other large water bodies.

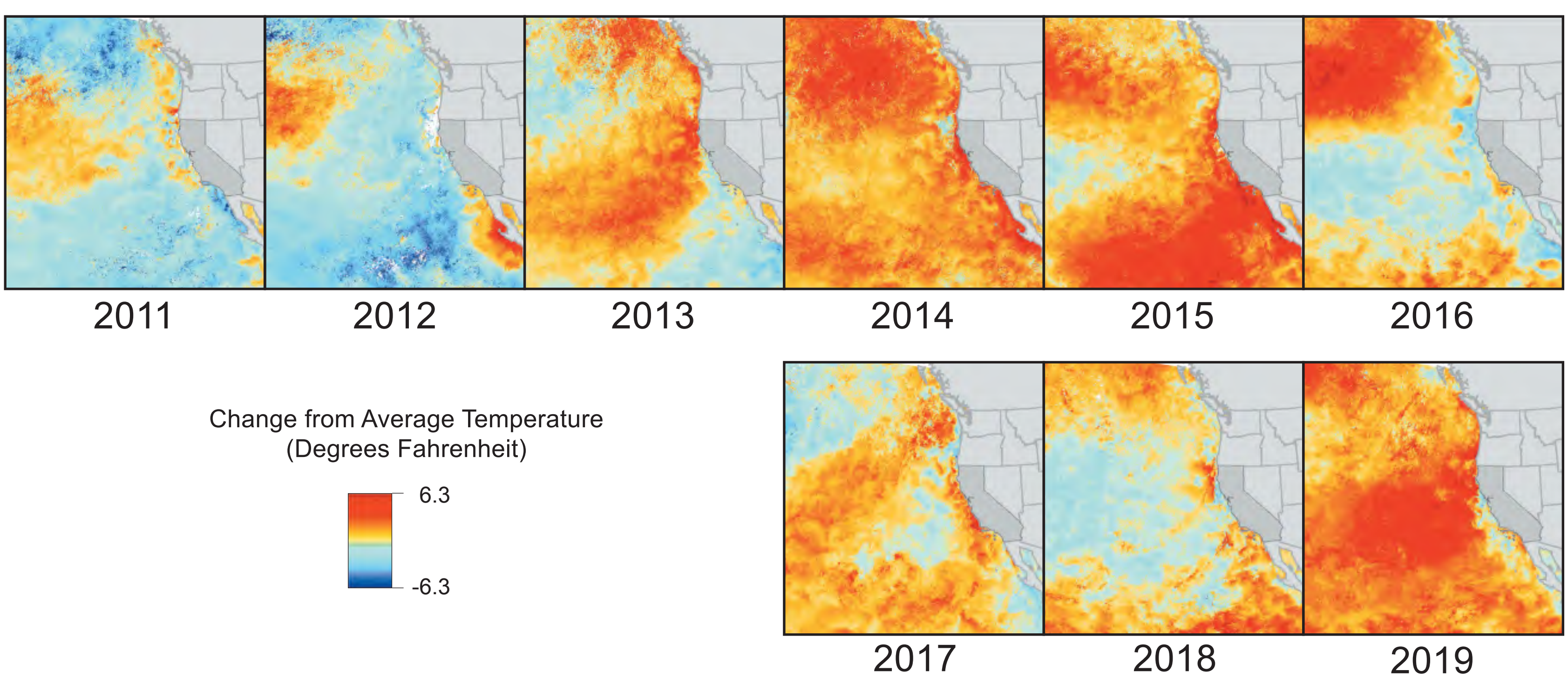
Buttonwillow Ecological Reserve. This area has been studied by the Bureau of Land Management, University of California at Santa Cruz, California Department of Fish and Wildlife, and The Nature Conservancy to document the negative effects of the 2012–2014 drought. Drought events are expected to increase in frequency as the climate changes.
Photo: Mike Westphal, BLM

Historical Change in Average Annual Temperature Between 1901–1960 and 1986–2016



Source:
Observed Changes in Annual Temperatures
Vose et al. (2017)

September Sea Surface Temperature Anomalies (2011–2019)



Source:
September Sea Surface Temperature Anomalies (2011–2019)
Ocean Ecology Laboratory (2019)

Note:
Monthly sea surface temperature (SST) anomalies were created by subtracting long-term averaged SST data from the average SST for each month shown.

Climate Change

Impacts to Biodiversity

Like humans, plant and animal species prefer certain climatic conditions and can tolerate some better than others. When exposed to climatic or environmental conditions beyond a given threshold, species can exhibit signs of physical stress. For example, extreme heat, rising water temperatures, ocean acidification, hypoxia (declining concentrations of dissolved oxygen), and changes in water salinity, can contribute directly to species loss or mortality or may prompt range shifts in the long term.

Range Shifts

Climate change is altering the environmental conditions that determine the distribution and composition of terrestrial and aquatic communities. For instance, as some locations become drier and warmer, vegetation is shifting to higher latitudes and elevations where the prevailing climate conditions are closer to what the vegetation type has experienced historically. Such vegetation changes can lead many mobile species to relocate to more suitable habitat, ultimately shifting their ranges. This movement can bring together species that were not previously in contact, resulting in new predator-prey relationships with cascading effects on food webs. Human-wildlife interactions may also increase as species move into new areas.

Atmospheric and global hydrology changes impact coastal and estuarine habitats and communities. For example, rising sea levels can change inundation periods for saltwater marsh, sandy beach, and rocky shore communities within the tidal zone. Changes in the distribution of species through the tidal zone will depend upon the rate of sea level rise as well as the availability of suitable habitat into which to expand.

Species that struggle to find suitable habitat may face extinction, extirpation, or range contraction. Range shifts have already been observed in California and across the globe.

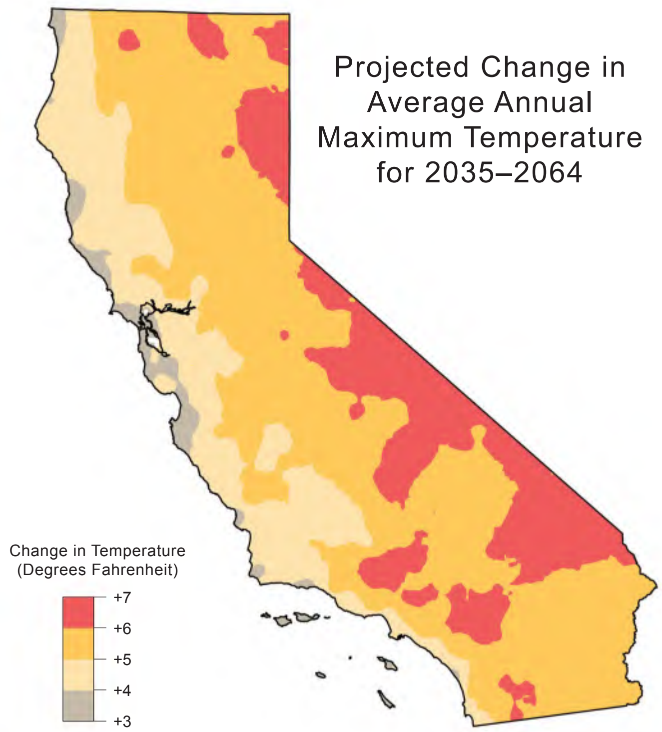
Phenological Events

Increasing temperatures can affect the timing of seasonal life cycle events, such as migrations, breeding, pollination, or flowering. These shifts can pose grave challenges for plant and animal species. For example, migrating birds may leave their wintering habitats too early and may encounter harsh weather conditions in their breeding grounds that may negatively affect their body condition and ability to breed successfully. Plants may flower earlier in the spring than usual due to warmer temperatures, but if pollinators are not hatching at the same time, plant reproduction could decline and pollinators' food sources could disappear, damaging what had been a long-standing, mutually beneficial relationship.

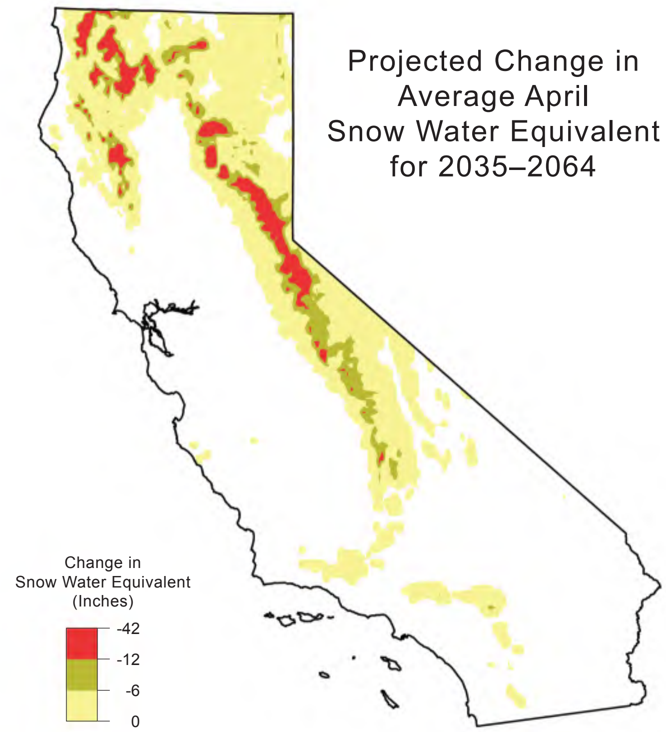
In the marine environment, changes in seasonal timing, intensity, and location of upwelling can affect the availability of prey species, which can then impact the growth, spawning, breeding, and survivability of species such as salmon, seabirds, and marine mammals. These upwelling characteristics are projected to change as the climate warms, with some models indicating more upwelling in the northern region of the state and less in the southern region (Rykaczewski et al. 2015). Impacts to species will depend on how well they can respond to these changes, given their respective life histories.

(continued)

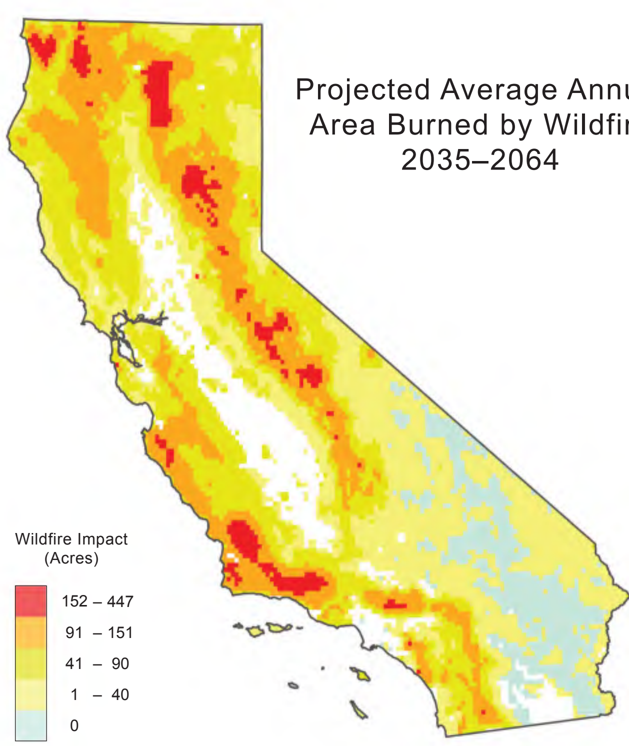
The Woolsey Fire burned 96,949 acres of Los Angeles and Ventura counties in 2018. Severe wildfire events are expected to become more frequent over the next several decades.



Source:
Projected long-term (30 year) Annual Average Maximum Temperature, Change from Historical Baseline, Mid-Century High Emissions (RCP 8.5), Fahrenheit
Pierce et al. (2018)

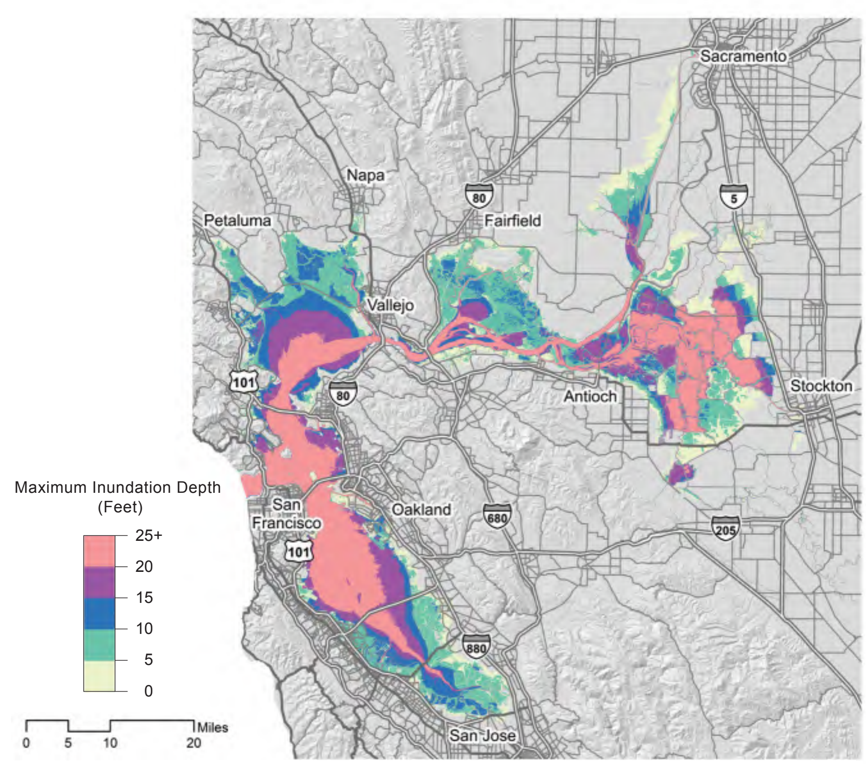


Source:
Projected Change in Average April Snow Water Equivalent for 2035–2064, RCP 8.5, 10GCMs (Inches)
Cal-Adapt (2020b)



Source:
Wildfire Simulations for California's Fourth Climate Change Assessment
Westerling (2018)

Projected San Francisco Bay and Delta Inundation



Sources:
Sea Level Rise Inundation Model – Sacramento San Joaquin Delta – UC Berkeley [ds2694]
Sea Level Rise Inundation Model – San Francisco Bay – UC Berkeley [ds2695]
Sea Level Rise Inundation Model – California Coast – UC Berkeley [ds2696]
Radke et al. (2017)

Note:
Maximum inundation depth for a projected sea level rise of 4.63 feet during a 100-year storm.

Climate Change

(continued from page 82)

Landscape and Habitat Fragmentation

As climate change alters vegetation patterns and water quality and availability, a species' habitat may become naturally disconnected, contributing to habitat loss or decline. Continued human population growth and urban sprawl further fragment the landscape by creating physical barriers that block species' movements. Climate-induced habitat fragmentation, exacerbated by physical barriers on the landscape, can lead to the decline of isolated wildlife populations, in part by increasing the potential for inbreeding that limits genetic variation and weakens populations' resilience. Barriers to movement can ultimately become barriers to species survival.

Invasive Species or Pests

Climatic changes can favor the spread of pests, pathogens, diseases, and invasive species, which already plague many native and endemic species.

Tree mortality in the Sierra Nevada due to severe drought. Trees weakened by persisitent drought conditions are more susceptible to diseases and pests.
Photo: U.S. Forest Service Region 5

The watershed-based map to the right illustrates that vulnerable aquatic species are concentrated in several areas, including the northwest corner of the state where cool, wet conditions are anticipated to shift north and out of the state. Species are most vulnerable in the Sonoran and Mojave deserts because remnant wetlands may dry up as temperatures increase and rainfall becomes less predictable.

Climate change has already affected animals, plants, and other organisms by shifting their abundance, distribution, and migratory, flowering, or mating patterns, and by directly affecting the habitat they depend upon (CEPA 2018):

• In the Santa Rosa Mountains, small shrubs, chaparral, and large conifers have moved upslope toward a cool, wet environment.

• The American pika (*Ochotona princeps*), a species accustomed to high elevations, is experiencing significant range contraction due to reduced snowpack, with limited ability to expand upslope (Stewart et al. 2017).

• Central Valley butterflies are appearing earlier in the spring than in the past.

• Several migratory songbird species have shifted their historical departure dates from wintering grounds and arrival dates at breeding grounds.

• Warmer temperatures have enhanced the bark beetle population, which has killed a record number of coniferous trees in recent decades, increasing wildfire risk in areas such as the southern Sierra Nevada.

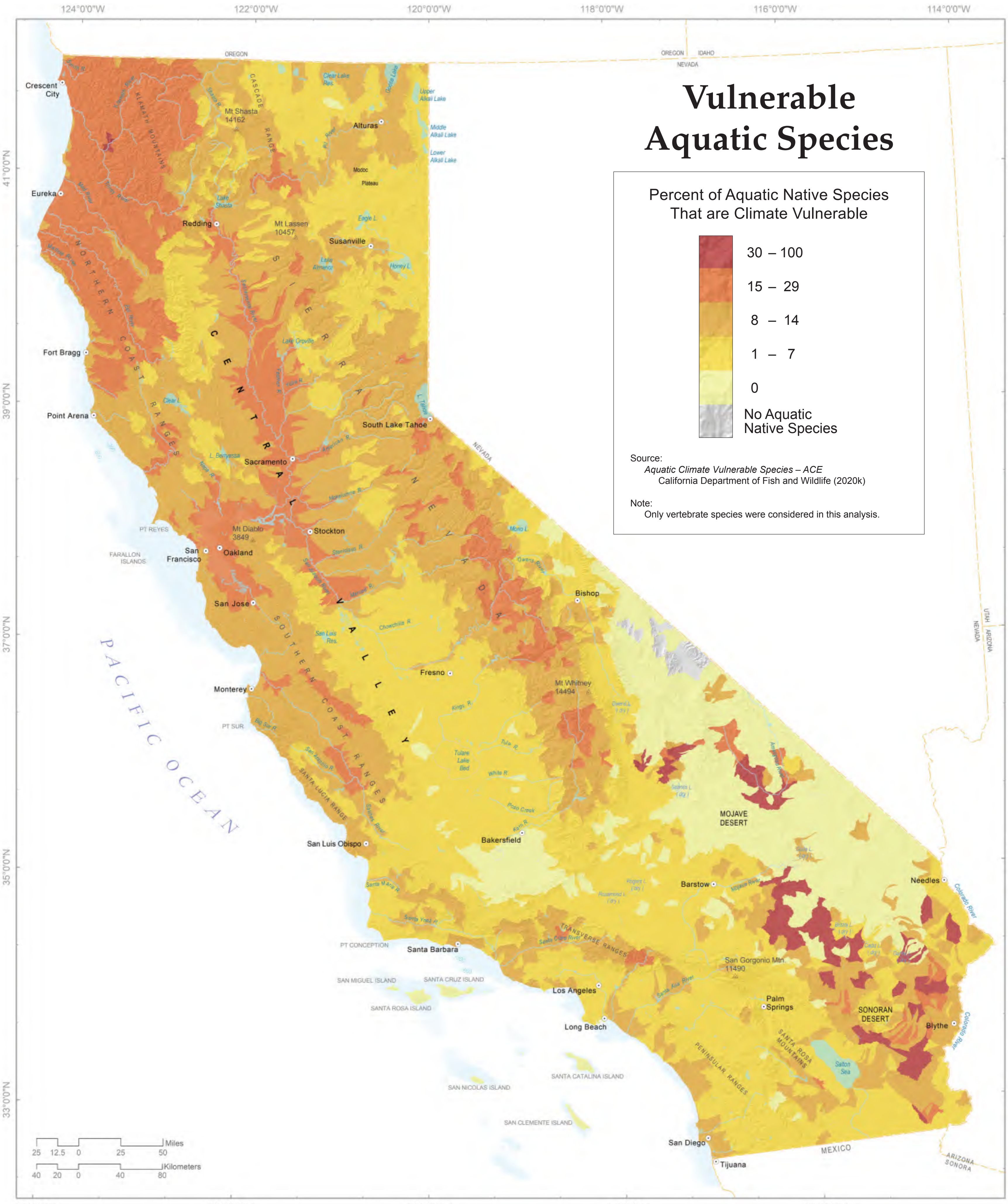
• The reduction in snowmelt and cold-water river and stream flows is affecting the Chinook Salmon's (*Oncorhynchus tshawytscha*) egg viability, spawning, and rearing conditions. This has led to increased variability in the annual number of adults returning from the ocean to the Sacramento River.

• A marine heatwave in 2013–2015 resulted in mass strandings of marine mammals and seabirds, documented species range shifts, and the closure of certain commercial fisheries (Cavole et al. 2016).

• Harmful algal blooms flourish in warm water conditions. These can suffocate fish, deplete oxygen in the water, and contaminate seafood and water used for drinking and recreation. Algal bloom occurrence has been increasing in California in recent years, affecting both marine and inland waterbodies.

• Ocean acidification off the coast of California has led to shell dissolution in sea snails and other physiological impacts to marine organisms including abalone, mussels, sea urchins, and crabs (CalOST 2018).

• California Mussels (*Mytilus californianus*) in the rocky intertidal along the north-central California coast died when unusually warm air temperatures occurred during mid-day low tides (Simons 2019). Such events are expected to increase as the climate warms.


Vulnerable
Aquatic Species
Percent of Aquatic Native Species
That are Climate Vulnerable
30 – 100
15 – 29
8 – 14
1 – 7
0
No Aquatic
Native Species
Source:
Aquatic Climate Vulnerable Species – ACE
California Department of Fish and Wildlife (2020k)
Note:
Only vertebrate species were considered in this analysis.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
ARIZONA
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Alturas
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
San Luis Obispo
Bakersfield
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
Palm Springs
Blythe
San Diego
Tijuana
Mt Shasta
14162
Mt Lassen
10457
Mt Diablo
3849
Mt Whitney
14494
San Gorgonio Mtn.
11490
CENTRAL VALLEY
SIERRA NEVADA
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
KLAMATH MOUNTAINS
CASCADE RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
SANTA ROSA MOUNTAINS
SANTA LUCIA RANGE
MOJAVE DESERT
SONORAN DESERT
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Colorado River
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Climate Change

Many threats to ecosystems are interrelated and the impacts may not become obvious until they are severe. Seemingly negligible effects of climate change on a species may ultimately alter an entire food chain. As the effects of these environmental changes compound, ecological tipping points may be reached, leading to rapid declines in ecosystem health and to species loss or extinction. For example, a healthy Bull Kelp (*Nereocystis luetkeana*) forest shifted to a purple urchin barren due to a catastrophic decline in kelp from a multi-year extreme warm water event and grazing from an increasing number of Purple Sea Urchins (*Strongylocentrotus purpuratus*) (Rogers-Bennett and Catton 2019). This resulted in a major decline in other species that rely on kelp, such as the Red Abalone (*Haliotis rufescens*) and the Red Sea Urchin (*Mesocentrotus franciscanus*). Just prior to this warm water event, a pivotal urchin predator, the Sunflower Sea Star (*Pycnopodia helianthoides*), experienced declines due to a sea star wasting disease. Low abundances of urchin predators and increased potential for warm water events under climate change may limit this system's ability to shift back to a kelp forest.

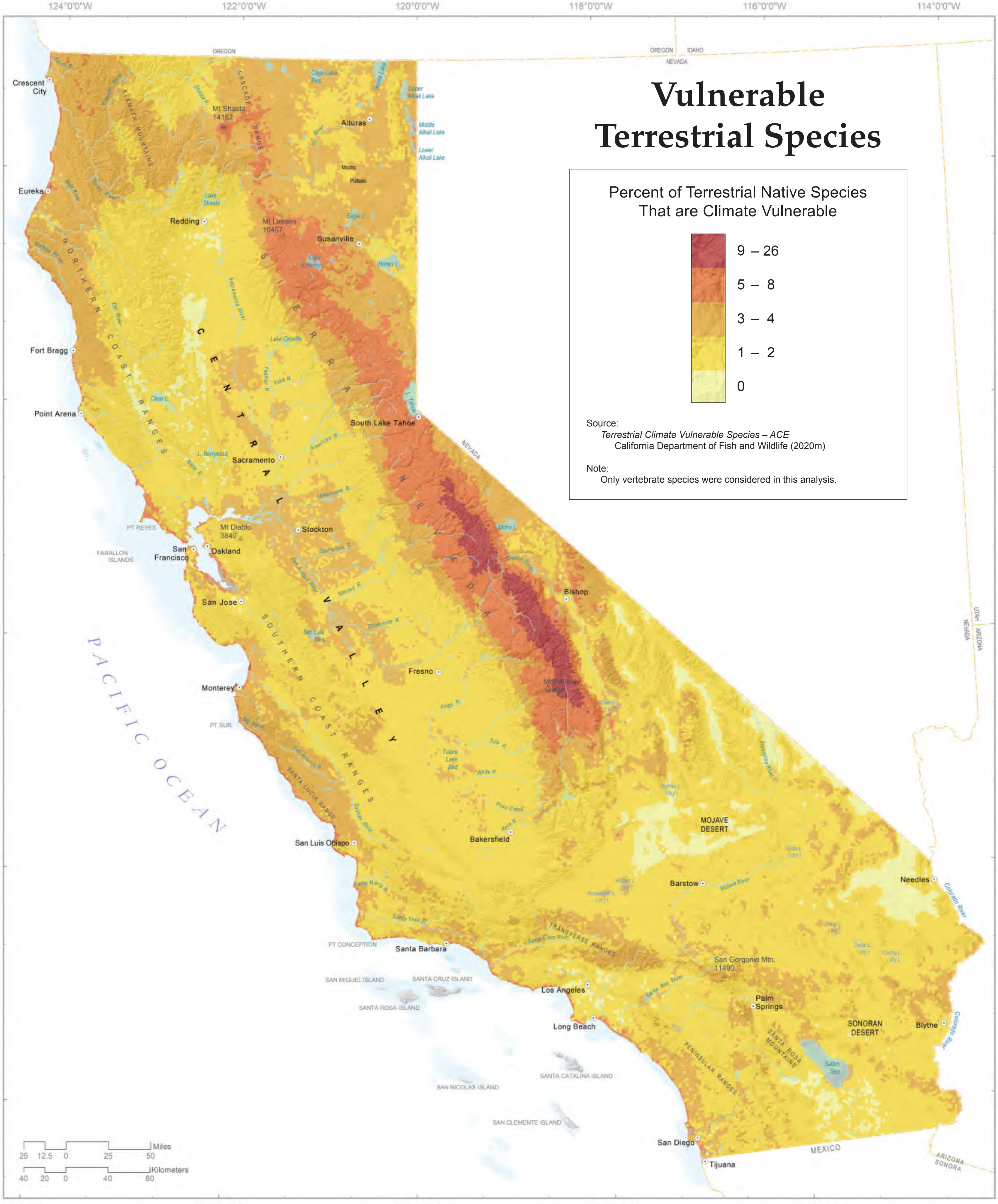
Recent observations have linked changes in the migratory patterns of Central Valley butterflies such as the painted lady (*Vanessa cardui*) to climate change. CDFW Photo: Annie Chang

Certain species and habitats are resilient to the effects of climate change and could potentially benefit from it, while others remain vulnerable. A species' vulnerability is determined by its exposure to projected changes, its biological sensitivities to those changes, and its ability to adapt. Species that require highly specific habitat conditions will likely have a harder time adapting to change than those that thrive under a wide variety of conditions. The map at right shows widespread vulnerability for terrestrial vertebrates, with an especially high proportion in the higher elevations where upslope movement is impossible. Species in coastal areas are also vulnerable due to sea level rise and the inability of their habitats to shift inland past existing infrastructure.

California Mussels (*Mytilus californianus*) within the rocky intertidal can be exposed to detrimental conditions such as unusually warm air temperatures during mid-day low tides. Photo © Claudia Makeyev

Prolonged climatic change will amplify the impacts discussed above and create ongoing challenges to the management and conservation of California's natural resources. Restoration, conservation, scientific research, and monitoring activities that inform adaptive management can help increase the resilience of natural lands to climate change. Restoration and protection activities can also increase the ability of natural lands to capture and store carbon, helping to mitigate climate change. A balanced portfolio of these actions will support robust, resilient ecosystems that are better equipped to adapt to the altered environmental conditions caused by climate change.

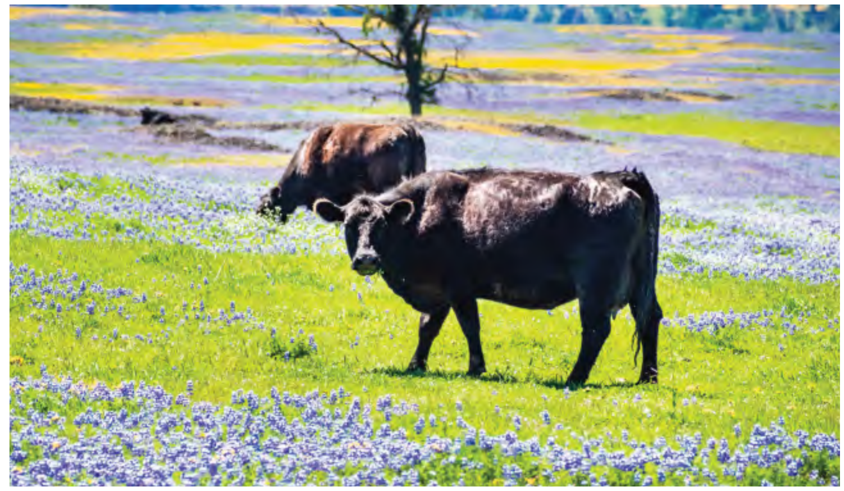
Migratory songbirds like Wilson's Warbler (*Cardellina pusilla*) are arriving at breeding and wintering grounds at different dates than historically observed.


Vulnerable Terrestrial Species
Percent of Terrestrial Native Species That are Climate Vulnerable
9 – 26
5 – 8
3 – 4
1 – 2
0
Source:
Terrestrial Climate Vulnerable Species – ACE
California Department of Fish and Wildlife (2020m)
Note:
Only vertebrate species were considered in this analysis.
OREGON
NEVADA
IDAHO
UTAH
ARIZONA
MEXICO
SONORA
PACIFIC OCEAN
Crescent City
Eureka
Redding
Mt Shasta 14162
Alturas
Mt Lassen 10457
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Mt Diablo 3849
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
San Luis Obispo
Bakersfield
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
San Gorgonio Mtn. 11490
Palm Springs
Blythe
San Diego
Tijuana
MOJAVE DESERT
SONORAN DESERT
NORTHERN COAST RANGES
CENTRAL VALLEY
SIERRA NEVADA
SOUTHERN COAST RANGES
KLAMATH MOUNTAINS
CASCADE RANGE
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
SANTA ROSA MOUNTAINS
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Salton Sea
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N

Conserving Biodiversity

The people of California employ several strategies to conserve the state's extraordinary natural heritage, both on land and at sea. These strategies include conservation planning, land ownership and stewardship, habitat restoration, and environmental law compliance. Government agencies, tribal governments, organizations, and individuals all cooperate in implementing these important protective measures.

Lands Conservation



North Table Mountain, Butte County, where diverse wildflower fields and cattle coexist. Grazing at appropriate levels helps maintain the health of the system by reducing cover of non-native grasses.

One of the greatest challenges for California is balancing the needs of society with those of nature. These needs are not always in opposition, however. Healthy ecosystems supply people with vital services such as clean water and air, flood protection, and pollination. To protect these valuable services, and biodiversity in general, land must be set aside to sustain the ecological health of California.

Nearly 23.5 million acres, approximately 23 percent of California, have already been set aside for conservation. Public lands, such as federal and state parks and wilderness areas, maintain a high degree of unspoiled wildness while providing some level of access for hunting, fishing, and other recreational activities. Not all protected lands are public, however. Non-profit organizations such as land trusts may purchase land to protect its natural character or important resources; private companies may purchase and manage areas to compensate for activities on other lands that may cause harm to protected species.

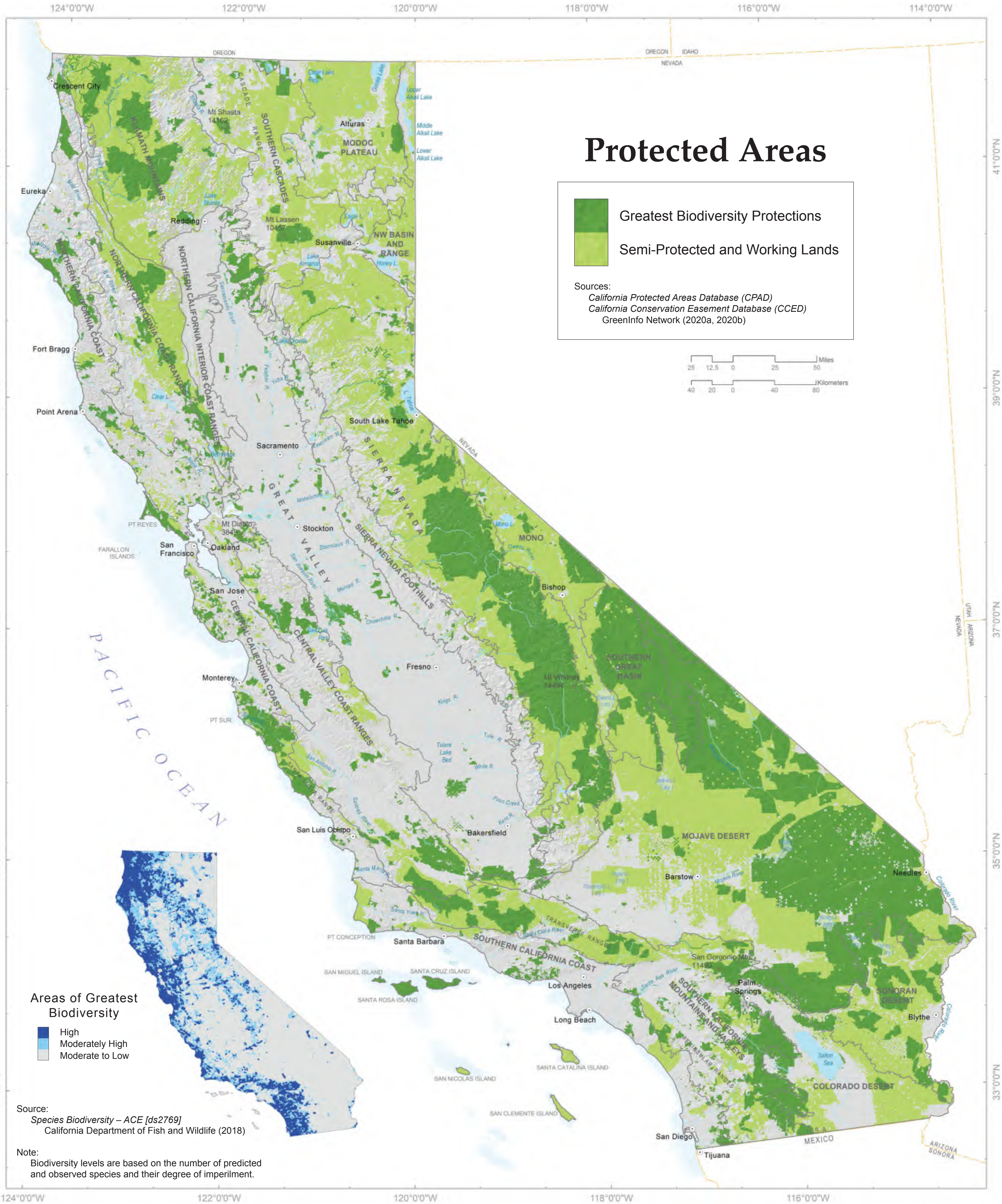
But "sparing" the land from human use is not the only path to conserving biodiversity. "Sharing" the land is a complementary approach, recognizing that well-planned human activities can limit detrimental impacts to, or even enhance, natural systems while also providing opportunities for human enterprise such as energy development, livestock grazing, mining, and timber harvesting.

Most federal lands such as national forests, grasslands, and deserts are managed by the U.S. Forest Service and Bureau of Land Management. These agencies are required to consider all possible uses and benefits when developing land management strategies. This multiple-use approach includes conserving plants and wildlife, protecting historical and cultural resources, and providing recreational opportunities, as well as sustaining extractive economic activities.

Private landowners may enter into agreements called conservation easements with government or non-profit organizations. They receive tax credits or other financial benefits in exchange for relinquishing some of their rights to develop the land while retaining others, such as the right to continue farming or ranching. Conservation easements document land use rights and restrictions that stay with the land in perpetuity, ensuring long-term protective measures. Other landowners agree to manage in a way that supports native wildlife, such as protecting spotted owl nest trees from timber harvest or flooding agricultural fields for use by waterfowl. These private "working lands" and the semi-protected public lands described above add up to about 30 million acres, an additional 30 percent of California, that contribute to environmental conservation.

Many state and federal programs promote conservation of wildlife and their habitats by providing financial resources and technical assistance to managers of public and private lands, significantly advancing conservation in California. Since 2015, the California Wildlife Conservation Board alone has leveraged over 100 million dollars, in partnership with government and non-government entities, to acquire and manage lands for resource protection and public access.

The highest levels of land protections tend to correspond with areas difficult for humans to use, as shown in the map to the right. These areas include much of the forbidding Mojave Desert and the rugged Sierra Nevada. These places are important for numerous species. However, comparison with the inset map shows many areas of California's richest biodiversity are frequently unprotected. The challenge for Californians is to bring these areas into better alignment: to confer the necessary levels of protections upon those places that are home to the greatest number of species, and those which are most vulnerable, so that the unique spectrum of life found in California is preserved for generations to come.



Protected Areas
Greatest Biodiversity Protections
Semi-Protected and Working Lands
Sources:
California Protected Areas Database (CPAD)
California Conservation Easement Database (CCED)
GreenInfo Network (2020a, 2020b)
Miles
Kilometers
Areas of Greatest Biodiversity
High
Moderately High
Moderate to Low
Source:
Species Biodiversity – ACE [ds2769]
California Department of Fish and Wildlife (2018)
Note:
Biodiversity levels are based on the number of predicted and observed species and their degree of imperilment.
PACIFIC OCEAN
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
MEXICO
SONORA
Crescent City
Eureka
Redding
Alturas
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Barstow
Needles
Santa Barbara
Los Angeles
Long Beach
Palm Springs
Blythe
San Diego
Tijuana
KLAMATH MOUNTAINS
SOUTHERN CASCADES
MODOC PLATEAU
NW BASIN AND RANGE
NORTHERN CALIFORNIA COAST
NORTHERN CALIFORNIA COAST RANGES
NORTHERN CALIFORNIA INTERIOR COAST RANGES
SIERRA NEVADA
SIERRA NEVADA FOOTHILLS
GREAT VALLEY
CENTRAL CALIFORNIA COAST
CENTRAL VALLEY COAST RANGES
MONO
SOUTHERN GREAT BASIN
MOJAVE DESERT
SONORAN DESERT
COLORADO DESERT
SOUTHERN CALIFORNIA COAST
TRANSVERSE RANGES
SOUTHERN CALIFORNIA MOUNTAINS AND VALLEYS
PENINSULAR RANGES
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
Mt Shasta 14162
Mt Lassen 10457
Mt Diablo 3849
Mt Whitney 14494
San Gorgonio Mtn 11490
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124°0'0"W
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120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N

Marine Managed Areas

California's marine resources are treasured for their natural beauty and for the economic and recreational opportunities they provide. Effective management of these resources requires balancing natural biodiversity and habitat conservation goals with human use and enjoyment of California's coast. A mosaic of different types of Marine Managed Areas (MMAs) in the state's nearshore waters aims to achieve these equally important goals. The California Department of Fish and Wildlife manages these MMAs, which include several designations with different levels of protection (see box).

In 1999, the California Legislature passed the Marine Life Protection Act, which required the state to redesign its existing patchwork of Marine Protected Areas (MPAs) into a science-based, ecologically connected statewide MPA Network. Prior to the passage of the Marine Life Protection Act, less than three percent of state waters were protected. Today, California's Network includes 124 MPAs and protects 16 percent of state waters. State Marine Reserves, where no take of any kind is allowed, are considered the backbone of the Network, accounting for nine percent of protected waters. Spanning the entire 1,100-mile California coast, the Network is one of the largest ecologically connected marine networks in the world.

The MPA Network was designed to protect and connect habitats such as kelp forests, rocky tidepools, sandy beaches, and deep marine canyons. A connected network allows the larvae of many coastal species to move from inside protected areas to other places, both inside and outside protected areas, populating habitats across the coast. Some MMAs share boundaries with land-based state and national parks, overlap with federally managed marine reserves, or are surrounded by larger national marine sanctuaries, further connecting coastal habitats both on land and at sea.

A Red Abalone (*Haliotis rufescens*) and a Black and Yellow Rockfish (*Sebastes chrysomelas*) in South Point State and Federal Marine Reserve, Channel Islands
CDFW photo: Amanda Van Diggelen

Abalone survey at the Sea Lion Cove State Marine Conservation Area
CDFW photo: Chenchen Shen

The management of the Network is a collaborative effort led by the Department. MPA Management Program activities fall under four focal areas: Outreach and Education, Research and Monitoring, Policy and Permitting, and Enforcement and Compliance (CDFW 2020n). The Department partners with other state and federal agencies, tribal governments, non-governmental organizations, researchers, and community members to carry out these program activities. Conserving the diversity of California's living marine resources is a core goal of the management program, which can help promote resiliency and safeguard the intrinsic and economic value of California's extraordinarily diverse coastal communities for generations to come.

Marine Managed Areas

The Marine Managed Areas Improvement Act established these MMA designations (CDFW 2020n). Three of these classifications (State Marine Reserves, State Marine Conservation Areas, and State Marine Parks) are a subset of MMAs called Marine Protected Areas.

State Marine Reserve: Prohibits damage or take, whether recreational or commercial, of all marine resources.

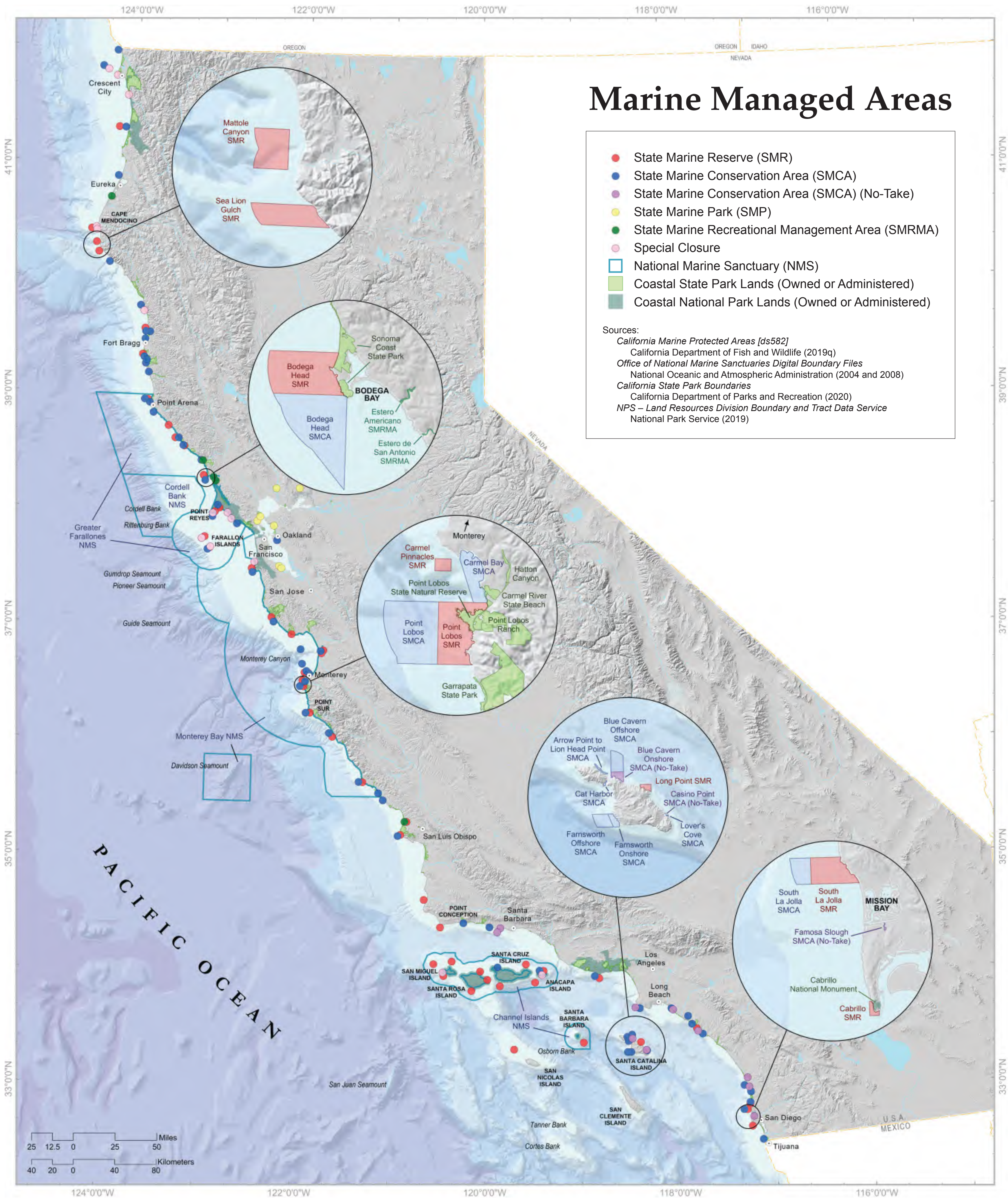
State Marine Conservation Area: Allows some recreational and/or commercial take of marine resources (restrictions vary).

State Marine Conservation Area (No-Take): Prohibits damage or take of all marine resources except for incidental take due to ongoing permitted activities.

State Marine Park: Prohibits damage or take of all marine resources for commercial use purposes.

State Marine Recreational Management Area: Limits recreational take of marine resources. Allows legal waterfowl hunting (restrictions vary).

Special Closure: Prohibits access or restricts boating activities in waters near sea bird rookeries or marine mammal haul-out sites (restrictions vary). Special closures are not considered MMAs but play an important role in marine resource management.



Marine Managed Areas
State Marine Reserve (SMR)
State Marine Conservation Area (SMCA)
State Marine Conservation Area (SMCA) (No-Take)
State Marine Park (SMP)
State Marine Recreational Management Area (SMRMA)
Special Closure
National Marine Sanctuary (NMS)
Coastal State Park Lands (Owned or Administered)
Coastal National Park Lands (Owned or Administered)
Sources:
California Marine Protected Areas [ds582]
California Department of Fish and Wildlife (2019q)
Office of National Marine Sanctuaries Digital Boundary Files
National Oceanic and Atmospheric Administration (2004 and 2008)
California State Park Boundaries
California Department of Parks and Recreation (2020)
NPS – Land Resources Division Boundary and Tract Data Service
National Park Service (2019)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
Crescent City
Eureka
CAPE MENDOCINO
Mattole Canyon SMR
Sea Lion Gulch SMR
Fort Bragg
Point Arena
Sonoma Coast State Park
Bodega Head SMR
BODEGA BAY
Bodega Head SMCA
Estero Americano SMRMA
Estero de San Antonio SMRMA
Cordell Bank NMS
Cordell Bank
POINT REYES
Rittenburg Bank
Greater Farallones NMS
FARALLON ISLANDS
Oakland
San Francisco
Gumdrop Seamount
Pioneer Seamount
San Jose
Guide Seamount
Monterey Canyon
Monterey
Carmel Pinnacles SMR
Carmel Bay SMCA
Hatton Canyon
Point Lobos State Natural Reserve
Carmel River State Beach
Point Lobos Ranch
Point Lobos SMCA
Point Lobos SMR
Garrapata State Park
POINT SUR
Monterey Bay NMS
Davidson Seamount
San Luis Obispo
Blue Cavern Offshore SMCA
Arrow Point to Lion Head Point SMCA
Blue Cavern Onshore SMCA (No-Take)
Long Point SMR
Cat Harbor SMCA
Casino Point SMCA (No-Take)
Lover's Cove SMCA
Farnsworth Offshore SMCA
Farnsworth Onshore SMCA
PACIFIC OCEAN
POINT CONCEPTION
Santa Barbara
SANTA CRUZ ISLAND
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
ANACAPA ISLAND
Los Angeles
Long Beach
Channel Islands NMS
SANTA BARBARA ISLAND
Osborn Bank
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
South La Jolla SMCA
South La Jolla SMR
MISSION BAY
Famosa Slough SMCA (No-Take)
Cabrillo National Monument
Cabrillo SMR
San Juan Seamount
SAN CLEMENTE ISLAND
Tanner Bank
Cortes Bank
San Diego
Tijuana
U.S.A.
MEXICO
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

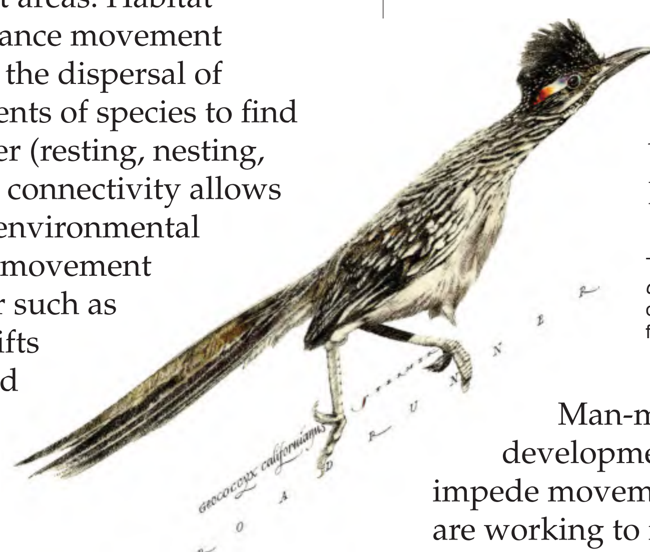
Habitat Connectivity

Mountain lion cub (*Puma concolor*). Mountain lions have large home ranges and often move several miles or more through the landscape every day, making habitat connectivity essential to their survival. CDFW photo

Habitat connectivity is a measure of how easily wildlife and plants can move through the landscape; it is determined by habitat types, barriers, and the spatial pattern of landforms. To maintain healthy wildlife populations and conserve biodiversity, it is important to protect natural areas that provide habitat—and equally important to ensure that species can move between those habitat areas. Habitat connectivity supports long-distance movement such as seasonal migration and the dispersal of young, as well as daily movements of species to find resources such as food and cover (resting, nesting, and hiding places). In addition, connectivity allows species to move in response to environmental changes, which might be rapid movement in response to a natural disaster such as a flood or forest fire, or slow shifts in the distributions of plants and animals in response to climate change. Without habitat connectivity, populations can become genetically isolated or may be unable to respond to changes in the environment, both of which can lead to population decline and local extinction. Ecological processes such as the movement of water, sand, and sediment, which are important for the maintenance of habitat areas like rivers, beaches, and dunes, also require connectivity.

Corridors and linkages are paths that connect natural areas. Some corridors are seasonal migration routes that are used year after year, such as paths used by mule deer and other large ungulates between winter and summer habitat areas. Others are narrow swaths of habitat that represent the last remaining natural connection through a modified landscape, such as a riparian habitat alongside a stream running through an urban or agricultural landscape. Linkages are broad swaths of natural habitat that connect larger natural areas and support species movement and ecological processes. The map on the facing page identifies a network of corridors and linkages needed to maintain habitat connectivity between remaining large natural habitat areas in California.

The desert tortoise (*Gopherus agassizii*) is threatened by habitat loss and fragmentation. Although the species does not generally move long distances on a daily basis, connectivity between populations is important for maintaining genetic diversity and reproductive success. Linear infrastructure such as a highway can pose a complete barrier to its movement. CDFW photo: Dave Feliz

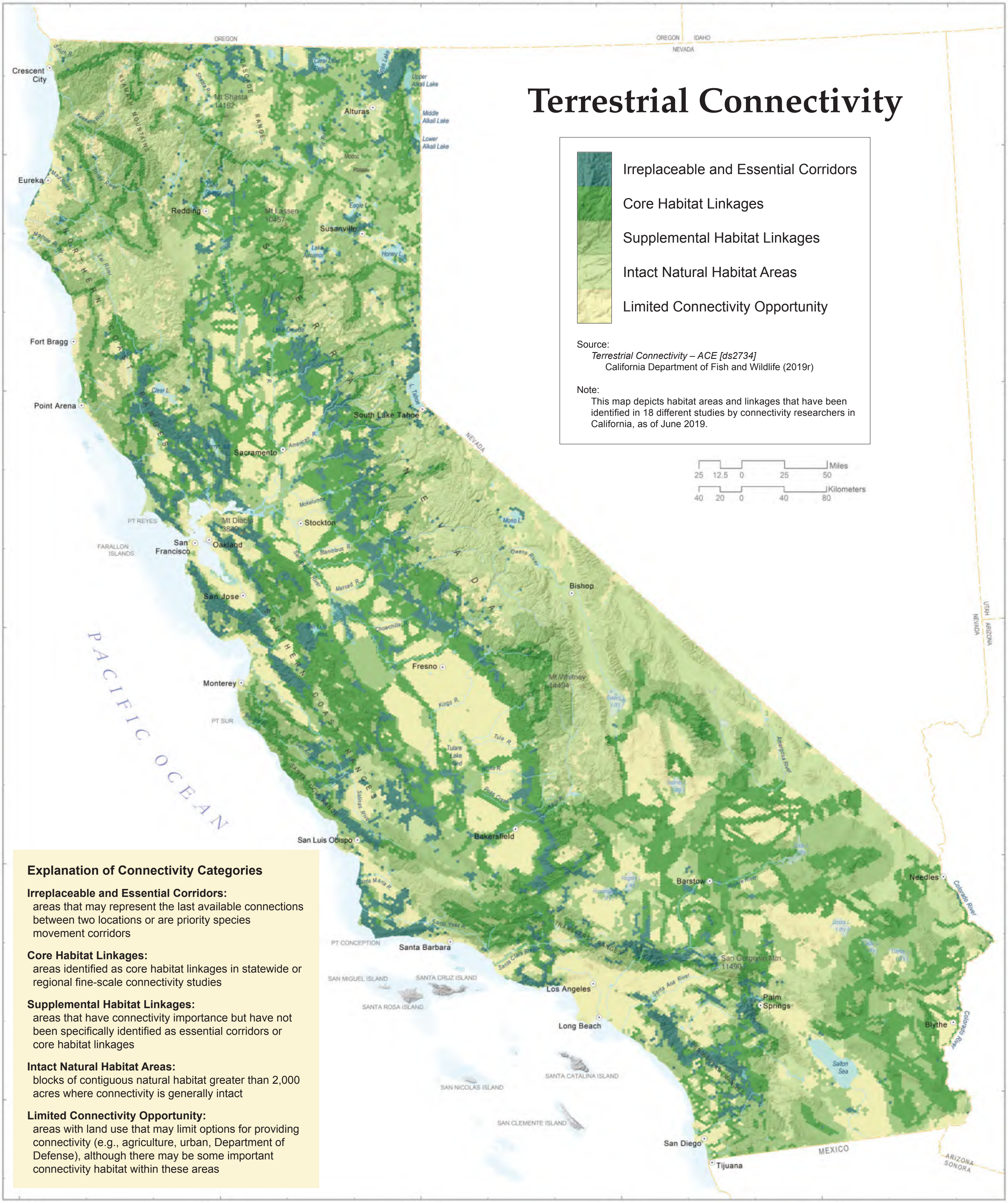


True to their name, Roadrunners (*Geococcyx californianus*) generally move by running along paths on the ground, which makes them sensitive to habitat fragmentation and to being hit by vehicles on roads.

Man-made infrastructure such as roads, development, and dams can act as barriers that impede movement through the landscape. Researchers are working to identify barriers and develop solutions to support wildlife movement around them. For example, crossing structures such as culverts or wildlife bridges can allow species to cross under or over busy roadways. How an animal moves through the landscape and whether it will use a wildlife crossing structure depends on the characteristics and behavior of individual species. Information on wildlife movement and behavior must be considered, together with detailed maps of landscape configuration, to plan for habitat connectivity.

Mule deer (*Odocoileus hemionus*) galloping through an underpass. Researchers use wildlife cameras to understand how animals use habitat corridors in the landscape and how barriers affect this movement. Photo: Highway 89 Stewardship Team, Caltrans

Terrestrial Connectivity



Explanation of Connectivity Categories

Irreplaceable and Essential Corridors:
areas that may represent the last available connections between two locations or are priority species movement corridors

Core Habitat Linkages:
areas identified as core habitat linkages in statewide or regional fine-scale connectivity studies

Supplemental Habitat Linkages:
areas that have connectivity importance but have not been specifically identified as essential corridors or core habitat linkages

Intact Natural Habitat Areas:
blocks of contiguous natural habitat greater than 2,000 acres where connectivity is generally intact

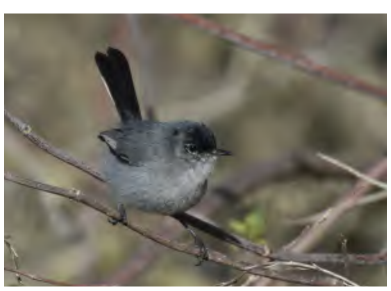
Limited Connectivity Opportunity:
areas with land use that may limit options for providing connectivity (e.g., agriculture, urban, Department of Defense), although there may be some important connectivity habitat within these areas

Regional Conservation Planning

The 1,800-acre Roddy Ranch property was conserved in 2013 through the East Contra Costa County NCCP for its value as an important wildlife movement corridor and a habitat for California Tiger Salamander (*Ambystoma californiense*) and California Red-legged Frog (*Rana draytonii*). CDFW photo: Sara Kern

California's human population is expected to increase by nearly 20 percent by the year 2060, to over 45 million people. Due to the widespread land conversion that will be required to support human needs, many species and natural communities are at risk of being lost. The heaviest growth is projected to occur in Southern California and the San Francisco Bay Area, in places that include several national biodiversity hotspots.

Conservation biologists have determined that the most effective way to ensure the survival of species is to protect natural areas large enough to support the diversity of habitats that species depend upon and connected enough to enable wildlife movement and adaptations to climate change (see the Climate Change chapter). People also recognize that having wildlands surrounding their neighborhoods and cities is an important part of their quality of life. The Department has several regional conservation planning tools that help to achieve these goals: the Natural Community Conservation Planning (NCCP) Program, the Regional Conservation Investment Strategies (RCIS) Program, and the Conservation and Mitigation Banking (Banking) Program. These programs have been developed in response to legislation promoting the conservation of California's species and natural habitats.



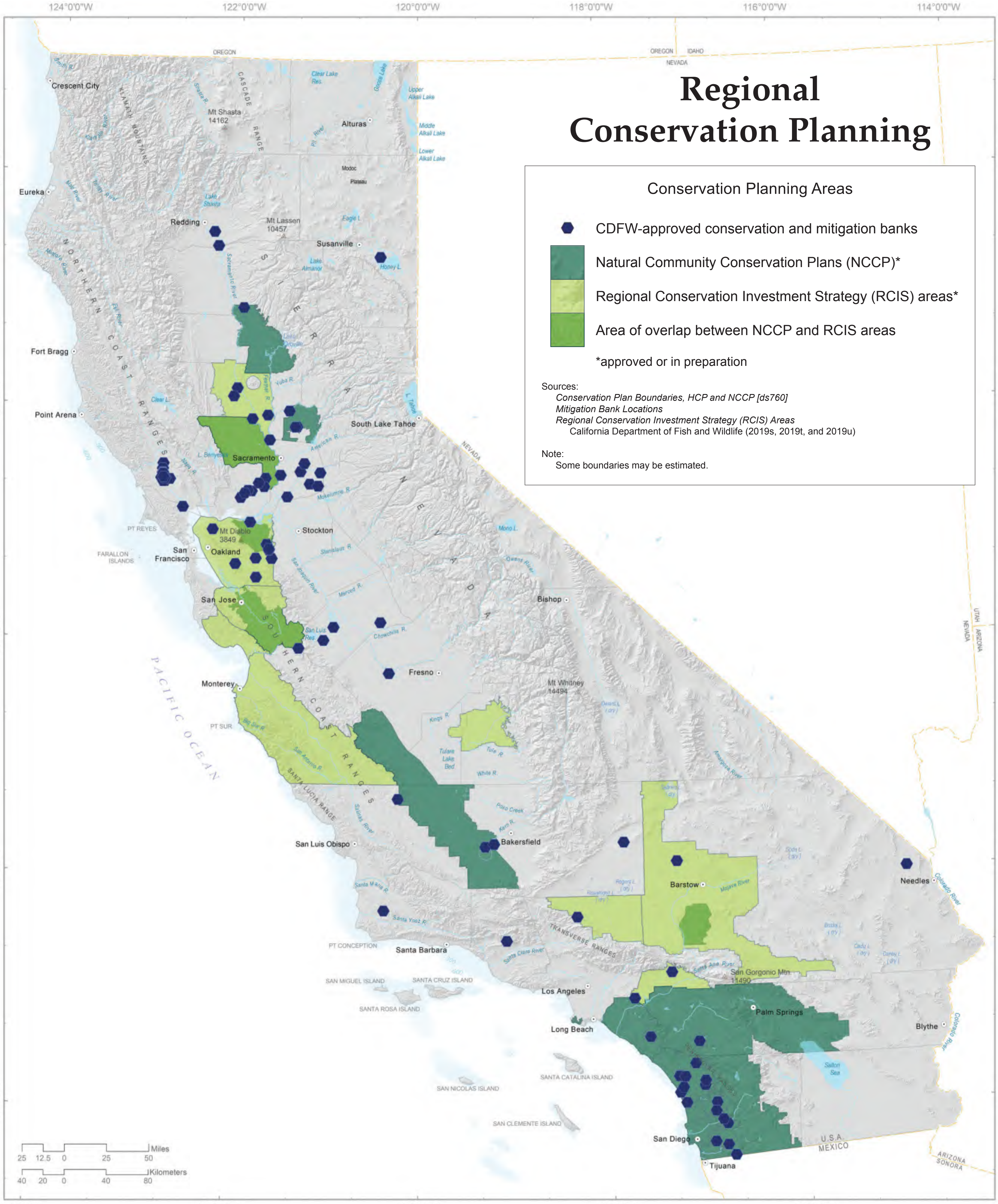
The impending federal listing of the California Gnatcatcher (*Polioptila californica*) as a threatened species was a primary impetus for the creation of the NCCP program in 1991. This species inhabits coastal sage scrub. Photo: Andy Reago and Chrissy McClarren

To address the conflicts between population growth and the preservation of California's rich biological diversity, the Department developed the NCCP program in 1991. The NCCP program relies on cooperation among government agencies at local, state, and federal levels; business and industry groups; landowners (more than 50 percent of special-status species occur on private land); conservation organizations; and the public. NCCP plans integrate the principles of conservation biology, endangered species laws, and local land use planning. Under an NCCP plan, an organization receives a permit for long-term habitat conservation in order to offset impacts to special-status species. To date, approved NCCPs include commitments to conserve more than 1.5 million acres of habitat.

More recently, the Department developed the RCIS program in 2017 to promote voluntary, non-binding regional conservation of species and habitats. RCISs first identify focal species, then specify objectives and actions to conserve and enhance habitat in the RCIS area for those species. Unlike an NCCP, there is no permit associated with an RCIS and no requirement to achieve the recommended conservation. However, if actions from the approved RCIS are implemented, mitigation credits may be created through Mitigation Credit Agreements to offset impacts from current or future projects. Nine RCISs are approved or in preparation as of this date, covering part or all of 11 counties.

The Banking program achieves conservation at a smaller landscape scale than NCCPs and RCISs. Banks are developed on a voluntary basis on privately or publicly owned land to conserve or enhance habitat and to create mitigation credits. Project proponents can then purchase mitigation credits to offset the environmental impacts caused by their projects. Banks are typically created as large, contiguous areas that maximize benefits to species. This is preferable to project-by-project mitigation, which tends to result in small, isolated patches of habitat. The Department is a signatory to over 80 banks.

The map at right shows the locations of NCCPs and RCISs that have been approved or are in preparation, as well as Department-approved banks. The Department encourages partnerships to form landscape-level strategies for wildlife and habitat conservation. It is a reliable method to address the pressures from economic and human population growth in California.


Regional
Conservation Planning
Conservation Planning Areas
CDFW-approved conservation and mitigation banks
Natural Community Conservation Plans (NCCP)*
Regional Conservation Investment Strategy (RCIS) areas*
Area of overlap between NCCP and RCIS areas
*approved or in preparation
Sources:
Conservation Plan Boundaries, HCP and NCCP [ds760]
Mitigation Bank Locations
Regional Conservation Investment Strategy (RCIS) Areas
California Department of Fish and Wildlife (2019s, 2019t, and 2019u)
Note:
Some boundaries may be estimated.
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
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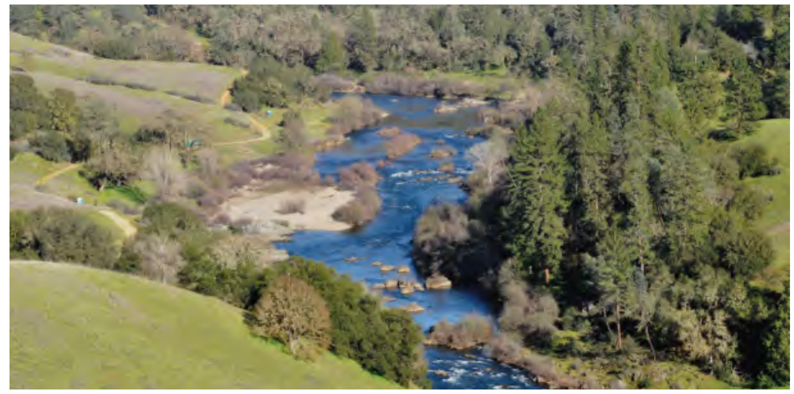
33°0'0"N
OREGON
NEVADA
IDAHO
Crescent City
Eureka
Redding
Mt Shasta
14162
Alturas
Mt Lassen
10457
Susanville
Fort Bragg
Point Arena
Sacramento
South Lake Tahoe
Stockton
Mt Diablo
3849
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Mt Whitney
14494
Bakersfield
San Luis Obispo
Santa Barbara
Barstow
Needles
Los Angeles
Long Beach
San Gorgonio Mtn
11490
Palm Springs
Blythe
San Diego
Tijuana
U.S.A.
MEXICO
PACIFIC OCEAN
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
NORTHERN COAST RANGES
SOUTHERN COAST RANGES
SIERRA NEVADA
SANTA LUCIA RANGE
TRANSVERSE RANGES
Salton Sea
25 12.5 0 25 50
Miles
40 20 0 40 80
Kilometers

Watershed Health



South Fork American River near Pilot Hill
Photo © Peter Ode

Streams and rivers are among the most biodiverse ecosystems on the planet, rivalling even coral reefs and rainforests. California's network of streams is over 200,000 miles long and supports thousands of species, many unique to California. Like all freshwater environments, streams are tightly linked to their terrestrial surroundings. Streams and their biota support a vast array of terrestrial biodiversity, especially in riparian areas. In turn, the health of streams depends on the health of the landscapes that they drain.

Stream-dwelling organisms are highly vulnerable to stressors associated with human activities. They absorb the effects of a vast array of stressors over time, including alterations to the stream channel and surrounding areas and to water quality and water quantity. Because different species of aquatic organisms are sensitive to different kinds of stresses, knowing which species can live in a specific stream can tell us a lot about the health of both the stream and its watershed. This is known as bioassessment.

Stonefly adult (*Salmoperla sylvanica*). Many insect species like this stonefly are sensitive to alterations of the upstream watershed.
Photo © John Sandberg

Many different groups of organisms call streams their home, but benthic macroinvertebrates (small, but visible, invertebrates like insects, snails, and crayfish) are well suited for bioassessments because they are abundant, highly diverse, and very well studied. Over the last 20 years, benthic invertebrate bioassessments have become widely adopted throughout California to assess, protect, and restore the state's freshwater ecosystems.

The two maps at the right summarize data about stream health based on benthic invertebrates, using a scoring tool called the California Stream Condition Index (CSCI, Mazor et al. 2016). The CSCI compares the specific invertebrate species observed in a test stream to a list of invertebrate taxa expected to occur if the stream is unaffected by human sources of stress. The expected list is created by comparing the stream to hundreds of similar reference streams, where upstream human disturbance is absent or minimal.

The CSCI score compares the species of invertebrates found at a site to those that would be expected in a similar healthy stream. CSCI scores are close to or greater than 1.0 when the community is intact. Scores significantly less than 1.0 indicate altered communities.

The smaller map represents the output of a landscape model that predicts the best CSCI scores that are expected to occur within a specific watershed given the amount of landscape development occurring there. These expected CSCI scores were modeled based on relationships between stream health and land use variables, including percentages of urbanization and agricultural development, roads density, and other variables. Watersheds with high values are expected to contain streams with high CSCI scores, whereas ones with lower values are expected to have poorer-scoring streams. More than 2,000 stream sites were included in this model.

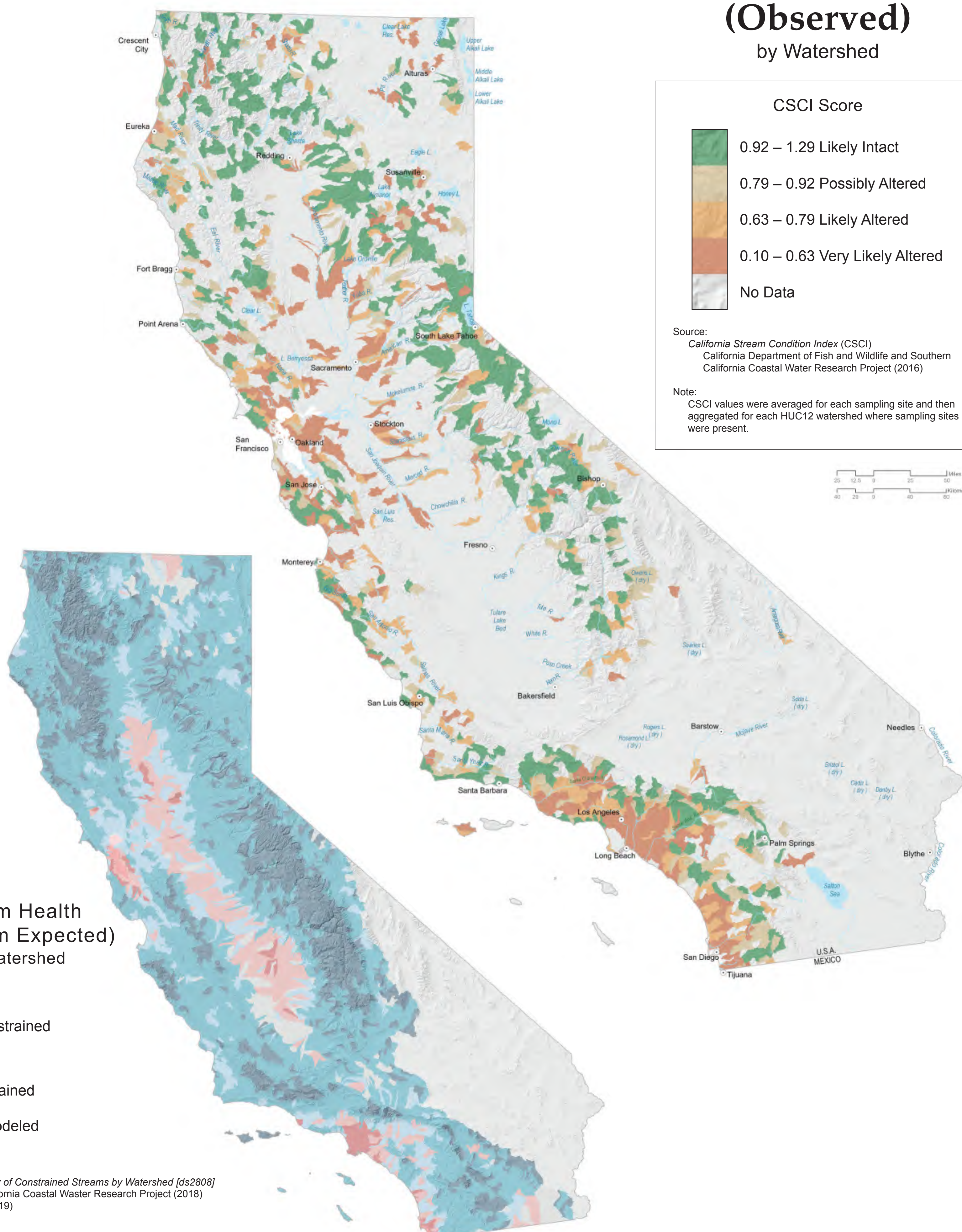
The larger map represents CSCI scores calculated from samples collected from over 3,000 unique stream locations. The color of each watershed represents the average CSCI score observed in streams within that watershed.

By comparing the information in these two maps, resource managers can identify areas where stream health may be underperforming or overperforming expectations. This provides much needed insight to guide prioritization decisions for protection, restoration, or additional monitoring and coordination.

Sampling for benthic macroinvertebrates
CDFW Photo

Stream Health (Observed)

by Watershed



CSCI Score

- 0.92 – 1.29 Likely Intact
- 0.79 – 0.92 Possibly Altered
- 0.63 – 0.79 Likely Altered
- 0.10 – 0.63 Very Likely Altered
- No Data

Source:
California Stream Condition Index (CSCI)
California Department of Fish and Wildlife and Southern California Coastal Water Research Project (2016)

Note:
CSCI values were averaged for each sampling site and then aggregated for each HUC12 watershed where sampling sites were present.

Stream Health (Maximum Expected)

by Watershed

- Likely Unconstrained
- Likely Constrained
- Not Modeled

Source:
Biological Integrity of Constrained Streams by Watershed [ds2808]
Southern California Coastal Waster Research Project (2018)
Beck et al. (2019)

Note:
Analysis was done using HUC12 watersheds with southeastern desert watersheds excluded from this comparison.

Habitat Restoration

Ackerson Meadow, Central Sierra Meadow Restoration Planning Project
Photo: Celestial Reysner, WCB

The California Department of Fish and Wildlife and the Wildlife Conservation Board manage continuous and competitive grant programs that enhance and restore natural habitats. The programs are funded with state and federal resources, including significant funding from state bond acts. The programs also rely on partnerships with contributing local governments; tribes; water districts; non-profit organizations; federal, state, and local community conservation corps; and private landowners. Collaborative efforts focus on restoration of natural landscapes to provide habitat for California's diverse native plants, fish, and wildlife.

A mountain meadow restoration at Perazzo Meadows in the upper Little Truckee River Watershed, funded by the Proposition 1 Watershed Restoration Grant Program
CDFW photo: Vicki Lake

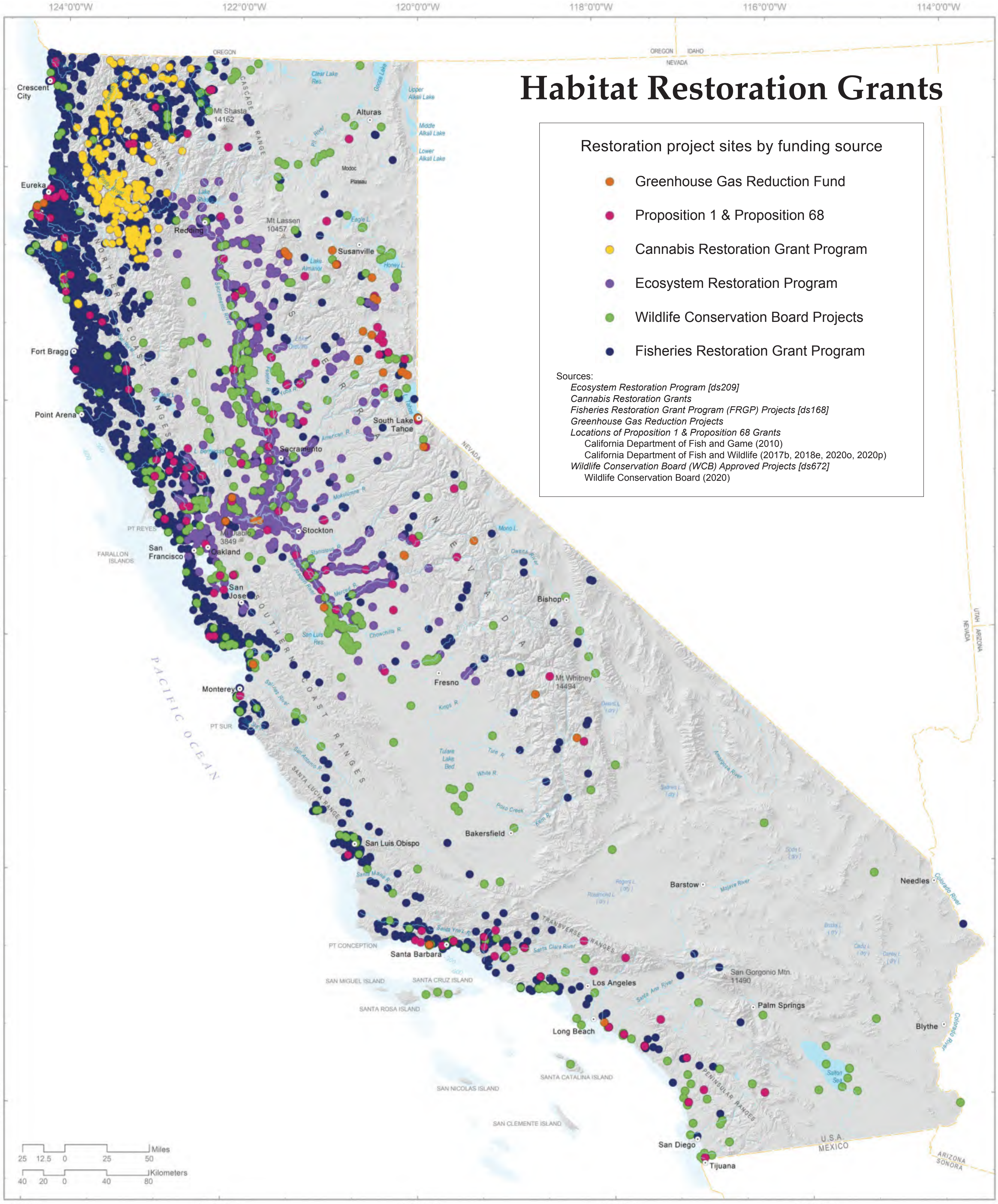
Restoring degraded habitats presents great opportunities to increase the biodiversity of native species. Restored habitats include rivers, streams, and their associated riparian areas, mountain meadows, inland and coastal wetlands, forests, and grasslands. Special status species are frequently targeted in these projects. Grant program agreements incorporate monitoring to ensure project effectiveness and to help inform planning and implementation of future projects.

General project goals include hydrologic function recovery, fish barrier removal, fuel load reduction, habitat connectivity, forest stand enhancement, and habitat and water quality improvements along the United States-Mexico border. Some projects are specifically designed to improve forest health after catastrophic fire, to sequester greenhouse gases, or to clean up and restore illegal cannabis cultivation sites. Hundreds of projects have been completed and are ongoing throughout the state. The map on the right shows the locations of active and completed restoration projects along with their funding sources. These programs have contributed hundreds of millions of dollars to support a future for California that ensures its rich biodiversity will remain self-supporting and resilient.

Funds have also been awarded for activities that indirectly affect habitat restoration. Examples are cooperative fish rearing, acquisition of riparian easements, project monitoring, watershed assessment and planning, support for watershed organizations, and increased public access and outreach. Outreach components may be classroom education for children or technical workshops for adults and watershed groups involved in restoration projects. Thousands of young people have learned about the importance of protecting our watersheds to create the habitat conditions necessary for species to thrive. Some grant programs designate funds specifically for projects in disadvantaged communities.

Natural landscapes have been degraded and altered over the years, so numerous opportunities exist for restoration projects that will benefit California's biodiversity. Restoring natural habitats is a commitment that these programs and partners have embraced, with the aim of maintaining and restoring California's diverse ecosystems for generations to come.

Monarch butterfly (*Danaus plexippus*) at the Monarch Butterfly Grove at Pismo Beach, funded by the California Monarch Recovery Project
Photo: Celestial Reysner, WCB


Habitat Restoration Grants
Restoration project sites by funding source
Greenhouse Gas Reduction Fund
Proposition 1 & Proposition 68
Cannabis Restoration Grant Program
Ecosystem Restoration Program
Wildlife Conservation Board Projects
Fisheries Restoration Grant Program
Sources:
Ecosystem Restoration Program [ds209]
Cannabis Restoration Grants
Fisheries Restoration Grant Program (FRGP) Projects [ds168]
Greenhouse Gas Reduction Projects
Locations of Proposition 1 & Proposition 68 Grants
California Department of Fish and Game (2010)
California Department of Fish and Wildlife (2017b, 2018e, 2020o, 2020p)
Wildlife Conservation Board (WCB) Approved Projects [ds672]
Wildlife Conservation Board (2020)
124°0'0"W
122°0'0"W
120°0'0"W
118°0'0"W
116°0'0"W
114°0'0"W
41°0'0"N
39°0'0"N
37°0'0"N
35°0'0"N
33°0'0"N
OREGON
IDAHO
NEVADA
UTAH
ARIZONA
Crescent City
Eureka
Redding
Mt Shasta 14162
Alturas
Mt Lassen 10457
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
PT REYES
FARALLON ISLANDS
Bishop
Fresno
Mt Whitney 14494
Monterey
PT SUR
PACIFIC OCEAN
Bakersfield
San Luis Obispo
Barstow
Needles
PT CONCEPTION
Santa Barbara
SAN MIGUEL ISLAND
SANTA CRUZ ISLAND
SANTA ROSA ISLAND
Los Angeles
San Gorgonio Mtn. 11490
Palm Springs
Long Beach
Blythe
SANTA CATALINA ISLAND
SAN NICOLAS ISLAND
SAN CLEMENTE ISLAND
San Diego
Tijuana
U.S.A.
MEXICO
ARIZONA
SONORA
CASCADE RANGE
NORTHERN COAST RANGES
SIERRA NEVADA
SOUTHERN COAST RANGES
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
Salton Sea
25 12.5 0 25 50 Miles
40 20 0 40 80 Kilometers

Glossary

abiotic — physical rather than biological; not derived from living organisms.

adaptive management — process that improves the management of biological resources by using new information gathered through monitoring, evaluation, and other credible sources as they become available, and that adjusts management strategies and practices to assist in meeting conservation and management goals (CDFG 2012).

alluvial fan — a wide, cone-shaped deposit of rocks, sand, gravel, and finer materials that has been deposited by a stream as it flows out of a mountainous area onto a plain.

alluvium — sediment deposited by a river or other flowing stream.

anadromous — fish species that spend most of their adult lives in the ocean but migrate to freshwater rivers and streams to spawn.

aquatic — growing in, living in, or frequenting water, usually open water; compare with **wetland**.

arachnids — a class of **arthropods** generally having eight legs and mainly living on land. This class includes spiders, scorpions, ticks, mites, and harvestmen.

arthropods — a group of invertebrate animals having an exoskeleton, segmented body, and paired, jointed appendages.

basin — a large-scale depression in the land surface which is wider than it is deep, with steep or gently dipping sides.

benthic — related to the bottom layer of a body of water.

biodiversity hotspot — a geographic area that is both high in biological diversity and at risk of destruction, often from human causes.

biogeography — the branch of biology that deals with the geographic distribution of plants, animals, and ecosystems.

biota — the plant and animal life of a particular habitat.

bioturbators (bioturbation) — animals or plants that rework soil and sediment through a variety of activities including digging, burrowing, ingestion, and defecation. Bioturbation is an extremely important ecosystem function and is considered a major driver of biodiversity.

branchiopods — a class of **crustaceans** including fairy shrimp, clam shrimp, and tadpole shrimp; mainly small, freshwater animals that feed on plankton and detritus.

California Natural Diversity Database (CNDDB) — a statewide inventory of the locations and conditions of the state's rarest plant and animal taxa and vegetation types. The CNDDB is a natural heritage program and is part of NatureServe's National Heritage Network, a nationwide network of similar programs.

chaparral — an ecological community composed mainly of shrubby plants with hard, evergreen leaves, adapted to the dry summers and moist winters of California's Mediterranean climate.

conservation easement — a purchased claim to some rights, generally development rights, on private property as a way of conserving both natural resources and private ownership.

continental shelf — the area of seabed around a large landmass where the sea is relatively shallow compared with the open ocean.

crustaceans — a large, diverse **taxon** of mostly aquatic **arthropods**. This subphylum includes crabs, crayfish, and shrimp.

deciduous — referring to a tree or shrub that sheds its leaves seasonally, usually in the autumn.

easement — see also **conservation easement**; a voluntary, legal agreement that permanently limits uses of the land in order to protect its conservation values.

ecoregions — as used here, defined as "sections" in the Bailey (1976) nomenclature, which are subdivisions of ecological provinces based on major terrain features such as a desert, plateau, valley, mountain range, or a combination thereof. Sections are large land areas of relatively homogeneous physical and biological components that interact to form environments of similar productive capabilities, response to disturbances, and potentials for resource management (McNab et al. 2007)

ecosystem — a natural unit defined by both its living and non-living components; a balanced system for the exchange of nutrients and energy. Compare with **habitat** and **vegetation type**.

ecosystem services — positive benefits that people obtain from wildlife or **ecosystems**, such as food and fresh water, pollination of crops and orchards, soil formation, and recreational opportunities.

endangered — one of several **special status** listing designations of plant and animal **taxa**. Under the California and federal Endangered Species Acts, endangered refers to a **taxon** that is in danger of becoming **extinct** throughout all or a significant portion of its range. The word endangered is also commonly applied to non-listed taxa in danger of extinction.

endemic — found only in a specified geographic region.

endemism — used here as a measure of distribution of those **taxa** that are found only in one specific area, such as one region or the state itself. A region of high endemism has many taxa restricted to it.

estuary — an area in which salt water from the ocean mixes with flowing fresh water, usually at the wide mouth of a river.

evergreen — referring to a tree or shrub that retains green leaves throughout the year.

exotic — a plant or animal that has been introduced to an area from outside its native range, either purposely or accidentally.

extant — still existing.

extinct — refers to a plant, animal, or v**egetation type** that no longer exists anywhere.

extirpated — refers to a plant, animal, or **vegetation type** that had been locally eliminated, but is not **extinct**.

fauna — all of the animal **taxa** in a given area.

flora — all of the plant **taxa** in a given area.

forb — a broad-leaved herb, such as clover, as distinguished from a grass or a woody plant.

gastropods — a large class of **mollusks** comprising aquatic and terrestrial snails and slugs.

geology — the earth's physical structure and substance, its history, and the processes that act on it.

georeferencing — the process of providing geographic coordinates that correspond to a location.

habitat — where a given plant or animal species meets its requirements for food, cover, and water in both space and time; may or may not coincide with a single **vegetation type**.

habitat connectivity — a measure of how easily wildlife, plants, and ecological process can move through the landscape.

harvestmen — the common name for members of the **arachnids**, distinguishable from spiders by their fused body regions and single pair of eyes.

hotspot — a location where a particular condition is concentrated. In this context, the condition may be species richness, risk of extinction, or some combination of these or other factors. Hotspots are relative to the area under consideration: ecoregion, state, world, etc.

HUC — Hydrologic Unit Code. The Watershed Boundary Dataset (USGS 2013) provides Hydrologic Units that define drainage areas for surface water. Hydrologic units are subdivided into progressively smaller units with each unit nested within the previous level. Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to twelve digits; HUC12 used in this atlas is the sub-watershed level.

igneous — referring to rocks formed by the solidification of magma due to volcanic processes at or below the Earth's surface (Harden 2004).

introduced — refers to any **species** intentionally or accidentally transported and released into an environment outside its native range.

invasive — a species which spreads rapidly once established and has the potential to cause environmental or economic harm. Most, but not all, invasive species are **introduced**; not all introduced species are invasive.

invertebrate — an animal without an internal skeleton. Examples are insects, clams, shrimp, and snails.

kelp forest — an underwater forest created by dense groupings of brown algae called kelp. Kelp forests occur in nearshore, nutrient-rich environments worldwide. They create a unique habitat that provides food, shelter, **substrate**, and nursing grounds for a diverse array of marine species (CDFG 2001).

latitude — an imaginary horizontal line representing degrees north or south of the Equator. The Equator is 0 degrees while the North Pole is 90 degrees north.

longitude — an imaginary vertical line representing degrees east or west of the Prime Meridian at Greenwich, London. Greenwich is 0 degrees while the line directly opposite it (in the Pacific Ocean) is 180 degrees west or east of the Prime Meridian.

magma — molten or semi-molten natural material beneath the earth's crust from which **igneous** rocks are formed.

Marine Protected Area — a named, discrete geographic area that has been designated by law to protect or conserve marine life and habitat (CDFW 2016b). This can be a marine or estuarine area below the mean high tide line or the mouth of a coastal river.

Mediterranean climate — climate characterized by dry summers and cool, wet winters, named for the Mediterranean basin, the largest area with this climate regime. Other areas include California and portions of Oregon and Baja California Norte, central Chile, southwestern South Africa, and southwestern Australia.

metamorphic — referring to **igneous** or **sedimentary** rocks that have been subjected to heat and pressure that alters the mineralogy, texture, or grains of the rock (Harden 2004).

migratory — refers to animals that travel seasonally. Migrations may be local or over long distances.

mima mounds — regular, low, dome-shaped mounds of soil and gravel clustered in areas that are relatively flat and poorly drained. These unexplained mound features, typically associated with prairies throughout the United States, are often an integral part of the local **vernal pool** landscape.

mitigation credit — a unit of important **habitat** created to compensate for impacts caused by projects to aquatic functions or to threatened, endangered, or other rare species and their habitats.

mollusks — a phylum of **invertebrate** animals with soft, unsegmented bodies, often enclosed in a calcium carbonate shell. This phylum includes snails, slugs, mussels, and octopuses.

montane — of mountainous country.

narrow endemic species — native species with restricted geographic distributions, often due to specific habitat requirements.

native — naturally occurring in a specified geographic region.

old growth forest — a forest that has not undergone any major unnatural changes (such as logging) for more than 100 to 150 years and thereby exhibits unique ecological features.

plant association — a vegetation classification unit defined by a diagnostic species, a characteristic range of species composition, physiognomy, and distinctive habitat conditions (Jennings et al. 2006). Associations reflect local topography, climate, substrates, hydrology, and disturbance regimes.

playa — a flat, dry area of an undrained desert **basin**, where shallow lakes may form during rainy periods.

pyroclastic — relating to rock fragments erupted by a volcano.

recruitment — the process of adding new individuals to a population through reproduction or immigration.

refugia — areas that will remain relatively buffered from climate change over time, enabling the persistence of ecological resources.

resilience — the capacity of any entity—an individual, a community, an organization, or a natural system—to prepare for disruptions, to recover from shocks and stresses, and to adapt and grow from a disruptive experience (Rodin 2014).

riparian — of or relating to the areas bordering rivers or streams.

rocky intertidal — the area of rocky shore that lies between the extreme high and low tidemarks. In California, it can be divided into three zones: the high intertidal zone that is only submerged for a short period during high tides; the middle intertidal zone that is regularly exposed and submerged during every tidal cycle; and the lower intertidal zone that is only exposed for a short period during very low tides.

run — a group of fish that migrates to fresh water to spawn during a specific time of the year.

salmonid — collective term for a family of fish that includes salmon and trout.

sedimentary — referring to rocks formed at or near the Earth's surface by accumulation of minerals, rock, and/or plant and animal fragments (Harden 2004).

soil horizon — a distinct soil layer whose properties differ from the layers above and below it (Harden 2004).

special status — collective term for all categories of plant or animal **taxa** whose populations are rare and at risk. The **CNDDB** tracks special status taxa, which meet one or more of the following criteria:

Is listed, is a candidate for listing, or is proposed for listing under the California or federal Endangered Species Acts or California Native Plant Protection Act as Endangered, Threatened, or (for plants only) Rare;

Is a federal "Species of Concern," an unofficial designation sometimes seen on U.S. Fish and Wildlife Service species lists;

Meets the criteria for listing, even if not currently included on any list, as described in Section 15380 of the California Environmental Quality Act (CEQA) Guidelines;

Has been designated as a special status, sensitive, or declining taxon by other state or federal agencies or non-governmental organizations, including Bureau of Land Management and U.S. Forest Service;

If an animal, is considered by CDFW to be a Species of Special Concern;

If a plant, is listed in the California Native Plant Society's Inventory of Rare and Endangered Plants of California (CNPS 2020b);

Is biologically rare, very restricted in distribution, declining throughout its range, or has a critical, vulnerable stage in its life cycle that warrants monitoring;

Has population(s) in California that may be peripheral to the major portion of its range but is threatened with extirpation in California; or

Is closely associated with a habitat that is declining in California at a significant rate (e.g., wetlands, riparian habitats, old growth forests, desert aquatic systems, native grasslands).

speciation — the process by which new **taxa** evolve.

species — the highest level of biological classification from which organisms can breed and produce fertile offspring under natural conditions.

stressor — a change in environmental conditions that places stress on the health and functioning of an organism, population and/or **ecosystem**.

subspecies — the level of classification below **species**; a genetically distinct group.

substrate — the surface on which an organism lives.

taxa — a term used to refer collectively to organisms at different levels of biological classification. For example, **species**, **subspecies**, varieties, and evolutionarily significant units (ESUs) together may be referred to as taxa. Singular is **taxon**.

taxon — the name that is applied to a group in biological classification, for example, **species**, **subspecies**, variety, or evolutionarily significant unit (ESU). Plural is **taxa**.

tectonic plate — one of many large plates (slabs of solid rock) which make up the crust of the earth and move slowly around it, sometimes colliding with or pulling apart from other plates.

terrestrial — growing on, living on, or frequenting land.

threatened — one of several **special status** listing designations of plant and animal **taxa**. Under the California and federal Endangered Species Acts, threatened refers to a **taxon** that is likely to become **endangered** in the foreseeable future. The word threatened is also commonly applied to non-listed taxa in danger of extinction.

tidepool — a shallow pool of seawater along a rocky shore that is exposed during low tides. Tidepools harbor many different types of seaweeds, **invertebrates**, and fishes (NOAA 2019).

topography — the shape of the surface of the earth, including mountains and valleys.

ultramafic — **igneous** rocks with very high iron and magnesium content and low (about 40 percent) silica (Harden 2004).

upland — a general term referring to **species**, **habitats**, or **vegetation types** in non-flooded or non-saturated areas.

upwelling — the process by which warm ocean surface waters are replaced by cooler subsurface waters. For regions such as California, with eastern boundary currents and winds that generally flow in a direction favorable for upwelling, surface waters are moved away from the coast and are replaced by cold, nutrient-rich subsurface waters. These nutrients support high productivity of fish, marine mammals, and sea birds.

urbanization — the degree to which natural landscapes have been altered by human development.

vagrant — an animal, usually migratory, straying outside of the normal range for its species. Many vagrants occur in California because of the state's large size; diverse **habitats** and **topography**; proximity to the ocean, where storms originate; long coastline and large marine area; and nearness to Canada, Asia, and Mexico.

vegetation type — a natural unit similar in definition to **ecosystem** but defined primarily by the composition of plant species; compare also with **habitat**.

vernal pool — seasonal **wetland** that forms in a depression on the soil surface above a water-impermeable layer of soil or rock. Plant and animal **taxa endemic** to vernal pools are those which can adapt to an annual cycle of flooding, temporary ponding, and drying.

vertebrate — an animal with an internal skeleton. Examples are birds, mammals, reptiles, amphibians, and fishes.

vulnerability — the susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt (Adger 2006).

watershed — defined here as a stream or river basin and the adjacent hills and peaks which "shed," or drain, water into it.

wetland — a general term referring to the transitional zone between **aquatic** and **upland** areas. Some wetlands are flooded or saturated only during certain seasons of the year. **Vernal pools** are one example of a seasonal wetland.

wildlands — collective term for public or private lands that are largely undeveloped and in their natural state.

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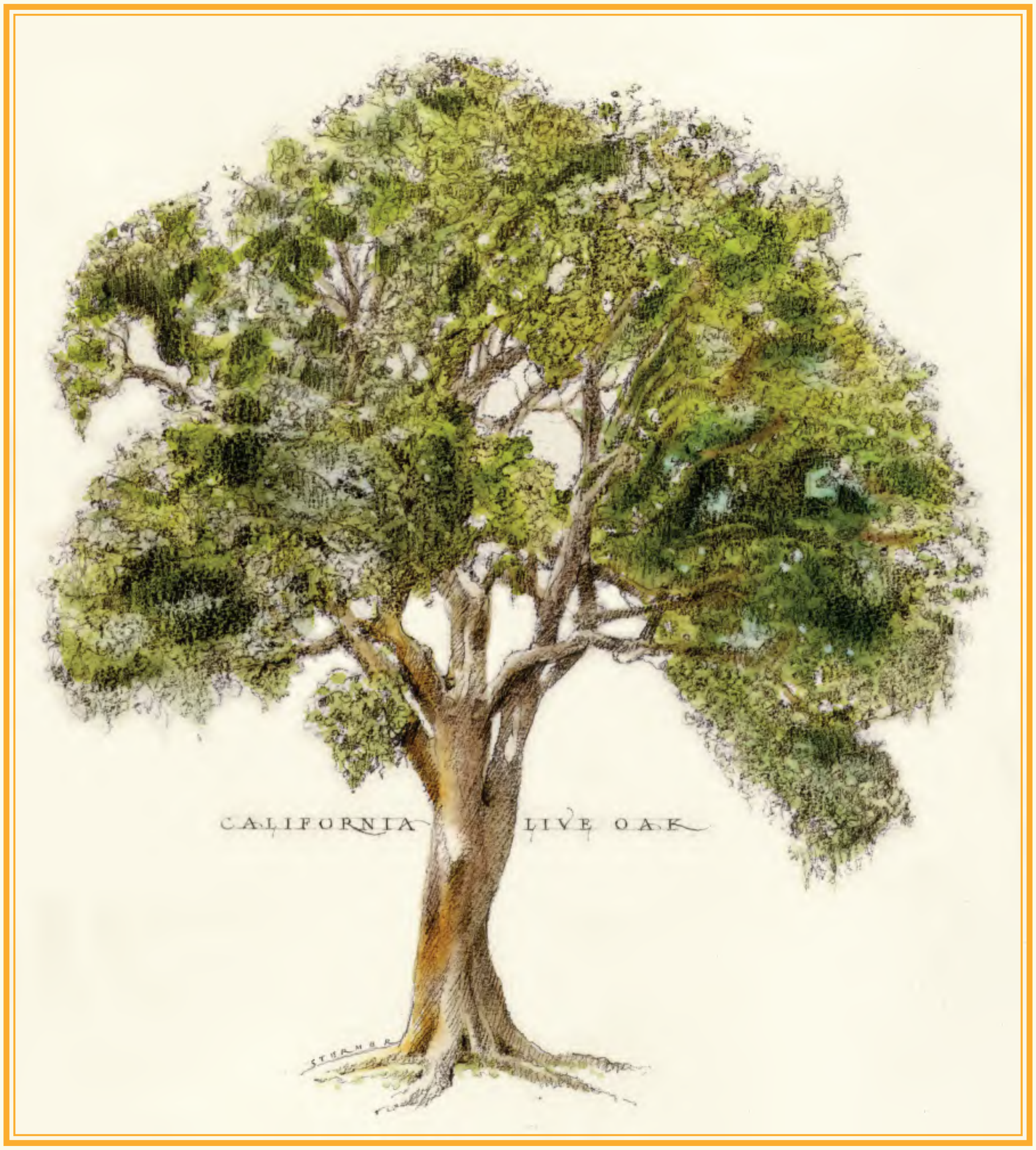

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