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

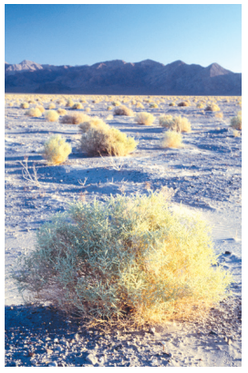
The patterns across the land that all of us see—forests, woodlands, meadows, chaparral, and grasslands—are made of different vegetation types. They are defined by their dominant or characteristic plant species, which are strongly influenced by non-living components such as soil, geology, climate, or 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.

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

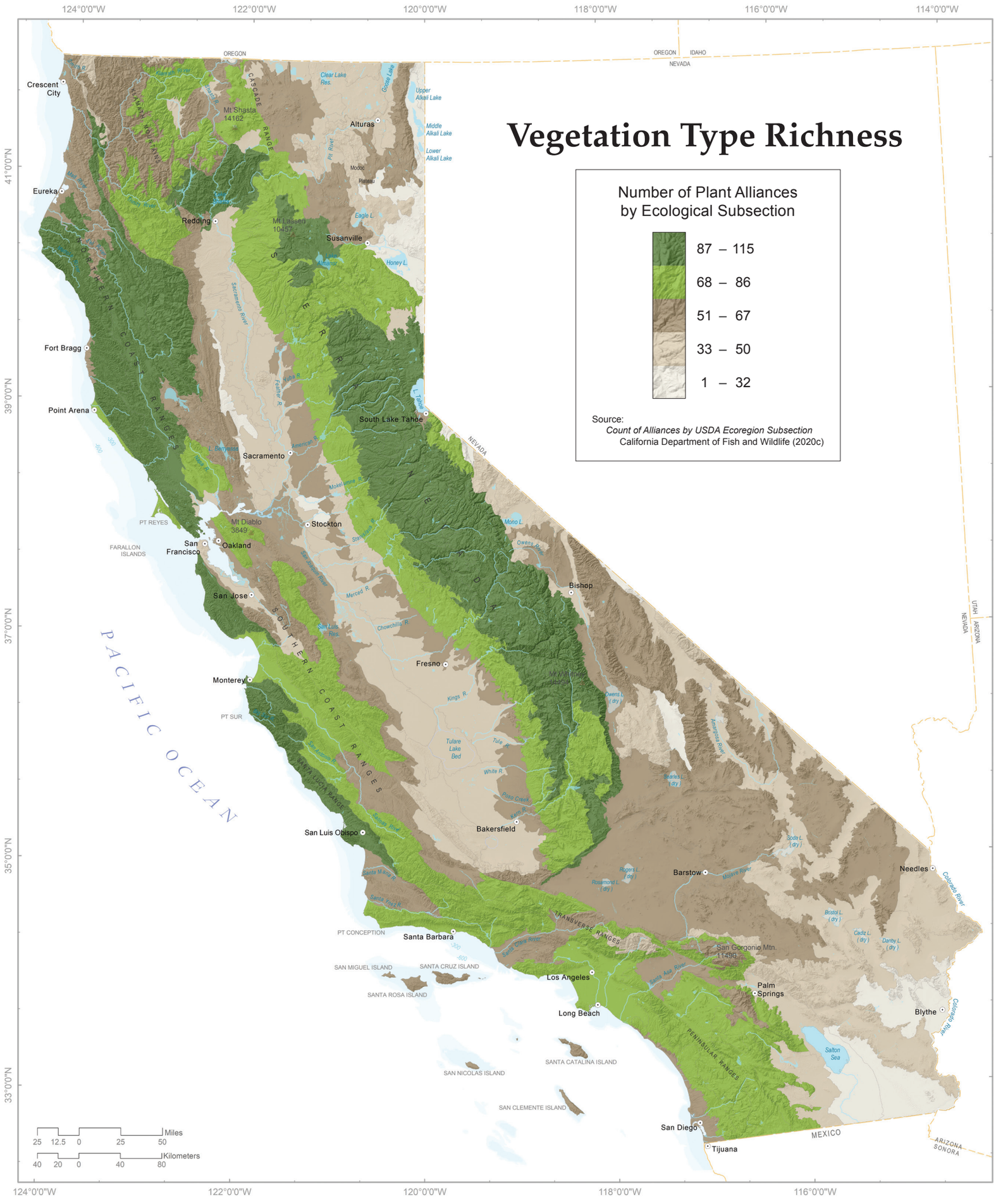
California boasts a wealth of vegetation types. The California Department of Fish and Wildlife currently lists over 2,000 distinct plant associations (CDFW 2019b). This is about 25 percent of the current number of plant associations in the entire United States National Vegetation Classification Hierarchy (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
Number of Plant Alliances by Ecological Subsection
87 – 115
68 – 86
51 – 67
33 – 50
1 – 32
Source:
Count of Alliances by USDA Ecoregion Subsection
California Department of Fish and Wildlife (2020c)
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
Mt Lassen 10457
Alturas
Susanville
Fort Bragg
Point Arena
South Lake Tahoe
Sacramento
Stockton
Mt Diablo 3849
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Santa Barbara
Los Angeles
Long Beach
Barstow
Needles
Palm Springs
Blythe
San Diego
Tijuana
PT REYES
FARALLON ISLANDS
PT SUR
PT CONCEPTION
SAN MIGUEL ISLAND
SANTA ROSA ISLAND
SANTA CRUZ ISLAND
SAN NICOLAS ISLAND
SANTA CATALINA ISLAND
SAN CLEMENTE ISLAND
KLAMATH MTNS
CASCADE RANGE
NORTHERN COAST RANGES
SIERRA NEVADA
SOUTHERN COAST RANGES
SANTA LUCIA RANGE
TRANSVERSE RANGES
PENINSULAR RANGES
Miles
25 12.5 0 25 50
Kilometers
40 20 0 40 80

Plants

Wildflowers at Tejon Ranch, near Lebec
Photo © Kristi Lazar

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).

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.

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

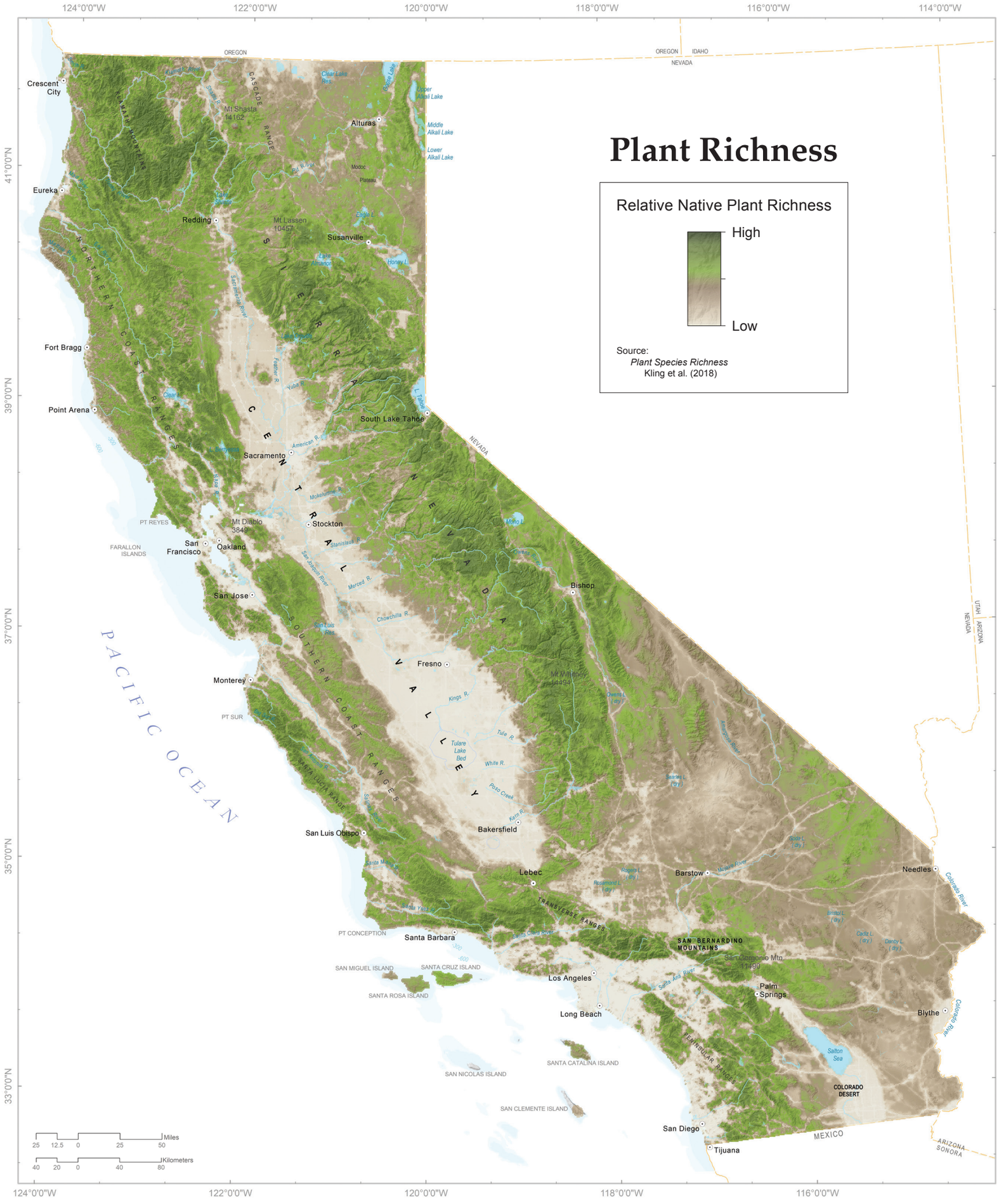
Bristlecone pine (*Pinus longaeva*)
Photo © Kristi Lazar

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. 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
PACIFIC OCEAN
Crescent City
Eureka
Redding
Fort Bragg
Point Arena
Mt Shasta 14162
Mt Lassen 10457
Mt Diablo 3849
Mt Whitney 14494
Alturas
Susanville
Sacramento
South Lake Tahoe
Stockton
San Francisco
Oakland
San Jose
Monterey
Fresno
Bishop
Bakersfield
San Luis Obispo
Lebec
Santa Barbara
Los Angeles
Long Beach
Barstow
Needles
Palm Springs
Blythe
San Diego
Tijuana
Salton Sea
Clear Lake Res.
Upper Alkali Lake
Middle Alkali Lake
Lower Alkali Lake
Modoc Plateau
Eagle L.
Lake Almanor
Honey L.
L. Tahoe
Mono L.
Owens L. (dry)
Searles L. (dry)
Rogers L. (dry)
Rosamond L. (dry)
Bristol L. (dry)
Cadiz L. (dry)
Danby L. (dry)
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
KLAMATH MTNS
CASCADE RANGE
NORTHERN COAST RANGES
CENTRAL COAST RANGES
SIERRA NEVADA
CENTRAL VALLEY
SOUTHERN COAST RANGES
TRANSVERSE RANGES
PENINSULAR RANGES
SAN BERNARDINO MOUNTAINS
COLORADO DESERT
Sacramento River
Feather R.
Yuba R.
American R.
Mokelumne R.
Stanislaus R.
San Joaquin River
Merced R.
Chowchilla R.
Kings R.
Tule R.
Tulare Lake Bed
White R.
Kern R.
Owens River
Amargosa River
Mojave River
Colorado River
Santa Ana 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

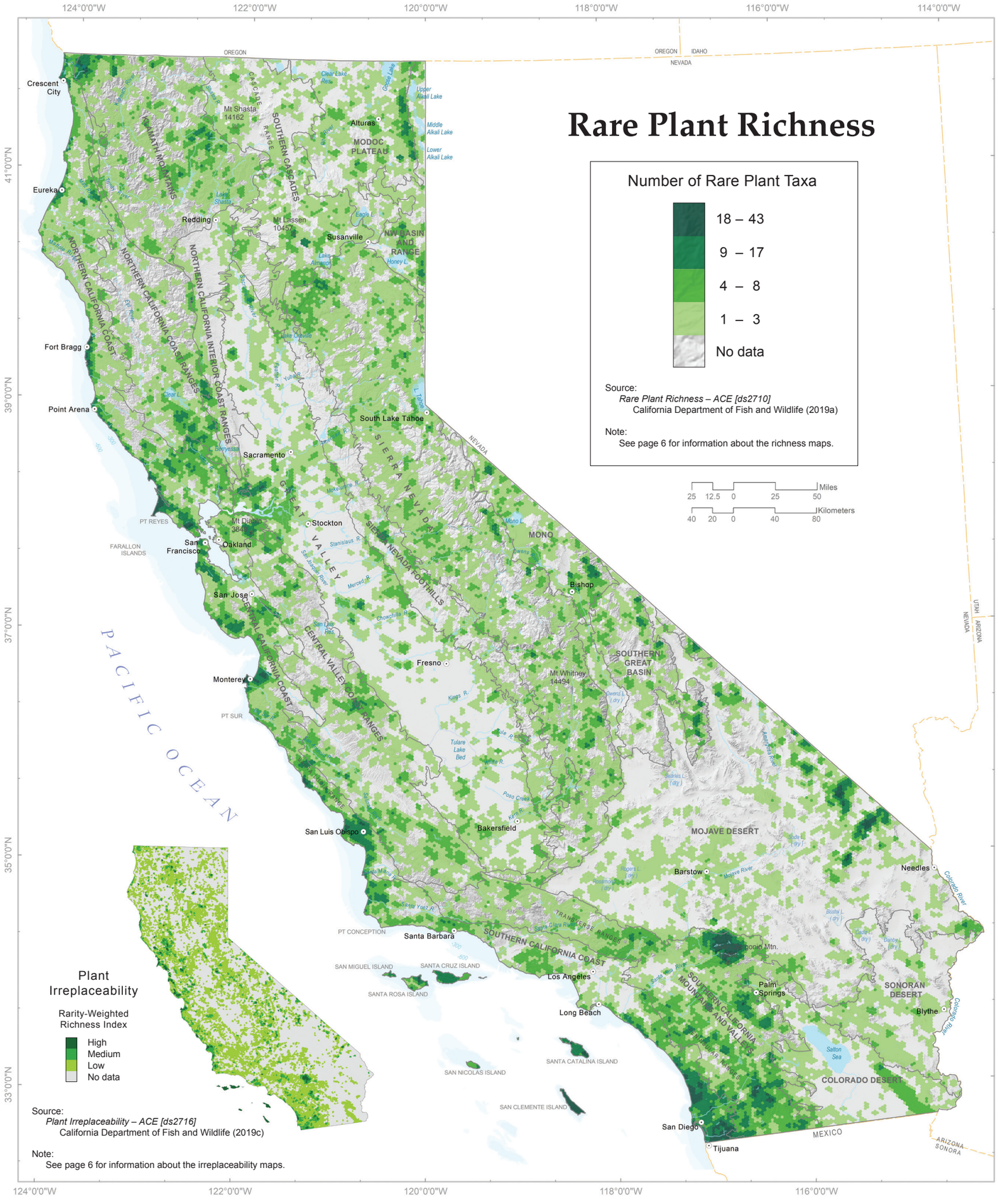
California's varied geology and soils help explain why California is so rich in plant species. The table at right lists the numbers of special status plants found on different substrates in California (CDFW 2020q), with serpentine-derived soils taking the lead in special status plant diversity. Serpentine 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



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.

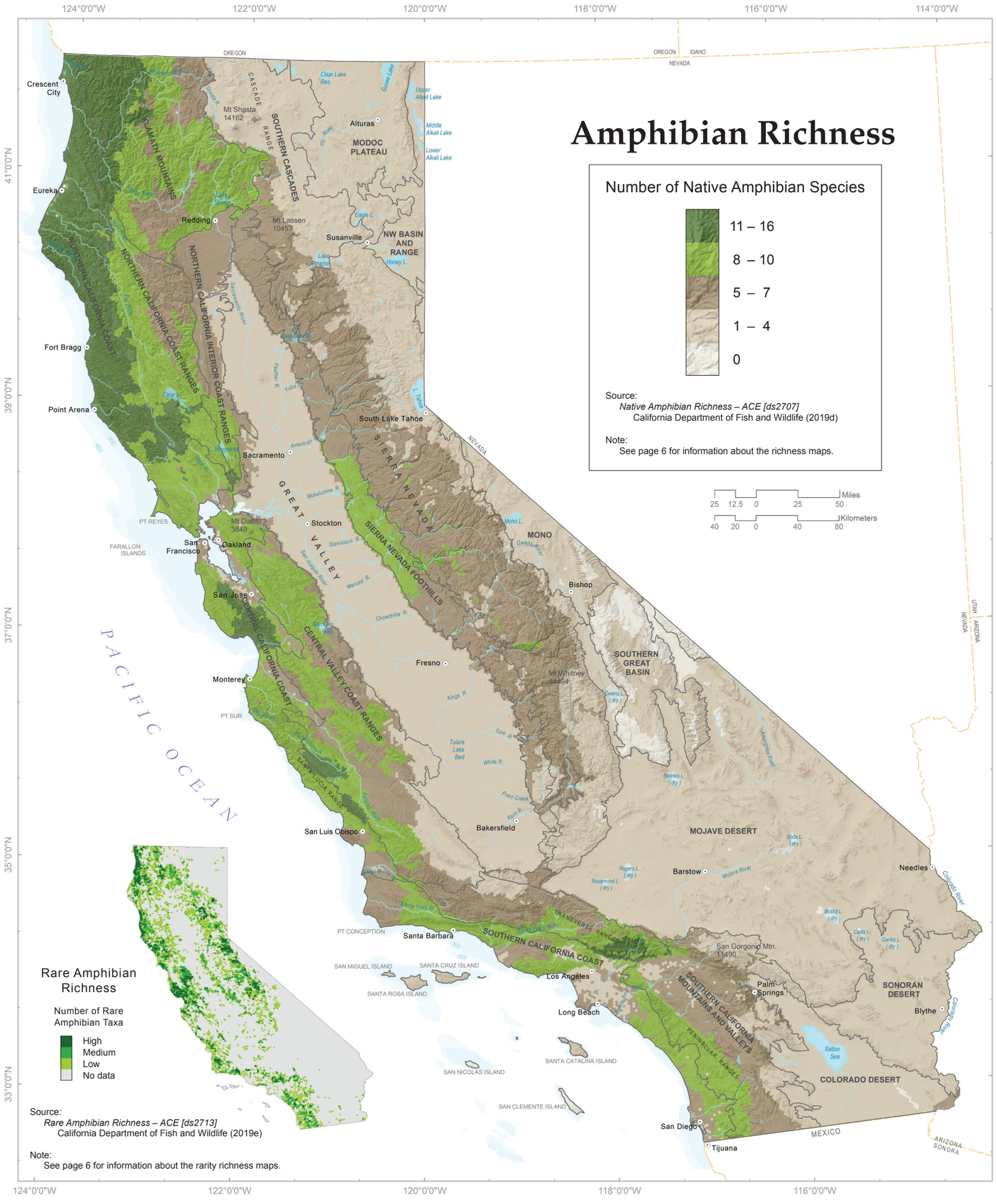
Ensatina (*Ensatina eschscholtzii*) are wide-ranging, variably colored lungless salamanders.
Photo © Ben Witzke

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



Reptiles

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

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.

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

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.

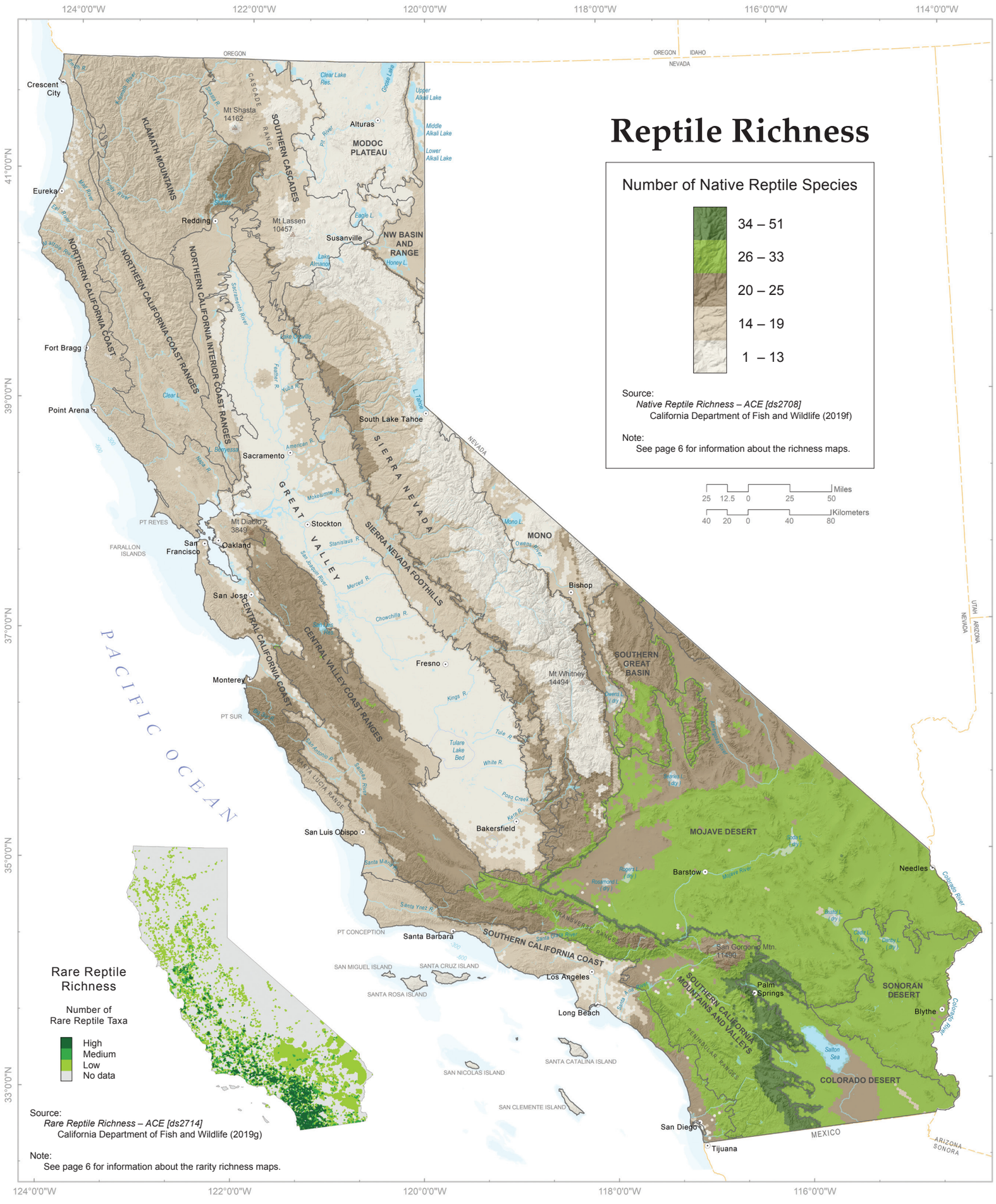
Much of California's remarkable reptile diversity isn't well known by the public. California is home to three species of native boas, snakes that are related to pythons, and three species of native geckos. Five species of legless lizards, who presumably lost their limbs as an adaptation to "swimming" 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



Source:
Native Reptile Richness – ACE [ds2708]
California Department of Fish and Wildlife (2019f)

Note:
See page 6 for information about the richness maps.

Source:
Rare Reptile Richness – ACE [ds2714]
California Department of Fish and Wildlife (2019g)

Note:
See page 6 for information about the rarity richness maps.

Birds

Verdin (*Auriparus flaviceps*)

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.

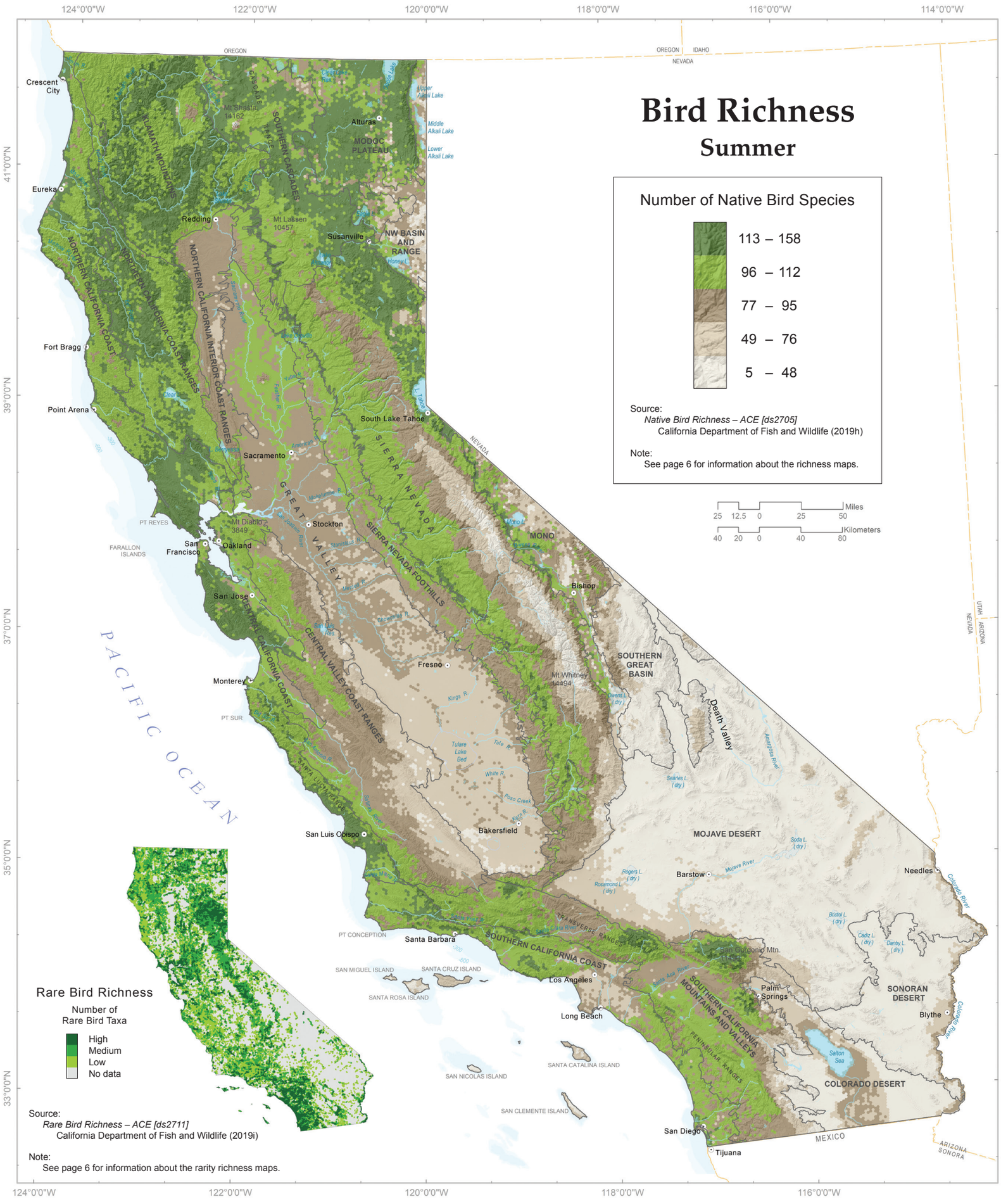
Summer

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



Source:
Native Bird Richness – ACE [ds2705]
California Department of Fish and Wildlife (2019h)

Note:
See page 6 for information about the richness maps.

Source:
Rare Bird Richness – ACE [ds2711]
California Department of Fish and Wildlife (2019i)

Note:
See page 6 for information about the rarity richness maps.

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.

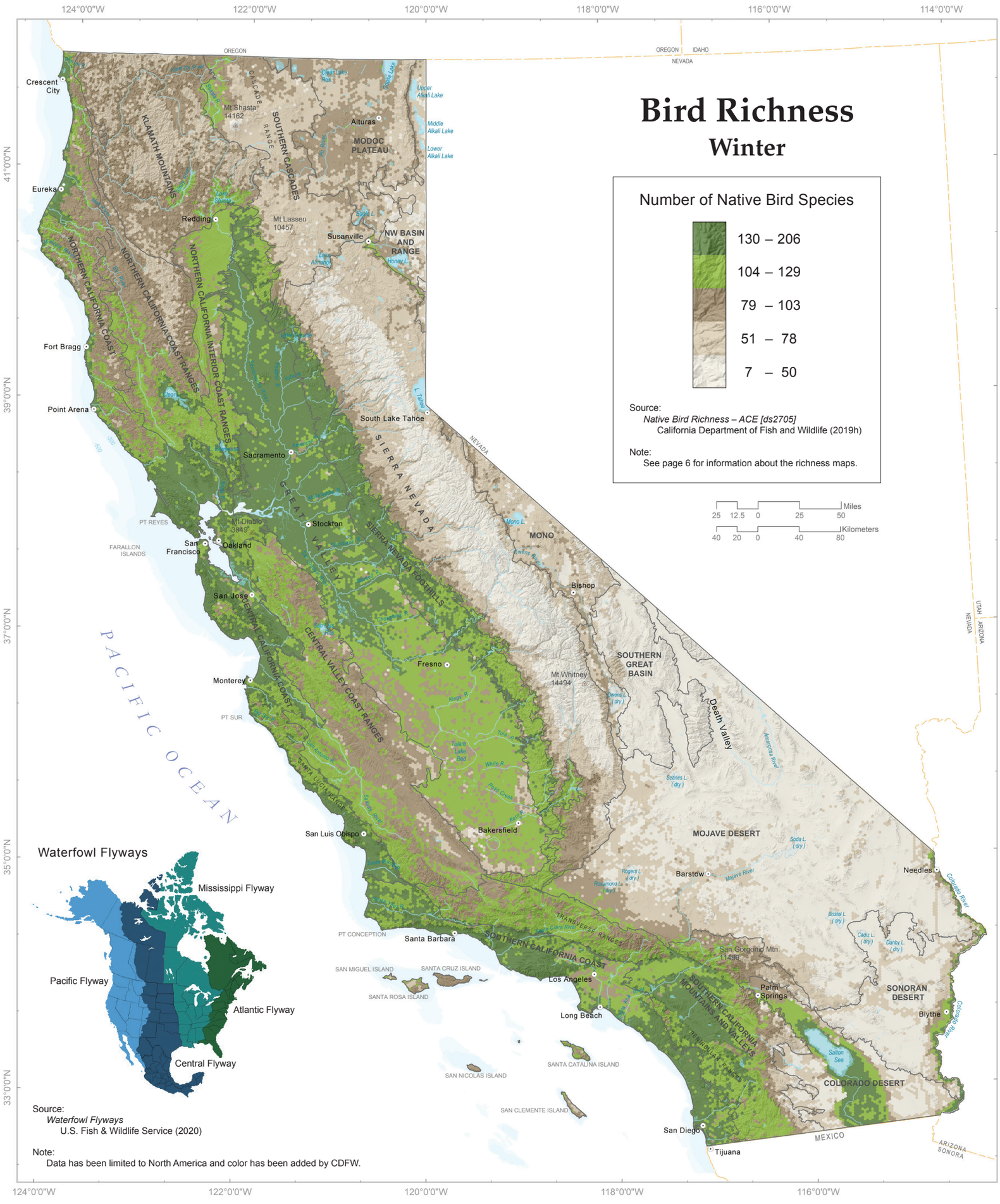
Long-billed Dowitchers (*Limnodromus scolopaceus*)
Photo © Steve Hampton

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



Source:
Native Bird Richness – ACE [ds2705]
California Department of Fish and Wildlife (2019h)

Note:
See page 6 for information about the richness maps.

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.

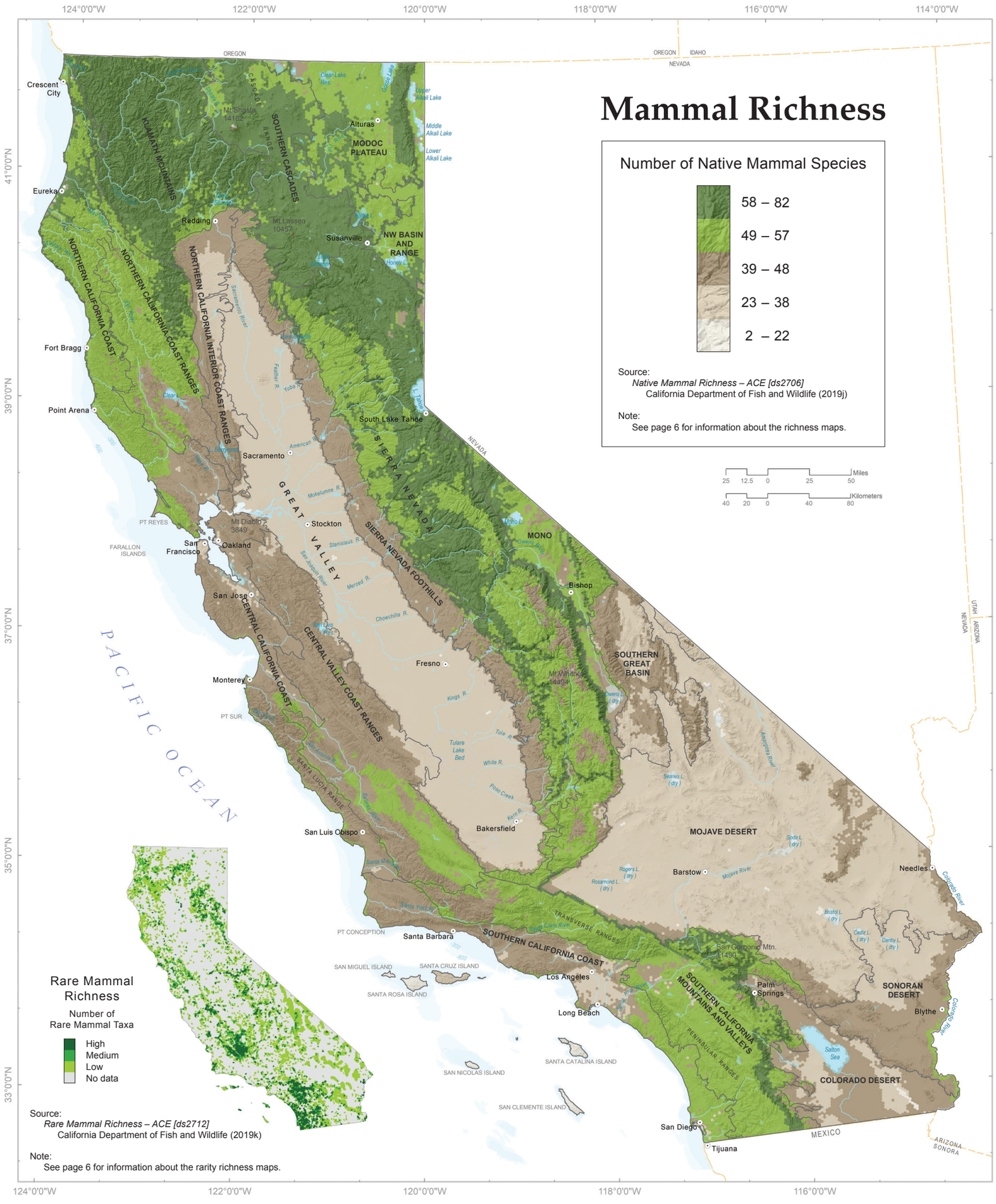
Because forested habitats offer many more opportunities for small and medium-sized mammals to make their homes than habitats like grasslands and scrub vegetation, it is not surprising that mammal species richness is high where forest vegetation occurs. This is especially true in the Klamath Mountains, 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.

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

Mammal Richness



Source:
Native Mammal Richness – ACE [ds2706]
California Department of Fish and Wildlife (2019j)

Note:
See page 6 for information about the richness maps.

Source:
Rare Mammal Richness – ACE [ds2712]
California Department of Fish and Wildlife (2019k)

Note:
See page 6 for information about the rarity richness maps.

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.

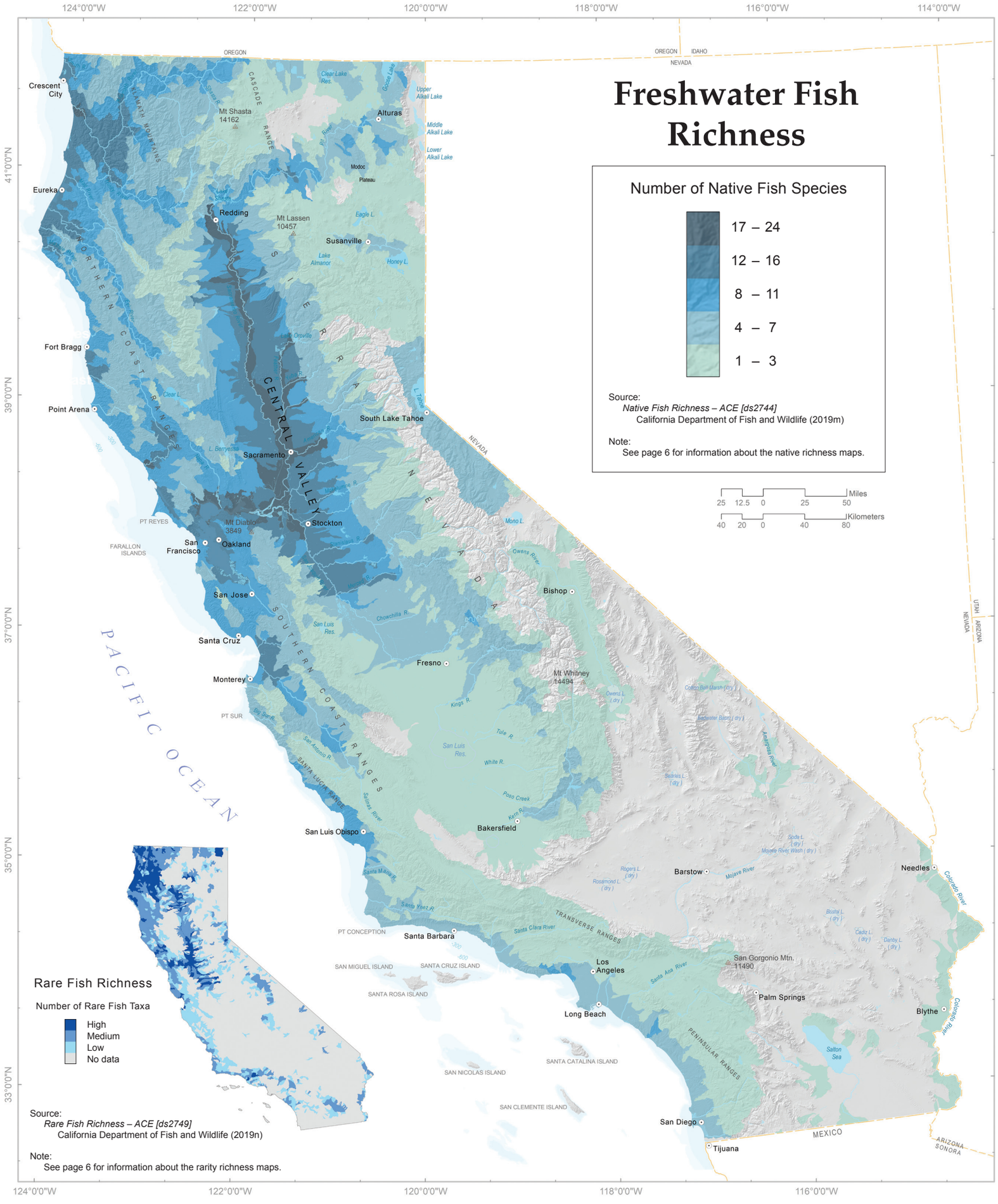
A majority of California's native fishes live in rivers of the Central Valley and North Coast, where water is more abundant. Major rivers of the North Coast include the Smith, Klamath, and Eel rivers, important for many of the state's anadromous species. The major rivers of the Central Valley are the 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