



## 2 California's Natural Diversity and Conservation Issues

"It is that range of biodiversity that we must care for – the whole thing – rather than just one or two stars."

– Sir David Attenborough

California has incredible wildlife diversity. The state's varied topography and climate have given rise to this remarkable diversity of habitats and a correspondingly varied array of both plant and animal species. California has more native species than any other state in the nation and also has the greatest number of endemic species, those that occur nowhere else in the world (CDFG 2003). One of 25 global hotspots for conservation is located in California, because of the remarkable biodiversity and significant threat of losing habitats and wildlife species unique to California (Myers et al. 2000).

California's biodiversity stems from exceptional variation in landscape features, latitudinal range, geological substrates and soils, and climatic conditions, resulting in a wide range of ecosystems to support plant and animal species. Alpine meadows; desert scrub; oak woodlands; diverse grasslands; vernal pool complexes; moist redwood forests; spring-fed lakes; freshwater streams, rivers, and marshes; coastal wetlands, beaches, dunes and bluffs; and giant marine kelp beds provide a wide variety of habitats that support a correspondingly diverse array of both plant and animal species.

Conserving the state's outstanding biodiversity creates many values. Wildlife provides significant economic and quality of life benefits to the state through recreation, tourism, sport and commercial harvest, and ecological services, such as pollination. Many of the places where wildlife thrives are often the same as those valued for recreation and other human activities. By learning the causes of impacts to the state's wildlife and the steps that can be taken to reduce those impacts, California's residents have the opportunity to become more active stewards of this precious natural treasure, ensuring that the Golden State remains an important place for viable wildlife populations for generations to come.

This chapter presents required Elements 1, 2, and 3 of SWAP 2015. After describing the context for biodiversity, it explains the distribution and abundance of wildlife, defines the Species of Greatest Conservation Need (SGCN), and discusses common pressures found throughout the state that are resulting in stresses to the SGCN.

## 2.1 Geographic and Topographic Diversity



Much of California's natural diversity is derived from the range of physical geography, with the primary drivers being regional shifts in geology, soils, topography, and climate. From the Pacific Ocean to the crest of the Sierra Nevada, California's topographic variety is unparalleled. Within 80 miles of one another lie the highest and lowest points in the lower 48 states - Mount Whitney at 14,495 feet and Death Valley at 282 feet below sea level. In California's offshore waters, rocky reefs, offshore banks, and underwater canyons also create a diverse marine landscape. The geology of California is primarily the result of volcanic activity and upheavals from tectonic shifts, which were then shaped by glaciers and erosion along the Pacific Ocean. Glaciation, sedimentary and volcanic deposits, movement along fault

zones, the uplift of subterranean rock and sediment layers, and gradual erosion created unique topographical features and a mosaic of bedrock and soil types.

Uncommon geologic features, such as the Traverse Ranges that run east to west in southern California, contain a wide variety of vegetation types ranging from desert to subalpine, which results in high levels of biodiversity. California's many islands create diverse marine habitats in the surrounding ocean, and provide a natural separation from mainland species resulting in the evolution of unique island species. Geology and soil are critical in the distribution of plants and associated animals throughout California. California exhibits 10 of the world's 12 soil orders. Unique soils types, such as serpentine and carbonite soils derived from bedrock, are uncommon outside of California and plants have evolved specifically to survive in these soils, creating a large number of endemic California plant species (CDFG 2003).

California's land is divided into 11 Geomorphic Provinces, many which include volcanic features. The Geomorphic Provinces are: Sierra Nevada, Cascade Range, Coast Ranges, Transverse Ranges, Peninsular Ranges, Klamath Mountains, Great Valley, Basin and Range, Modoc Plateau, Mojave Desert, and Colorado Desert (CERES 2014). California's offshore waters are divided into the San Diegan zoographic province to the south and the Oregonian Province to the north (Briggs 1974).



## 2.2 Climatic Diversity



The state's geography and topography have created distinct local climates ranging from high rainfall in northwestern mountains to the driest place in North America, Death Valley. North to south, the state extends for almost 800 miles, bridging the temperate rainforests in the Pacific Northwest and the subtropical arid deserts of Mexico. Many parts of the state experience Mediterranean weather patterns, with cool, wet winters and hot, dry summers. Summer rain is indicative of the eastern

mountains and deserts, driven by the western margin of the North American monsoon. Along the northern coast abundant precipitation and ocean air produces foggy, moist conditions. High mountains have cooler conditions, with a deep winter snow pack in normal climate years. Desert conditions exist in the rain shadow of the mountain ranges.

While the state is largely considered to have a Mediterranean climate, it can be further subdivided into six major climate types: Desert, Marine, Cool Interior, Highland, Steppe, and Mediterranean. California deserts, such as the Mojave, are typified by a wide range of elevation with more rain and snow in the high ranges, and hot, dry conditions in valleys. Cool Interior and Highland climates can be found on the Modoc Plateau, Klamath, Cascade, and Sierra ranges. Variations in slope, elevation, and aspect of valleys and mountains result in a range of microclimates for habitats and wildlife. For example, the San Joaquin Valley, exhibiting a Mediterranean climate, receives sufficient springtime rain to support grassland habitats, while still remaining hot and relatively dry in summer. Steppe climates include arid, shrub-dominated habitats that can be found in the Owens Valley, east of the Sierra Nevada, and San Diego, located in coastal southern California.



The marine climate has profound influence over terrestrial climates, particularly near the coast. Additionally, the state is known for variability in precipitation because of the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Oscillations are the cyclical shifting of high and low pressure systems, as evidenced by the wave pattern of the jet stream in the northern hemisphere. The ENSO is the cycle of air pressure systems influenced by the location of warm and cold sea temperatures. El Niño events occur when waters are warmer in the eastern

Pacific Ocean, typically resulting in greater precipitation in southern California and less precipitation in northern California, and La Niña events occur when waters are colder in the eastern Pacific resulting in drier than normal conditions in southern California and wetter conditions in northern California during late summer and winter. The warmer ocean temperatures associated with El Niño conditions also result in decreased upwelling in the Pacific Ocean.

## 2.3 Habitat and Species Diversity

California's varied geography, topography, soils, expanse of ocean waters, and climate have created a variety of habitats across the state, supporting many native plant and animal species found only in California.

### 2.3.1 Plant Diversity

California has the highest numbers of native and endemic plant species of any state, with approximately 6,500 species, subspecies, and varieties of plants, representing 32 percent of all vascular plants in the United States (CDFG 2003; University of California, Berkeley 2014). Nearly one-third of the state's plant species are endemic (Stein et al. 2000), and California has been recognized as one of 34 global hotspots for plant diversity (Conservation International 2015). Within the California Floristic Province, which encompasses the Mediterranean area of Oregon, California, and northwestern Baja, 2,124 of the 3,488 species are endemic, representing a 61 percent rate of endemism (Willoughby 2011).

Over 200 species, subspecies, and varieties of native plants are designated as rare, threatened, or endangered by state law, and over 2,000 more plant taxa are considered to be of conservation concern.

The state's native flora includes many unique or unusual species. The giant sequoia, an ancient species that has survived from the Tertiary Age, is one of the most massive living organisms known. Coastal redwoods are the tallest trees in the world, reaching as high as 321 feet, taller than a 30-story building (Faber 1997). A 4,846-year-old bristlecone pine in California's White Mountains, called Methuselah, was considered the oldest living non-clonal organism (Vasek and Thorne 1988), until superseded by the discovery in 2013 of another bristlecone pine in the same area with an age of 5,064 years (Rocky Mountain Tree Research 2012). California is home to the smallest flowering plant in existence, the pond-dwelling water-meal, less than one-tenth of an inch across. The state also supports nine species of carnivorous plants, including sundews, butterworts, and the California pitcher plant. Numerous species have adapted to grow on serpentine soils that are low in calcium and high in magnesium, chromium, nickel, and other heavy metals toxic to most plant species. Closed-cone conifer species, such as pygmy cypress and some chaparral plants need hot fires to complete their life cycles (Faber 1997).

California contains examples of most of the major biological provinces, or biomes, in North America, including grassland, shrubland, deciduous forest, coniferous forest, tundra (alpine), mountains, deserts, rainforest (temperate), marine, estuarine, and freshwater habitats. Each of these biomes contains many different types of plant communities, such as redwood forests, vernal pool wetlands, or blue oak woodlands. Altogether, the state supports over 100 types of forests and woodlands, over 200 types of shrublands, and over 150 plant communities dominated by herbaceous plants (Sawyer et al. 2009). Some of California's plant species and communities, such as mixed conifer forests, chamise chaparral, and creosote scrub, are widespread. Others are highly restricted in their distributions, such as unique stands of Crucifixion-thorn, Gowen cypress, Hinds walnut, and Torrey pine.

Some parts of the state are particularly rich in plant species diversity. Areas with the greatest number of plant species are the Klamath and inner North Coast ranges, the high Sierra Nevada, the San Diego region, and the San Bernardino Mountains. Other regions with considerable plant diversity are the North and Central Coast Ranges, the Cascade Range, the Sierra Nevada foothills, and the western Transverse Range (CDFG 2003).

### 2.3.2 Terrestrial Wildlife Diversity

California has a large number of animal species, representing a substantial proportion of the wildlife species nationwide. The state's diverse natural communities provide a wide variety of habitat conditions for wildlife. The state's wildlife species include approximately 100 reptile species, 75 amphibian species, 650 bird species, and 220 mammal species (CDFW 2014b). Additionally, 48 mammals, 64 birds, 72 amphibians and reptiles, and 20 freshwater fish live in California and nowhere else (CDFG 2008; Shuford and Gardali 2008.)

The state has remarkable native fauna, including the largest bird in North America, the California condor (Poole and Gill 2002); the Blainville's horned lizard that squirts blood from its eyes as a defense mechanism (Stebbins 2003); the tailed frog, which is among the most primitive living frog species (Ford and Cannatella 1993); four new species of legless lizards (Papenfuss 2013); and the once-endangered California gray whale. Recently, an individual gray wolf explored the northeastern portion of state (see *The Story of Wolf OR7*, below). Wolverines had been extirpated from the state since the 1930s (Schwartz et al. 2007), but recently, an individual has taken up residence in the Sierra Nevada near Truckee. In addition, a rare Sierra Nevada red fox (*Vulpes vulpes necator*) was sighted in January 2015 in Yosemite National Park for the first time in nearly 100 years.

Some of California's natural communities are particularly rich in wildlife species, supporting hundreds of species each. Twenty-four habitats—including valley foothill riparian, mixed conifer, freshwater wetlands, mixed chaparral, and grasslands in the state—support more than 150 terrestrial animal species each (CDFW 2014a). Oak woodlands also are among the most biological

diverse communities in the state, supporting 5,000 species of insects, more than 330 species of amphibians, reptiles, birds, and mammals, and several thousand plant species (CDFG 2003).

### **The Story of Wolf OR7**

The male wolf known as "OR7" was born in northeastern Oregon in spring 2009. The Oregon Department of Fish and Wildlife (ODFW) fitted it with a radio-collar in February 2011. Biologists designated the wolf OR7, because it was the seventh wolf radio-collared in Oregon. Its collar transmits location information to satellites daily and is continuing to function in 2015.

Until spring 2011, OR7 was a member of northeastern Oregon's Imnaha pack. The Imnaha pack was first documented in 2009 and currently occupies much of the Imnaha River drainage (east of the communities of Enterprise and Joseph) in Wallowa County. The founding members of this pack migrated into Oregon from Idaho.

In 2011, OR7 dispersed from the Imnaha pack. The dispersal of younger individuals from a pack is common. Dispersing wolves generally attempt to join other packs, carve out new territories within occupied habitat, or form their own pack in unoccupied habitat. From 2011-2013, OR7 continued to make short and long distance movements between southern Oregon and Northern California. He traveled thousands of miles across Oregon and back and forth into Northern California before finding a mate in the southern Cascades on the Rogue River-Siskiyou National Forest. In early spring 2014, OR7 and his mate had pups, marking the first known wolf reproduction in the Oregon Cascades since the mid-1940s. In January 2015, Oregon wildlife officials designated OR7, his mate and their pups the Rogue Pack.

For more information about OR7 or the Rogue Pack, see <http://www.dfw.state.or.us/wolves/>. For information about wolves in California, see <http://www.dfg.ca.gov/wildlife/nongame/wolf/>.

California's species display a variety of life histories, illustrating the many ways wildlife can adapt to a wide variety of habitats. Some of California's wildlife species are habitat specialists, adapted to the vegetation, forage resources, landscape features, or climate of a particular natural community and are found almost exclusively in these communities. Other species depend on a number of specialized plants, landscape features, or other resources within close proximity to each other. As with plant species, some wildlife species are not only dependent on a certain habitat type, but are also restricted to a very small geographic range, perhaps occurring at only one site in the world.

The valley elderberry longhorn beetle, for example, eats and reproduces only on the elderberry bushes found in Central Valley riparian habitats (U.S. Fish and Wildlife Service [USFWS] 2014a). The marbled murrelet, a seabird, spends most of its life swimming and foraging in the ocean, but flies inland to nest, where it relies almost entirely on the branches of old-growth redwood and Douglas fir trees to provide wide nesting platforms (USFWS 1997). The willow flycatcher is dependent on willow thickets for feeding, cover, and reproduction (CDFW 2014a). The endangered salt marsh harvest mouse prefers pickleweed stands for cover and reproduction (CDFW 2014a). The bank swallow nests in natural river banks (CDFW 2014a).

Some species are restricted to a very small geographic range, because the species is strongly associated with a habitat that is naturally limited in extent or that has grown scarce. This

geographic restriction can also occur when a new subspecies has evolved as a result of being isolated from other populations of the same species by geological or climatic changes. The desert slender salamander (state and federally listed as endangered), for example, is known only from two small populations in the Santa Rosa Mountains in Riverside County. The species is a relic of cooler, moister climate regimes, but now is restricted to canyon areas that provide cliffs and rock crevices where there is continuous water seepage (CDFW 2014a). The Mount Hermon June beetle and Zayante band-winged grasshopper (both federally listed as endangered) are restricted to small outcrops of sandstone and limestone soils derived from marine sediments, known as Zayante sandhills habitat, in the Santa Cruz mountains (USFWS 1998). The island fox, the world's smallest grey fox (state listed as threatened), occurs only on the six largest Channel Islands off the coast of Santa Barbara and Ventura counties (USFWS 2005b). There are many other examples of species with very limited ranges in California, including invertebrates limited to a particular group of vernal pools and invertebrates, reptiles, and amphibians restricted to particular desert dune or spring systems.

Several animals forage primarily on one or very few plant species. One such species is the greater sage grouse, which feeds primarily on sagebrush. The red tree vole lives in northern California coastal fog forests and eats only the soft inner tissue of Douglas fir needles (Williams 1986); pinyon jays seek pinyon, ponderosa, or Jeffrey pine seeds (CDFW 2014a); the chisel-toothed kangaroo rat of the northeastern Great Basin is largely dependent on one species of saltbush (CDFW 2014a); and larval geometrid moths of the genus *Drepanulatrix* eat only leaves of *Ceanothus* species (CDFW 2014a).

Some of California's unique wildlife species are adapted to survive in harsh environments. In the Central Valley, coastal southern California, and elsewhere, seasonal vernal pools evaporate quickly in the hot, dry summer conditions, leaving behind cracked and dry ground. Invertebrates, such as fairy shrimp species, are adapted to this cycle, producing a tough casing that allows their eggs to remain dormant in desiccated conditions, only to emerge the following summer after winter rains refill pools (USFWS 2005a). Kangaroo rat species that inhabit the deserts, eastern Modoc plateau, coastal southern California, and southern San Joaquin Valley are all well suited for extremely dry conditions (Williams et al. 1998). They have specialized kidneys that enable them to excrete solid urine, conserving water and allowing them to survive for long periods without drinking. The alpine chipmunk lives in the Sierra Nevada, typically at elevations higher than 9,000 feet, where in average or wetter years the ground is covered with a snow pack from 5 to 10 feet deep for nearly five months of each year. It survives by storing adequate seeds and other food resources during the summer months to sustain it through the winter (CDFW 2014a).

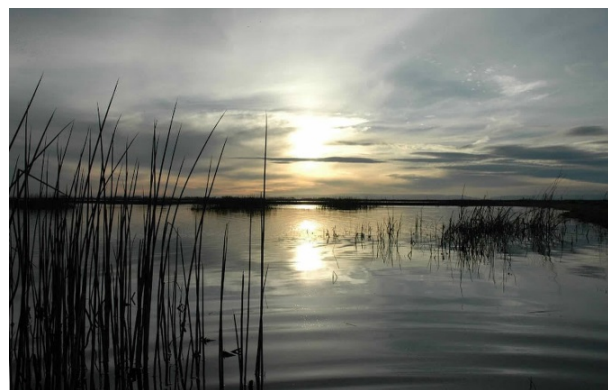
Some species are habitat generalists, able to survive in many different conditions and to make use of many resources to meet their needs for survival. While some entire species' populations are restricted to small areas, there are also wildlife species that are notable for their ability to travel widely, or for their large home ranges occupied by just one individual or family of the species.

Herds of mule deer and pronghorn antelope, for instance, will migrate distances of more than 100 miles traveling between their summer and winter ranges in northern California. The California bighorn sheep summers in the high elevations of the Sierra Nevada (up to 14,000 feet) and migrates to lower-elevation sagebrush-steppe habitat (below 5,000-6,000 feet) to escape deep winter snows (Zeiner et al. 1990). Some predators, such as the mountain lion, badger, and fisher, may cover thousands of acres when hunting; much larger areas are required to sustain entire populations (Pierce et al. 2000). Predators also exist in close proximity to the urban areas and rely on remnant habitat corridors, although they face population pressures from lack of prey, inbreeding, and direct threats from urbanization, such as car strikes and public safety concerns.

Many of California's species also travel substantial distances over the course of their seasonal migrations. The Pacific Flyway and Central Valley supports some of the greatest concentrations of wintering waterbirds in the world, including millions of waterfowl and shorebirds. Birds that spend their summers in the upper mountainous elevations, such as the yellow-rumped warbler and cedar waxwing, descend tens or hundreds of miles during the wintertime to forage in the milder climates of the Central Valley or along the coast. Long-distance migrating birds, including numerous species of swallows, terns, hawks, shorebirds, and songbirds, forage or nest seasonally in California. The golden-crowned sparrow uses California as a winter home and spends summer months far to the north and the Swainson's hawk migrates between California and South America, as far south as Argentina. Other species travel from elsewhere to overwinter in California. One such species, the monarch butterfly, takes multiple generations to make the migration to and from overwintering sites. Conserving the diversity of these migratory species not only conserves California's diversity, but also the diversity of many other countries.

### 2.3.3 Aquatic and Marine Diversity

California exhibits a wide range of aquatic habitats from the Pacific Ocean to isolated hillside seeps, to desert oases that support both water-dependent species and provide essential seasonal habitat for terrestrial species. Perennial and ephemeral rivers and streams, riparian areas, vernal pools, and coastal wetlands support a diverse array of flora and fauna, including 150 animal and 52 plant species that are designated special-status species (California Coastal Conservancy 2001). The California Natural Diversity Database identifies 123 different aquatic habitat-types in California, based on fauna. Of these, 78 are stream habitat-types located in seven major drainage systems: Klamath, Sacramento-San Joaquin, North/Central Coast, Lahontan, Death Valley, South Coast, and Colorado River systems (Jensen et al. 1993). These drainage systems are



Dave Feliz, CDFW



geologically separated and contain distinctive fishes and invertebrates. California has approximately 70 native resident and anadromous fish species (Moyle and Davis 2001), and 72 percent of the native freshwater fishes in California are either listed, or possible candidates for listing as threatened or endangered, or are extinct (Moyle et al. 1989).

From the steep creeks of the Sierra Nevada to the wide and powerful rivers of the Central Valley, California's streams and rivers are the life-blood of the watersheds they occupy, supporting an array of invertebrates, fishes, amphibians, birds, and mammals. The cool, steep headwater streams join with strong rivers, which (when unhindered by human activity) slow and meander, depositing fertile sediments and recharging underground aquifers in their floodplains before heading out to sea or ending in a land-locked basin. This headwater-to-sea connectivity is critical for California's anadromous fish, which rely on rivers and perennial streams for spawning habitat and safe passage to the Pacific Ocean for later life stages.

Two of the largest coastal rivers are the Klamath River, which runs for 263 miles, and the Eel River, which runs for 196 miles, both in the northern Coast Range. These two rivers support the second and third largest salmon and steelhead populations in California (with the Sacramento River being the largest) (Taylor 1978). Coastal rivers are also home to aquatic mammals, such as river otters and beavers, and amphibians and riparian birds, including endemic species.

Two major river systems drain and define the two parts of the Central Valley. The Sacramento River, supported by its major tributaries, the Feather River, Yuba River, and American River, flows south through the Sacramento Valley for about 450 miles. The Sacramento River carries far more water than the San Joaquin River and is one of the largest U.S. rivers that empty into the Pacific Ocean, second only to the Columbia River in Oregon (Sacramento River Watershed Program [SRWP] 2015). The Sacramento River also supports one of the most important salmon fisheries in California, with four separate runs of Chinook salmon (SRWP 2015). In the San Joaquin Valley, the San Joaquin River flows north for about 365 miles, supported by several tributaries, such as the Merced, Tuolumne, Stanislaus, and Mokelumne rivers. Historically, the extensive marsh system along the San Joaquin River hosted one of the largest concentrations of wintering waterfowl in the world (USFWS 2006). Although much of this habitat has been lost, the Central Valley and the San Joaquin River continue to provide critical habitat for migrating waterfowl.

The rivers of the Central Valley converge in the Sacramento-San Joaquin Delta (Delta), a complex of fresh and brackish water wetland channels and sloughs that wind around islands mainly used for agriculture. Freshwater from the rivers mingles with saltwater from the Pacific Ocean, creating the San Francisco Bay estuary system, the West Coast's largest estuary (California Department of Water Resources [DWR] 2015). The Delta provides a rich and productive environment for more than 500 species of wildlife, including 20 endangered species, such as the salt marsh harvest mouse and the delta smelt (DWR 2015). Additionally, the Delta serves as a vital migration path for the single largest run of salmon in California. The Delta is also

the hub of the state's water distribution system and provides water for two-thirds of all Californians and millions of acres of irrigated farmland.

Coastal and freshwater wetlands provide important wildlife habitat and critical ecological services, including altering and transforming pollutants in runoff water, controlling floods, moderating sediment delivery, promoting groundwater recharge, sequestering carbon, and protecting shorelines from erosion. Coastal wetlands include brackish and saltwater wetlands, such as saltmarsh that are found within a variety of estuary types, including river-mouth, canyon mouth, lagoon, coastal dune-creek, bay, structural basin, and artificial drain estuaries. Freshwater wetlands are not connected to the ocean and they can be found along the boundaries of streams, lakes, ponds, or even large shallow holes that fill up with rainwater. They may stay wet all year long, or the water may evaporate during the dry season. California's many estuaries provide invaluable habitat for birds, mammals, fish, and other wildlife. The sheltered waters of estuaries provide a safe haven and protective nursery for small fish, shellfish, migratory birds, and coastal shore animals. Estuaries include habitat for numerous special status or declining species of mammals (e.g., Southern California salt marsh shrew), birds (e.g., Belding's savannah sparrow), fish (e.g., tidewater goby), and insects (e.g., mudflat tiger beetle) (Ferren et al. 1996). An example of this diversity is found in the Elkhorn Slough estuary near Monterey Bay, which is home to more than 100 sea otters, as well as over 100 species of fish and 550 species of invertebrates (National Estuarine Research Reserve System [NERRS] 2015).

Vernal pools are a unique type of rain-fed seasonal wetland that occurs in depressions underlain by poorly drained or restrictive soil types. California vernal pools contain standing water during the winter and spring and are completely dry during the hot Mediterranean summer. As the standing water evaporates the pool and the surrounding soils can become saline, alkaline, or acidic. Many specially-adapted crustaceans, amphibians, insects, and plants occur only in vernal pools (CDFW 2015).



Athena Maguire, CDFW

California's rocky offshore islands typically support a limited number of species, but are nonetheless important habitats for those species that depend on them. The Channel Islands provide habitat for numerous endemic species, including 23 species of terrestrial wildlife. The Farallon Islands host some of the largest breeding colonies of seabirds in the United States, and numerous marine mammals, including California sea lions and endangered blue and humpback whales (Farallones Marine Sanctuary Association 2014).

Rocky reefs, offshore banks, underwater canyons, coral gardens and kelp forests harbor an extraordinarily diverse number of marine species. Intertidal zones provide habitat for worms, clams,

crabs, small fishes, and shorebirds, while the pelagic zone of the open ocean supports species of plankton, fish, marine birds, and marine mammals, such as whales and dolphins. Giant kelp beds within the nearshore waters off of southern and central California are one of the most diverse biological communities known to exist in the world's oceans, with over 800 species of marine organisms dependent on the kelp forests at some point in their life history. While many variations in marine fauna and habitat types exist at numerous scales, many marine species along the California coast generally occur either north or south of Point Conception (34.5° North Latitude), with warm and temperate habitat to the south in the San Diegan zoographic province and cool temperatures of the Oregonian Province to the north (Briggs 1974). The marine biome is the major producer of plant biomass from sunlight and nutrients (primary productivity). These plants, ranging from small phytoplankton to large macro-algae, represent the basic food source for all life in the ocean, and support the extensive biodiversity of this system. In areas where northwest winds cause cold, nutrient-rich water to move towards the surface from the deep, a process known as upwelling, plankton abound attracting squid, sardines, krill, and other forage species. These species, in turn, attract predatory animals, including sharks, marine birds, and whales.

## 2.4 Species of Greatest Conservation Need

A key element of updating the SWAP is identifying and compiling information on the species of wildlife that are indicative of the state's biological diversity and have the greatest need for conservation. These species are referred to as Species of Greatest Conservation Need (SGCN). For SWAP 2015, technical teams developed criteria and evaluated species, resulting in a revised SGCN list of invertebrates, amphibians, reptiles, fish, birds, mammals, and plants. The improved set of criteria was developed to ensure a more scientifically rigorous and focused list compared to the list of SWAP 2005.

### 2.4.1 Criteria to Select Species of Greatest Conservation Need

Criteria 1 includes species listed as threatened, endangered or candidate species in California under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA). State and Tribal Wildlife Grants (SWG) discourages the use of funds solely on federally listed species and on species that already have dedicated funding. Although these species are included in the SGCN list, it does not imply a funding preference or prioritization.

Criteria 2 includes species for which there is a conservation concern. The species under the second criteria are generally equivalent to the California Species of Special Concern (SSC) designation. Other conservation concern designations are described below under each category of species. The SSC designation carries no formal legal protection; the intent of the designation is to focus attention on animals of conservation risk, stimulate research on poorly known species, and achieve conservation and recovery of these animals before they meet criteria for

listing as threatened or endangered. More information about CDFW's process of evaluating SSC, as well as their lists by taxa and life history accounts, including habitat association, population trends, and range maps, can be found online at <http://www.dfg.ca.gov/wildlife/nongame/ssc/>.

Criteria 3 includes species that were identified by CDFW as being highly vulnerable to climate change. The methods used to identify SGCN are described below for each category of species.

## **Invertebrates**

Invertebrates that are state or federally listed are included under Criteria 1. Invertebrate species under Criteria 2 have a NatureServe State Conservation Rank of S1. The NatureServe ranking represents a score that reflects a combination of Rarity, Threat, and Trend factors within California's state boundaries. Rarity is weighed heavier than the other two factors. An S1 ranking is defined as Critically Imperiled in the state because of extreme rarity (often five or fewer populations) or because of factor(s), such as very steep declines, making it especially vulnerable to extirpation from the state. Marine invertebrates are included under Criteria 2 if they are subject to a take or harvest prohibition by CDFW or National Marine Fisheries Service (NMFS), if they are under a federal rebuilding plan, or if they are considered to be overfished.

## **Fishes**

Fishes that are state or federally listed are included under Criteria 1. Freshwater and anadromous fish species identified under Criteria 2 include SSC and species subject to a take or harvest prohibition by CDFW or NMFS, a federal rebuilding plan, or consideration of being overfished. The SSC report update from the 1995 report for fish includes information on the distribution, abundance, and status of species (<http://www.dfg.ca.gov/wildlife/nongame/ssc/fish.html>). Climate vulnerability for fish was determined using the methods and evaluation presented in Moyle et al. 2012. The methodology uses expert opinions of the authors and literature reviews of the status and biology of the fishes to score both status of each species ("baseline vulnerability") and likely impact of climate change ("climate vulnerability"). When the total scores for baseline and climate vulnerability were combined, they produced a score that indicated the overall vulnerability to climate change. Species with a highly vulnerable or critically vulnerable score are included as SGCN under Criteria 3.

## **Amphibians and Reptiles**

Amphibians and reptiles that are state or federally listed are included under Criteria 1. CDFW updated the list of amphibian and reptile SSC (Thomson et al. 2012) and those species are included as SGCN under Criteria 2. The SSC report (in process, see <http://www.dfg.ca.gov/wildlife/nongame/ssc/amphibian-reptile.html>) contains species accounts and distribution maps for 48 amphibian and reptile special concern taxa (11 salamanders, 14 anurans, 2 turtles, 12 lizards, and 9 snakes). Each species account contains a description of the animal, taxonomic



remarks, distribution and life history information, habitat description, status, management recommendations, and a range map. Under Criteria 3, a highly vulnerable status was assigned to amphibians and reptiles, if any of the following occurred:

- ▲ 90-100 percent of the (sub)species' currently occupied cells were predicted to decline in suitability by 2050 (Warren et al. 2014);
- ▲ greater than 40 percent of currently occupied localities and/or greater than 50 percent of the species' range were predicted to become unsuitable by 2050 (Wright et al. 2013); or
- ▲ expert opinion by the SSC Technical Advisory Committee predicted the (sub)species would be highly sensitive to climate change over the next 100 years (Thomson et al. 2012).

## **Birds**

Birds that are state or federally listed are included under Criteria 1. Since the 2005 version of the SWAP, CDFW updated the bird SSC list (BSSC; Shuford and Gardali 2008) and those are included as SGCN under Criteria 2. The BSSC report includes species accounts for the 63 ranked taxa to document general range and abundance, seasonal status in California, historical range and abundance in California, ecological requirements, and threats; additionally, management, research and monitoring recommendations are presented (<http://www.dfg.ca.gov/wildlife/nongame/ssc/birds.html>). Species with a high vulnerability score are included as SGCN under Criteria 3. These species were determined through an extensive climate change vulnerability assessment for birds (Gardali et al. 2012). The methodology is described below.

To quantify climate vulnerability, a taxon's sensitivity and exposure were considered. Sensitivity was determined by intrinsic traits of species (habitat specialization, physiological tolerances, migratory status, and dispersal ability) that make them vulnerable to climate change. Exposure was determined by the extrinsic factors (habitat suitability, food availability, and extreme weather) that will result from climate change. Sensitivity and exposure were scored independently; then, the two scores were multiplied to generate a climate change vulnerability index. To integrate the climate change vulnerability index with the BSSC list, Gardali et al. (2012) took a similar approach to that proposed by the U.S. Environmental Protection Agency (EPA) to integrate climate change vulnerability with existing stresses for threatened and endangered species (EPA 2009). A matrix combined the priority Climate Change Vulnerability of California ranks from each list to produce a final integrated list.

## **Mammals**

Mammals that are state or federally listed are included under Criteria 1. Since the 2005 version of the SWAP, CDFW is in the process of updating the mammal SSC list (MSSC). Species listed on the current MSSC list are included as SGCN under Criteria 2. The MSSC report (in process, see <http://www.dfg.ca.gov/wildlife/nongame/ssc/mammals.html>) lists 36 species and subspecies of land mammals native to California determined to be potentially threatened with extinction in

California. Species accounts for each taxon include initial description references, information on distribution, population status, and habitat, recommendations for additional assessment and conservation actions, taxonomic remarks, and distribution records. The vulnerability of California's land mammals was assessed for SWAP 2015 using scores developed for the MSSC update. For the MSSC project, a team of experts used a scoring system to quantify the conservation status of all the approximately 580 native land mammal taxa (species and subspecies) in California. Score definitions were developed for eight conservation factors, including population size, population trend, range size, range trend, population concentration, threats, endemism, and climate change. Mammals with a high risk ranking are included as SGCN under Criteria 3.

## **Plants**

Plants that are state or federally listed are included under Criteria 1. Marine plant species where take or harvest is prohibited by CDFW or NMFS are included under Criteria 2. Plants with a California Rare Plant Rank of 1B.1, which indicates they are rare or endangered in California and elsewhere and are seriously threatened, are also included as SGCN under Criteria 2.

### **2.4.2 List of Species of Greatest Conservation Need**

The list of SGCN for SWAP 2015 is included in Appendix C. The list includes 414 fish and wildlife species, 264 invertebrate species, and 475 plant species. In Chapter 5, the SGCN are identified as they occur within the provinces and conservation units for each of the targets. Common stresses and pressures affecting SGCN habitats are described in Chapter 5. Conservation strategies intended to relieve conservation targets from negative impacts and/or enhance habitat conditions are also identified in Chapter 5.

While plants are included in the list of SGCN, presence of SGCN plants were not included as a separate criteria used to prioritize or select targets when developing regional SWAP strategies. USFWS accepts plants as SGCN, but they are not currently eligible for SWG funding. However, plants will benefit from implementation of SWAP 2015 strategies incidentally when occurring in habitats conserved for animal SGCN. CDFW has chosen to include plants on the SGCN list, so SWAP 2015 would be a comprehensive conservation planning document.

## **2.5 Challenges in California Ecosystems**

The condition of many of the state's natural communities and wildlife is impaired. This impaired or degraded condition, which can be manifested in many ways, is referred to as a stress in this document. Stresses results from pressures, which are usually, but not always, related to human activities. This section describes commonly identified stresses and pressures across the state

from the information gathered by regional teams. The order in which they are described is not indicative of their level of importance or severity.

**Key Ecological Attribute (KEA):** Aspects of a target's biology or ecology that if present, define a healthy target and if missing or altered, would lead to the outright loss or extreme degradation of that target over time.

**Pressure:** An anthropogenic (human-induced) or natural driver that could result in impacts to the target by changing the ecological conditions. Pressures can be positive or negative depending on intensity, timing, and duration.

**Stress:** A degraded ecological condition of a target that resulted directly or indirectly from pressures (e.g., habitat fragmentation).

## 2.5.1 Major Stresses

Stresses are attributes of a conservation target's ecology that are impaired directly or indirectly from pressures. Degraded key ecological attributes (KEAs) are stresses. Understanding the ecological stresses experienced by California wildlife and ecosystems is one of the critical steps to define conservation strategies needed to counteract them.

### Categories of Stresses

- ▲ Climate Factors
- ▲ Changes in Geophysical and Disturbance Regimes
- ▲ Changes in Soil Characteristics
- ▲ Changes in Hydrology and Water Characteristics
- ▲ Changes in Ecosystems
- ▲ Geological Events

This section summarizes the standardized stresses identified by CDFW. Stresses related to Climate Factors are discussed in Section 2.5.3. Several categories of stresses described below are interrelated and many of these stresses will be exacerbated by climate change as discussed in Section 2.5.3. The standardized list of stresses in Table 1.5-3 were not used in the analysis of the Marine Province due to uniqueness of marine ecosystems. Stresses for the Marine Province are identified in Section 5.7.

## Changes in Geophysical and Disturbance Regimes

### Change in Sediment Erosion-Deposition Regime

Natural geomorphic processes, i.e., sediment deposition and transport, are very important to the quality of California's aquatic habitats. Altered soil and sediment deposition in California is an important ecosystem stress primarily caused by human modification of physical river processes. Gravels and sediments within riverine systems provide microhabitats for invertebrate species, and are essential for spawning and nesting of many freshwater and anadromous fish species. Release of fine sediments from water projects, agriculture, and construction can be equally damaging. Fine sediments and silt cover natural creekbed substrates and fill in deep pools, degrading important habitats for native amphibians, fishes, and invertebrates. Additionally

sediments can bind to and carry pollutants through the water column and cause increased turbidity reducing photosynthesis and interrupting the aquatic food chain (Newcombe 2003).

Historically, sediment was deposited at the river delta or along the river's banks by flood events, creating deep floodplain soils (Busch and Smith 1995; Poff et al. 1997). Over-bank flooding also flushed the soils of built-up salts, creating more favorable soil-nutrient conditions for vegetation growth. As a result of dams, flood control facilities, and water diversion structures, natural sediment transport has been severely diminished or blocked, and natural flooding has been reduced in frequency and magnitude in downstream river reaches. Altered hydrologic regime has resulted in unnatural changes in vegetation communities along rivers and estuaries, such as a documented change from high quality habitat dominated by native cottonwoods and willows to invasive tamarisk, which can withstand drier conditions and saltier soils (Briggs and Cornelius 1998, Poff et al. 1997). Reductions in the amount of sediment transported to the ocean can decrease beach or sandy subtidal habitat available to marine species. As another example, arroyo toad breeding sites that are created when floods deposit sediments as sandbars have been diminished by altered hydrologic regimes. Where human activities have fragmented watersheds and changed natural sediment dynamics and flow regimes, sediment deposition has been interrupted, reducing the extent of sandbars and gravel habitats necessary for this species' survival (USFWS 2014b). Similarly, habitat for the Coachella Valley fringe-toed lizard has been degraded by alterations to the sand transport processes that maintain dunes in the Coachella Valley.

### Change in Natural Fire Regime

The frequency, intensity, and seasonal timing of fire in the landscape have been major factors determining the composition of flora throughout the state. Fire-dependent vegetation types cover over half the surface area of California (Sugihara et al. 2006). Alteration of natural fire regime is an important ecosystem stress, particularly in forest and shrub-dominated habitats (Ainsworth and Doss 1995). Widespread forest management practices, including fire suppression without active forest management, as well as increases in



NPS

human-caused wildfires, have altered fire regimes. Due to fire suppression, the Sierra Nevada and northwestern California have experienced less frequent fires than have historically occurred, causing a buildup of forest fuels. However, southern California is experiencing larger and more frequent fires than under historic conditions (Safford and Van de Water 2014). In some cases these altered fire regimes have caused dramatic changes in regional habitats. For instance, because of altered natural fire regimes, densities of white fir and incense cedar have increased at the expense of live and black oaks, which are very important to many wildlife species, including acorn woodpecker, band-tailed pigeon, black bear, and dusky-footed woodrat. Drought-stressed forest may already be more prone to fire because of tree deaths from pests and drought, and are



made even more vulnerable to fire because of an increased buildup of fuels from altered fire regimes. These drought-stressed conditions can be exacerbated by climate change. Fire suppression in forested areas leads to dense, even-aged forest stands that lack habitat complexity. It can also cause a build-up of fuels that can result in higher-than-natural intensity and heat of wildfires, which can destroy otherwise fire-adapted plants and damage soil structure (Baker and Shinneman 2004; Kauffmann 2004).

The effects of wildfires differ among ecological communities. In sage scrub, chaparral, and grassland systems, lightning-induced fires are relatively frequent and plants have evolved to germinate post-fire. Human-caused fires, however, have resulted in unnaturally high fire frequencies, especially along roads and near the urban-wildland interface, interrupting the natural successional dynamics of these habitats. These more frequent fires can decrease the quality of aquatic habitats by reducing shading and woody debris, as well as directly damaging terrestrial habitats.

Areas where fire was relatively rare, such as the high desert, have experienced an increase in fire frequency because of changes in vegetation. Increased fuel loads associated with invasive species have resulted in an increased number of fires (Brooks 1999). The increased fire frequencies then favor the Mediterranean grasses that were introduced to California with the arrival of European settlers and livestock. Once established, the non-native grasses grow in a dense-thatch pattern that chokes out native vegetation, lowers habitat quality for wildlife, and provides additional fuel for the cycle of frequent burning (Keeley 2009).

### **Change in Extreme Events**

The change in the type, frequency, intensity, or length of climatic extreme events in California is closely related to the effects of climate change. Climate change may alter the frequency and/or intensity of extreme weather events such as severe storms, winds, droughts, and frosts. For example:

- ▲ In southern California, any increase in Santa Ana wind conditions, combined with warmer, drier summers, could escalate economic and environmental loss to wildfires in California.
- ▲ An increase in the number or intensity of thunderstorms, which form over land and pick up more acids and other pollutants than Pacific frontal storms, may mean more acid rain and increased murkiness in Sierra lakes (from nutrient enrichment).
- ▲ Pests, such as pine bark beetles, could become more prominent or more destructive, if shifts in climate conditions stress trees.
- ▲ El Niño warming may encourage toxic algal blooms in bays and estuaries and depress offshore ocean productivity.
- ▲ On shore, heavier, and/or more frequent rains induced by El Niño could increase the frequency of the rodent population booms that precede hantavirus outbreaks (Field et al. 1999).

## **Changes in Soil Characteristics**

Soils act as water reservoirs and filters, provide nutrient cycling for the plant community, and offer habitat to an incredible diversity of microorganisms, insects, and burrowing animals. The soil and above ground communities are inextricably linked and changes in one have repercussions in the other. Soil organisms depend on aboveground vegetation for the sugars and carbohydrates produced during photosynthesis, and plant growth is dependent on the microbial community's ability to convert and release mineral nutrients so that they are available for plant uptake. The soil community metabolizes organic and inorganic pollutants, releasing them as carbon dioxide and water and preventing contamination of water sources. Maintaining the biodiversity of the soil ecosystem is a crucial factor ensuring the success of these processes.

### **Change in Nutrients**

The nutrient availability within a soil ecosystem is tied directly to organic matter inputs from the plant and wildlife community and the biodiversity of the soil community. Nutrient availability is cyclical and the amount of nutrients released for use by the above ground community must be balanced by organic matter inputs. As native ecosystems are converted for other uses, the soils community undergoes a series of changes related to nutrient cycling. Soils disturbed for agricultural use experience accelerated rates of organic matter decomposition, gradually depleting the soils nutrient reserves. Additionally, soil compaction reduces the available habitat for the microbial community and can slow nutrient processing. In areas where native plant species are removed or replaced, their symbiotic fungi are cut off from their primary food source and disappear from disturbed site. These fungi are critical in obtaining nutrients for their host plants and their loss can make reestablishment of native species difficult even after other habitat conditions have been met. These stresses on the soil ecosystem ultimately result in reduced quantity and quality of food and habitat for wildlife species, for example, by reducing plant cover and species richness or by simplifying community structure.

### **Change in Pollutants**

California's soils have been exposed to pollutants as a result of intensive agriculture, industrial activity, mining, and other human activities. Some pollutants can be toxic to members of the soil community, which can affect the food chain. Additionally, when a soil contains high concentrations of heavy metals such as lead, zinc, and copper, or constituents such as mercury, arsenic, hydrocarbons or pesticides, these contaminants can be mobilized by the soil community and can accumulate in plant and animal tissues (Smical et al. 2008). The concentration of some pollutants can be amplified as they are passed from prey to predator in a process known as bioaccumulation. An example of this would be lead concentrations in soil accumulating in earthworms and being transferred to moles and shrews (Pierzynski et al. 2000).

### Change in Soil Chemistry

Changes in soil pH have a strong effect on the relative availability of nutrients and minerals. Acidification of soils can lead to excessive availability of some minerals, including aluminum, which can be toxic to plants at high levels. Soil chemistry is also highly dependent on the presence of very small soil colloid particles which are found in clay minerals and soil organic matter. These colloids hold a static electrical charge which allows the soil to bond with and retain excess nutrients and pollutants that are carried into the soil. As soil organic matter is depleted through erosion, ground disturbance, vegetation removal, or lowering of the water table, the soil loses its ability to filter out pollutants which can lead to impacts on surface and groundwater quality (Pierzynski et al. 2000).



Scott Bauer, USDA

### Change in Soil Moisture and Temperature

The availability of soil moisture has a direct impact on the number of soil animals that a given area can sustain. This is evident in the relative abundance of biological activity in mountain compared to desert soils (Hendricks 1985). Additionally, the moisture content of a soil is directly correlated to the soil temperature. Changes in moisture and temperature can affect the suitability of a soil to provide habitat for burrowing animals (Kumar and Pasahan 1993).

## Changes in Hydrology and Water Characteristics

### Change in Runoff and River Flow



Dave Feliz, CDFW

Rivers, streams, and estuaries in California have been substantially modified and controlled since the Gold Rush. As a result, the natural hydrologic processes of the state's system of rivers, lakes, streams, and estuaries have also been substantially altered, which has created significant ecosystem stress on native aquatic species. Land development, construction of dams, flood control structures, diversions of water, and groundwater withdrawal all change the volume, timing, hydraulics, sediment load, and temperatures of water that runs off the landscape into the ground and/or streams. These impacts are exacerbated by drought conditions and climate change. These changes affect aquatic habitats necessary for species survival.

As a result of these alterations, natural riverine habitat is lost and fish migration routes are disrupted. In many regions of the state, diversions and groundwater pumping deplete river basins to the point where river reaches regularly dry up or are diminished to such low flows that

native species cannot survive. As examples, this has occurred in the Carmel River on the Central Coast (CDFG 1996), the Colorado River in the Colorado Desert (Pitt 2001), the Mojave River in the Mojave Desert (CDFG 2004a), and the Scott and Shasta rivers in the North Coast-Klamath Region (CDFG 2004b). The impacts of river diversions and groundwater depletion become much more pronounced during drought conditions.

### **Change in Water Temperature**

Water temperatures can be affected by many variables including drought, the presence or absence of riparian vegetation, stream diversions, the temperature of discharged water from reservoirs, and other factors. Many aquatic species are cold blooded and are easily affected by changes in temperature. A change in temperature of 5°C (41°F) can be harmful to fish species and a difference of only 2°C (35.6°F) can mean the success or failure of an egg hatch (Poff et al. 2002). In most cases, changes in temperature resulting from human activities trend upward, an exception would be the release of cold bottom water from a reservoir. The drop in water temperature from such a release can impact a warm water fishery for miles downstream. In general, most other activities will raise the temperature of receiving waters resulting in reduced dissolved oxygen content of the water, increased metabolism and oxygen demand for aquatic species, higher solubility of toxic substances, increased algae growth and eutrophication, and ultimately (if temperature maximums are exceeded) death (Poff et al. 2002).

### **Change in Water Chemistry**

As discussed above, increases in water temperature can reduce the amount of dissolved oxygen in water and increase the solubility of toxins. Water chemistry can also be altered by the consistency of waste water discharges, contaminated or acidic surface runoff, excessive evaporation during dry periods, or saltwater intrusion. Increases in salinity and contaminants, or changes in water pH have direct impacts on aquatic species which are typically adapted to a narrow range of conditions. Additionally, heavy metals such as cadmium, lead, and chromium dissolve more easily in acidic water, leading to bioaccumulation and toxicity issues higher in the food chain. In extreme cases, the chemistry of a water body can be altered to the extent that is no longer suitable as a water source for terrestrial wildlife (such as in the case of streams effected by acid mine drainage).

### **Change in Water Levels and Hydroperiod**

Hydroperiod refers to the length of time that a wetland, lake, or pond holds water. Hydroperiod can vary from as short as a few weeks for some seasonal wetlands, to very long or permanent for lakes and ponds. The hydroperiod of a wetland is critical for determining what amphibian species can successfully breed in the wetland. Hydroperiod determines the length of time amphibians larvae have for developing to the point where they can leave water for land as well as determining the predators to which they are exposed. If a pond or wetland remains dry during the breeding and egg laying season for any amphibian species, it will likely not provide breeding habitat for those amphibians that year, regardless if conditions change later in the season (Tarr and Babbitt 2012). Extending the hydroperiod, such as through the discharge of



urban runoff into seasonal wetlands and vernal pools, allows perennial species to gain a foothold, and results in a shift to perennial wetland habitat, which can be no longer suitable for the unique flora and fauna that have adapted to the seasonal nature of these features.

### **Change in Flood Occurrence, Frequency, Intensity, and Area Flooded**

The shallow and nutrient dense waters of flooded areas provide excellent habitat for immature fish and other aquatic species. Many bird species rely on floodplains to provide wintering habitat or stop-over nutrition during migrations. Changes in the season of flooding can affect the availability of seed for migrating birds. Unseasonably high flows from hydroelectric projects, or urban runoff, can flush amphibian and fish spawning sites, or deposit sediment on egg masses, while the restriction of seasonal high flows to conserve water and electricity storage can interrupt the regeneration of riparian habitats that rely on flood events and lead to unsuitably high water temperatures.



Michael Nevins, USACE

### **Change in Groundwater Tables**

Springs are locations where groundwater naturally emerges from the Earth's surface in a defined flow. Springs can form seasonal or perennial pools, support wetlands, or form the headwaters of streams. A seep is a moist or wet area where groundwater reaches the surface but does not pond. Fluctuations in the groundwater table alter the seasonality or flow rates of these water features. Groundwater withdrawals in an area can reduce the pressure in an aquifer, causing groundwater levels to drop and decreasing flows from springs and seeps. Fractured bedrock aquifers found in mountainous areas typically have smaller watersheds and water storage capacity than deep alluvial aquifers found in valley areas. These smaller groundwater resources are more easily affected by periods of drought or groundwater withdrawal, but also rebound quickly in wet years. Groundwater decline can result in reduced habitat or loss of water sources for wildlife species. This can be a critical issue in the case of isolated springs and seeps, where wildlife species may be unable to relocate or may have to travel long distances to reach the next available water source.

### **Change in Nutrients**

The amount of nutrients in a stream or lake is a function of the geology and vegetation within its watershed, and the amount of sediment that has been deposited. Newly formed lakes typically have rocky bottoms and very limited fertility. As a lake ages, nutrient rich sediments are washed into the bottom of the lake, increasing its fertility. Although this is a natural process, it can be accelerated by man-made nutrient sources such as runoff from urban and agricultural areas. As the nutrient level of a water body increases, so does the productivity of algae and aquatic plants. This increase in productivity is accompanied by increases in decomposition which

uses up oxygen. In small or shallow lakes, the entire lake can become oxygen starved, resulting in the death of fish and other aquatic species.

## **Ecosystem Changes**

### **Change in Community Structure or Composition and Change in Functional Processes**

Degraded terrestrial habitat quality is one of the state's most widespread stresses. It can occur in many forms, such as loss of community structure and composition or changes to ecosystem processes. It can result in diminished ecosystem functions, such as food, water, or cover, which are critical to species survival. Examples of common pressures resulting in habitat degradation include pollution, invasive species introduction, livestock grazing, intensive recreation, or soil erosion. Natural phenomena that are altered or intensified by human activities, such as droughts, flooding, or wildfire, can also result in habitat degradation.

Degradation of aquatic habitat quality is also a major stress in California. Land reclamation and water projects have fundamentally altered the historic connection between land and water in California. The reduced hydrologic connectivity between primary aquatic habitat and areas that were periodically flooded by tides and spring flows has decreased the abundance of key habitats for native aquatic species, simplified edge conditions that supported diversity, and diminished important habitat gradients. Installation of dams and diversions on major rivers has cut off historic fish migration routes. However, recent restoration projects along the Klamath River, in the Central Valley, and along coastal streams seek to restore fish passage and habitat for anadromous species.

Marine habitat degradation is also a widespread stress in the state. Degradation can occur from stormwater runoff and other non-point source pollution; contamination from pesticides, trash, heavy metals, or pathogens; or alteration of adjacent lands, such as alterations to estuaries or flow regimes. Invasive species can also cause marine habitat degradation and are easily transported into California waters in the ballast water of out-of-state or international ships.

Development adjacent to freshwater waterways and riparian corridors has limited natural river processes and meander by reducing floodplains and riparian and adjacent upland vegetation. The reduced riparian and adjacent upland vegetation is less effective in buffering waterways from urban runoff, providing essential vegetative structure for shading streams, and supporting upland activities of amphibians, reptiles, birds and mammals that use riparian habitat for nesting, foraging, roosting, or basking. Even in areas with no direct development or apparent human influence, upstream activities from dam or culvert installation, water diversion, or loss of abutting riparian or upland habitat can degrade aquatic habitats. Also, changes in the volume, character, and hydrograph of stormwater flows or dam releases within streams that have otherwise natural features can lead to unfavorable water temperatures and reduction in foraging, spawning, and rearing habitat quality.

Loss of physical community structure and vegetation composition has been documented to directly reduce animal species diversity. In areas with heavy recreational use, construction of rock dams, deposition of trash and human waste, or trampling lead to habitat degradation and increased stresses on native species. Upland habitat degradation can occur from off-highway activities, loss of natural disturbance regimes (such as fire), or invasive plant and animal species. Feral domestic dogs and cats harass and prey upon wildlife near residential neighborhoods or outdoor recreation areas. Ornamental plants in urban edge areas change the vegetation composition and result in the loss of necessary host plants for specialized species and pollinators, as well as increased vulnerability to other stresses (e.g., fire, disruption of successional dynamics and increased exposure to existing or novel diseases).

### **Change in Spatial Distribution of Habitat Types**

Habitat loss, through permanent or temporary conversion to other purposes, is another important stress that occurs throughout California. It is often the result of land development, infrastructure projects, and agricultural activities. Habitat loss can result in the elimination of individuals or populations from the area that is converted. Habitat loss is typically permanent when it is the result of development. However, habitat loss caused by agricultural use, pollution, and invasive species can sometimes replace the existing habitat with a different seral stage or habitat type that still retains value; this change can also sometimes be reversed. In a recent study, rangeland conversion in California between 1984 and 2008 was analyzed using time series Geographic Information Systems (GIS) data and classified resulting land uses with aerial imagery (Cameron et al. 2014). In total, over 195,000 hectares (480,000 acres) of rangeland habitats, or about three percent of available rangelands were converted during this 24-year period. Residential and associated commercial development was the primary reason (49 percent of conversions), but agricultural intensification was also a major cause (40 percent).

Much of California's wetland habitat loss was from the conversion of wetlands for agriculture during the late 19th and early 20th century (Garone 2011). More recently, urban and suburban development has resulted in the loss of additional upland and aquatic habitat. Some habitat types have been reduced to a small fraction of their historic extent. For example, vernal pool habitats, which are the home of many endemic species, such as the delta green ground beetle and the conservancy fairy shrimp, have been reduced to less than five percent of their historic area (USFWS 2005a). Estuaries in the San Francisco Bay system have been reduced to about 15 percent (CalEPA 2015) and coastal sage scrub to about 18 percent (Pollak 2001) of historic extent. An estimated 90 percent of the historic acreage of all wetland types has been lost (Dahl and Johnson 1991).

Populations of species that depend upon these habitats have declined significantly. Development throughout the historic range for Swainson's hawk has reduced available foraging and breeding habitat, and the loss of marsh habitat has led to a dramatic reduction in tricolored blackbird populations resulting in a recent reevaluation of the species' listing status.

## **Habitat Fragmentation and Change in Biotic Interactions**

The stress of habitat fragmentation is a secondary effect of habitat loss and a process where natural areas are divided into smaller, isolated remnants by the loss of plant communities or change in ecosystem processes. This can occur through degradation or removal of a portion of originally connected habitats or construction of linear features that divide habitats. Habitat fragmentation in California occurred in pre-history from natural climatic or geological processes that transformed the landscape, such as glacial advances, volcanic activity, geologic faulting and tectonic movement, and mass land slumping. Significant habitat fragmentation in historic times was almost entirely because of direct or indirect human pressures, including alterations of water regime, conversion of land for development, mining, agriculture, and construction of linear projects, such as highways or canals.

Habitat fragmentation often causes decreases in biodiversity and impairment of ecosystem functions. Fragmentation reduces the amount of functional habitat in an area and can isolate species into subpopulations that are more susceptible to extinction from other causes, including natural disasters, disease, invasive species, or climate change.

Habitat fragmentation inhibits the movement of individuals travelling between separate populations. This reduced movement leads to inbreeding, which reduces genetic diversity and a population's ability to adapt to environmental changes. In the case of plants, habitat fragmentation can reduce the movement of animals that carry pollen or propagules, and prevent plant communities from moving over time in response to climate change. For some species with relatively small ranges—especially reptiles, plants, and small mammals—the lack of connectivity to movement corridors threatens survival of many populations. Maintaining connectivity allows these limited-home-range species to shift habitats to adjacent areas, if populations experience habitat loss or degradation. For species with larger home ranges, habitat connectivity may be required across a much larger swath of the landscape. Because resources for these species are dispersed across a broader area, habitat fragmentation may result in the loss of a necessary constituent for survival (e.g., sufficient breeding or foraging habitats).

Examples of habitat fragmentation in California include the conversion of native grasslands to agricultural uses in the Central Valley, which fragmented once continuous grasslands into remnant patches surrounded by other vegetation types. In southern California habitat fragmentation has occurred as historic movement corridors between mountain ranges were urbanized.

## **Changes in Succession Processes and Ecosystem Development**

Successional dynamics is the process of ecological succession or the typically predictable change in species composition of a community over time. Ecological succession follows either the creation of new unoccupied habitat, such as after a lava flow or severe landslide, or the disturbance of an existing vegetation community by natural or human-induced actions, such as fire, timber harvesting, landscape grading, or incompatible grazing. It is characterized by early rapid changes in community composition shortly after a disturbance, which is typically



dominated by fast-growing or pioneering species, followed by a slower rate of changes that gradually leads to a stable climax community composition in late succession.

Disruption of natural successional dynamics is an important stress. It can occur either because natural succession is inhibited or repeated disturbances by human activities take place. The lack of ongoing disturbance over time, such as an ecologically isolated habitat that is not allowed to burn because of human safety concerns, prevents the regeneration of those early successional, pioneering species. Agriculture, timber harvest, and heavy recreational uses can interrupt the establishment of late successional or climax species, which are typically less tolerant of disturbance and require a longer time to become established.

### **Volcanoes**

More than 500 volcanic vents have been identified in California. At least 76 of these vents have erupted, some repeatedly, during the last 10,000 years (Miller 1989). Volcanoes can have devastating effects on habitats and ecosystems. Ecosystems may be destroyed by direct impact from pyroclastic flows or buried by hot rock debris and indirect impacts resulting from melted snow or burnt vegetation.

### **Earthquakes and Tsunamis**

Dominant losses from earthquakes are to structures and potentially to humans; however, these events can also result in environmental consequences. Species and ecosystems may be damaged by the shocks and shifts in land surfaces, as well as alterations in local hydrologic systems. Coastal ecosystems may be directly damaged by tsunamis or indirectly through changes in water chemistry or the introduction of invasive species.

### **Avalanches, Landslides, and Subsidence (Sinkholes)**

Avalanches, landslides, and sinkholes have a variety of ecological effects, and many of these effects can be amplified by other factors. Generally, avalanches and landslides bring additional sediment into river systems, degrading water quality and silting reservoirs. Timber harvests and fires that remove vegetation increase the incidence of landslides and the probability of slope failure during the wet season. Landslides create bare ground that is subject to erosion and to invasion by non-native species. Sinkholes may directly impact species and ecosystems.



Adam Dubrowa, FEMA

## **2.5.2 Major Pressures on Ecosystems**

As recognized in the Governor's most recent Environmental Goals and Policies Report, California's population is projected to add 12 million residents between 2013 and mid-century,

growing to 50 million people by 2050 (Office of Planning and Research 2013b). The state's continued growth leads to an array of human-induced pressures that make supporting this growth in harmony with the state's wildlife a distinct challenge. A summary is presented in this section describing the major pressures on the state's ecosystems that have been identified by CDFW regional teams during the preparation of SWAP 2015.

#### Pressures

- ▲ Agricultural and forestry effluents
- ▲ Airborne pollutants
- ▲ Annual and perennial non-timber crops
- ▲ Climate change
- ▲ Commercial and industrial areas
- ▲ Dams and water management/use
- ▲ Fire and fire suppression
- ▲ Fishing and harvesting aquatic resources
- ▲ Garbage and solid waste
- ▲ Household sewage and urban waste water
- ▲ Housing and urban areas
- ▲ Hunting and collecting terrestrial animals
- ▲ Industrial and military effluents
- ▲ Introduced genetic material
- ▲ Invasive plants/animals
- ▲ Livestock, farming, and ranching
- ▲ Logging and wood harvesting
- ▲ Marine and freshwater aquaculture
- ▲ Military activities
- ▲ Mining and quarrying
- ▲ Other ecosystem modifications
- ▲ Parasites/pathogens/diseases
- ▲ Recreational activities
- ▲ Renewable energy
- ▲ Roads and railroads
- ▲ Shipping lanes
- ▲ Tourism and recreation areas
- ▲ Utility and service lines
- ▲ Wood and pulp plantations

## Housing and Urban Areas; Commercial and Industrial Areas



Economic and population growth is a driver for development, leading to an increased need for housing, commercial development, services, transportation, and other infrastructure, which places pressure on the state's land, water, and other natural resources. California's population grew by nine percent between the 2000 census and the 2010 census (California Department of Finance [CDOF] 2014a). From 2000 to 2010, California

gained 3.4 million residents (CDOF 2014b), which is a decrease in the rate of growth from the 1990 to 2000, when over 4 million residents were added (CDOF 2005). Although the rate of growth is estimated to continue to gradually slow over time, substantial additional population increase is projected at the rate of 2.5 to 3.5 million people per decade between 2015 and 2050 (CDOF 2014c).

Growth and development, including urban, commercial, and industrial development, can contribute to all of the major stresses described above. Conservation strategies need to take into account the pressures of continuing development demand. Progressive conservation planning on state, federal, and local levels has tempered the ecological effects of growth through conservation and mitigation requirements, such as policies requiring no net loss of California wetlands, and the creation of reserves for species and habitats. Smart growth principles have incentivized infill projects, higher urban density, and transit-oriented development where the ecological impact is typically less than exurban locations. These smart growth principles are being integrated into regional land use and transportation planning through the creation of legislatively-required sustainable communities' strategies, such as the Plan Bay Area. Additionally, demographic shifts are predicted to result in a decreased demand in traditional single family homes and an increased demand for transit-oriented or walkable multifamily-density communities. Large public works and infrastructure projects focused on repair of existing roads, and implementation of additional transit options are expected, including a state-sponsored high speed rail system, beginning in the Central Valley and ultimately extending from San Francisco and Sacramento to San Diego. Additional urban and infrastructure development will continue to lead to habitat loss, habitat fragmentation, and decrease in the quality of remaining natural areas.

### **Garbage and Solid Waste; Household Sewage and Urban Waste Water; Industrial and Military Effluents; Air-Borne Pollutants**

Along with growth and development come pressures from excess waste and pollutants from point and nonpoint sources. Garbage and solid waste may directly entangle wildlife. Runoff from residential and commercial areas, landscaped yards, roads and parking lots, and domesticated animal feces include pollutants and pathogens. Particulates, pollutants, and pathogens deposited from the air can degrade aquatic and terrestrial ecosystems and marine habitats. Discharges from power plants, sewage plants, and other industrial facilities are high in pollutants and pathogens.

### **Roads and Railroads; Utility and Service Lines; Shipping Lanes**

Existing transportation infrastructure, such as roads and highways, can be a barrier to wildlife movement, creating fragmented habitats and direct mortality from vehicle and wildlife collisions. Continued population growth increases the demand for transportation facilities for urban, regional, intercity, and long-distance travel. Caltrans estimates that the capacity of existing rail, air, and highway transportation systems will need to be increased (Caltrans 2015). The California Transportation Plan calls for an increase in intermodal transportation systems, including increased freeway reliability, express and high occupancy vehicle lanes, and increased connectivity between transportation types and across modes of transportation (Caltrans 2015). The majority of these connections will occur along existing transportation corridors and increase

mobility between existing modes of transportation including intercity bus and rail (Caltrans 2015). The focus on improvements to existing corridors and connections between travel modes should minimize new habitat fragmentation from state highways. However, local roadways and other infrastructure have the potential to create additional habitat fragmentation.



The development of new infrastructure and expansion of existing infrastructure can also result in direct habitat loss. The construction of California's high speed rail system, when completed, will become the largest infrastructure development project in the state's history. The first phase of a high speed rail system to connect Sacramento, San Francisco, Los Angeles, and San Diego broke ground in January 2015 and it is eventually expected to extend from Sacramento to San Diego, totaling 800 miles. In addition, the High Speed Rail Authority (Authority) is working with regional partners to implement a statewide rail modernization plan to upgrade local and regional rail lines. Like many large-scale transportation projects, without proper planning and consideration during the design phase to anticipate species and habitat needs, these rail projects may result in devastating impacts to biological resources, including loss or degradation

of habitat for threatened and endangered species and wetlands through land conversion, loss of habitat connectivity, and construction related impacts (Authority and Federal Railroad Administration 2005).

California has numerous shipping lanes along its coast connecting ports to the rest of the world. In recent years, a record number of whales have been hit and killed by ships sailing along the California coast. Changes have been made to the mile-wide shipping lanes that funnel traffic into the San Francisco Bay and to the ports in Los Angeles and Long Beach. Some modifications have been made specifically to reduce the presence of ships in areas whales are known to frequent (Perlman 2014). In addition to direct mortality on species, shipping lanes introduce pollutants, pathogens, and invasive species to California marine ecosystems.

## **Parasites, Pathogens, and Disease**

Growth and development and the infrastructure that follows bring humans and domesticated animals in contact with wildlife species and ecosystems. Harmful plants, animals, or pathogens and other microbes may be introduced to these ecosystems and species. Parasites, pathogens,

and diseases that affect wildlife populations may be released directly or indirectly due to human activities (see more information about wildlife diseases in the text box below).

### **Wildlife Diseases**

Pressures and stresses resulting from development, environmental degradation, and habitat reduction are the focus of the wildlife conservation strategies in SWAP 2015. These strategies are designed to enhance ecosystems by reducing the pressures on targets, which are habitat-based (e.g., plant communities, fish assemblages, and marine ecosystems). Wildlife species are also subject to stress from diseases resulting from exposure to pathogens, parasites, toxins, and other biological and physical agents. This disease-related stress is not necessarily based on habitat condition.

Wildlife diseases sometimes result in significant mortality events. Disease may be broadly defined as a physiological disturbance that compromises health. If applied on a wildlife population or ecosystem scale, it can be defined as a physiological disturbance resulting in disruption of demographic functions that compromise population or ecological health. If affected substantially by disease, wildlife populations can become unhealthy, losing resilience and self-sustainability.

The conservation strategies in SWAP 2015 promote functioning ecosystems and enhancing wildlife habitats. Wildlife within healthy, functioning ecosystems are more resilient at a population level to diseases than wildlife in degraded habitats. In this way, the SWAP 2015 strategies help address wildlife disease issues in California.

Although not explicitly identified as a stress in the SWAP analysis, CDFW is fully involved in wildlife disease research, monitoring of wildlife disease effects, and identifying management programs to reduce and mitigate disruption of wildlife populations. The Wildlife Investigations Lab (WIL) is CDFW's center for tracking, understanding, and responding to wildlife diseases in California. WIL's mission is to investigate, monitor, and manage population health issues in California's wildlife. WIL staff provides expertise, service, training, and resources to assist in assessing wildlife populations, wildlife mortality response, biological sampling, study design, and analyses of events and disease effects. WIL's responsibilities have increased over time to include the statewide investigation of all wildlife mortality events, research studies and surveillance of diseases, wildlife health and condition monitoring, prevention of zoonotic diseases (animal disease that can be transferred to humans), and wildlife rehabilitation, among other non-disease duties.

Research funding for ecological studies of disease has increased over the past decade due, in part, to the human health risks posed by emerging zoonotic, infectious diseases in wildlife and domestic animals (e.g., hantavirus, West Nile virus, avian influenza, and severe acute respiratory syndrome [SARS]). More research, diligent monitoring and investigation of observed wildlife disease, and innovations in wildlife management are needed and will continue to be pursued by CDFW. With effective treatment and time, unhealthy wildlife populations and degraded ecosystems can recover.



## Dams and Water Management/Use



The management of water resources in California results in numerous pressures on rivers, the Delta, wetlands, estuaries, and aquifers in the state. Across all regions of the state, limited water resources are managed to meet water and power supply needs and to accommodate urban communities and agricultural production. Water management activities include the operation of dams and diversions, development and operation

of irrigation canal systems, extraction of groundwater, and construction of flood-control projects such as levees and channelization. These activities can reduce the amount of water available for fish and wildlife, obstruct fish passage, and result in numerous other habitat alterations. In all regions of the state, aquatic, wetland, and riparian habitats support rich biological communities, including many special status species, and degradation of these habitats represents a serious threat to the state's biological heritage.

Increasing pressures from development and agriculture, as well as the expectation of longer droughts resulting from climate change, have exacerbated California's water shortages. It is anticipated that additional water conservation, water recycling, watershed management, managed wetland water supply, conveyance infrastructure, desalination, water transfers, and groundwater and surface storage will be necessary.



DWR

Conservation strategies in the aquatic ecosystems of the state will be heavily influenced by the ongoing efforts to manage water supplies. Many of California's water supply and flood protection infrastructure are no longer functioning properly or have exceeded their life cycles. This aging water supply and flood management infrastructure, badly in need of maintenance or replacement, has led to declines in species and ecosystems. The California Water Plan Update (DWR 2013b) identified strategies for establishing reliable water supplies and restoring ecologically sensitive areas. DWR is conducting planning for three large surface water storage projects, i.e., raising Shasta Dam, the proposed Temperance Flats Reservoir, and expansion of the San Luis Reservoir, along with off-stream storage in the Sacramento River watershed.



### Extended Drought – A California Reality

In 2015, California entered the fourth year of an ongoing drought. The state is no stranger to long periods of drought. This is the tenth widespread, multi-year drought period within the state's history since 1900. Stream flow reconstructions based on tree-ring data show that far more severe and long-lasting droughts have occurred prior to historic record keeping. Although the severity of the drought varies across the state, no area remains unaffected.

Drought-related wildlife effects begin with decreased vegetation growth, or in food-chain terms, reduced primary plant productivity for wildlife food that decreases ecological energy flow. As grasses and other wildlife food plants are less productive, food availability diminishes for herbivorous species. Exemplary of the interconnected food web, reduced vegetative food energy ripples up trophic levels as a stress of insufficient nutritional energy available to insects, small mammals, reptiles, and carnivorous predators, as well. Undernourished animals with fat must draw from these reserves, which can lead to weakened health and ultimately starvation. During the current drought, CDFW's Wildlife Investigations Lab discovered poor body condition, emaciation, and secondary infections in young red-tailed hawk carcasses in central and southern California (Batter 2014).

As the drought lingers, water-associated and more deeply rooted plants are affected. Gradually, water sources and availability shrink or disappear completely. Some plants species will go dormant in response to lack of water; others will simply die and depend on seed banks to support later regeneration. The lack of water reduces a plants ability to resist insect infestations and disease, leading to additional mortality. An increase in dormant and dead vegetation sets the stage for more frequent and overly severe wildfires, followed by accelerated wind and water erosion.

As water bodies shrink, their wildlife inhabitants and migratory visitors are forced into concentrated areas. Migrating ducks, geese, and swans that reside or spend the winter on California's ponds, wetlands, and lakes must cope with smaller water areas. Lack of precipitation reduces the amount of habitat available for migratory and resident waterfowl and shorebirds, forcing them to become concentrated in the smaller water bodies and wetlands. Large numbers of confined waterfowl make infection by a bacterial disease, such as avian cholera, easier, so it can spread rapidly, and potentially cause the death of thousands of birds.

Rising water temperatures in the state's aquatic systems also occur because of greater warming of smaller water bodies or the lack of cold water reserves in reservoirs from reduced snowpack. Cold water fisheries can lose their eggs, fry, or fingerling fish, as the low flows in streams are heated to near-fatal temperatures. Warm water species are not immune. The combination of warmer water and concentrated nutrients can lead to algal blooms, stressing the fish because of decreased dissolved oxygen resulting in the potential for suffocating fish.

It is important to remember that drought as a stress, by itself, is a part of California's history and ecological processes—a natural phenomenon. Native plant and animal species have survived droughts for centuries with adaptation strategies for times of drought stress and the opportunity for rapid recovery when the water regime improves.

The challenge for wildlife conservation is when drought stress exacerbates human pressures, causing extirpation or, in the extreme, extinction. The potential for the imminent extinction of the endangered delta smelt (*Hypomesus transpacificus*) has been recognized, because the current drought has worsened the pressures that have led to the species' endangerment, such as competition and predation by non-native species, altered food supply, contaminants, and water exports (Moyle 2015). Although this is a high-profile example at the heart of often intense debates about water allocation and aquatic habitat management decisions in California, it is emblematic of the difficulties experienced by a number of fish and wildlife species in drought-affected habitats where the natural drought stress combines with human pressures on wildlife.

SWAP 2015 provides strategies that address water management and maintenance of the quality of aquatic habitats and terrestrial habitats that are affected by drought stress. Also, CDFW has been pursuing many urgent actions to protect fish and wildlife species and habitats that face these challenges. Actions include fish rescues,

anadromous fish migration assistance, wildlife rescue and relocation where they interact more with urban areas, well installations and improved water systems for CDFW Wildlife Areas, agreements with water users to reduce surface water diversions, consultation with state and federal water agencies about water system operations to protect aquatic habitat and species, habitat restoration projects, and more extensive monitoring of fish and wildlife conditions. Funding for drought responses such as these will continue to be one of the important fiscal strategies for fish and wildlife conservation employed by CDFW in times of extended drought.

## Fire and Fire Suppression



Harry Morse, CDFW

was lightning, followed by human-related causes, including power lines, arson, and vehicles (CAL FIRE 2015). Lightning-caused fires typically occur above 5,000 feet in altitude, but are recorded to have occurred at much lower elevations (Burcham 1957).

Natural causes of fire include lightning, sparks from falling rocks, volcanic activity, and the spontaneous combustion of plant materials and other organic matter (Barbour et al. 1980). Of these, lightning is the most influential factor, and in California lightning strikes have occurred over 62,000 times a year on average (Sugihara et al. 2006). In California, the most common cause of the state's 20 largest fires

Wildfire risk reduction and suppression activities are designed to address the most common fire ignition causes. Risk reduction actions can include fuel reduction through mechanical or herbicide treatment and establishment of fire breaks, particularly in the wildland-urban interface. Fire risk reduction and suppression activities can have variable effects on wildlife, depending on the specific management actions and environment in which the actions occur. For example, in some areas bird and mammal diversity and abundance can increase with moderate levels of forest thinning for fire fuel management, but decline with heavier levels of thinning (Verschuyl et. al. 2010.).

Control of invasive plants is another fire risk reduction action. For instance, red brome (*Bromus madritensis* ssp. *rubens*) and other invasive annual grasses increase fire frequencies in the western Mojave Desert in California, and cheatgrass has been part of the fuel in sagebrush fires in the Owens Valley (Lambert 2010). In a study of fires over the past decade in the Great Basin, which includes parts of California, cheatgrass fueled the majority of the largest fires and influenced 39 of the largest 50 fires (Balch et al. 2013). In cheatgrass grasslands, the average size and frequency of fire is greater compared to other vegetation types. The authors conclude that cheatgrass is creating a novel grass-fire cycle that makes future fires more likely (Balch et al. 2013).

Climate is also a primary determinant of fire patterns (Halsey 2004). Risk of large wildfires is projected to increase as a result of climate change influences, most substantially in the Sierra Nevada foothills, Trinity Alps, Great Basin, and Coast Range (CNRA 2014). In light of this, climate change will add a significant variable to efforts to understand future fire regimes and to identify

fire risk management measures that can adjust to changing fire risks and maintain the mosaic of habitats (Grissino-Mayer and Swetnam 2000). Additionally, the expansion of residential communities into fire-dependent ecosystems creates a conflict between maintaining ecological integrity and protecting property. The expansion of new development into fire-dependent ecosystems can be partially mitigated through the application of smart growth principles that concentrate new development near existing communities.

### **Annual and Perennial Non-Timber Crops; Livestock, Farming, and Ranching; Agricultural and Forestry Effluents**

Agriculture is an essential component of California's economy. The state is a major producer in the fruit, vegetable, tree nut, and dairy sectors (U.S. Department of Agriculture [USDA] 2014). Historic conversions of native habitat to agriculture in California have been significant. Today approximately 70 percent of the Central Valley is used for agriculture, with the vast majority of this land conversion occurring prior to the 1970s (USGS 2014). While agricultural lands no longer represent native vegetation types, they can provide important habitat for wildlife species, such as flooded rice fields of the Central Valley that provide waterfowl habitat. Habitat loss and or degradation can occur through land conversion from one type of agriculture to another, including conversion of field and row crops or grazing lands to orchards or vineyards. Deep ripping of fields to create subsurface conditions conducive to orchards and vineyards can destroy wetlands as well as essential upland habitat for sensitive species such as California tiger salamander, and lead to habitat fragmentation. Diversion of water for irrigation can contribute to altered hydrologic regimes, and nutrient laden runoff can degrade aquatic habitat. Illegal marijuana groves, particularly in the northern portions of the state, have similar but more pronounced impacts than other agriculture, because of their location in remote and otherwise undisturbed areas and lack of regulatory oversight.

Ongoing agricultural practices can have a range of direct and indirect ecosystem consequences, positive or negative, because of chemical treatments, land management practices and water use. For instance, controlled grazing has been found to have a beneficial effect on vernal pool grasslands (Marty 2005), and uncontrolled grazing to be damaging to sensitive riparian areas and anadromous fish habitat (Willis et al. 2011). Field crops can provide foraging habitat for raptors, such as Swainson's hawk, and rice fields and stock ponds can provide foraging and aquatic habitat for reptiles such as giant garter snake (federal and state threatened), amphibians, bats and birds, such as tricolor blackbird (state endangered). Agriculture can harm those same species through chemical treatments, removal of nesting habitat, or direct mortality from harvesting and maintenance activities. Agricultural runoff containing fertilizers and pesticides can also pollute and degrade aquatic and marine habitat. Conversely, crop damage from wildlife can cause substantial economic loss and public health risks necessitating enhanced measures to control access to crops by wildlife.

Legislation, public policies, and landowner conservation practices have helped slow impacts of agricultural practices to species and habitats. For example, farmers can apply for subsidies to avoid

disruption of tri-colored blackbird nesting, to restore wetlands and other waters, to implement best management practices for grazing, and to manage field crops for the benefit of wildlife (e.g., rice field management to provide habitat for giant garter snake and migratory birds) (USDA 2015).

## **Logging and Wood Harvesting; Wood and Pulp Plantations**

California has approximately 99.6 million acres of land area, of which 33.2 million acres are forested. Of the total forest land in California, private landowners hold 13.0 million acres (39 percent). National forest lands account for 15.8 million acres (48 percent). Other public lands account for the remaining 13 percent or 4.2 million acres. Approximately 19.5 of the 33.2 million forested acres in California are classified as timberland. Timberland is forest land that is producing or capable of producing more than 20 cubic feet of wood per acre per year. National forests contain 9.8 million acres (51 percent) of timberland. Private landowners hold approximately 8.9 million acres (45 percent). The remaining four percent (less than 1 million acres) is held by other public landowners (Morgan et al. 2012).

California's timber harvest was 1,733 million board feet (MMBF) during 2006. Nearly 60 percent (996 MMBF) of the timber harvest came from five counties. Humboldt County had the largest proportion at 20 percent (356 MMBF), followed by Shasta County with a timber harvest of 209 MMBF. A total of 77 primary forest products facilities operated in California during 2006. These included 33 sawmills, 25 bioenergy plants, 10 bark and mulch plants, four reconstituted board plants, two veneer plants, and three manufacturers of other primary wood products (Morgan et al. 2012).

While managed forests provide significant habitat for fish and wildlife, timber harvest can fragment forest habitat, with adverse effects on wildlife and ecosystems. Forest roads can introduce invasive plant and animal species. Poorly constructed or maintained roads and ground disturbance resulting from timber harvest can also result in soil erosion and increased surface-water runoff. While temporary in nature, these impacts can have short-term or cumulative effects when concentrated in space and time.

## **Renewable Energy; Mining and Quarrying**



As of 2011, 70 percent of the electricity used within the state was generated in California (California Energy Commission [CEC] 2014a), with natural gas comprising 45 percent of the electrical energy generation source. Renewable energy generation represents a needed and major response by California to green-house gas emissions and the threat of global climate change. Under the Renewable Portfolio

Standard (California Public Utilities Commission [PUC] 2014), California has a goal to increase the electricity generated from renewable energy sources by 33 percent by 2020. Renewable generation is expected to be achieved through increased development of solar and wind generation, as well as biomass, geothermal, small hydroelectric, and possibly wave energy generation sources. Energy generation projects and transmission infrastructure have the potential to result in the loss of and degradation of wildlife habitat, as well as direct mortality. Pressures on wildlife habitat include temporary or permanent habitat loss, habitat fragmentation, and indirect impacts from disturbance, vehicle traffic, noise, the introduction of non-native or invasive species, and predator subsidies (e.g., perching sites) that increase predation. Development of new energy projects and the ongoing operations and maintenance of existing projects have the potential to result in direct mortality and species displacement. Siting of industrial-scale solar and wind generation projects may require locations in remote areas with existing high-value habitats.

Most utility-scale solar generation projects are located in the California desert or remote agricultural lands, increasing impacts to otherwise undeveloped lands, and requiring additional electrical transmission facilities. Solar plants have been built or are planned in San Luis Obispo County and rural southern California, including Riverside, Kern, Inyo, San Diego, San Bernardino, Imperial, and Los Angeles Counties. The ecological impacts of these large solar plants are primarily habitat loss, degradation, and fragmentation because of the solar array fields, and the associated transmission infrastructure. The USFWS recently identified risks to birds because of solar flux, impact trauma, and predation associated with the operation of large solar facilities in southern California (Kagan et al. 2014). In addition, a canine distemper virus outbreak that resulted in the deaths of several desert kit foxes inhabiting a solar development area raised questions regarding potential interactions between disturbance from large-scale renewable energy development, disease transmission dynamics, and disease resistance (Clifford et. al 2013). The impacts of solar and other renewable energy development are being addressed through comprehensive regional conservation planning efforts, such as the California Solar Initiative and Self-Generation Incentive Program (SGIP) which provide incentives for customers to install renewable distributed generation technologies that directly serve their on-site load. This type of solar production does not require development of natural lands and minimizes habitat loss.

Biomass is energy production from wood waste, agriculture and food processing wastes, organic urban waste, waste and emissions from water treatment facilities, landfill gas and other organic waste sources and makes up about 2 percent of current energy production (PUC 2012). The use of fuels from high fire risk areas as biomass has biomass production potential that would both reduce fire risk that damages natural lands and produce renewable energy (CALFIRE 2010; PUC 2012).

Geothermal comprised 4.4 percent of energy generation in the state in 2014 and has one of the lowest life-cycle emissions of any energy production source (Matek and Garwell 2014). Half of the known geothermal resources are untapped, including the Salton Seas Known Geothermal

Resource Area. The Salton Sea Restoration and Renewable Energy Initiative proposed to finance air quality management and habitat restoration activities in the Salton Seas Area with funds from geothermal energy production (Imperial Irrigation District 2015). While geothermal typically has a smaller footprint than other energy production and therefore leads to less impact to many habitats, as with other energy production resources, transmission infrastructure would be required for further geothermal development.

Existing and new hydroelectric projects affect fish migration, sediment and gravel transport, and hydrology, which results in habitat loss below and above dams. The alteration of natural river flows through dam release schedules that prioritize energy generation can change flow volumes and water temperatures, creating stressed or lethal conditions for aquatic species, or strand fish along stream margins.

Wind energy currently accounts for approximately 6 percent of California's energy production and is expected to continue to grow under renewable energy mandates, primarily through the utility-scale wind farms located in areas with wind speeds of at least 13 miles per hour. Wind farms exist throughout California with major concentrations in the Burney, Solano, Altamont, Pacheco, Tehachapi, Palmdale, San Geronio, Kumeyaay, and Ocotillo areas. The CEC has identified additional areas with high wind resource potential in the primarily undeveloped areas along the eastern slopes of the Sierra Nevada Mountains, along the Peninsular and Cascade Ranges, the Channel Islands, and throughout the Mojave Desert (CEC 2014b). Installation of large wind farms in these areas may lead to new pressures from energy generation developments, which can lead to direct wildlife mortality or diminishment of habitat quality. Direct mortality concerns relate primarily to the risk of avian and bat collisions with wind turbines and associated wires. Habitat degradation can occur from landscape alteration and introduction of invasive species from access and service roads and energy infrastructure that eliminates native vegetation, modifies drainage, or increases human activity in remote areas. Large-scale wind energy facilities have the potential to alter localized micro habitats associated with areas downwind of the rotor turbulence zone. The potential impacts range from alterations in wind, surface temperatures, precipitation and evaporation levels, and soil moisture levels (Lovich and Ennen 2013).

California's existing coastal and bay-side power plants use antiquated cooling technology that pulls in over 16 billion gallons of cold seawater per day (State Water Resources Control Board 2008). This "once-through cooling" technology kills fish and other marine species each year in California, including endangered Chinook salmon and Delta smelt. California also includes existing on and off-shore oil and gas wells, and it contains the country's largest recoverable shale oil reserves in the Monterey Shale formation (US Energy Information Administration 2011). Development of oil and gas reserves can result in direct habitat loss and fragmentation from infrastructure development, direct mortality from spills, and indirect impacts from increased human activity in otherwise undisturbed areas. Regional habitat conservation plans can offset some of the impacts of energy production by developing comprehensive protection and mitigation strategies for multiple species and habitats.



Approximately 44.7 million acres of subsurface mineral estate underlies federal surface land, 2.5 million acres underlies private lands, and 592,000 acres underlies Native American Tribal land. There are 166 active mineral sales contracts in California and 165,000 ounces of gold produced annually (BLM 2014).

## **Recreational Activities; Tourism and Recreation Areas; Hunting and Collecting Terrestrial Animals**



Outdoor recreation and exposure to nature is important to foster an appreciation of nature; however, recreation in sensitive habitats can cause pressures resulting in habitat degradation. Recreational use of public lands in California involves a large number of visitors, both from state residents and out-of-state tourists. Extensive areas of federal and state lands offer high-quality outdoor recreation opportunities. Visitation data (BBC Research and Consulting

2011) from federal agencies (National Park Service [NPS], U.S. Forest Service [USFS], Bureau of Land Management [BLM], USFWS, and U.S. Army Corps of Engineers) indicate that federally managed lands in California average approximately 90 million visitor days per year. The California State Parks System averages approximately 78 million visitor days per year.

Large numbers of outdoor recreation users in sensitive areas can directly damage natural systems by reducing vegetative cover, compacting soil, disturbing biotic soil crusts (i.e., cryptogams), increasing soil destabilization and erosion, disturbing breeding and foraging areas, contaminating natural lands and waterways through inappropriate disposal of trash and human waste, and by introducing non-native species. Indirect impacts may also occur to natural areas through increased development of recreational access points and supporting infrastructure such as roads, visitor facilities, and campgrounds. Visitor litter in parks and public lands can encourage increased corvid populations (jay, crow, and raven), which contributes to greater competition with and predation upon other native wildlife.

Recreational off-highway vehicle (OHV) use can have adverse effects on soil conditions, native plant communities, and sensitive species. On public lands, authorized and unauthorized OHV trails open relatively undisturbed areas to increased use. The vehicles can disturb or run over wildlife, crush and uproot plants, spread invasive plants, and disturb soils, contributing to erosion and sedimentation of aquatic habitats.



Concentrated recreational use in highly sensitive areas, such as streams, coastal habitats, and riparian zones by hikers, picnickers, mountain bikers, and equestrians can damage these systems, reducing vegetative cover and disturbing sensitive species. Concentrated fishing, especially in populated area can lead to localized depletion of fisheries. Trampling, and collecting, can deplete floral and faunal populations, reduce biodiversity, and alter trophic and community structures in frequently visited natural habitats. Pressures from recreation can be reduced through proactive recreation planning and public education.

### **Invasive Plants/Animals; Introduced Genetic Material**

Human introduction of invasive species is a critical existing pressure that is expected to continue. Introduction of invasive species into the California ecosystem has occurred since the earliest European settlements. Some of these introductions have been intentional, such as the plants imported as ornamentals for horticulture, while other introductions have been unintentional when species arrive in the state along with the movement of people and goods. As California's population and economic activity has grown into its current size, the points of origin for people and goods coming to the state now span the globe. This has led to a diverse society and economy, but also has left California vulnerable to introductions of species from all around the world.



California is particularly vulnerable to invasive species because of its diverse ecosystems and communities. This ecosystem diversity, however, also means that species from all over the world may be able to find suitable habitat somewhere in the state. When species are introduced into these habitats they often find conditions similar to their home range that will allow for the establishment of reproducing populations.

The quantity of potential habitat and the high volume of transportation into California from other states and countries have had the unintended effect of introducing so many invasive species into the state that management of these non-native organisms is now a high priority for resource managers. Efforts are underway to combat invasive species and prevent new introductions such as new regulations on the release of ballast water in California waters and mandatory inspections of recreational boats in some lakes. Although most of the thousands of species brought into our state cause no harm, a small percentage is able to thrive in California to the detriment of native plants and wildlife. The colonization by invasive species, particularly invasive grasses, is expected to increase with climate change (Sandel and Dengermond 2011).

Invasive species harm California's wildlife by disrupting native plant and animal communities. Some introduced species are voracious predators, such as introduced trout species that have significantly contributed to the decline in mountain yellow-legged frog (Hammerson 2008). Others out-compete native species for resources, some spread diseases, and some are capable

of re-engineering the environment to suit their needs, changing hydrology, soil chemistry, and fire regimes. In addition, some are transmitting novel diseases into the state. Many also degrade recreational activities from hunting to boating, camping, and hiking. The introduction of invasive species has been an especially detrimental pressure on estuaries such as the San Francisco estuary, which is likely the most invaded estuary in the world with over 230 species of invasive species (Cohen and Carlton 1998). Though it is difficult to quantify harm from invasive species in financial terms, a conservative estimate places the cost to the United States at over \$100 billion each year, including damage to agriculture and infrastructure (Pimentel et al. 1999).

Appendix E describes major invasive species in California, state and interagency programs to address invasive species, and recommendations and strategies for invasive species management in California.

### **Fishing and Harvesting Aquatic Resources; Marine and Freshwater Aquaculture**

Fishing activity in California has changed over time largely due to increased regulation (to conserve resources) and environmental, social and economic factors. In 2013, commercial fisherman landed more than 363 million pounds of seafood at California's coastal ports. Top fisheries included California spiny lobster, Chinook salmon, Dungeness crab, groundfish (rockfish, roundfish, flatfish), market squid, red sea urchin, and coastal pelagic fish (sardine, anchovy, mackerel) (California Sea Grant 2013).

Fishing activity varies within and among California's coastal regions as a function of the distribution of species, ocean environment, management context, port infrastructure, and market demand. In 2012, approximately 1,900 commercial fishing vessels landed catch at California ports. Mendocino, Monterey, and Los Angeles counties had the greatest number of vessels with landings at their ports (California Sea Grant 2013).

Direct collection of marine resources for food, fish bait, or decoration can deplete populations, reduce biodiversity, and alter habitat structure. Removal of species may also result in indirect effect on other populations by disrupting the ecological balance within the ecosystem.

Aquaculture is the process of raising and harvesting plants or animals in an aquatic environment. Marine aquaculture has a long history in California beginning with oyster culture in the late 1800s. CDFW is the lead agency for leasing and permitting of marine aquaculture on state and private water bottoms in bays and estuaries, and ensures that marine resources and essential habitat are protected. In California, marine aquaculture for commercial purposes is currently limited to oysters, abalone, clams, and mussels.

## **Military Activities**

Military bases in California include Air Force Bases, Army Bases, Coast Guard Bases, Marine Corps Bases, and Navy Bases. Military operations associated with these bases may include both ground and aerial warfare training and testing.

For example, Edwards Air Force Base (AFB) is an approximately 306,700-acre facility bordered by Kern, Los Angeles, and San Bernardino counties. Edwards AFB has been operational since 1948 and provides military aircraft testing and training. Activities include bombing ranges, low-altitude high-speed maneuvers, radar intercept areas, and weapons testing and training.

## **Other System Modifications**

Pressures in the "Other System Modifications" category are actions that convert or degrade habitat in service of "managing" natural systems to improve human welfare. For example, floating and submerged artificial structures along the shoreline (including pier pilings).

### **2.5.3 Vulnerability to Climate Change**



Ascent Environmental

Global climate change is a major challenge to the conservation of California's natural resources. To address this challenge, CDFW has been at the forefront of research, policy development, and implementing actions in statewide and national efforts to assess the potential effects of climate change, and to assess and minimize the vulnerability of California's wildlife and habitat to these effects.

This section addresses the degree to which climate change is affecting California, both statewide and for the provinces addressed in SWAP 2015. Projected climate change effects (i.e., exposure) are summarized, along with associated stresses to wildlife species and habitat. Pressures include changes in the duration, frequency, or severity of extreme events, such as wildfire, storms, floods, and extreme temperatures. Also, longer-term climate trends and associated ecological vulnerabilities in response to these stresses may directly threaten sensitive habitats and species, particularly those with limited adaptive capacity (e.g., sea-level rise, ocean acidification, vegetation shifts, and modified hydrology).

This section describes a sampling of work accomplished to date by CDFW and other agencies and partners at the local, state, and national level to identify climate adaptation strategies and

implementing actions. As summarized below and addressed in further detail in subsequent chapters, CDFW has integrated climate change into the pressure assessment and ratings described in the *Summary of Key Changes from SWAP 2005* (Section 1.4.2), such that conservation strategies in the SWAP are intended to minimize the negative effects (or risks) of climate change on wildlife and habitat.

## **Climate Change Exposure in California**

The effects of climate change can be described in terms of primary exposure to various physical changes in the climate and environment caused by global climate change, such as temperature, precipitation, and sea level rise, as well as stresses experienced by vulnerable wildlife and habitats as a result of these exposures (e.g., habitat loss and



fragmentation, migration barriers, increases in presence and prevalence of invasive species).

These vary considerably from region to region within California. An overview of statewide exposure to climate change is presented below. Summaries of regional variations in each SWAP province are included in appropriate sections of Chapter 5.

### **Temperature**

According to the Intergovernmental Panel on Climate Change (IPCC), global average temperature is expected to increase by 0.3 to 4.8°C (0.5 to 8.6°F) by the end of the 21<sup>st</sup> century, depending on future greenhouse gas emission scenarios (IPCC 2014). In California, average temperatures are likely to increase significantly by the end of the 21<sup>st</sup> century with a projected increase of approximately 1.5°C (2.7°F) above 2000 averages by 2050 and, depending on emission levels, 2.3 to 4.8°C (4.1 to 8.6°F) above 2000 averages by 2100 (California Natural Resources Agency [CNRA] 2014).

### **Precipitation**

In addition to projected increases in average temperature, precipitation levels in California will also be affected by climate change. Many climate models predict that the disparity in precipitation between various parts of the state will be even greater in the future, with the southern part of California becoming drier (DWR 2013b). The projected drying trend is caused by an expected decline in the frequency of rain and snowfall. In projections with relatively small or no declines in precipitation, central and southern parts of the state can be expected to be drier from the warming effects alone, because the spring snowpack will melt sooner, and the moisture contained in soils will evaporate during long dry summer months (CEC 2012a).



The volume of precipitation falling as snow at higher elevations in California is expected to decrease, along with an overall reduction in snowpack levels in the Sierra Nevada and other mountain ranges. Based on historic data and modeling, DWR predicts that the Sierra Nevada snowpack will experience a 25 to 40 percent reduction from its historic average by 2050 (DWR 2008). Most of the snowpack decrease is expected to occur in the northern portion of the Sierra Nevada, where mountain peak elevations are lower. An increase in precipitation falling as rain rather than snow in the Sierra Nevada could lead to increased flows in rivers and streams after storms, with increased potential for floods and erosion, because water that would normally be held as snow and ice in the Sierra Nevada until spring could flow into the Central Valley concurrently with winter storm events.

Increases in extreme precipitation events could also result from warmer temperatures, including the phenomenon of "atmospheric rivers," wherein warmer winter weather systems could bring more intense, narrow bands of heavy precipitation in a river-like manner over parts of the state in a relatively short time period (CEC 2012a). Flood events coinciding with high tide events could result in widespread low land flooding and pollution, followed by proliferation of mosquito borne pathogens (CNRA 2009).

### **Sea Level Rise and Ocean Acidification**

Global climate change is already contributing to sea-level rise, which will continue at increasing rates as warming continues. Along California's coastline, the average sea level rose approximately 7 inches during the 20th century (CEC 2012a:9). Assuming that sea level rise along the California coast continues to track global trends, projected sea levels along the state's coastline south of Cape Mendocino are expected to increase from 12 to 61 cm (5 to 24 inches) by 2050, compared to 2000 levels, and 42 to 167 cm (17 to 66 inches) by 2100 compared to 2000 levels. North of Cape Mendocino, geologic forces are causing much of the land to uplift, resulting in a slower projected rate of sea level rise than California's coastline to the south. Between 2000 and 2100, sea level north of Cape Mendocino is projected to rise approximately 10 to 143 cm (4 to 56 inches) (California Ocean Protection Council [OPC] 2013).

Increases in carbon dioxide and other gases from human activities are changing the chemistry of the world's oceans. These gases are absorbed into the oceans' surface water, which results in a decline in pH. This process, known as ocean acidification, threatens marine ecosystems. The current rate of ocean acidification is unprecedented over the past hundreds of millions of years; similar past events have been accompanied by major marine species extinctions (Feely et al. 2012). While oceanic uptake of carbon dioxide from the atmosphere provides a valuable service to human societies by moderating the severity of climate change, it is having a profound long-term impact on marine chemistry and biology (Bille et al. 2013).

### **Change in Freshwater Hydrologic Regimes**

Increases in temperature, along with changes in precipitation and snowpack, are already contributing to hydrologic change across numerous California watersheds. Further changes are



projected as a result of climate change by the end of the 21st century, with effects varying throughout the state. Many regions are projected to experience overall drier average conditions, while others could see slightly wetter conditions depending on specific regional characteristics. Watersheds located in the Sierra Nevada, Cascade Range, and Northwestern ecoregions are expected to be drier, whereas some watersheds in the Central western and Southwestern areas show increasing hydrologic activity under a wetter scenario. The degree of change in watersheds already characterized by low rainfall (e.g., deserts) is expected to be minimal (Thorne et al. 2015).

### **Wildfire Risk**

As noted earlier in this chapter, wildfire risk is expected to increase as a result of climate change throughout California. This increase in risk is caused by a number of climatic changes, including earlier snowmelt, higher temperatures, and longer dry periods resulting in a longer fire season. Potential climate-related changes in vegetation (e.g., proliferation of invasive species or reduced moisture content in vegetation), and ignition potential from lightning may indirectly contribute to increases in wildfire risk. Under a higher global emissions scenario, increases in the occurrence of large fires statewide are projected to increase from 58 to 128 percent above historical levels by 2085 and estimated burned areas are projected to increase from 57 to 169 percent, depending on location (CEC 2012a).

## **Climate Change Stresses in California**

The secondary effects of climate change on wildlife can be described as stresses to species and their habitats in response to the primary exposure impacts described above. They are either additive to or amplify existing stresses to wildlife and habitat that may already exist due to land use change, development, or other human-induced pressures. These secondary effects have the potential to significantly increase the risk of biodiversity loss and species extirpation or extinction. Statewide climate change stresses to wildlife and habitat were identified in the 2009 *California Climate Adaptation Strategy* (CCAS) and supplemented by the updated 2014 report, *Safeguarding California* (CNRA 2009; CNRA 2014):

### **Temperature**

- ▲ Temperature-sensitive terrestrial plant and animal species will be exposed to thermal stress as a result of warmer temperatures and, thus, may need to either shift within their existing ranges and/or shift their geographic range in response to climate changes. These shifts may occur towards higher latitudes, higher elevations, cooler coastal environments, or local microclimatic refuges, depending upon interactions with precipitation, topography and soils, and species behavioral and life history characteristics.
- ▲ The amount of additional warming and associated thermal stress may exceed the tolerance of some terrestrial species, particularly endemic ones. Where relocation access is blocked off by natural landscape features or human development, species will need corridors to establish habitat connectivity or face a growing risk of extinction.

- Similar stresses and barriers apply to aquatic species, but their migratory limitations may be greater. For example, vernal pool and freshwater lake species are likely to be more susceptible to extirpation, because of disappearance of habitats or inability to move to new aquatic environments. Additionally, warming of lake and stream temperatures will adversely affect food supply and fitness of aquatic species.
- The problem of invasive species is likely to become more challenging in the future, as climatic changes may favor the spread of these species. Invasive species are typically more competitive than native species, especially those in damaged/degraded environments.
- Species migration/movement and invasions, along with changes in behavior of climate-sensitive species, will alter species interactions and community dynamics; these changes may have negative effects on critical ecosystem services.

### Precipitation

- Changes in precipitation patterns will alter stream flow and severely affect fish and amphibian populations during their life cycle (e.g., spawning, migration), because of changes in timing and volume of flows. For example, low-flow conditions and higher stream flow temperatures are particularly threatening to cold-water fish. Flooding as a result of earlier or more rapid snowmelt could also lead to increases in soil erosion, sedimentation, and pollution affecting aquatic habitats.
- Changes in the composition and structure of riparian communities may result from changes in precipitation and flow and could contribute to increased management conflicts as the needs of humans and wildlife compete for limited resources.
- Projected increases in drought conditions, including prolonged and more intense drought, will reduce stream flows and increase water temperatures, further degrading stream and terrestrial habitat quality, as well as the adaptive capacity of ecosystems. Drought also exacerbates other climate-related exposures, such as saltwater intrusion in coastal areas and increased wildfire risk in forests or grassland.
- Longer fire season trends over the last three decades and increased number of large, intense wildfires are projected to continue, increasing the risk of vegetation and habitat conversion, spread of invasive species, and losses in biodiversity and ecosystem services.



Lawrence Erikson, North American Field Herping Association

### Sea Level Rise and Ocean Acidification

- Accelerating sea level rise, especially at the increasing rates projected for the 21st century, may result in the loss of substantial areas of important habitat for a variety of coastal species. For example, coastal marshes are often constrained by deep water on one side and development on the upland side. Sea level rise could convert some of this habitat to open water, causing intertidal, salt marsh habitat to disappear, because it cannot move upslope.
- Both aquatic and terrestrial coastal ecosystems may see growing problems with invasive species.

- Sea level rise will result in increased salt water intrusion into fresh water resources near the coast and reduce the amount of fresh water available for plants, wildlife, and competing agricultural and metropolitan uses.
- Changing ocean conditions, such as changes in ocean chemistry (i.e., acidification), can directly impede the growth and development of certain species at various life stages, and may have broader impacts on the marine food web. Ocean acidification leads to decreased shell growth in key species such as sea urchins, mussels, oysters, abalone, and crabs, thus making the animal more susceptible to predation, as well as decreased skeleton production of deep sea corals and hydrocorals (Largier et al. 2010).

## **Vulnerability of Species and Habitats to Climate Change**

Vulnerability to climate change can be defined as the degree to which a system is exposed to, sensitive to, and unable to cope with or adapt to the adverse effects of change (CEC 2012a). The degree of vulnerability of California's wildlife to climate change will vary considerably depending on many factors, such as the intrinsic sensitivity of a given species and/or its habitat to climate exposure and related stresses, the adaptive capacity of species and habitat to these effects, and other existing environmental stresses unrelated to climate change. Thus, the projected effects of climate change within specific regions in the state must be examined in light of all of these factors.

Numerous studies have been conducted or are underway in California to assess the vulnerability of species and habitats to climate change, particularly those already considered to be critical or at risk. These include (but are not limited to) the following examples:

- A study of the vulnerability of California's at-risk birds to climate change (Gardali et al. 2012) found that 128 out of 358 avian taxa are classified as vulnerable to climate change. The study found that wetland species are the dominant group of those considered vulnerable to climate change, compared to other habitat groups. Out of the 29 avian taxa listed as state and federal species of concern, 21 are also classified as vulnerable to climate change. Integration of the findings from this study resulted in the addition of five taxa to the California's Bird Species of Special Concern list and an increase in the priority rank for ten.
- CDFW, with support from the California Landscape Conservation Cooperative, conducted a vulnerability assessment of 156 rare plant species in California to determine which will be subject to negative impacts from climate change (Anacker et al. 2011). This study employed the NatureServe Climate Change Vulnerability Index (CCVI) to assess vulnerability. Future habitat suitability was examined for these 156 species to assess potential range shifts under various climate change scenarios. Of the 156 rare plant species studied, 99 (63 percent) were determined to be moderately or more vulnerable to climate change.
- UC Davis, with support from CDFW, conducted a climate vulnerability assessment of 153 reptile and amphibian species in California (Wright et al. 2013). The study found that approximately 60 to 75 percent of reptile and amphibian species were predicted to experience little direct loss of climatically suitable habitat by 2050. Reductions in climatically-

suitable habitat were predicted to be largest for reptiles in the southern mountains and deserts, with reductions for amphibians occurring statewide. The species ranked highest for climate risk include many that are already of conservation concern and tend to be endemic species with small ranges.

- ▲ A study on climate vulnerability of freshwater fish in California (121 native fish taxa and 43 non-natives) found that native species had greater climate change vulnerability than non-native species (Moyle et al. 2012). Of the species studies, 83 percent of native fish had critical or high climate change vulnerability versus 19 percent for non-native species.
- ▲ UC Davis, with support from CDFW, is currently undertaking an assessment of the climate impacts to vegetative communities in California state-wide. Results of the assessment will be available on the California SWAP website <http://www.dfg.ca.gov/SWAP/>.
- ▲ The Gulf of Farallones and Cordell Bank National Marine Sanctuaries conducted a joint study in 2010 on climate change effects and potential impacts on marine species and habitat along the north-central California coast (Largier et al. 2010).

## **Climate Adaptation Strategies**

In 2008, Governor Arnold Schwarzenegger signed Executive Order S-13-08, which called on state agencies to develop California's first strategy to identify and prepare for the expected impacts of climate change. In 2009, the first CCAS was completed in response to the executive order. The CCAS was developed under the leadership of CNRA, working through the state's Climate Action Team. Projected climate change impacts, risks and strategies to address these risks were identified for seven sectors, including biodiversity and habitat. Six adaptation strategies were identified, along with near-term and long-term implementing actions for each. The six strategies include:

- ▲ establish a system of sustainable habitat reserves;
- ▲ management of watersheds, habitat, and vulnerable species;
- ▲ regulatory requirements;
- ▲ research and guidelines;
- ▲ education and outreach; and
- ▲ implementation of adaptation strategies.

Since the CCAS was completed in 2009, there have been numerous accomplishments applicable to the biodiversity and habitat sector. Several key examples from CDFW include the following:

- ▲ February 2010 Essential Habitat Connectivity Project Report and Data (Spencer et al. 2010): CDFW and Caltrans commissioned a team of consultants to produce a statewide assessment of essential habitat connectivity using the best available science, data sets, spatial analyses, and modeling techniques. The goal was to identify large remaining blocks of intact habitat

or natural landscape and model essential connectivity areas between them that need to be maintained, particularly as corridors for wildlife.

- ▲ CDFW Vision for Confronting Climate Change in California: In 2011, CDFW issued a vision statement entitled "Unity, Integration, and Action: CDFW's Vision for Confronting Climate Change in California." This report outlined CDFW's objectives for responding to climate change.
- ▲ CDFW Climate College and Climate Education: In early 2012, CDFW launched a ten-month climate literacy program to build staff capacity for incorporating climate considerations into existing professional responsibilities. Although the CDFW Climate College was designed to provide a basic foundation of climate literacy to CDFW staff, the course was open to the public. The inaugural year of the CDFW Climate College was completed in June 2013. More than 340 participants participated in the first year of the CDFW Climate College. A second iteration of the Climate College was carried out in 2014, and was focused on climate change impacts and issues in the marine environment. The CDFW Climate Science Program also features a variety of online educational materials related to biodiversity and climate change including resources for teachers, a collection of relevant vulnerability assessment tools and guidance, and information on CDFW projects helping to plan for or minimize impacts associated with climate change.
- ▲ First-of-its-kind Statewide Network of Marine Protected Areas: In 2012, 19 Marine Protected Areas (MPAs) became effective in the northern California coastal region, completing the nation's first statewide coastal system of marine protected areas.
- ▲ National Fish, Wildlife, and Plants Climate Adaptation Strategy (National Fish, Wildlife and Plants Climate Adaptation Partnership 2012): CDFW collaborated with federal, tribal, and state partners and played a lead role in creating the first National Climate Adaptation Strategy for fish, wildlife, and plants. This strategy promotes a nationwide unified approach to climate driven adaptation strategies, reflecting shared principles and science-based practices to safeguard the nation's biodiversity, ecosystem function and sustainable human uses of fish, wildlife and plants. The National Climate Adaptation Strategy was released in 2012.

CNRA updated the CCAS in 2014, and published the report, *Safeguarding California: Reducing Climate Risk* (CNRA 2014). CDFW led the development of the Biodiversity and Habitat Sector chapter, which contains key strategies and actions that build upon the 2009 CCAS strategies, including the following:

- ▲ Develop management practices to help safeguard species and ecosystems from climate risks.
  - Improve habitat connectivity and protect climate refugia.
  - Implement adaptive management studies to refine approaches for conserving biodiversity, especially for species and communities vulnerable to climate change.
- ▲ Enhance biodiversity monitoring in California to detect climate impacts and inform responses.

- ▲ Support environmental stewardship across sectors.
  - Promote nature-based solutions for adapting to climate risks.
  - Create, maintain and support tools that help resource managers determine when and where to focus conservation activities that will protect biodiversity in the face of climate risks.
- ▲ Improve understanding of climate risks to biodiversity and habitats.
  - Complete habitat and vegetation mapping.
  - Refine regional connectivity analyses.
  - Perform additional climate vulnerability analyses.
  - Improve understanding of extreme events and disturbance regimes.
  - Identify opportunities to address the emissions that contribute to climate change.
- ▲ Information Sharing and Education.
  - Create and maintain partnerships that support biodiversity conservation in a changing climate.
  - Promote public education and outreach on climate change impacts to biodiversity.
  - Provide support for the continuation of the CDFW Climate College and educational outreach efforts and link those efforts to broader state climate literacy programs.

The climate adaptation strategies and implementing actions in both the 2009 CCAS and the 2014 *Safeguarding California* have informed the SWAP conservation strategies presented in Chapter 4. California's climate adaptation strategies are also consistent with the strategic framework provided in the National Fish, Wildlife, and Plants Climate Adaptation Strategy. Additionally, the tables shown in Appendix F identify how the SWAP conservation strategies outlined in Chapter 4 align with these state and federal strategies and thus achieve important climate adaptation co-benefits.