Chapter 5

Biogeography: Distribution of Plants and Animals

A Breathtaking Assemblage of Living Organisms

The state's astounding variety of biotic communities with their diverse collections of plants and animals is examined in this chapter. The living laboratory we call California is so enormous and biologically diverse that the study of it poses some problems: Where do we start? How do we organize our study? How do we classify the various living environments? Of course, these same problems confront botanists, zoologists, and biogeographers around the world. However, scientists studying California's plants and animals have engaged in exceptionally fascinating and controversial debates involving these problems and other related issues. Their debates often revolve around the diversity, connections, and change that are major themes throughout this book.

The diversity of California's plants and animals is in large part a result of the state's wide range of latitude and elevation and its position on North America's subtropical and mid-latitude west coast.◆

KEY ISSUES AND CONCEPTS

◆ **The state's unusual biological diversity makes it a challenging place to study and classify plants and animals. More general organizational schemes that include the use of biomes and vegetation zones and belts reflect efforts to simplify these studies.**

◆ **California exhibits the tallest, largest, and some of the oldest plants in the world. Communities vary from thick forests to sparse deserts and from riparian woodlands to sandy dunes. Remarkable diversity is the rule.**

◆ **The organization of California's plants into communities is most effective, compared to other organizational schemes. These communities, with their species, are in various stages of succession as they evolve within specific environments. In this chapter, a general survey of each plant community's habitat and structure is followed by more detailed discussions of specific plants and animals common to each community.**

◆ **Water availability, temperature, solar radiation, humidity, elevation, soil, slope exposure, fire, human impacts, and a host of other factors determine the nature of each plant community. Generally, the greatest biomass and diversity will be found in California landscapes where water is available for the longest period and year-round temperatures are mild.**

◆ **Most of the state's plants and animals have adapted to long summer drought, occasional fire, and other environmental conditions and events common to California.**

◆ **A transition of plant communities is evident in cismontane California from the coast to inland valleys and from sea level to higher elevations. The most general changes result from climatic conditions reviewed in Chapter 4.**

◆ **In dry transmontane California, plant communities are generally more lush at higher elevations and near oases, where cooler, moister conditions prevail. Such plants and animals yield to the more widespread, hardier desert scrub species better adapted to adverse conditions in lower deserts distant from water sources.**

◆ **Ecologic islands, riparian, dune, and other isolated plant communities result when local habitats differ from their general surroundings.**

◆ BIOMES

Past biogeographers have sometimes tried to organize terrestrial California into general ***biomes***. (Biomes are defined as the largest regional ecologic units, or subdivisions, of plants and animals.) The logic of this system is that biomes are the largest recognizable terrestrial ecosystems, and an ***ecosystem*** represents a group of interacting organisms and the physical environment in which they live. This simplified approach provides only the most general categories and associations of California's plants and animals. Consequently, the organizational approach based on biomes is no longer embraced by scientists who search for a realistic understanding of California's living landscapes. It only serves as a starting point in our study.

Knowledge of specific ***habitats*** is also critical in the study of the distribution of plants and animals. (Habitats include a combination of physical factors that represent the environmental conditions in which organisms live. These include climate, slope, soil, drainage, and many other factors that are especially important to plants and animals of California.)

In the simplistic biome scheme, the *forest* biome is often the most productive and has the greatest ***biomass*** (total weight of organisms). In California, these

biomes appear in more favorable habitats, where there is more water and where temperatures are not too extreme. These forests are abundant in higher elevations of cismontane California and especially across the western slopes of central and northern California's major mountain ranges. More specific forest biomes in California are the *temperate coniferous forests* (needle-leaved) and *temperate deciduous forests* (broad-leaved, often found mixed with coniferous forests in the state).

The *scrub biome* could include environments from the coastal scrub to the chaparral and even into oak woodlands. (Some biogeographers may not use the scrub biome. They might consider chaparral to be a dwarf, *sclerophyll forest*, and they might consider the oak woodland communities with their scattered trees to resemble a *savanna biome*.) Regardless, we are now considering plants and animals that suffer from considerable water shortages or other adverse conditions compared to their forest neighbors. These are typical of the Mediterranean environments of lower and middle elevations throughout much of cismontane California, especially in southern and central California.

The *grassland* biome includes most of cismontane California's inland valleys, where even drier and hotter summers may eliminate most trees and shrubs.

The *desert* biome includes most of transmontane California, where water shortages are most severe and temperatures are extreme. Only the hardiest plants and animals can survive in these environments with low biomass and less ***species diversity*** (number of different species).

Finally, the *tundra biome* is found only in California's highest alpine environments. Here, cold temperatures and short growing seasons are important limiting factors for plants and animals.

Some very general connections can be made when comparing California's biomes, vegetation structures, and habitats to other regions of the world (see Figure 5-1). Many of these connections may have become apparent during our review of the state's weather and climate. One obvious example is how the state's Mediterranean scrub is similar to that of Chile, the southwest coast of South Africa, southwest Australia, and the Mediterranean. All five locations exhibit the typical Mediterranean climates discussed in Chapter 4—east of dominant subtropical highs, winter rain and summer drought, and most experience coastal fog. Another connection is the temperate marine coniferous forest common to northern California. Note how Mediterranean scrub often yields to similar forests in other areas of the world where climates become cooler and wetter. More specific and numerous are the similarities to other geographic locations created by a wide range of altitudes and mountain barriers.

◆ VEGETATION ZONES AND BELTS

Just as there is controversy and oversimplification with the biomes scheme, early attempts to organize California into generalized ***life zones*** yielded categories that are too broad. In the 1890s, C. Hart Merriam recognized a transition of life zones in Arizona, from the hot and dry lower deserts to the cooler and wetter forests at higher elevations. He and others after him made this simple connection: while traveling from lower to higher elevations in the southwestern United States, we may encounter six major biotic zones. These zones (Merriam's Life Zones) resemble what we might observe if we were traveling, instead, from drier and hotter northern Mexico to northern Canada.

Although crude, this concept was sometimes applied to California in general, and the Sierra Nevada in particular, with surprisingly successful results. As we review these life zones here, we will use coinciding ***vegetation zones*** to describe them. The different, but related, concept of vegetation zonation by elevation is a little more specific and was proposed by scientists long after Merriam's Life Zones (see Figures 5-2a and 5-2b).

The Lower Sonoran Zone is identified below about 300 m (1,000 feet) on the slopes of the western Sierra Nevada and below about 1,200 m (4,000 feet) on the eastern rainshadow slopes where there is desert and grassland vegetation similar to the hot, dry Sonoran Desert. Below about 1,200 m (4,000 feet) on the western slopes and 2,000 m (6,500 feet) on the eastern slopes is the Upper Sonoran Zone. These higher semiarid environments are somewhat cooler and more moist. Chaparral, woodland, and even some pine forest begin to dominate on western slopes, while sagebrush rules on the rainshadow slopes of the east side.

From about 1,100–1,800 m (3,500–6,000 feet) on the western slopes and 2,000–2,400 m (6,500–8,000 feet) on eastern slopes are the cooler and wetter mixed forests of the Transition Zone. A mix of yellow pine forests covers western slopes, while the resilient Jeffrey Pine grows on eastern slopes. From about 1,800–2,600 m (6,000–8,500 feet) on western slopes and 2,400–3,000 m (8,000–10,000 feet) on eastern slopes is the Canadian Zone. Lush forests of lodgepole pine and red fir grow in this still cooler and wetter belt. From 2,600–3,200 m (8,500–10,500 feet) on the western slopes and at higher elevations on eastern slopes is the Hudsonian Zone, home of the subalpine belt. Here are communities similar to the coldest woodlands, or taiga, around Hudson Bay, where only short, widely spaced trees are found.

Above all of these, at the highest elevations, is the Arctic-Alpine Zone with its alpine belt vegetation. Here, above the tree line, organisms are under greatest stress from the very cold temperatures and short growing seasons somewhat similar to arctic tundra.

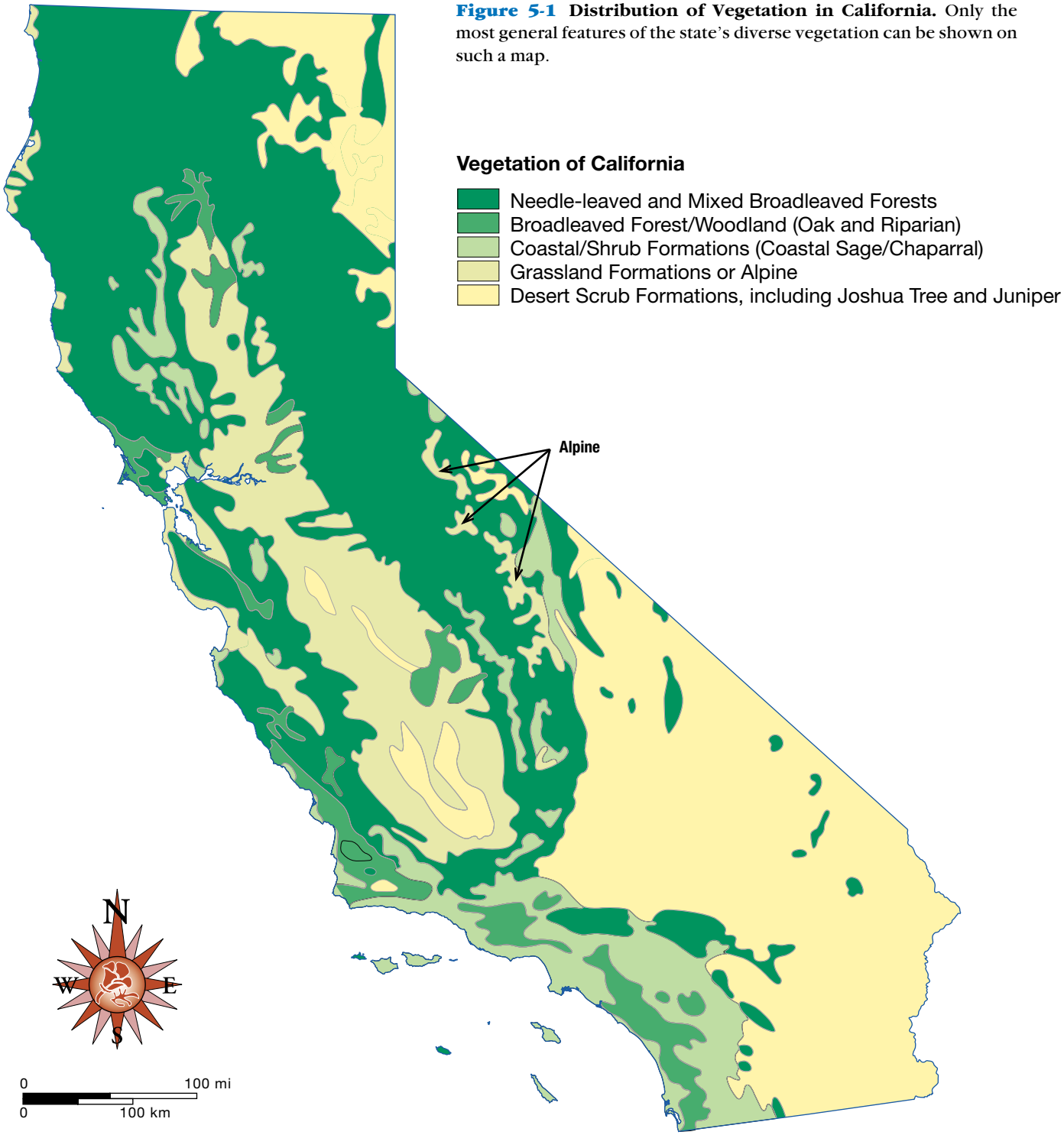


Figure 5-1 Distribution of Vegetation in California. Only the most general features of the state's diverse vegetation can be shown on such a map.

Note how these zones and belts are characteristically tilted up into higher elevations on the eastern rainshadow sides of mountain ranges. This is typical in California, where you must travel to higher elevations in transmontane ranges to experience the moist conditions typical of lower elevations facing the ocean. A good biogeographer will also notice that, though these zones are easy to understand, they are still too general for California. There are just too many other factors that determine which type of community will exist at any one location—there are too many exceptions to these schemes.

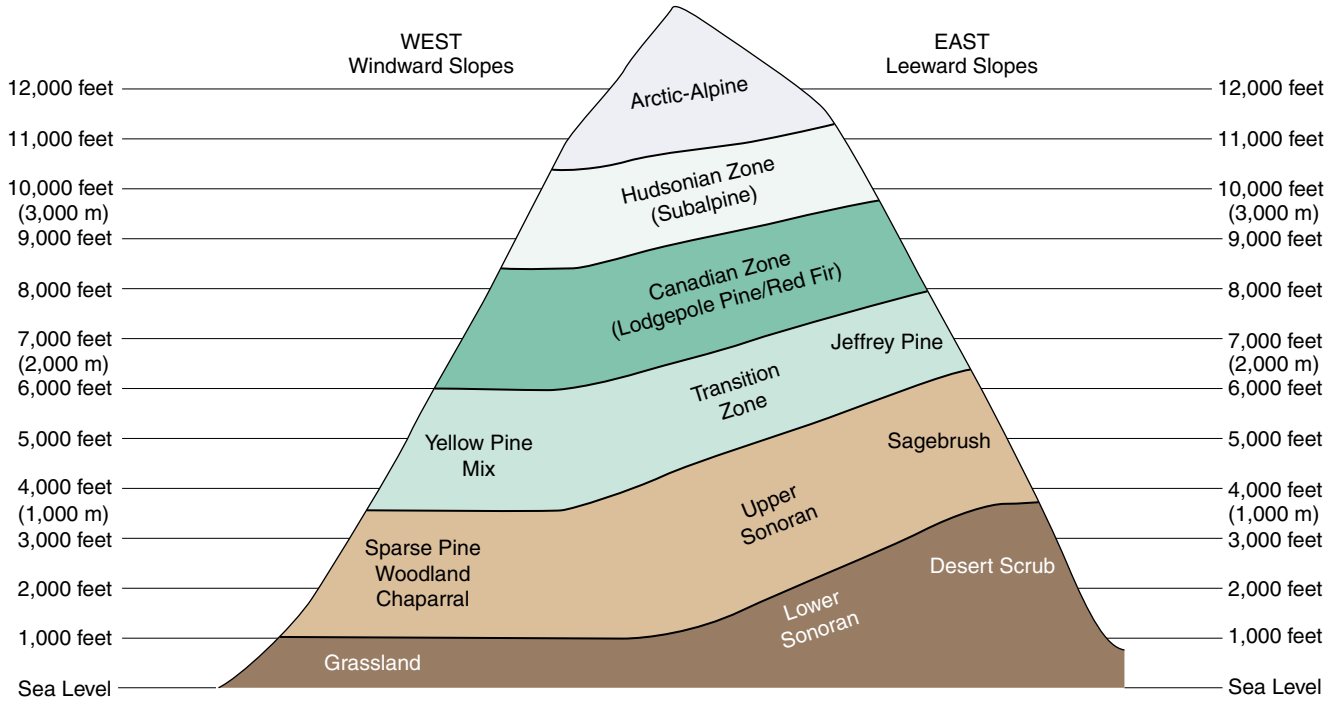


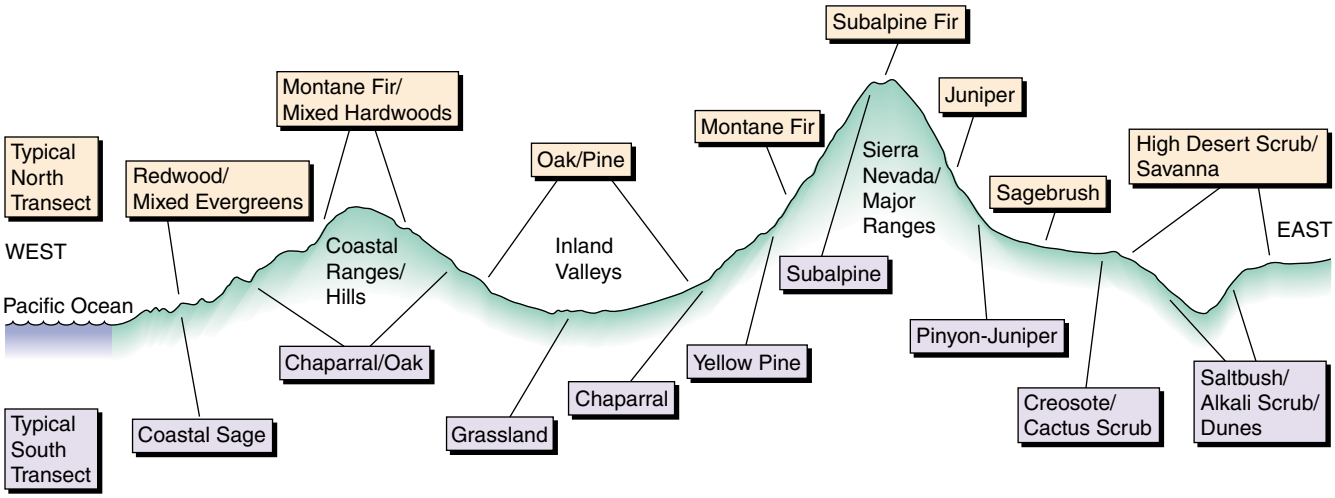
Figure 5-2a Vegetation Zones and Belts. Cross section showing simplified model of vegetation zones and belts across the Sierra Nevada, from west to east.

◆ LIVING COMMUNITIES

Therefore, in this chapter, we use plant communities to paint a picture of California's living landscapes. We have already defined the more general biomes and ecosystems. In contrast, a community refers to the relationships among animals and plants in an area. More specifically, it might be defined as a group of plants and animals that interact with their environment within a space-time boundary. This is a more precise method of studying habitats and life forms based on dominant species. It has been widely accepted and used since Phillip Munz and David Keck developed it in 1959 (see Figure 5-2b).

Each community and its species has evolved over time as a result of dispersal events, climate, slope, soils, fires, human interaction, and many other factors. Such

Figure 5-2b Vegetation Transects. Still simplified, but more realistic, are these transects from west to east across the entire state. Some plant communities common to northern California are listed in their proper locations above the transect; several southern communities are shown from west to east below the transect.



ecologic ***succession*** is a gradual, but continual, process after each event or disturbance. A series of intermediate seral (non-climax) communities may eventually mature to a ***climax community***. Such a climax community is considered to be in equilibrium so that it can maintain itself until the next event or disturbance. One example is how many of the state's plant communities are still evolving from the effects of the last Ice Age that ended more than 10,000 years ago.

During that short 10,000 years, plant communities have adapted, and continue to adapt, to smaller climate changes. On smaller scales, ecologic succession may follow a volcanic eruption, fire, flood, or landslide. This makes us question the concept of succession and how we might define a climax community. Many modern scientists argue that the whole idea of a climax community is idealistic at best and that we really should consider our plant communities to be in dynamic equilibrium. Regardless, it would benefit any biogeographer studying this state to consider each plant community's stage of succession and the time since the last disturbance. These considerations help explain the complicated montage of plant communities commonly encountered in the state's landscapes.

We will begin at the coast and sweep inland, first at lower elevations, then up to the higher mountain terrain of cismontane California. We will then break to examine some exceptions or islands in the general trends. Finally, we will look at some of the plants and animals of transmontane California, on the rainshadow sides of the mountains and in California's deserts.

Specialized botanists and zoologists may cringe at the thought of such a general survey of only the salient features of California's life forms, but it is the appropriate approach in a book searching for more general connections and relationships. Information in this chapter has been drawn from many major surveys of California's plant communities. When there was conflict among the experts, especially in the classification of specific plant communities, efforts were made to find common ground.

◆ COMMUNITIES OF CISMONTANE CALIFORNIA'S LOWER ELEVATIONS

Coastal Sand Dune and Beach Communities

Beach refers to the strip of coastline above mean tide inland to the greatest extent of storm waves during highest tides. A foredune often marks the inland boundary of this strip that is occasionally inundated and disturbed by wave action. Beach plants and animals must adapt to at least rare invasions of ocean waves. ***Coastal sand dunes*** may extend well inland of the beach and foredune to more stable ground. Though organisms here are protected from or elevated above wave action, they must adapt to shifting sands. Technically, the terms ***coastal strand*** or ***littoral strip*** are synonymous with beach, though, unfortunately, they have been used to describe both beach and dune zones.

Habitat and Structure

Marine air moderates surface temperatures and brings vital moisture to coastal dunes, unlike their counterparts

Figure 5-3 A combination of natives and introduced species are found on these wind-swept dunes around Morro Bay. In contrast to human disturbances, many plant species are responsible for stabilizing the dunes. Still, they must survive shifting sand, salt spray, and summer months without rain.

in California's deserts. Winter storms may bring waves that wreak havoc on California's beaches, but they also bring frequent clouds, drizzle, and rain over the dunes. Summer fog and stratus keep temperatures down and relative humidities up, resulting in lower evapotranspiration rates on coastal dunes. Due to the marine air, summer air temperatures are rarely hot (especially on the north coast) and winter temperatures are rarely cold enough for frost (especially on the south coast). Just as ocean water temperatures may change by only a few degrees Celsius during the seasons, the difference in monthly mean air temperatures is no more than 6°C–9°C (about 13°F) at any one location. At first glance, this may seem like an ideal environment for plants.

Though air temperature extremes are not nearly as severe as on desert dunes, exposed sand surfaces even along the coast experience dramatic changes. Because many dune plants grow close to the sand surface, they may endure wild fluctuations in temperatures. As high winds along an exposed coastline keep the disturbed sand moving, they also bring sea salt spray.

Add to this the nutrient-poor substrate where water drains through so rapidly in one place only to pond in nearby hollows, and we recognize conditions that present a series of challenges to living organisms. Because the amount of disturbance and sand and salt spray varies, and because soil conditions change dramatically, we expect to find a wide variety of organisms adapted to the wide variety of conditions from the harsh sandy beach to more stable dunes farther inland.

Though about 23 percent of the California coast is beach and dune, these plant communities account for less than 1 percent of California's land surface. Many of California's dune communities have been destroyed or altered, especially in the south. However, a few good examples of natural dune environments exist, especially to the north. The largest coastal dune fields are west of Santa Maria and include southern portions of Pismo State Beach. At a few locations, lines of dunes protect bays such as Morro Bay south of Morro Rock. Extensive dune communities (some undisturbed) stretch along parts of the coast from Cape Mendocino to the Oregon border. Human disturbances, such as trampling and off-road vehicles, have repeatedly destroyed anchoring vegetation and set formerly stabilized dunes in motion, especially along the central and southern California coasts, often with costly results.

Plants. Just above the high tide level, pioneer dune plants appear. These plants grow close to the ground and often have interconnected roots that form an extensive network below the sand, including deep tap roots. Such root systems also absorb available moisture and stabilize the sand. Most plants prefer the more protected leeward sides of coastal dunes. Many are perennial succulents that conserve water; light gray leaves that reflect light and reduce evapotranspiration rates are common. Introduced beach and dune grasses are especially common in the north, while salt grass and more desert-like species are more common on California's southern coastal dunes.

Other notable plants often have common names which may summarize some of their characteristics. They include Beach Bur or Silver Beachweed (*Ambrosia chamissonis*), Yellow and Beach Sand Verbina (*Abronia* spp.), Beach Pea (*Lathyrus littoralis*), with its clusters of tiny pink and white flowers, and the beautiful Dune or Beach Morning Glory (*Calystegia* or *Convolvulus soldanella*), growing from deep roots from Oregon to the Mexican border. Beach or Dune Evening Primrose (*Camissonia cheiranthifolia*) may also be common. Like many of the grasses, other aggressive introduced species have stabilized dunes but have also crowded out native plants. They include the tiny pink Sea Rocket (*Cakile maritima*), and Ice Plant (*Carpobrotus* or *Mesembryanthemum chilensis*) covered with its tiny, shiny blisters. Hottentot Fig (*Carpobrotus* or *Mesembryanthemum edulis*) is also common, with its slender, juicy fingers pointing up out of the sand. These last few introduced plants are commonly used as ground cover on California's human landscapes.

Where coastal dunes stretch farther inland in California, there is more protection from wind and salt spray. Dunes are more stable and support richer soils that provide friendlier environments to living organisms. A wider variety of plants and animals can thrive, giving rise to a mixture of dune plants and many species commonly found in coastal scrub communities. These include Dune or Coastal Buckwheat (*Eriogonum parvifolium*), Tree Lupine (*Lupinus arboreus*) and Coastal Silver Lupine (*Lupinus chamissonis*), and showy herbaceous flowers such as California Poppy (*Eschscholzia californica*). Even stands of Coyote Bush (*Baccharis pilularis*) are established on stable sand and are often joined orreplaced by California Sagebrush (*Artemisia californica*) in more southerly locations.

On many of the oldest and most stable dunes, succession has produced impressive biomass. On the north coast, the climax dune forest includes Shore Pine (*Pinus contorta contorta*) and Sitka Spruce (*Picea sitchensis*) trees. Moving toward the drier dunes to the south, undisturbed climax communities may include species common in oak woodlands, chaparral, and desert-like conditions farther south. Exceptions to this include hollows and traps where fresh water is ponded at the surface or is immediately below the surface, allowing dune slack communities to evolve. Marsh and/or riparian plants such as sedges, rushes,

and willow thrive in these spots and phreatophytes grow where water can be tapped just below the sandy surface.

Animals. Insects, lizards, mice, and other small animal tracks on the dunes are indicators of the scarcity of food and the lack of larger mammals. Strikingly similar tracks may be found on the harsh dune environments of California's inland deserts. Larger predators on the coastal dunes are usually birds, including red-tailed hawks, kestrels, and gulls. Meanwhile, various species of bees and butterflies are among the flying pollinators of specific flowers in the dunes. One of the most famous is the El Segundo Blue Butterfly (*Euphilotes* or *Shijimiaeoides battoides allyni*). It has been isolated only on the dunes just above Dockweiler Beach below the planes taking off from Los Angeles Airport! These endangered butterflies have enjoyed impressive local media attention as they feed off beach buckwheat on the last dunes remaining in this region. They have become one of the many symbols of what Los Angeles loses as it grows. They also symbolize the dozens of native dune plants and animals that have become endangered or extinct as humans modify and destroy California's delicate coastal dunes.

Coastal Scrub Communities

Coastal scrub plant communities are also known as coastal sage scrub or soft chaparral. These names correctly suggest the similarities with chaparral. However, the smaller plants with softer leaves and the more frequent sage and other aromatic species are conspicuous differences, especially in the south. These scrub communities are common along California's coast from Oregon to the Mexican border, but they often creep farther inland and to higher elevations toward the south, into the Coast Ranges, and even along the lower slopes of the Transverse and Peninsular Ranges. Coastal scrub communities are, however, restricted to elevations usually below about 750 m (2,500 feet) throughout California. Most coastal scrub species are adapted to frequent fire.

Habitat and Structure

Coastal locations guarantee some of the mildest diurnal and seasonal temperatures in the world. Moist air masses pass over before being lifted by mountains, so winter precipitation is less than it is on nearby higher terrain. Great variations in winter rains in the coastal scrub range from more than 180 cm (70 inches) in the north to less than 25 cm (10 inches) to the south. This results in a wide variety of species in areas from the wet north to the semiarid conditions along the south coast. Summer fog and low stratus are common along California's entire coastal strip, delivering lower temperatures and higher humidities in the coastal scrub than at inland locations during the dry summer months.

Coastal scrub will gradually blend and merge into a variety of other plant communities along broad ecotones (transitional zones between two different habitats). The type of community will depend on local and regional conditions such as climate, slope exposure, and soil. Coastal scrub may invade coastal dune communities which have been stable for many years. Without disturbances, it may evolve into forest communities on the north coast. Coastal scrub species frequently blend into oak woodland, grassland, and chaparral communities, especially to the south. Semidesert species, including succulents, become common near the Mexican border.

Though only about 2.5 percent of California is coastal scrub, these plant communities are seen frequently by

Figure 5-4 The view looks over coastal sage scrub along the central California coast. Buckwheat and poison oak are a few of the many native plants growing along with introduced species here. This landscape shows signs of human impacts. Cool coastal fog and low clouds help these plants and animals survive summers without rain.

many Californians because large agricultural and population centers have been established among them. Unfortunately, this is also why these plant communities contain many of California's rare and endangered plants and animals. It is also why many Californians frequently and incorrectly assume that the weeds and other introduced species that thrive on the disturbed urban fringe are natural elements of these communities.

Coastal scrub communities are generally recognized by the drought-adapted, short, scrubby bushes and shrubs less than 2m (6 feet) in height. Dense growth is common, especially on north-facing slopes and the north coast. An explosion of soft green growth and spring wildflowers is common after wet winters, especially during the first few years following wildfires. By late summer, the same communities have turned dry and dusty; shades of golden, gray, and brown dominate as some plants drop their leaves in these thorny, water-stressed environments.

Plants. On the wetter north coast, species include taller bushes such as Coyote Bush or Chaparral Broom (*Baccharis pilularis*) and Tree Lupine (*Lupinus arboreus*). Lower shrubs include monkey flowers, especially Sticky Monkey Flower (*Mimulus* or *Diplacus aurantiacus*), and wild berries, including California Blackberry (*Rubus vitifolius*). Salal (*Gaultheria shallon*), with its berry-like fruits, and Poison Oak (*Toxicodendron* or *Rhus diversilobum*) are also common.

Poison oak is common along much of California's coast, growing from close to the ground to overhead vines where vegetation and wetter conditions will support it. Its shiny leaves grow out in groups of three and often turn pink and red by late summer and fall. Even after dropping its leaves, stems contain the toxic oils which can cause severe and painful rashes. Poison oak can often be identified by its smooth stems, as it lacks the hairs and thorns of wild berry plants.

Understory herbs such as Sword Fern (*Polystichum munitum*), Bracken Fern (*Pteridium aquilinum*), and various flowering plants are indicators of wetter soils in north coastal scrub communities.

Moving south, the above species are often joined or replaced by plants better adapted to prolonged drought, especially on south-facing slopes. When their shallow, extensive root systems can gather water, soft-stemmed shrubs and herbs grow rapidly. Most lose leaves or die back during the summer drought. This is in contrast to the harder chaparral species which usually have deeper root systems and are ***sclerophyllous***. (***Sclerophylls*** are evergreen plants with stiff, leathery leaves.)

California or Coastal Sagebrush (*Artemisia californica*) is a classic and often dominant coastal scrub shrub. Its tiny, soft, grayish-to-light-green leaves are strongly aromatic and they have been used to make healing washes and teas. It is not a true sage but it is in the sunflower family. True sages (*Salvia* spp.) are also common and sometimes dominate the coastal scrub. Black Sage (*S. mellifera*) has dark leaves and black stems, Purple Sage (*S. leucophylla*) has lighter leaves and purple flowers, and White Sage (*S. apiana*) has white leaves and is very common. All of these true sages have opposite leaves growing on square stems and have pungent aromas. Some plants may be draped with the parasite dodder, also known as witches' hair or broom for its rusty orange tangle of stringy stems.

The many species of buckwheat (*Eriogonum* spp.) also have tiny leaves. Their dense clusters of tiny flowers form terminal heads upon small shrubs. Pink flowers of California Buckwheat (*E. fasciculatum*) turn a conspicuous rusty brown when they dry. Other small plants common in California coastal scrub include Deer Weed (*Lotus scoparius*), a small shrub with only a few small leaves on slender stems and numerous tiny, classic pea-shaped flowers. Various monkey flowers (*Mimulus* spp.) are also common.

During long periods without fire, many woody coastal scrub species may grow a few meters (several feet) tall. They may grow into the chaparral communities. Like chaparral plants, most of these crown-sprout after fires. Laurel Sumac (*Malosma* or *Rhus laurina*) has classic taco-shaped leaves and is not frost tolerant. Lemonade Berry (*Rhus integrifolia*) grows along the immediate coast. Its red, acidic berries may be used to make a bitter drink. Its relative, Sugar Bush or Sugar Sumac (*Rhus ovata*) is usually found farther inland where summers are hotter. These last three species often grow in southern coastal scrub on north-facing slopes.

Into the Driest Coastal Scrub. Even farther south, especially on more exposed, south-facing slopes, these coastal scrub communities become southern semidesert coastal scrub or maritime desert scrub. Plants are usually smaller and more widely scattered. Species tolerant of even drier conditions include Yucca or Our Lord's Candle (*Yucca whipplei*). With its long, narrow, sword-like leaves, it has been described as looking like a giant pincushion. California Indians weaved fibers from the leaves to make baskets and other necessities and ground the roots to make soap. Older Yuccas bloom and die after sending out roots that produce younger plants nearby. For more than 1m (3 feet), clusters of its white flowers bloom

along the top of a stalk that is even taller. These stalks become conspicuous to humans during late spring and early summer; they are even more attractive to the Yucca Moths (*Tegeticula* spp.), whose larvae feed off the Yucca fruit that develops from the moth-pollinated flowers. Indians roasted flower stalks and ground the seeds for flour.

Prickly Pear Cactus (*Opuntia littoralis* and other *Opuntia* spp.) are common on the driest slopes. With thorns removed, their large, fleshy pads and their fruits (called "tunas") have been eaten since the Indians and Spanish discovered them. Bright yellow sunflowers of California Encelia or Bush Sunflower (*Encilia californica*) have dark brown centers and grow at the end of long stalks. Bush Sunflower is related to Brittlebush (*Encelia farinosa*), which grows only in the driest regions, especially inland, in southern California's lower deserts. Stonecrops or Live-forevers (*Dudleya* spp.) are very peculiar plants that survive on exposed coastal rock faces and cliffs; many are now rare or endangered.

Animals. Numerous animals of the coastal sage scrub are similar or identical to desert species. Insects, arthropods, lizards, snakes, birds, and small mammals account for much of the limited animal biomass, a reflection of the low productivity in these communities. Ectothermic animals are often more successful here because they are more efficient energy users; many conserve energy by becoming dormant during severe drought. Often, lizards feed on the abundant insects and spiders, snakes (fewer in number) may feed off all three, and various birds may eat any of them.

The Coast Horned Lizard (*Phrynosoma coronatum*) has a wide range across California and is closely related to the desert species. This flat, rounded, prehistoric-looking insect eater prefers ants, but has been seen eating bees. It can change its shade to match the color of its usually exposed and sandy background. Populations are rapidly decreasing as habitats are destroyed and humans harass and capture them. Numerous other lizards are common in many open areas across California, including the very common Western Fence Lizard or Blue-Bellied Lizard (*Sceloporus occidentalis*) and the Side-Blotched Lizard (*Uta stansburiana*). Both can be seen doing push-ups in the sun, probably to attract mates and to scare off potential predators.

With its alternate light and dark longitudinal stripes or circular rings, the largest banded snake in California is the Common Kingsnake (*Lampropeltis getulus*). It eats lizards, small mammals, and other snakes, including rattlesnakes, which are also at home in coastal scrub and many other California communities. The Gopher Snake (*Pituophis melanoleucus*) imitates rattlesnakes in looks and behavior, but it preys on small rodents, lizards, eggs, and birds by crushing them. It is the largest and perhaps most common snake in southern California.

Numerous small mammals live in the coastal scrub and throughout California. They include many species of small mice with large ears, which survive by eating seeds, insects, and a variety of other foods. The nocturnal Deer Mouse (*Peromyscus maniculatus*) is a common example. The California Mouse (*Peromyscus californicus*) is one of the largest mice in California. Pocket mice and white-footed mice species are also common throughout these habitats. Different species of woodrats or packrats (*Neotoma* spp.) are notorious for gathering sticks and other available or discarded debris in piles to make their large nests. They may survive extreme drought by eating prickly pear cactus for water. Many species of kangaroo rats (*Dipodomys* spp.) are common from the coast to the desert. With powerful hind legs, they can leap to avoid predators such as different species of rattlesnakes. The California Ground Squirrel (*Spermophilus beecheyi*) is a larger rodent that is commonly seen during the day. All of these rodents are common throughout many California habitats, especially into the chaparral; many become food for snakes, birds, or larger mammals.

Without abundant food, the larger mammals are few and usually must roam through or make visits to the coastal scrub for food while birds have the advantage of being able to fly to food and water sources. Mammals become more common and include larger species in areas that are ecotones to other plant communities, especially near wetter habitats farther north. These may include ringtails, bobcats, mountain lions, gray fox, coyote, mule deer, and even black bears.

Grasslands

Originally, about 13 percent of California was covered by grasslands. These are mostly in California's inland valleys, especially those tucked behind coastal hills or mountains. They are not deserts; they are usually a part of cismontane California. These great valleys include the Sacramento, San Joaquin, and Salinas and other inland valleys surrounding the Bay Area as well as inland regions of the southern California coastal plains.

Habitat and Structure

Most grasslands receive less winter precipitation than adjacent higher terrain where chaparral and woodland may dominate. Summers are long, hot, and dry. Winter rains

Human Imprints

The range of grasslands across California probably expanded slightly due to early human activities, but productivity has decreased more recently. Native Americans were the first to modify these marginal environments by burning them, knowing that the fresh regrowth would support more game animals. Ranchers have cleared borderline coastal scrub, chaparral, and oak woodland to introduce Mediterranean grasses and expand their grazing land for domestic livestock. Eventually, native grasslands became the most modified, destroyed, and misunderstood general plant community in California. Early pictures of land surrounding Spanish missions and Mexican ranchos sometimes illustrated the already barren, trampled, overgrazed land.

This is one reason why these parts of California that were once native grasslands have often been mislabeled natural desert. It is estimated that about 700,000 small cattle and sheep grazed California landscapes during the peak of the Spanish Period. By 1862, 3 million cattle and 9 million sheep grazed in California, many near gold rush populations. Because European grasses were adapted to centuries of this intensive grazing, they thrived in California's grasslands as native grasses disappeared. Unfortunately, continued overgrazing and overfarming have destroyed about one third of these once productive lands. Expanding networks of deep rills and gullies and windblown dust and sand are common evidence of the accelerated soil erosion in California's marginal lands; pursuit of short-term profits at the expense of long-term productivity is often the cause.

drain quickly through the thick, porous soils of these inland valleys, often leaving roots dry; poorly adapted plants wither by early summer. There are also coastal grasslands scattered from Oregon past the Mexican border. Though precipitation may be greater and temperatures milder, coastal grasslands often grow in fine-grained or nutrient-poor soils that may become waterlogged in winter but can dry into formidable hardpan surfaces in summer. Most trees and even shrubs cannot survive in these adverse environments due to a lack of water or nutrients or both.

These communities are often divided into valley grasslands and the cooler, wetter northern coastal grasslands or coastal prairie. Inland valley grasses creep into higher elevation chaparral and woodland communities where soils become poor or into drier, south-facing slopes. Along the coast, they are also more common on south-facing slopes; they may grow into woodlands where more moisture is available to plants for a longer period or they may yield to coastal scrub or chaparral where soils become more porous.

This is a community restricted to elevations below about 1,200 m (4,000 feet). Only about 1 percent of California's native grasslands, with their perennial bunchgrasses and other species adapted to these adverse conditions, have survived. Invasions of more aggressive, nonnative weeds and European grasses, overgrazing, farming, and urbanization have eliminated most of the original grasslands. Of the few remaining patches of native California grasslands, the Carrizo Plain (just west of the southern San Joaquin Valley) is probably the largest; it was saved by the California Nature Conservancy.

California's Kansas? In Elna Bakker's classic book, *An Island Called California*, she referred to the grassland plant community as "California's Kansas," illustrating striking similarities to the U.S. Great Plains grasslands. For example, the pronghorn antelope and tule elk, like the plains buffalo, played the role of large grazers in California's Central Valley.

Bakker also pointed out the many differences between the two environments. California's grasslands are frequently interrupted by other plant communities. Even the Great Central Valley has wide fingers of riparian woodlands, scattered vernal pools, and extensive wetlands meandering down from the Sierra Nevada and spreading across the valley. Though temperatures drop to freezing each winter, California's inland valleys never experience the prolonged hard freezes and bitter cold of the Great Plains. Finally, while California's grasslands are stressed and challenged by prolonged summer drought,

Figure 5-5 Grasses mix with oak trees in this transition between communities that is so common throughout California. The grasses have dried in summer's heat, but some species of oak trees will survive with their sclerophyllous leaves. Grasses will rule at lower elevations, while oak trees should be more numerous at elevations above this scene.

the Great Plains enjoy occasional spring and summer downpours.

Consequently, California's perennial bunchgrasses are ready to explode into growth during the first warm early spring days, while plains grasses will emerge from buried roots later in the spring. By late spring, California's grasslands are already stressed in drying soils, while plains grasses thrive well into summer. California's native bunchgrasses are better adapted to the long summer drought, but the introduced European species quickly turn to brittle brown and gold in early summer heat.

Plants. Hundreds of plant species once flourished and are now scattered in California's native grasslands, some of which are often seen in bordering plant communities. They include perennial bunchgrasses, annual grasses, and annual wildflowers. The most common native perennial grasses include Purple Needlegrass (*Stipa pulchra*) and the bluegrasses (*Poa* spp.). In spring, these bunchgrasses grow quickly from tufts to produce flowers. The many introduced grasses which now dominate and are most frequently seen across California's grasslands include wild oats (*Avena* spp.), fescues (*Vulpia* or *Festuca* spp.), brome (*Bromus* spp.), and many others. Growing among the grasses, native wildflowers may produce the most remarkable displays of spring. They include California Poppy (*Eschscholzia californica*), various lupines (*Lupinus* spp.), Owls Clover (*Orthocarpus* spp.), and many sunflowers, such as Goldfields (*Lasthenia californica* or *L. chrysostoma*). Growing from bulbs, mariposa lilies (*Calochortus* spp.), amaryllis such as Blue Dicks (*Dichelostemma pulchella* or *Brodiaea pulchella*), and iris such as Blue-Eyed Grass (*Sisyrinchium bellum*) add to the brilliant spring displays.

Also common in California grasslands are the many species of mustard; most of them are introduced weeds. Black Mustard (*Brassica nigra*), with its small yellow flowers atop slender stems sometimes grows higher than 2m (6 feet); it is responsible for turning many California hillsides into fields of yellow in spring. Franciscan padres first spread these very successful invaders with black seeds. Even the edible Wild Radish (*Raphanus sativus*) is a very common introduced member of the mustard family. Horehound (*Marrubium vulgare*) is a mint introduced as a cold remedy. It is now common in disturbed sites and fields, where its fruits turn into annoying burrs which are distributed after they have attached to animal fur or to our clothing. Many different native and introduced thistles are also common. Some introduced thistles are so aggressive that they are quickly spreading from their disturbed sites and overtaking native habitats.

In the northern coastal grasslands or coastal prairie, many different species of perennial bunchgrasses are commonly joined by sedges, rushes, perennial forbs, and species also found in valley grasslands. Because soils remain wetter for longer in these northern grasslands, foliage is also greener throughout the year.

Animals. We have already noted the impact of domestic livestock on California's grasslands. A diverse assemblage of native fauna also lived in or wandered through the many adverse conditions common to these habitats. Most of these animals thrived with the abundant moisture and fresh growth of spring, but struggled to survive in dried habitats of late summer. Classic lessons in the study of California ***food pyramids*** are often taken from these grasslands.

There are abundant small herbivores, or primary consumers, especially insects. Grasshoppers, ants, and crickets compete with small mammals and birds for edible new growth in spring and seeds later in the year. Meadow mice, pocket mice, kangaroo rats, gophers, and California ground squirrels share the grasslands with seed-eating birds such as goldfinches and sparrows. With fewer predators, the gopher population has exploded to more than thirty per acre in some fields. Jackrabbits, with their giant ears, may be seen darting between covers to eat native and introduced plants.

Grasshopper mice, deer mice, and lizards prey on many insects as do carnivorous birds, such as kingbirds, nighthawks, and meadowlarks. Other secondary consumers, such as snakes, coyotes, foxes and badgers, and predatory birds, such as burrowing owls and American kestrels, may eat small mammals. Some of these animals, such as the coyote, are omnivores; they consume a wide variety of plants and animals to increase chances for survival in adverse conditions.

Red-tailed hawks are frequently seen soaring above grassy areas in search of rodents or reptiles for dinner. With their light undersides and red-tinted tails, they seem to glide effortlessly in daily thermals until they swoop down on their stunned prey. Numerous burrows, which punctuate these grasslands, indicate efforts by smaller mammals to escape both extremes in weather and their predators. As we work our way through the pyramid from the producers toward the tertiary consumers, the size of the animals generally increases, but the total biomass greatly decreases.

Tule elk and pronghorn antelope were the two large grazing animals of the Central Valley grasslands. The Tule elk, the smallest elk in North America, is indigenous to California and was endangered for years. After

near extinction, numbers increased into the hundreds within natural reserves in the San Joaquin and Owens Valleys. Now overgrazing by increased populations is becoming a problem. A herd size of 2,000 is often the number cited by those who want to maintain a healthy population in California's reserves. This Tule Elk (*Cervus elaphus nannodes*) is smaller than the Roosevelt Elk (*Cervus elaphus roosevelti*) of northwestern California.

Pronghorn antelope were also nearly driven out of California, except for the northeastern part of the state, but there are populations of this species in other states. The rare or endangered status of so many California grassland animals is an obvious result of rapid encroachment of human activities and populations and the destruction of these plant communities.

Oak Woodlands

Often referred to as foothill woodlands and sometimes grouped under the more broad, global biome, "savanna," oak woodland plant communities may contain several different types of oak trees and associated species. They are spread and scattered around cismontane California from Oregon to Mexico usually in areas wetter than grasslands, but drier than forests. Oak woodlands surround the Central Valley.

Habitat and Structure

Various oak trees may appear with or replace grasslands at higher elevations with more precipitation or where soils trap and hold water for longer periods, especially on north-facing slopes. Oak woodland may also replace coastal scrub or chaparral where porous soils become more fine-grained and are capable of storing more water, especially in cooler, shadier habitats. In contrast, the wetter California forests may be replaced by oak woodlands at lower elevations or on drier, south-facing slopes, or where soils will not support forest growth.

At least sixteen species of oaks (*Quercus* spp.) and their woodlands grow from just above sea level throughout cismontane California. They may reach higher elevations above 1,500 m (5,000 feet), especially in southern California. Climates are typically California Mediterranean with mild, wet winters followed by warm, dry summers. Depending on moisture and soil conditions, oak trees may be widely scattered with only grasses below. On wetter, especially north-facing sites, or near canyon bottoms, numerous large oak trees may even join pines or riparian species to form a dense woodland with an understory of shrubs. Stately oaks are often a part of the scenic photographs and paintings depicting historical and rural California hillside landscapes. Covering about 4 million hectares (10 million acres) or 10 percent of California, they also provided many Native Americans with the most common source of staple food—the acorn. Oak woodlands continue to provide unique shelter and food for hundreds of animal species.

The best illustration of how oak woodland communities fit into California's biogeographic landscapes is found along the western Sierra Nevada. Traveling up from the drier valley grasslands, sparse oak trees and shrubs are first noticed until, at higher elevations, denser oak woodlands and shrubs may alternate with chaparral and forest species. Gradually, the oaks give way to pines in the higher elevation ecotones between oak woodlands and cooler, wetter forests.

On coastal slopes, wetter forests may give way to oak woodland on drier south-facing slopes in northern California. In contrast, southern California's south-facing slopes are often too dry for oaks; the coastal scrub, grasslands, or chaparral only yield to oak woodlands in wetter locations, such as north-facing slopes. Travelers through the Coast Ranges along highways such as 101 are certain to pass through a variety of oak woodlands that often contribute to California's picturesque landscapes.

Plants. Oregon Oak, or Garry Oak (*Quercus garryana*) is a deciduous white oak tree common to northern California and southern Oregon oak woodlands. Growing inland from California's coastal forests, it is the only California oak tree distributed widely outside the state. More common to central California, especially on the drier, hotter inland slopes is Blue Oak (*Quercus douglasii*), actually another deciduous white oak tree. These large oaks have lobed leaves up to 7.5 cm (3 inches) long and feed numerous acorn-eating mammals. To the south, they are replaced by the less common Engelmann Oak or Mesa Oak (*Quercus engelmannii*), a semi-evergreen white oak with long, smooth leaves, restricted to slopes south of the Transverse Ranges.

Commonly found on wetter and north-facing coastal slopes from the Coast Ranges south is Coast Live Oak (*Quercus agrifolia*). As its name implies, it is evergreen and commonly grows in clusters on coastal slopes adjacent to coastal scrub, chaparral, and grassland communities. Its small, hard, spiny leaves suggest adaptations to drier climates more typical of chaparral species, such as its very similar but much smaller relative, California Scrub Oak (*Quercus dumosa* or *berberidifolia*). An even closer relative that grows on many central California stabilized sand dunes is the Dwarfed Coast Live Oak or Pygmy Oak (*Quercus agrifolia* var. *frutescens*). This dwarf variety may survive the strong, salty winds, poor soils, and other adverse conditions which rule out larger oaks.

Golden-Cup Oak or Canyon-Live Oak (*Quercus chrysolepis*), with its giant yellow cups holding each

acorn, and Black Oak (*Quercus kelloggii*) are common on moist and higher elevation sites and are some of the most widely distributed oaks from northern to southern California. Large-lobed leaves of deciduous black oaks are often responsible for producing the fall colors on southern California's higher mountain slopes.

The Valley Oak (*Quercus lobata*) is California's largest oak. Growing on low hills and in valleys from northern California to the Santa Monica Mountains, it forms open savannas in drier areas and forests near riparian strips. Individuals more than 30 m (100 feet) tall with nearly equal diameter crowns and trunk diameters up to 3m (9 feet) have been measured. They also have very large, lobed leaves and long acorns. Most of the original stands have been destroyed for firewood or replaced with grazing and agriculture. Interior Live Oak (*Quercus wislizenii*) grows mostly in higher elevations of inland California, from the Cascade and Sierra Nevada foothills to the Peninsular Ranges, where it becomes shrubby in a drier habitat.

In California, deciduous oaks are often identified by their larger, softer leaves, while evergreen oaks usually have smaller, harder leaves.

Many of the deciduous oaks are found in northern California or at higher elevations; they may drop their leaves to escape past or current winter cold. Evergreen oaks live in milder climates or have adapted to the cold. They often have extensive and deep root systems that can access water most of the year. Oaks often grow in clusters because they resprout after fires or where squirrels buried acorns and did not retrieve them. Human activity, such as trampling or overwatering the root systems, and especially habitat destruction due to agriculture and urbanization has already wiped out many of California's oak woodlands. Numerous California communities have passed laws to discourage the continued destruction of oak trees.

A Wealth of Other Plants Mix with the Oaks. Several other interesting plant species are commonly associated with oak woodlands. California Buckeye (*Aesculus californica*) is California's native in the horse chestnut family and is common in and near oak woodlands of central California. In spring, stalks to 13 cm (5 inches) long are covered with white flowers. This ***drought-deciduous*** small tree loses its leaves by late summer, leaving the large buckeyes, or horse chestnuts, dangling like pendulums in the autumn breezes. Native Americans shelled, ground, cooked, and leached them for a high-carbohydrate staple dish similar to mashed potatoes; they are still an important source of food for animals.

Redbud (*Cercis occidentalis*) grows on hillsides surrounding the Sacramento Valley and along the western Sierra Nevada. It is winter-deciduous, but is covered with tiny pink flowers by early spring. As a member of the pea family, its brown pea pods are another important food source for animals.

The California Black Walnut (*Juglaus californica*) becomes locally dominant in oak woodlands especially

Figure 5-6 This mix of chaparral and oak woodland is typical of the Sierra Nevada above the drier foothills, but below the cooler, wetter mountain forests. These plants must adapt to long, hot, dry summers that do not bring the fog and low clouds of coastal locations.

on north slopes from Santa Barbara through Orange County. Walnut woodlands are found in the Ojai Valley and in the Puente and San Jose Hills south and west of Pomona. Some stands grow in the middle of recent urban sprawl, but many have been eradicated. This California walnut can be identified by its long, opposite leaflets. Its walnuts are not commercial quality, but hungry squirrels do not seem to mind. In even wetter sites, the oaks are joined by the more widely distributed California Bay or Laurel (*Umbellularia californica*), with its dark green, overwhelmingly pungent bay leaves. This species is usually found in wetter communities, such as mixed evergreen forest. Where coastal summer fog is common, thin veils of Lace Lichen (*Ramalina menziesii*) are draped over and hanging from oak trees like delicate yellow-green hair or beards, providing surfaces where more moisture may condense.

Especially at higher elevations and on wetter sites, pines mix with the oaks. Gray (Digger) Pine (*Pinus sabiniana*) is the first to appear in some of the driest locations, where it grows in foothill woodlands surrounding the Central Valley and into the Coast Ranges in the same areas as blue oak. It is called gray pine because of its long silver-to-light-green needles. This dry, scraggly pine may also be seen protruding above chaparral plants as it divides into several large branches.

Like most dry pines, it produces very large cones with seeds that were important for California Indians and are still vital to the survival of some animals. Several other pines and plants from grassland, coastal scrub, chaparral, and forest plant communities may mix with woodlands when conditions are favorable. Common understory plants such as poison oak are examined within more proper settings before and after this section.

Animals. Close inspection of oak trees reveals numerous smaller species and some of the larger species of animals making their homes and gathering food there. Excellent examples of a few of California's parasitic and plant-eating insects include tiny aphids, which suck plant juices, and the white flies, oak moths, and tent caterpillars that consume green leaves. Larvae hatch from many species of butterflies to feed on oak leaves. Millions of various borers and beetles are puncturing through the bark of oak, pine, and other trees throughout California, sometimes killing the weaker trees. Bark beetles devastate pine stands during severe drought years when trees lack the sap to encapsulate such invaders. Spotty patches of brown, dead pines grew to large clusters across the Sierra Nevada and other California mountain regions as bark beetle infestations killed thousands of trees during the early 1900s, marking the end of the longest drought in California history. As one of the worst droughts to hit southern California dragged through the first years of the twenty-first century, beetles devastated entire mountain forests.

Gall insects include the cynipid wasps. Females lay their eggs on oak leaves or stems, the eggs hatch, and larvae eat the plant, making irritating chemicals which cause the tree to grow a large gall at that point. New wasps eventually emerge from the protection of these crusty, hollowed, paper-light brown galls, leaving puncture holes upon exiting. Larger galls may look like small, dried apples clinging to stems. Other parasitic insects prey on oak woodland animals, such as the bot flies on small mammals and the fleas, mosquitos, and biting flies on small and large animals.

A variety of birds eat the acorns and insects of oak woodlands. The acorn woodpecker prefers to drill its holes in softer dead trees to store the acorns it gathers. These powerful woodpeckers have distinctive red caps. Natural inner cushions protect the head from impacts caused by constant drilling. They also eat insects in the bark or in the air. Scrub jays hide their acorns in rich soil, where the forgotten morsels may sprout to seedlings. Numerous other animals, such as mule deer and squirrels, make acorns an important part of their diets. Some species, such as mice and rabbits, use oak understory for cover, while others, such as hawks and owls, use the top of oaks as observation posts. From their perches, such predators might spot one of the many amphibians, reptiles, or small mammals for dinner. Large mammals such as the fox, coyote, bobcat, mountain lion, and black bear may live in or wander through these woodlands, especially within ecotones merging into other plant communities.

Chaparral

Nearly 10 percent of California is covered with one of its most widespread and famous plant communities—chaparral. Throughout cismontane California, chaparral is found in drier spots with poor soils to the north. It becomes far more common to the south, especially on porous soils inland from the coastal scrub up to higher elevations where it may finally yield to cooler, wetter montane forests. Therefore, the isolated chaparral we see only in drier spots to the north becomes more widespread as we sweep south, especially into the southern Coast Ranges and Sierra Nevada. It dominates the foothill and mountain slopes of cismontane southern California to higher elevations. Areas of chaparral even spread into a few transmontane desert locations, where it begins to resemble chaparral in Arizona and northern Mexico.

Habitat and Structure

Though many chaparral species are also found in "soft chaparral" coastal scrub communities, true chaparral tends to be a taller, thicker, more evergreen community. It may receive more precipitation on higher slopes in winter, but suffer through hotter, drier summers in areas more distant from coastal fog and stratus. Typically, extensive roots penetrate through very porous soils which may be well-drained, but nutrient poor.

Chaparral is the model Mediterranean, drought-adapted plant community. Most of the dense thickets of shrubs are sclerophyllous, a term referring to the hard leaves which often are small with waxy or resinous coatings and fine hair. Leaves may also curl or be oriented to decrease direct sunlight, all adaptations to keep transpiration rates down during the long, hot summer droughts. Though productivity is relatively low, it averages six times higher than deserts. Whether chaparral is dominated by small shrubs only several cms (a few inches) tall, or dwarf woodlands more than 4m (12 feet) high, these woody plants provide an almost impenetrable evergreen cover wherever they grow across California slopes.

In even the most thorough study of chaparral, it would be a challenge to examine the more than 800 plants, including more than 200 woody plants that make up California's chaparral communities. Here, we focus on a few of the more common species. Many of California's chaparral communities may be distinguished and classified by the dominant species or by habitat characteristics, such as location (island versus Sierran versus semidesert, etc.) or elevation, or soils. The assemblage of plants in western Sierra Nevada chaparral is quite different from that found on California's Channel Islands; the heavier rains and snows of winter and hot dry summers in the western Sierra Nevada are not known to the plants of the islands. Another example of chaparral diversity is the persistent high humidity, fog, and stratus of the islands, which is not known to the semidesert chaparral growing near piñon-juniper and Joshua tree woodlands of transmontane California.

Chaparral species may also occur in locations where forest or woodland is expected, but where outcrops of poor soils such as those weathered from serpentine have created adverse conditions. In southern California, chaparral may replace oak woodland or grassland where fine-grained soils change to the very coarse, porous, and well-drained substrate favored by chaparral plants' roots. Finally, slope exposure is a major factor that determines the dominant chaparral species. A quick glance at chaparral on smaller, local hillsides within California's major landscape trends reveals the shorter, sparse plant cover on drier south-facing slopes that face direct sun. Compare this to the taller, thicker, and lusher growth on cooler, wetter north-facing slopes facing away from direct sunlight. In marginal environments, slope aspect may even produce completely different plant communities on opposite slopes.

Many of the herbs and wildflowers of adjoining communities, such as grassland and coastal scrub, are also common in chaparral; this is especially true in open areas or after fires.

Fire

All chaparral communities are adapted to fire. Many species crown sprout (regrow from root crowns) after fires. Some shed seeds which will only germinate after a good scorching is followed by moisture. A greater diversity of herbs and other species follows during the first few springs immediately following fires; the diversity and numbers of animals explodes along with the spectacular displays of wildflowers and fresh growth. Some of the herbs are considered "***pyrophyte*** endemics," because they only germinate and grow after fires. As the years after fire pass, species diversity usually decreases as the woody chaparral thickets grow taller at the expense of low ground cover.

After many years, only a few larger species may dominate. These mature stands often contain large openings below the canopy cover from the ground up to several cms (inches) high. The cavities provide passageways for small animals below the cover of chaparral, while enormous quantities of dead stems and leaves and other dried debris accumulate on and around the base of these plants. This fuel will contribute to the next wildfire, when temperatures may reach 700°C (1,200°F), and the fire succession cycle will continue.

Fire plays an important role in most California plant communities, especially in those adjacent to chaparral. Fire may ravage some California chaparral and coastal scrub slopes as frequently as every 15 years, on average. The drought-adapted plants contain plenty of fuel and relatively little moisture by summer's end. Chamise (*Adenostoma fasciculatum*), a common chaparral dominant, is known to burst into flames as a fire *approaches*, when temperatures reach 427°C (800°F). It is no surprise that this is a classic drought-adapted species that crown sprouts after a fire and produces seeds which may lay dormant for years until they are scorched. Although fires are beneficial in the long term for plant communities, humans often consider them catastrophic disasters.

Plants. Numerous species of manzanita (*Arctostaphylos* spp.) grow throughout and sometimes dominate California chaparral from near sea level to higher mountain slopes. Light green leaves grow from a background of dark red, woody stems and smooth red bark, which make this an attractive species in the wild and a great ornamental plant for domestic gardens. From its attractive pink flowers the famous "little apples" develop—berries that gave manzanitas their common

Californians and Fire

We have built within numerous plant communities where fire is inevitable. Each fall, the national media displays yet another California housing tract or community burning to the ground. Many of these fires burn through several different plant communities and human settlements in one day and rank as some of the greatest fire disasters in our country's history. They often involve world-famous locations, such as Malibu, Laguna, Beverly Hills, Santa Barbara, Oakland, and Berkeley. Such human disasters are compounded by the mudflows and severe erosion that follow when winter rains pound the hillsides made barren by the fires. In nature, these events may carry away many of the nutrients deposited on the soil by fire. In built environments, the homes and structures not destroyed by the fire may be damaged or swept away in the next winter's floods. Californians have built in fire country, suppressed fires, and paid the price in the long term.

Though California Indians started their share of fires, there is evidence of frequent, smaller fires throughout California long before humans played a role. These fires were started by lightning and probably burned much smaller areas because they occurred on days with rain and higher humidities. It is also likely that smoldering logs and embers left by smaller fires erupted weeks or months later during dry, windy conditions, occasionally causing more spectacular and widespread wildfires. During much of the 1900s, humans suppressed natural fires throughout California, allowing dangerous accumulations of dried fuel near their communities. As a result, modern wildfires—sometimes started by accident or by arson—often erupt when hot, dry winds can fan flames feeding on excessive accumulations of fuel.

It is impossible to stop and difficult to direct a firestorm blazing through overly mature chaparral or other plant communities when temperatures are near 38°C (100°F), relative humidities are below 10 percent, and winds are gusting over 80 km per hour (50 miles per hour). Yet, these are frequently the conditions firefighters encounter during autumn's Santa Ana winds in southern California. Each year, these infernos return as regularly as the seasons. Because of past fire suppression, today's wildfires may burn so much accumulated fuel and reach such high temperatures, they kill native plants and animals that may have otherwise survived to quickly repopulate an area.

Consequently, from civilization's standpoint, California has one of the most dangerous and destructive fire seasons in the world and Californians constantly argue about what to do about it. Even in some of our most remote forests and parks, we have aggressively attacked wildfires to "save" valuable timber, watershed, or recreational lands. We have only recently learned that by allowing some wildfires to burn or by practicing control burning, we will actually restore plant communities to their natural states and decrease the threat of more disastrous fires in the long run.

These are difficult policies to implement in a state with more than 37 million people, especially when lives and valuable property and resources are at stake. The most obvious correction we can make is to stop building in fire-prone regions. In the long run, we will save lives and spend less money on fighting fires and on disaster aid. This will require more knowledgeable and careful land-use planning in the future. Unfortunately, such long-term, common-sense solutions are difficult to implement with increasing pressure from growing populations to expand farther into California's wild areas, areas often seen to offer a part of the California Dream.

Today, developments continue to encroach upon areas destined to burn in California. The wide ribbons of fire breaks—areas where vegetation is cleared along strips connecting one ridge after another—are particularly obvious in southern California. These may serve as future battle fronts where fire crews are seen on TV, making their brave stand against the next threatening fire. On days with higher humidities and gentle breezes, fire crews may start control burns. These burns are designed to clear accumulated dead fuel and return a plant community to more natural conditions so that the next fire is not so hot.

After fires ravage hillsides near the urban fringe, local crews may even seed the slopes with fast-germinating, nonnative grasses. These introduced seeds are often washed away with the first winter rains; they rarely provide a better long-term plant cover for protection from erosion than the native species with which they compete. The practice continues because it is seen as "doing something" to protect the community. California's annual dramas are played out each year with the suspense, tragedy, and irony experienced by countless human populations around the world who have dared to venture into regions where the powerful forces of nature are still in control. In California, the resulting landscapes reveal fascinating interactions between nature and humans.

Figure 5-7 This fire burns through the chaparral along I-5 north of Los Angeles where the Tehachapis meet the Transverse Ranges. Fire crews would eventually extinguish another fire that was likely started by a careless passerby. Most of these plant communities have adapted to such scorching.

name. Manzanita is also used in about fifty California place names. It frequently creeps into other plant communities, such as yellow pine forest, where it may dominate the understory. Except for its different flowers and lack of red bark, the Silk-tassel Bush (*Garrya* spp.) could be mistaken for manzanita.

Several species of ceanothus (*Ceanothus* spp.), with their small, green leaves, are often called California lilac. Different species grow tiny clusters of various colored flowers from white to blue that bloom in the chaparral from lower elevations in late winter to higher elevations into summer. Rubbing the flowers with water may produce a mild, sudsy soap. Nearly pure stands of ceanothus may grow higher than a few meters (several feet) to maturity within several years after fire. They may die of old age within 10 years to clear the way for other species. With nitrogen-fixing roots, they help increase soil fertility for plants to follow. They are also known to throw or pop their seeds away when mature. Though they may not crack unless they land on very hard surfaces, the seeds will crack in later fires.

Mountain Mahogany (*Cercocarpus betuloides*) is another typical chaparral species that is a nitrogen fixer. Smaller plants from the pea family such as Deerweed (*Lotus scoparius*) and lupines (*Lupinus* spp.) also typically move in after fires as nitrogen fixers and restore soil fertility.

Chamise (*Adenostoma fasciculatum*) is another chaparral species found in almost pure stands. However, it often grows as a lower shrub in drier sites with even more classic drought and fire adaptations (some were reviewed in the previous "Fire" section). With its tiny, hard leaves (which superficially resemble buckwheat) and extensive root systems, it may be the most common chaparral species in California.

Red Shanks (*Adenostoma sparsifolium*) is often called ribbon bush or ribbonwood due to the dry strips or ribbons of rusty bark that peel, hang, and curl off the plant. It also has tiny leaves, but it grows much taller than chamise to form dwarf woodlands, usually in very mature stands between elevations of about 600 m (2,000 feet) and 1,800 m (5,900 feet), which have not been burned for many years.

Especially common on southwestern Sierra Nevada chaparral slopes is Flannel Bush (*Fremontodendron* or *Fremontia californicum*), with its long, conspicuous stalks of yellow spring flowers. It is commonly associated with montane chaparral, but also grows on the dry side of the Transverse Ranges. Its other name, Fremontia, was taken from the historical figure, John C. Frémont, and was adopted for the publication of the California Native Plant Society.

Various desert and scrub varieties of oak grow in the chaparral, including California Scrub Oak (*Quercus dumosa*). Its dwarfed size and its small, thick, hard, and often spiny leaves are among this plant's typical chaparral characteristics. It is important to many animals of the chaparral, especially as a source of acorns.

Other interesting and important chaparral plants were overlooked here for the sake of space. It is said that Toyon (*Heteromeles arbutifolia*), has the holly-like leaves that gave Hollywood its name. It is also known as Christmas berry, for its ripe red clusters of berries which appear in front of a green leaf background by late December. Toyon grows in many chaparral communities, including the hills above Hollywood. Man Roots (*Marah* spp.), or wild cucumbers, grow each year as vine-like plants creeping through chaparral and adjacent communities. They emerge from a giant tuber which may reach the size of a person. Its baseball-sized fruits grow giant thorns which make them resemble weapons from a science fiction movie. Once cut open in spring, they may also resemble cucumbers with their internal seeds. Various currants and gooseberries (*Ribes* spp.), other berry plants (*Rhamnus* spp.), and such species as Sugarbush (*Rhus ovata*) are also common in the chaparral.

Animals. Though productivity may nearly double after a fire, production in the chaparral still averages about 600 g per sqm per year (5,300 pounds per acre per year), compared to only 335 g/sqm/year (3,000 pounds per acre per year) of biomass in coastal scrub. Because biomass decreases by about 90 percent for every step up the food pyramid, total animal biomass depends upon such productivity. Consequently, chaparral also supports more animal life than coastal scrub and desert communities, but fewer animals than California's wetter forests. Although many chaparral communities provide abundant berries, seeds, and acorns for primary consumers, there may also be fresh herbs and flowers, especially in new growth after fires.

Because annual droughts with literally no rain may stretch from April or May into October or November, water is often the most important limiting factor for the survival and growth of plants and animals. This favors the survival of animals that can slow their metabolism to hide from drought or travel greater distances in search of water.

Many species wander into chaparral from adjacent plant communities. Most coastal scrub animals may

also thrive in chaparral habitats where they will find less open space, but more protective cover.

Smaller Animals of the Chaparral. Most chaparral birds have the advantage of flying to distant water sources. Like many other animals, they are often dull brown or gray for camouflage in the dry, drought-tolerant foliage. California's state bird, the California quail, is common in many plant communities and is frequently seen scurrying through openings or cavities in the chaparral. This dark bird grows up to 39 cm (11 inches) long. It waddles through the brush, eating vegetation, seeds, and insects. California quail have a conspicuous reddish brown crown with a protruding black topknot feather that resembles a dangling miner's head lamp pointing the way for the bird. During severe drought years, some plants eaten by California quail contain larger amounts of chemicals that inhibit quail reproduction.

The wrentit is a small bird who sings "The Song of the Chaparral," a call resembling the high-pitched bouncing of a ping-pong ball after it is dropped on a tile floor, with smaller time intervals between successive bounces. It is quick and difficult to spot. The wrentit is just one of the many animals that dine on abundant berries and insects in the chaparral. Other birds with distinctive sounds include the morning dove's "coo," screeches of the cactus wren, and, at night, the deep "whoo" of the great horned owl. Along with the owls, red-tailed hawks and red-shouldered hawks are skilled and fierce predators. The list of other common chaparral birds is a long one, including the rufous-sided towhee, California towhee, California thrasher, and scrub jay. Hummingbirds, such as Anna's hummingbird, with its metallic red throat and crown and green back, are among the others.

Ants, grasshoppers, beetles, bees, and butterflies are among the insects commonly seen that play important roles in chaparral communities. Arthropods such as spiders and scorpions are seen as ferocious predators by some smaller animals, but as scrumptious morsels by others. Smaller arthropods such as ticks and mites are also sources of food for some, but are frequently annoying nuisances to many animals and humans who may unknowingly gather them by brushing against chaparral vegetation. By the twenty-first century, confirmed cases of Lyme disease from ticks caused concern among some California outdoor enthusiasts.

Reptiles are far more common in these dry habitats than amphibians, and most species are shared by other plant communities, such as the coastal scrub. The striped racer is a snake which races through the chaparral with its head held high. Its sleek, longitudinal stripes may pass at speeds up to 7 km (4 miles) per hour, as it hunts many kinds of smaller animals. As the name implies, the common gopher snake (which only looks like a rattlesnake) is one of many species helping to keep rodent populations under control.

The western rattlesnake is one of the most common of the chaparral rattlers, and it often has the typical diamond pattern on its back. After biting their prey, rattlesnakes often follow their victims to where the animals finally drop from effects of the venom. There and then, dinner is served. Contrary to myth, few Californians ever die from rattlesnake bites, except when small children or people with strong allergic reactions are bitten. The bites, however, can cause a few days of violent illness.

Larger Animals of the Chaparral. Though larger animals are fewer and so are rarely observed, they may be seen searching for smaller animals or various edible plant parts in the chaparral. Small mammals, such as woodrats, often represent food for larger predators. The California quail can become a meal for coyotes, foxes, bobcats, or even Cooper's hawks. Where coyote may feed on almost anything at any time, the smaller ringtail cats hunt birds late at night and may be attacked by great horned owls.

Mountain lions survive by ranging over large distances of more than 256 sq km (100 square miles), hunting for mule deer and other larger animals. It is no surprise that recent human encounters with mountain lions in California have been mostly in areas where

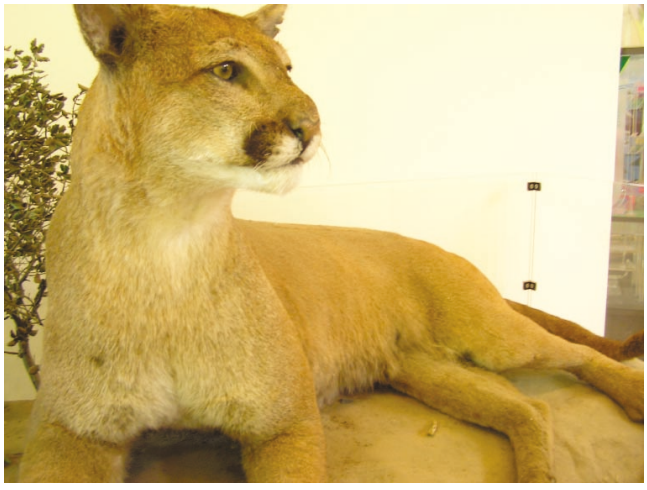


Figure 5-8 One of the most powerful predators in California, the mountain lion, requires a large range. You will not get this close to a wild cougar, nor will they want to get so close to you. They are being sighted more often where suburbs have encroached into their hunting grounds.

Bears and People

The bear on California's state flag will not be found in any of the state's plant communities. The California Grizzly Bear (*Ursus arctos*) is extinct. They once roamed in large numbers through many California plant communities from the coast through lower-elevation inland regions. However, they were most often spotted around grassland, chaparral, and woodland communities. Their huge shoulders and claws were rarely used to rip apart larger animals. They were more commonly used to dig for roots, tubers, smaller mammals, and colonies of tasty ants and termites.

The grizzly is now remembered as a fierce and powerful giant—its average size was about 900 pounds—that was hunted to extinction by the early 1900s. From the time of Spanish settlement, grizzly bears were seen as dangerous obstacles to the expansion of California farm and grazing lands. Accounts of famous grizzly encounters and hunts started with the Spanish and continued through the 1800s. The last grizzly in southern California was probably spotted in the Santa Ana Mountains before 1910. One report locates one of the last California grizzly bears with her cub near Kings Canyon before 1915. However, the last recorded grizzly bear killing was in Sequoia a few years earlier. Most records confirm their extinction by then, accelerated by the $10 reward received for each dead bear. The subspecies relative of this bear survives from the northern Rockies into Canada.

The California grizzly's smaller and more docile relative—the Black Bear (*Ursus americanus*)—is common today, especially throughout central and northern California's forests and in many other productive plant communities. The black bear's diet is similar to its extinct grizzly relative: various kinds of plants, berries, roots, tubers, and small animals. However, it lives in California's cooler forests and sometimes hibernates, habits that were *not* associated with the California grizzly. The several black bears introduced from the Sierra Nevada to southern California's San Bernardino Mountains since the 1930s have thrived. By the 1990s, their population had swelled to more than 300 in that mountain range alone.

As more humans visit and settle in these marginally wild regions, more frequent bear encounters delight the sensationalist Southern California news media. Each year, these black bears wander out of the forest and into the urban fringe of Southern California's inland valleys. They become the stars in news stories when they are filmed rummaging through garbage and even bathing in hot tubs in the suburbs. When one young boy was mauled while camping in the San Bernardino Mountains in July 1996, graphic pictures of the recovering youngster's wounds and film of the hunt for the renegade bear was one of the top news stories on local Los Angeles TV broadcasts for days. Increasing bear encounters in Northern California are also making the news; they are also the result of encroaching developments.

These events are not new to Californians. After years of repeated encounters, nuisance bears learn not to be afraid of humans. They also learn to associate the presence of humans with food. For years, bear management programs in parks and other wildlands emphasized the identification and tagging of problem bears who had become too "tamed." These bears were usually transported back up to more isolated wildlands, where it was hoped they would return to their wild ways and natural diets. Unfortunately, many such bears have stubbornly walked great distances right back to the nearest people. These bears, who have lost their ability to survive on their own, become dangerous to humans and are usually killed.

there is accelerated human encroachment into wildlands. The sensationalist media has exploited these unfortunate events. However, in California, there has been an average of only one mountain lion attack on humans every few years. As expected, the smaller bobcat is restricted to smaller ranges of about 4 sq km (1.5 square miles) and usually to hunting smaller animals, such as rodents and birds.

Mixed Evergreen Forest

In transition between the drier oak woodland and chaparral communities and the wetter, more productive coastal and montane coniferous forests are the mixed evergreen forest communities. In coastal mountains of the north, these forests are usually inland from the heavier winter rains, summer fog, and coastal coniferous forests. However, they grow closer to the coast compared to the oak woodlands even farther inland that endure extreme drought and hot summers. In the western Sierra Nevada and the southern coastal mountains, they appear higher in elevation, above the warmer, drier oak woodland and chaparral, but below the cooler, wetter montane coniferous forests.

Throughout California, where wetter coniferous forests might be expected, especially to the north, mixed evergreen forests may grow in patches on drier south-facing slopes and in nutrient-poor soils. Where chaparral and oak woodland are expected, especially farther inland and to the south, patches of mixed evergreen stands may appear in wetter, more productive sites, such as north-facing slopes. Nearly 5 percent of California is covered by these mixed evergreen forest communities.

Habitat and Structure

The name, mixed evergreen forest, correctly suggests that most of the trees are hardwoods (especially oaks) that keep their leaves throughout the year. In California's

Mediterranean climates outside the wetter coniferous forests, most of these trees survive with sclerophyllous (hard) leaves, which help cut transpiration rates. However, a greater variety of trees often mix in, including numerous conifers and broadleaf, winter-deciduous trees, depending on moisture and soil conditions. Species common in the poor soils of the closed-cone coniferous forest communities may also be found here. Many understory species, such as those typical of the chaparral, commonly creep in from other plant communities. It is not difficult to imagine this plant community as a broad ecotone bridging its drier, less productive, and its wetter, more productive neighbors; it shares species and structural characteristics (physiognomy) with them.

Plants. In central and southern California, mixed evergreen forest may include or be dominated by Coast Live Oak (*Quercus agrifolia*), Canyon Live Oak or Golden-Cup Oak (*Quercus chrysolepis*), or Interior Live Oak (*Quercus wislizenii*). In the Sierra Nevada and higher elevations of the Transverse and Peninsular Ranges, the broadleaf, winter-deciduous Black Oak (*Quercus kelloggii*) may appear at the expense of other species such as Coast Live Oak. These communities are not only denser than California's oak woodlands, but they include many other tree species.

Madrone or Pacific Madrone (*Arbutus menziesii*) and Tanoak or Tanbark Oak (*Lithocarpus densiflora*) are both evergreen trees with large, oval leaves, but Madrone's bark and flowers contribute to its likeness to a giant manzanita. Known as Oregon myrtle in Oregon and pepperwood in parts of California's Coast Ranges, the previously examined California Bay or California Laurel (*Umbellularia californica*) may have the most pungent aroma of any tree in California's mixed evergreen forest. Big-Leafed Maple (*Acer macrophyllum*) not only displays its classic, giant palmate leaves, but it is the largest maple in California and may occur in mixed evergreen forests throughout the state. A quick look at this maple (especially its large leaves) reveals why it cannot survive on California's drier, more exposed slopes.

Conifers often associated with the yellow pine forests mix in at higher elevations of the Sierra Nevada and in southern California. Coulter Pine (*Pinus coulteri*), with its long, dull needles and giant cones, thrives in these communities. Big-Cone Douglas Fir or Big-Cone Spruce (*Pseudotsuga macrocarpa*) grows only in southern California, mostly on north-facing slopes. It is far more adapted to drought and fire and has much larger cones than its relative, Douglas fir, which grows in wetter habitats to the north.

In California's northern mixed evergreen forests, species that require more moisture usually join the mix. Exceptions are found only on the driest, most exposed sites, where chaparral-like species such as Huckleberry Oak (*Quercus vaccinifolia*) are found. Also growing as shrubs among the oaks are Bush or Golden Chinquapin (*Chrysolepis sempervirens*). The leaves and structure of this member of the beech and oak family make it look right at home in drier, mixed evergreen sites. However, it is also found in completely different communities, such as in high elevations of the Sierra Nevada. Its relative, Giant Chinquapin (*Chrysolepis chrysophylla* or *Castanopsis chrysophylla*) grows as a much larger tree in wetter mixed evergreen sites and even into redwood forest communities. As yellow pines become more com-

Figure 5-9 Mixed forests along the Salmon River in northern California may exhibit many different species. This is in a transitional landscape away from the coast, but not so far inland to produce a strong rainshadow. The canyon, with its water sources, grows a thicker forest cover than what you might find on more exposed slopes. High country is in the distance.

mon, they are joined by other conifers, including Sugar Pine (*Pinus lambertiana*), Knobcone Pine (*Pinus attenuata*), Western White Pine (*Pinus monticola*), and Incense Cedar (*Calocedrus decurrens*).

However, when species such as Douglas Fir (*Pseudotsuga menziesii*), Port Oxford Cedar (*Chamaecyparis lawsoniana*), Western Hemlock (*Tsuga heterophylla*), and Grand Fir (*Abies grandis*) become more common, they indicate a transition into the wet, lush coastal coniferous forest communities found only on the northwest coast. Soil chemistry may become the important factor for location of many of these species. On the wettest slopes, especially in the Klamaths, the fast-growing straight and tall Douglas fir often dominates and may even be joined by an occasional Coast Redwood (*Sequoia sempervirens*). In these ecotones between the marginal and most productive plant communities in California, species distributions are determined by distance from the ocean, soil, slope angle and aspect, disturbance from fire or logging, and numerous other factors. The truly diverse and complicated "mixed" evergreen forest lives up to its name.

Accompanying this plant diversity is an often abundant and wide variety of animals. An example of the variety of foods available to animals is the Oregon White Truffle (*Tuber gibbosum*). This tasty underground mushroom is one of many important fungi that grow in the soil and on the roots of trees below the mixed evergreen forest. They also serve as treats for rodents, such as the golden-mantled ground squirrel.

Animals. Most animals of mixed evergreen forests are quite common in surrounding plant communities. Mice, chipmunks, chickarees, and squirrels are typical small mammals here. The western gray squirrel prefers to eat acorns, so its nests are often found in oak trees. The tree canopy provides protection from hawks and other predators as this skilled climber with a large bushy tail darts up and around the trees gathering and stashing acorns. Raccoons make their homes in tree cavities and roam at night for a wide variety of food. Their comical-looking facial markings resemble masks. Even their eating habits, such as washing themselves and their food when water is available during dinner, can be entertaining.

There are numerous members of the weasel family in California, especially in different plant communities of the northwest. Many of them are fierce predators; they are usually more common near water. Rarely seen in the northwest forests are wolverines, badgers, fishers, weasels, martins, and minks. Rare river otter live in burrows out of the water. Skunk are more common; their famous scent glands and thick fur on long bodies with short legs are characteristic of the weasel family.

Mule deer graze throughout California, and they frequent mixed evergreen forests. They eat fresh sprouts and herbs and often establish noticeable grazing lines marking the upper limits of their reach. This abundant animal is the only native deer in California. Their numbers were once controlled by mountain lions, but the population is often decreased by hunting today. Like many wild animals, the behavior of these graceful deer may change as they are exposed to humans who may think they are "cute." Humans who try to befriend and feed deer and other wildlife in California put the animals at risk. The animals may turn away from their natural diets and methods of getting food, often leading to poor nutrition and more dependance on humans. This can be dangerous for people as well; even deer have, when cornered, defended themselves and kicked and killed startled tourists in places like Yosemite.

As many as 100 bald eagles nested in California in the twenty-first century, while more than 600 winter in the state each year. Most concentrate just south of the Oregon border, especially in the Klamath River area when salmon or steelhead are abundant. They may be seen perched on taller trees and snags near rivers and in plant communities such as mixed evergreen forests. By the late 1960s, their nesting numbers had dropped to twenty after heavy hunting and concentrations of DDT had nearly destroyed reproductive cycles. Since the protection given them with enforcement of the 1972 Endangered Species Act, bald eagle populations have dramatically rebounded so that they have been seen as far south as the Mexican border.

Coastal Coniferous Forest Communities

From the Oregon border to Big Sur, California's coastal coniferous forests represent the southern extension of some of the most impressive temperate rainforests in the world. Though these forests were and are more extensive from coastal Alaska through western Washington and Oregon, they are just as impressive and contain many of the same species where they are strung along California's north coast. Because they contain the tallest living trees in the world, it could be argued that portions of California's coastal forests are even more spectacular.

Habitat and Structure

Parts of these forests are scattered all the way to the sea, but they are usually located slightly inland from the stronger winds and salt spray coming off the beach. They grow from the western slopes of the Klamaths south into the northern and central Coast Ranges. In the

TALLEST TREES IN THE WORLD

Native stands of Coast Redwood (*Sequoia sempervirens*) are scattered from the southwestern tip of Oregon along coastal slopes south to Big Sur. Coast redwood is endemic to this region, but it was more widespread across the western United States during glacial periods. Ice Age fossil remains of coast redwoods have been found as far south as Los Angeles, where it apparently grew within local canyons. Today, it is restricted to the immediate coastal slopes inland to about 16 km (10 miles), except to more than 32 km (20 miles) inland where coastal fog and stratus are siphoned with sea breezes through major west–east canyons. The transition from dense coastal redwood forests to drier forests to oak woodland and even drier communities often within several kms (miles) from west to east is remarkable. South of the Bay Area to Big Sur, coast redwood is usually restricted to patches in local cooler, wetter microclimates.

The tallest trees were cut decades ago before they were protected. However, remaining virgin growth is protected in today's state and national parks, and trees can reach higher than 110 m (360 feet) to become the tallest trees in the world. A young redwood's growth may average more than 0.5 m (1.5 feet) per year for more than a century. In some areas, 4,525 kg/ha (4,000 pounds per acre) per year of added growth accumulates the greatest total above-ground biomass known to California—up to 346 kg/sqm (1,500 tons per acre).

Native redwood stands are dependent on many other factors besides heavy winter rains, persistent summer fog, and the absence of prolonged frost. In river valleys, spectacular floods may leave thick silt deposits, destroying other species, but the coast redwood thrives by growing new shallow root systems higher on the trunk.

Fires usually burn around the fire-resistant bark, clearing the surface of competitors and leaving open soil where new redwood seeds may sprout and seedlings thrive. Chemicals in the thick bark also discourage insects and diseases from harming redwoods. Consequently, the world's tallest trees may live for more than 2,000 years (though the bristlecone pine in the White Mountains is the oldest and *Sequoiadendron giganteum* in the Sierra Nevada has the greatest mass). When coast redwoods finally burn or are cut, they vigorously sprout from stumps. Individual trees often grow from rings of interconnected stumps and roots.

Figure 5-10 California's coast redwoods are the tallest trees in the world. They usually grow where there are heavy winter rains, persistent summer fog, and rich alluvial soils.

north, where average precipitation may reach 250 cm (100 inches) per year, these forests cover all the slopes down from exposed ridges on fertile soils. At the southern edge of their range, near Big Sur, where precipitation drops to near 50 cm (20 inches), these forests only grow at the bases of wetter north-facing slopes and within canyons. The northwest coast also has the shortest summer drought in California; rainy seasons usually start earliest and end last here.

The effects of summer drought are also curbed by the persistent summer fog and stratus which hugs the coast. Not only does this maritime air keep summer temperatures cool and relative humidities high, decreasing evapotranspiration rates, it also results in fog drip that can actually add some moisture to the soil during periods without precipitation. Up to 25 cm (10 inches) of fog drip per year has been measured beneath forest canopies along parts of California's coast. The maritime air also moderates winter temperatures so that snow is rare and temperatures seldom drop below freezing. With abundant water and moderate temperatures, there are few limiting factors. Consequently, where soils are favorable, production is higher here than in any California plant community.

Plants. Botanists often divide these plant communities into two segments. The north coast coniferous

forest communities include a wide variety of species common to the Pacific Northwest coast, but they do not usually include coastal redwoods. The coastal redwood forest shares some of the Pacific Northwest coast species, but it has its own characteristics and is exclusively Californian. We will examine the coast redwood only after looking at some of the other common species in California's northwest coastal forests.

Even the names of the species indicate that these are usually stately trees more common to the cool, damp forests farther north, forests with few rivals on Earth. Grand Fir (*Abies grandis*), Sitka Spruce (*Picea sitchensis*), and Western Hemlock (*Tsuga heterophylla*) may dominate and be joined by other trees such as Western Red Cedar (*Thuja plicata*) and Port Oxford Cedar (*Chamaecyparis lawsoniana*). Hardwood species may grow on the fringe of or represent an understory below these forests. Big-Leaf Maple (*Acer marcrophyllum*), California Bay or Laurel (*Umbellularia californica*), Madrone (*Arbutus menziessii*), and Tanoak or Tanbark Oak (*Lithocarpus densiflora*) are examples.

Below these canopies, the ground cover must be adapted to constant damp conditions with filtered light at best. Herbs such as Redwood Sorrel (*Oxalis oregana*), shrubs such as the various wild berries, and numerous fern such as Bracken Fern (*Pteridium aquilinum*) and Sword Fern (*Polystichum munitum*) are common. A water-loving, velvety coating of green moss seems to cover every surface from rocks to trees to bare ground. Fires may clear out these understory species and logging opens the forests to successional species adapted to more light and less moisture.

The two most common trees growing in these forests are also the most important to California's timber industry. Douglas Fir (*Pseudotsuga menziesii*) and Coastal Redwood (*Sequoia sempervirens*) may be found separately or mixed together. They grow fast, straight, and tall and provide high-quality, valuable wood which has many uses. Because Douglas fir grows—along with other species such as Red Alder (*Alnus oregana*)—as a natural successional species, it is preferred by the timber industry when replanting after logging an area. Because most of northwestern California's private and public forest lands are now tree farms, successional species such as Douglas fir are far more common than before logging began.

Currently, more than 90 percent of California's original forest lands have been logged at least once. This means that if you are wandering through a California forest, you are likely to be viewing at least a second- or third-growth stand. If you have the opportunity to visit the less than 10 percent remaining of California's truly old-growth forests, you are in an environment more representative of California's past. Many of these remnants are protected in California's parks and wilderness areas, but some of them are at the center of controversies pitting the timber industry against those who want to save the trees. Perhaps such controversy over so little land illustrates the enormous value of this timber and the pressures and conflicts that will continue as so many interests ask for more from the state's precious resources.

Animals. Termites and other insects join the fungi and other decomposers to recycle decaying organic debris in California's north coastal forests. Slimy, shell-less, bright yellow banana slugs grow up to 15 cm (6 inches) long as they ooze among and devour decaying organic debris in moist forests. Many kinds of moisture-loving salamanders, birds, and mammals, including the black bear, are also found here.

Once often seen foraging along boundaries between the north coastal forests and their meadows from northern California to Canada, Roosevelt Elk (*Cervus elaphus roosevelti*) numbers also declined rapidly until recently. Also known as *wapiti* (Shawnee for white rump), males grow spectacular antlers and may weigh up to 450 kg (1,000 pounds). These territorial bulls are famous for their violent battles, when they charge and lock horns during the fall rutting season. Dominant bulls may win control of more than ten cows. The few remaining herds are added attractions for wildlife enthusiasts among the big trees. A few members of its smaller subspecies relative, the Rocky Mountain Elk (*Cervus elaphus nelsoni*), remain in isolated sections of northeastern California.

◆ MONTANE CONIFEROUS FOREST COMMUNITIES AND ABOVE: AN OVERVIEW

Various montane coniferous forest communities grow on mountain slopes from above about 300 m (1,000 feet) in the north to above 1,500 m (5,000 feet) in southern cismontane California. Sparser mountain forests may be found at even higher elevations in transmontane California. In northwest California, montane coniferous forests may appear between the wetter forests to the west and drier communities to the east. Such low elevations in the rest of California are usually too dry to support pine forests, but from the Klamaths to the northern Coast Ranges and from the Cascades to the Sierra Nevada, these communities are widespread. Farther south, coniferous forest communities are more restricted to patchy

and isolated higher country, especially in the Transverse and Peninsular Ranges.

The various montane coniferous forest communities cover nearly 20 percent of California. At higher elevations, they grade into less productive alpine communities above the tree line.

Belts of Vegetation Zones Across California

Starting in the transition above chaparral and oak woodland communities, the first dry pines begin to appear on California's mountain slopes where temperatures are cooler and precipitation is greater. At slightly higher elevations, these trees eventually grow together to form the mixed coniferous/lower montane or what is also known as the yellow pine forests. Moving farther up, coniferous forest species more common to wettest montane habitats are found at even higher, cooler elevations.

In high country above these lusher forests, annual precipitation begins to decrease again, producing less-dense stands of shorter trees more tolerant of prolonged freezes and snowpacks. We have now passed through the red fir/lodgepole pine communities, into the subalpine forest. Finally, at highest elevations, even dwarfed trees disappear in the harsh, exposed terrain of the Alpine Zone above the tree line. In transmontane California, including the rainshadow sides of California's major mountain ranges, these plant communities or vegetation zones are usually squashed closer together and tilted up into higher elevations. Our review of these plant communities begins at lower elevations and works into the highest California terrain.

Mixed/Lower Montane Coniferous Forests

Habitat and Structure

Lower or mixed montane coniferous forest communities cover about 10 percent of California. Tree height is usually not as impressive as in the northern coastal forests. Outside the giant sequoia forests, tallest trees may grow up to 60 m (200 feet). Undergrowth ranges from sparse in drier forests and poor soils to tall, dense, thick shrubs and small trees, often with species more common to adjoining plant communities. Hardwoods such as oaks often join the pines. In drier environments, the needle-leaf tree species tend to have much larger cones and seeds, increasing their chances of survival in adverse conditions.

Most of the soils are made of porous materials weathered from especially granitic bedrock, and they tend to reflect the acidic nature of the pine needles which accumulate and decay on the forest floor. A variety of herbs, grasses, and spring wildflowers are common below breaks in the canopy, especially after fires, but they turn brittle and brown by the end of the summer drought. Fire has played an important role in determining the physiognomy and species distribution within these mixed montane coniferous forest communities.

These communities could be considered to be within the Transition Life Zone above the drier Upper Sonoran Life Zone communities and below the colder parts of the Canadian Life Zone. More generally, these forests are found above California's flat valleys and below the more exposed, steep, rocky slopes of higher elevations. This explains why they are sometimes called lower montane forests. Another common name is yellow pine forest, which technically refers to forests dominated by ponderosa, Jeffrey, and sometimes coulter pine. However, this label is often also used to describe mountain forests with similar physiognomy, but different dominant conifers. You can see why these communities are sometimes labeled as mixed montane coniferous forests. In this section, we will start with the lower, drier pines and generally work up into the higher, cooler, wetter forests. With so many different dominant species, it will become obvious why there is so much difficulty agreeing on one name for these communities.

Plants. Often growing among the chaparral and oak communities is Gray (Digger) Pine (*Pinus sabiniana*), which was examined in a previous section. Coulter Pine (*Pinus coulteri*) is especially common in open stands along the boundaries of dry pine forests from the Bay Area south into Baja. Like gray pine, it has long needles, but they are darker green. Coulter pines grow the largest cones in the world. In lower elevation open forests of southern California on wetter north-facing slopes and in protected canyons usually above about 900 m (3,000 feet), they may grow near Big-Cone Douglas Fir (*Pseudotsuga macrocarpa*). Sometimes called big-cone spruce, this is related to the Douglas fir of the north except, as expected in the drier south, its cones are much larger.

Ponderosa Pine (*Pinus ponderosa*) and Jeffrey Pine (*Pinus jeffreyi*) look much alike and form similar forests. Like coulter pine, both are three-needle pines, but Ponderosa Pine has large plate patterns on its trunk. It also grows sharp spines turning out from its smaller cones, earning its other name, "prickly ponderosa." Jeffrey Pine has long, narrow ridge patterns on a bark that smells like vanilla or butterscotch when sniffed. Its cones grow spines turned inward. Ponderosa is the most widespread pine in the western United States and is vital to the timber industry.

Because Jeffrey Pine survives colder winters with average January temperatures less than −1°C (30°F), more severe drought, and even lightning strikes, it is more common in the challenging higher elevations to

Owls and Timber

Due to destruction of up to 90 percent of its preferred habitat, the Northern Spotted Owl (*Strix occidentalis caurina*) was classified as a threatened species by the federal government in 1990. These owls prefer to nest in the larger, taller trees, especially in old-growth forests, but their numbers dwindled as decades of intensive logging replaced old growth with tree farms. To environmentalists, the spotted owl was just one of many indicators of California's vanishing old-growth forests. As the owl's threatened status was used to help slow cutting, the bird represented a roadblock to the timber industry in its efforts to access remaining old-growth stands for the sake of short-term profits.

This controversy boiled over into a media-hyped and oversimplified national debate about "jobs versus the environment." It happened to coincide with a nationwide recession and retooling from labor-intensive to high-tech logging practices by larger timber firms. Instead of focusing on rational discussion and debate about long-term habitat and watershed destruction and sustainable yields for a healthy, long-lived timber economy, emotional images of lost jobs and soaring unemployment were broadcast by the media from traditional small California timber towns.

As the economies of these small California towns suffered into the twenty-first century, timber industry executives and employees searched for and found their perceived enemies in those who regulated cutting. There was little honest debate about the future of California's forests, while the media thrived on the simplistic war they helped create. (By the late 1990s, pairs of northern spotted owls were observed adapting to life in second-growth forests.)

With continued habitat destruction, it was no surprise that numbers of the California spotted owl, a different subspecies of the northern spotted owl, were also decreasing. It often makes its home in older, larger trees in mountain forests farther inland, such as in the Sierra Nevada. In January 1993, the National Forest Service slowed logging in many of these forests to keep the California spotted owl from becoming threatened and to avoid renewed confrontation between timber interests and environmentalists. However, the timber industry still complained about the further loss of short-term revenue.

the north and drier forests into Baja. Even in the Klamaths, Jeffrey Pine grows with chaparral on the driest sites and poorest soils. In the Warner Mountains in California's northeast corner, Jeffrey Pine grows at lowest, driest sites. It yields to Ponderosa on higher, wetter slopes, which yields to washoe pine (a rarer yellow pine of the western Basin and Range) above about 2,600 m (8,000 feet). These Washoe Pines (*Pinus washoensis*) grow here with the most extensive Quaking Aspen (*Populus tremuloides*) woodlands away from riparian habitats in California. Such impressive stands of aspen suggest environments similar to the Rocky Mountains, where there is less summer drought. Aspen are also noted for their extensive networks of interconnected tree roots.

Shifting west, Douglas Fir (*Pseudotsuga menziesii*) is restricted to moist forests throughout northern California and was discussed with the north coast coniferous forests. Its cones hang down from drooping limbs. Sugar Pine's (*Pinus lambertiana*) numerous clumps of five needles make bushy stems. These are the tallest pine species in the world (up to 75 m (245 feet) and they grow some of the longest cones—more than 30 cm (12 inches) in length. The attractive sugar pine was named for its sweet sap. It is widespread throughout California's conifer forests. In contrast, Pacific Yew (*Taxus brevifolia*) is a rare, slow-growing conifer found in deep shade of old-growth forests only in northern California and beyond. This tree became famous when the National Cancer Institute announced that chemicals from its bark and roots inhibit the growth of tumors.

Incense Cedar (*Calocedrus decurrens*), with its reddish bark, might be mistaken for small giant sequoia if it weren't for its branching chains of leaves that resemble flat needles. White Fir (*Abies concolor* var. *lowiana*) invades wetter and higher yellow pine forests throughout northern and southern California. This white fir may become dominant above yellow pine forests where average annual precipitation is more than 100 cm (40 inches). Its white bark and rows of short needles that point up from the stem make it easy to identify. Surprising relic stands of white fir atop the New York, Clark, and Kingston mountain ranges in the eastern Mojave are actually a Rocky Mountain variety known as *Abies concolor* var. *concolor*. These trees were stranded and then isolated on high north-facing slopes of these desert mountains with other species during the last several thousand years as California climates became warmer and drier.

To illustrate the diversity and complexity of California's montane coniferous forests, note that several of the previously discussed species are among the sixteen conifers growing within a 2.6 sq km (1 square mile) area near Russian Peak in the Klamath National Forest of Siskiyou County, southwest of Scott Valley. This may be the greatest variety of different conifer species growing naturally within any area of its size in the world.

Largest Trees in the World

Giant Sequoia (*Sequoiadendron giganteum*) grows only in about seventy-five mostly small groves on the western slopes of the Sierra Nevada. Perhaps the most spectacular of California's numerous endemics, it is the largest (but not the tallest) living thing on Earth. Giant Sequoias only grow on the wetter slopes above about 1,350 m (4,400 feet) and below about 2,600 m (8,500 feet) in the western Sierra Nevada, often in habitats with and similar to white fir. They are also relics of a wetter period, when they grew down to about 900 m (3,000 feet) elevation and were far more widespread. They are restricted to slopes that were not carved by glaciers.

Many of the largest trees are more than 60 m (200 feet) tall, weigh more than 1,000 tons, and are more than 2,000 years old; some are more than 3,000 years old. Many of the largest are in Sequoia National Park's Giant Forest, where the General Sherman Tree stands more than 83 m (273 feet) tall. The General Grant Tree in adjacent Kings Canyon National Park is more than 81.5 m (268 feet) tall with a 12.3 m (40.3 feet) diameter base. Growth rates for some young trees are up to 60 cm (2 feet) per year, which are some of the fastest rates in the world. How have these ancient giants grown so tall and survived so long?

They thrive on moisture from winter's heavy orographic precipitation. Snow packs average more than 3m (10 feet) by winter's end, melting into deep soils where giant sequoias' extensive shallow roots are anchored. They survive summer drought by growing in moist, sheltered sites. Their bark is up to 60 cm (2 feet) thick, and it is resistant to fire, insects and parasites, fungus, and disease.

The first branches and exposed living portions of the giants are usually near the top, high above the reach of ground fires. Heat from occasional ground fires opens cones to shed seeds, while the flames on the forest floor leave soft, nutritious soils and clearings where new seedlings can get plenty of sun. Fire is also important to clear the forest of smaller plants and trees such as white fir, which, if too tall, could direct fires in a ladder effect toward the higher living crowns of the giant sequoias. This is one reason why suppression of fire in these forests actually threatens the giant sequoias. Control burns and managed wildfires should increase the health of these forests.

Loggers began to cut these giants by the 1870s. When the giant sequoias fell, however, their wood splintered into myriad pieces. Though many trees were cut for scrap uses, the poor quality wood saved the remaining groves from destruction until conservationists were able to protect them in national parks. Most of the older trees finally die when their crowns become too heavy and they fall over. Today, the extensive shallow roots may be trampled by visitors, weakening the anchoring systems and making some of the trees more vulnerable to topple.

Figure 5-11 After measurements proved sequoias in Sequoia and Kings Canyon National Parks to be the largest trees in the world, they were given names, such as this General Sherman Tree.

Plants Closer to the Ground. It was previously mentioned that a number of hardwood trees, shrubs, herbs, grasses, and wildflowers common in other plant communities may mix with the conifers in these transitional montane coniferous forests. Such species as Black Oak (*Quercus kelloggii*), a common and widespread winter-deciduous tree with large-lobed leaves, adds to the fall colors and contributes to diversity throughout California's mountain forests. It often grows on drier sites and south-facing slopes adjacent to wetter coniferous forests along with species such as Canyon Live Oak or Golden-Cup Oak (*Quercus chrysolepis*).

On the mountain forest floor, about thirty-four species of paintbrush (*Castilleja* spp.) grow in nearly every California plant community; their flowers add delightful color below the forest fringe. They photosynthesize like most plants to produce food, but they are also partially parasitic as they attach to roots of shrubs to steal moisture and minerals. In many species, the bright red colors actually come from large, leaf-like

bracts, which look like brushes dipped in paint, framing the much smaller flowers.

Snow Plant (*Sarcodes sanguinea*) does not photosynthesize, but it attaches its roots to and feeds off fungi which break down decaying organic material in the soil. Its peculiar bright red stalks grow up to one foot (30 cm) out of the spring snowmelt. Pinedrops (*Pterospora andromedea*) is another mycotrophic or saprophytic plant that looks like a skinny version of snow plant but has no roots and simply steals directly from fungi associated with other plants. These and other mycotrophic herb species are common in moist, shady spots below the forest floor where layers of organic materials accumulate and decay. They are also common below the canopy of red fir forests at higher elevations.

Animals. Just as these environments support intermixed plant species, they are also home to a mixture of critters that are common to adjacent lower- and higher-elevation communities. Review the animals surveyed in lower-elevation communities (such as oak woodland and chaparral) and in higher-elevation communities for a glimpse of these animals.

Red Fir and Lodgepole Pine Forests/Upper Montane Forests

Habitat and Structure

We now move to higher elevations above the giant trees and denser montane coniferous forests to more exposed mountain slopes. In northern California mountains, we must first pass through the often cool, dense growth of the red fir forests, where annual precipitation is greater than any other mountain community. Here, the colder temperatures, heavy snows, and shorter growing seasons prohibit many lower elevation species from invading. More than 150 cm (60 inches) of precipitation may fall each year in wetter sites, with total snow falls up to 13 m (more than 42 feet) per year building snow packs more than 4.5 m (15 feet) high by winter's end.

Above about 2,500 m (above 8,000 feet) elevation, moving toward the Subalpine Zone, lodgepole pine may become more dominant, as precipitation decreases with height. Because lodgepole pine survives harsher conditions, it often replaces red fir in waterlogged soils at lower elevations or on more rocky sites exposed to the colder climates of higher elevations. At even higher elevations in southern California, more prolonged summer drought prohibits growth of red fir. Here, upper limits of montane coniferous forests often blend directly into lodgepole pine forests. Red fir often mingles with upper limits of the montane coniferous forests in northern mountains, and lodgepole pine may be common in higher subalpine communities. However, these two species often mingle in the north to form a separate plant community between the communities above and below them. Merriam may have labeled this community as part of the Canadian Life Zone; others have used the term "Upper Montane Forest."

Plants. The two varieties of California's Red Fir (*Abies magnifica*) are widespread in northern California high country but grow only a short distance into southern Oregon and western Nevada. Red fir often replaces white fir at higher northern California elevations. It has redder bark, larger cones, and more rounded, shorter needles than white fir. It is also a common Christmas tree known as "silver tip." Growing on well-drained soils usually above about 1,600 m (5,000 feet) and below 3,000 m (10,000 feet), it may

Figure 5-12 Deer graze in a mountain meadow near Medicine Lake in northeastern California. This mountain rises up above drier Modoc country. At these higher elevations, cooler temperatures and more precipitation support conifer forests with pine, fir, and hemlock like the one in the distance.

tolerate cold better than any other conifer. Noble Fir (*Abies procera*) replaces it in the Klamaths; Cascade Fir or Lovely Fir (*Abies amabilis*) takes over north of California's Cascades. Both are very similar to red fir.

Red fir and lodgepole pine stands are frequently struck by lightning. Fires caused by lightning may clear patches of these trees so that local regrowth is usually the same age. Though lodgepole pine may grow in sunny clearings caused by recent fires, it is often replaced by red fir, which thrives in shadier habitats established many years after fire.

Varieties of Lodgepole Pine (*Pinus contorta*) are widespread throughout western North America. The variety *murrayana* grows from the higher forests of the Klamaths and Cascades as low as 1,800 m (6,000 feet) and into the Sierra Nevada up to 3,600 m (12,000 feet), usually above red fir forests or where soils are too waterlogged or dry to support the less versatile red fir. In the Peninsular Ranges, upper limits of montane coniferous forests change to lodgepole pine at higher elevations. Lodgepole's name refers to the structural support it provided for California Indian homes. It has a white bark with scales, needles in clusters of two, and small, sharp cones. The tallest lodgepole pines grow up to 30 m (nearly 100 feet) in the most mature, healthy stands. It and red fir often represent the highest elevation stands of dense, tall trees in California, but lodgepole pine grows in more adverse conditions.

Small stands of Quaking Aspen (*Populus tremuloides*) may join lodgepole pine in wetter riparian habitats. Resembling but growing above sugar pine in more rocky, exposed soils into subalpine communities is Western White Pine or Silver Pine (*Pinus monticola*). It grows square plates on its bark and its branches curve up; it grows much smaller cones than sugar pine. In contrast, stems of Mountain Hemlock (*Tsuga mertensiana*) and its cones droop down. Other trees such as Western Juniper (*Juniperus occidentalis occidentalis*) and Jeffrey pine also grow on more exposed slopes, joining red fir and lodgepole pine into the subalpine communities.

Yellow-green staghorn lichens grow on the trunks of many trees down to the average snow accumulation line, which may be more than 4.5 m (15 feet) from ground level. Dark, shady conditions, bitter cold, and heavy snows inhibit understory growth in red fir and lodgepole pine forests. Shrubs are often restricted to openings below an otherwise dense forest cover. They include mountain species of manzanita (*Arctostaphylos* spp.) adapted to cold and snow. Mountain or Bush Chinquapin (*Chrysolepis sempervirens*) is found in several other California plant communities with its spiny fruits bearing nuts eaten by squirrels and bears. Currant, mountain berry, and other shrubs are joined by herbs and summer wildflowers, which may be more common in coniferous forests of lower elevations or in subalpine communities at higher elevations. Mycotrophic or saprophytic plants, similar to those examined as part of the coniferous forest ground cover, annually spring up through late spring's melting snowpacks, below the denser red fir or lodgepole pine canopy, where abundant organic debris has accumulated.

Animals. One of the most notorious animals living within these communities is the Lodgepole Needle Miner (*Coleotechnites milleri*), the larvae of a small moth. The moths are abundant in August when they lay their eggs, which later hatch into small caterpillars that will bore into the needles of the lodgepole pine. In large numbers, they may kill the trees, leaving open patches of dead pines to be followed by more diverse species and the eventual return of lodgepole pines. Some early forest managers, seeing this as an unfortunate waste of valuable timber, unknowingly sprayed infested forests with DDT and other poisons to control the "pests." Many of the more than forty predators that kept needle miner numbers under control (including gleaning birds, such as mountain chickadees, wasps, and other insects), were also harmed by the spray; this created even more serious long-term problems.

The Mountain Chickadee (*Parus gambeli*), a small gray bird with black and white bands on its head, is just one of many birds living in these forests. It is a model gleaner, a bird that climbs up and down trees picking insects from bark. It lives in many different California forests and woodlands and requires some patience to spot. Its lonely three-note call is a familiar mood-setter in a quiet forest. Mountain bluebirds, Clark's nutcracker, sapsuckers, woodpeckers, and numerous cone crackers are among the list of birds seen and heard in these communities. Great horned and pygmy owls swoop down on rodents and other small animals for dinner.

Mice, pocket gophers, shrews, and ground squirrels populate the forest floor. There are eight different species of chipmunks in the Sierra Nevada alone. These are actually small squirrels, and each inhabits different communities. In these high-altitude zones with deep snow, gray squirrels are replaced by chickarees, which live in trees above the snow pack and feast on pine and fir seeds. Black-tailed jackrabbits are replaced by snowshoe hares, which are more skilled at hopping through deep drifts. Other larger animals include weasel, fox, coyote, and black bear. Marten or pine marten are large weasels that attack and feed on smaller mammals such as squirrels and chipmunks. These long, short-legged animals are quick and

deadly hunters through the trees and deep snow; their thick fur is well suited to long, cold winters.

Subalpine Forests

Habitat and Structure

We now venture still higher to California's subalpine forest communities. Though some of the species creep up from the red fir and lodgepole pine forests, all plants and animals must be specially adapted to the long, bitter-cold winters. Here, summer growing seasons may last only 7 to 9 weeks, and frost is common even then. Subalpine forests grow at elevations just above 2,000 m (6,500 feet) in the Klamaths, but they grow at higher elevations inland in the Cascades. This is also true in the Sierra Nevada, where the most extensive subalpine communities are found in California. On isolated southern and eastern high mountains, these plant communities begin as high as 3,000 m (nearly 10,000 feet). Because very little of California's topography has been lifted to such high elevations, it follows that these plant communities represent a very small percentage of the state. Due to such harsh conditions, the biomass and species diversity is limited compared to most other California communities.

In all locations, subalpine forests' upper limits mark the ***tree line***, where environmental conditions are so harsh that trees cannot survive. Above the timberline, temperatures could drop as low as 40 degrees below 0°F. The harsh winter may be followed by quick snowmelt runoff and severe summer drought where poor soils are often incapable of supporting tree growth.

Below tree line, on wetter slopes to the north, precipitation may reach 125 cm (nearly 50 inches), or it may average below 70 cm (28 inches) in isolated southern and eastern highlands. Almost all precipitation falls as snow, except for the few summer showers in the north and a few summer thunderstorms in the south that break the short warm season's drought. Soil water is frozen throughout the year, except for the short summer, when snowmelt may quickly run off exposed, rocky surfaces only to be lost to lower elevations and forests. High winds are a constant challenge to life, especially during winter.

Subalpine species may be most interesting due to their ability to survive in such harsh environments. These are communities where desiccating winds drive ice pellets to form flag trees. Their windward sides look blasted, battered, and bare, with more protected branches on the leeward sides growing and pointing away from the prevailing winds. Terms like *krummholz*, a German word for bent or twisted wood, describe the tortured nature of some of these stunted species. They are often dwarfed to the height of the average snow pack. Any tree that grows above this line is exposed to the deadly, fierce, cold blasts of winter or to the violent avalanche. When soils finally thaw, some plants even photosynthesize in the dim light below the protective snow cover.

Though many trees are dwarfed to near shrub size, true shrubs are not common in subalpine plant communities. Some shrubs may be more typical of the snowy forests at lower elevations. Summer's herbs, grasses, and wildflowers must quickly spring from melting snows, grow, bloom, and return to seed before autumn's first heavy snow. Many of these species are also common in higher alpine communities and are especially dense in well-watered mountain meadows.

Plants. Mountain Hemlock (*Tsuga mertensiana*) grows mostly on wetter sites in northern California subalpine communities and is widespread throughout the northwestern states. Needles grow out from all sides of its branches; it looks like a fir but is actually a pine. Whitebark Pine (*Pinus albicaulis*) also grows in the north and into the Pacific Northwest, but Limber Pine (*Pinus flexus*) grows on drier, rocky slopes in central and southern California and into highlands of the southwestern states. Both of these trees have long needles at the ends of stems and may look like lodgepole pine, but their needles are in clusters of five instead of two.

Its common name, Foxtail Pine, describes the needle-covered branches of *Pinus balfouriana*. This species survives only where summer showers break the drought in the Klamaths and where summer thunderstorms occasionally dump rain on the southern Sierra Nevada. Evidence for the slow growth of many trees in these forests is found in a few foxtail pine measured at more than 3,000 years old. The largest junipers in the world grow in the Sierra Nevada and some species creep into California's subalpine communities, but they often become twisted testimonies to the torturous life on these exposed slopes. Several trees of the red fir and lodgepole pine forests, such as western white pine, are also found in subalpine communities.

Great Basin Sagebrush (*Artemisia tridentata*) is one example of the few hardy shrubs from other plant communities that have invaded and adapted to these adverse subalpine environments. In moist habitats, high-elevation species of willow, mountain berries, herbs, and wildflowers common to alpine communities may be established.

Great Basin Bristlecone Pine (*Pinus longaeva*) is a subalpine tree growing near the timberline in California's higher transmontane mountains. It often grows near limber pine, but in poor soils weathered from dolomite. Bristlecone pine is found in the White, Inyo, and Panamint Mountains with limber pine, but it grows alone on higher and nutrient-poor dolomitic soils and in the Last Chance Mountains. Some bristlecone are the oldest trees on earth; the oldest has been growing in California's White Mountains for more than 4,600 years.

These are the harshest subalpine conditions, where extreme winter cold combines with extreme drought in the rainshadow of the Sierra Nevada. Nearly all precipitation falls as snow and much of that sublimates in the windy, dry conditions that follow. Bristlecone pine may look somewhat like foxtail pine, but even foxtails could not survive these harshest of habitats. Somehow the gnarled, dwarfed bristlecones survive. In these environments of ultra-slow growth and decay, scientists have used downed wood, Carbon 14 dating, and tree rings from bristlecone pines to trace climate and timberline variations back 8,000 years.

Animals. Many animals living in California's subalpine communities may also be found either in the lodgepole pine and red fir forests below or in the alpine communities above. Numerous species migrate out by winter to escape the deadly cold. This includes as many as thirty species of birds. Perhaps the most notorious and commonly heard is the noisy Clark's nutcracker. These are large gray jays with white markings on black wings. Because Clark's nutcrackers may store more than 30,000 seeds per season in caches of fifteen, many subalpine pines rely on these birds to disperse and plant their seeds, which may produce seedlings, which eventually grow in clumps. This is similar to the clumping of oak trees in communities at much lower elevations, caused when gray squirrels bury acorns and do not retrieve them.

Meanwhile, other birds such as bright blue mountain bluebirds may be spotted on tree tops or hovering above the unsuspecting insects that will serve as their next meals. Most of these birds migrate to lower elevations or to southern latitudes for the winter.

Mountain Juniper (*Juniperus occidentalis* ssp. *australis*) grows conspicuous nutritious fruits with seeds that may not germinate unless they have passed through the digestive systems of birds or mammals. This helps disperse their seeds and eventually seedlings into different plant communities. Just as insects, mice, chipmunks, squirrels, birds, and other animals depend on subalpine plants for survival, so do the plants often benefit from the activity of these animals. These relationships will be considered in more detail in the next section on alpine communities.

Alpine Communities

Less than 1 percent of California has been lifted to elevations above the tree line. On these isolated islands in the sky, terrible cold and wind create such harsh conditions that even dwarfed trees cannot survive. The tree line may drop down to nearly 2,000 m (about 7,000 feet) in the Klamaths, but it is a little higher on Mount Shasta, Lassen Peak, and in the Warner Mountains. The timberline continues to tilt upward from the northern Sierra Nevada south until it approaches 3,350 m (11,000 feet) in the southern Sierra Nevada. It is slightly higher in the drier White and Inyo Mountains to the east. Only three solitary spots of alpine communities emerge just above the tree line in southern California: at more than 3,000 m (10,000 feet) near and on the Transverse Range peaks of San Antonio and San Gorgonio, and on the Peninsular Ranges' Mount San Jacinto.

During the Pleistocene Epoch Ice Age, when many of the northern highlands were covered with ice, these alpine communities extended down more than 1,200 m (4,000 feet) elevation to include nearly 10 percent of the state.

Habitat

Precipitation continues to decrease with elevation gain from the subalpine; annual totals up to 100 cm (40 inches) are common in the central Sierra Nevada, with more precipitation in the Klamaths and less to the south and east. Almost all precipitation falls as snow; even the occasional summer thunderstorm may produce hail, sleet, and snow. Winter temperatures below −18°C (0°F) are common, and temperatures frequently drop below freezing even on summer nights. Winter snows will bury plants in drifts that may not melt until late summer. Then, intense summer sun can dry and damage plants.

Fierce winds will then batter plants in exposed sites and intensify evapotranspiration rates as the dry, rarefied air blasts through. Following the summer thaw, snowmelt rapidly drains down rocks and porous regolith into the forests below. This leaves alpine communities stranded without water during the shortest growing seasons in California, ranging from one to two months. The only exceptions are in meadows and lakes where water has been dammed. Most soils are rocky, poor, acidic, and unproductive. Though trees are eliminated, an amazing variety of life forms are successful in these habitats.

Often referred to as the Alpine Zone, C. Hart Merriam placed these communities in the Arctic-Alpine Zone (above the Hudsonian Zone), while some generalists simply call it tundra. It is not surprising that plants similar to California's alpine communities grow in the far north latitudes of North America's tundra, also beyond the timberline. Other plants, adapted to summer's drought, are related to those in California's driest deserts. You may find many of the more than 600 species of hardy alpine plants in other California communities. About 200 species grow only in alpine habitats. Here, we can only begin to look at the structure of these communities and a few of the species surviving in them.

Plants. Perhaps the most hostile of California's environments are on the bare, exposed, rocky alpine slopes known as alpine fell-fields. Clinging to these

surfaces with little or no soil are sometimes dense mats or cushions of growth. Lichen is found where fungus can anchor in and gradually weather rock and where algae can join to carry out its role of photosynthesis. In cracks and sheltered spots, perennial prostrate plants hug the surface but grow more extensive root and subterranean stem systems below. These plants lie ready to grow and flower as soon as the short, unreliable mid-summer growing season begins. They join annual herbs to produce spectacular wildflower displays. Many of these species have the large flowers required to quickly attract pollinators. Various grasses and sedges may join the crowd to help capture and protect finer particles from erosion.

Sunflowers, buckwheats, and lupines are among the hundreds of common plants here. Species names often reflect the nature of the plants and their habitats. Paintbrushes include Alpine Paintbrush (*Castilleja nana*). Various phlox include Coville's Phlox (*Phlox covillei*), while Pussy Paws (*Calyptridium umbellatum*), Evening Primrose (*Oenothera xylocarpa*), the bright blue flowers of Sky Pilot (*Polemonium eximium*), and bright yellow sunflowers of Alpine Gold (*Hulsea algida*) are among numerous flowers adding color to California's otherwise barren summertime alpine landscapes.

In and near alpine meadows, water is available for a longer period into the growing season and soils are usually better developed. Grasses and sedges may accumulate to form dark sod or even peat bogs in wetter locations. A few shrubs growing near these meadows include heather and willow. The edges of meadows are first to erupt in summer wildflowers, a splash of color which shifts toward herbs near the center of meadows within a few weeks. Many of these meadows were once lakes and are continuing through their successional stages. At lower elevations, lodgepole pine or other dwarfed trees may eventually encroach; in driest high country, annual grasses and sagebrush scrub may invade. But, in most of California's highest country, communities resembling alpine tundra are usually the climax. Avariety of species growing in so many changing habitats demands more attention than is possible in this fleeting sweep through California's plant communities.

Animals. Many larger animals and birds are capable of migrating from the alpine to lower elevations during winter. The California or Mountain Bighorn Sheep (*Ovis canadensis californiana*) is one of three subspecies of California's bighorns that were once far more numerous. Most mountain bighorn live in the central Sierra Nevada, but there is a small herd in the Warner Mountains. They once migrated to lower elevations, such as the Owens Valley, during winter, but human barriers and activities have impeded these migrations. Diseases, habitat destruction, and overgrazing by domestic livestock greatly reduced their numbers in California to about 350 by 1990, prompting wildlife biologists to implement programs to save them.

More abundant deer also migrate to lower slopes during winter. Birds have the advantage of migrating rapidly to feed on seeds and insects of the alpine and then leaving to escape harsh conditions ushered in by winter. The gray-crowned rosy finch is the only bird that nests in the alpine, but it will fly down the east slopes of the Sierra Nevada during harsh winter weather.

Figure 5-13 This view looks over conifer treetops from lower elevations toward higher Sierra Nevada environments. High country rocky slopes in the distance are above tree line. They represent hostile habitats where only the hardiest plants and animals can survive.

Other animals, such as most rodents, hibernate through the winter. This state of slowed metabolism helps them conserve resources and body fat accumulated during their summer and fall food-gathering frenzies. Among the mice, gophers, chipmunks, and squirrels is the approximately 25 cm- (10 inch-) long Belding's ground squirrel; it may be seen on rocks in the central Sierra Nevada, screaming alarm calls to warn of a possible incoming predator. It hibernates for up to 8 months, living off body fat from summer's seeds and insects.

The largest squirrel of the Sierra Nevada is the plump and furry-tailed yellow-bellied marmot. It can grow twice as long as Belding's ground squirrel and weigh more than 10 pounds just before the long winter hibernation begins. Numerous marmot heads may be seen protruding above rocks. Their loud whistles also warn of possible dangers.

A few animals remain active in winter. The pocket gopher burrows through the substrate, eating roots and other plant parts buried under the snow. Pikas, also known as cony or chief hares, are the size of rats but have rounded ears and no tail; they look like and are more related to small rabbits and hares. They collect and guard piles of nutritious herbs near their rocky shelters so that they may snack and survive through the winter. Pikas also make territorial calls when approached, unless the predator is a marten or long-tailed weasel, which are capable of navigating through the rock cavities in quick pursuit. When these skilled predators are hungry, the only way to escape being served as the next meal may be to run for it! Though the white-tailed jackrabbit is seen in drier southern Sierra Nevada and Great Basin alpine habitats, northern California's snowshoe hare usually remains below the tree line. Both of them change color to blend with seasonal backgrounds.

◆ RIPARIAN COMMUNITIES

Any habitat or community located on or adjacent to a river bank or other freshwater body is considered riparian. Because water availability is usually the most important limiting factor for most California plants and animals, it is not surprising to find the greatest biomass and species diversity in riparian communities. Especially toward southern California, water shortages limit the growth and survival of plants and animals; remarkable changes in the size, diversity, and density of organisms is striking along water courses.

This is where coarse-grained soils often contain abundant nutrients and organic materials. This is where plant roots and animals can search out year-round sources of surface, soil, or shallow groundwater. This is where explosive growth and successful reproduction are encouraged by the abundance of fresh water instead of being limited by its scarcity. This is where the plants and animals closer to water courses must adapt to periodic flooding and sediment deposits, and this is where wildlife will find abundant food, water, and shelter.

Riparian Habitats and Structures

There is an astounding variety of riparian communities in cismontane California. Some are narrow strips along tiny seasonal streams or in deep, narrow canyons. Some are wide, sprawling swaths of forests adjacent to major perennial rivers that seasonally flood across broad valleys. The most impressive riparian forests were the extensive gallery forests up to 16 km (10 miles) wide that poured into the Central Valley along meandering rivers spilling out of the Sierra Nevada. Some of the largest Valley Oaks (*Quercus lobata*) grew in these forests. Today, less than 10 percent of the original 400,000 ha (about 1 million acres) of Central Valley riparian woodlands remain.

Throughout California, whether riparian communities have taller shrubs, small trees, or towering giants, they are relatively moist, cool, shady, protected habitats. Brief exceptions may be noted in winter where dominant broadleaf deciduous trees lose foliage and open the surface to sunlight. This also explains why California's brightest fall colors are seen along its riparian woodlands.

Generally, the presence of water encourages the establishment of plant and animal species typical of wetter communities, and the differences are more dramatic in southern California. In contrast to much of the state, summers are more productive in riparian zones because water remains available; winters are least productive where broadleaf deciduous trees common to riparian communities become dormant. Though humans have greatly reduced riparian communities to less than 1 percent of the state, these areas attract constant attention as they contain some of California's richest assemblages of flora and fauna and its most precious commodity—water.

Today's remaining riparian communities continue to slice and meander through every California plant community. They range from moist, dense redwood forests growing in fresh, wet sediments in northwestern California to ribbons of noticeably thicker and taller shrubs lining the washes of southeastern California deserts.

Plants. Many different species of willow (*Salix* spp.) grow with their characteristic elongate leaves in riparian communities from the coast to the highest mountains back down into the hottest deserts. Depending on the species and habitat, they may grow as prostrate shrubs to dense thickets of large shrubs to tall trees up to 10 m (more than 30 feet).

ECOLOGIC ISLANDS

There is one big advantage of using generalists' past attempts to classify California's plants and animals into overly simplified biomes or vegetation zones—they often provided structure and organization to clarify what many saw as too confusing and complicated. Though there is still healthy controversy, in the last few decades a confusing array of conflicting information about the biogeography of California has been studied, debated, agreed upon, and reorganized.

The old methods may be likened to grouping everyone with the same skin color or accent in California into the same culture or assuming everyone from the same culture has the same lifestyle and habits. This is where overgeneralizing may become meaningless and counterproductive. Even most generalists now agree that to understand the diverse plant and animal communities in California, we must go far beyond the few generalized biomes and vegetation zones. This section is devoted to ecologic islands because they are examples of extremely important plant communities that are too easily overlooked using those old methods of classification.

Habitats

Ecologic islands include habitats which are isolated and different from their surroundings, and they may appear in any portion of California for many reasons. They could include cliffs or talus slopes in the midst of otherwise gentle topography. They could be sources of fresh water in an otherwise **xeric** (dry, desert-like) landscape. Many such factors, and the plant communities that result, are examined in other parts of this chapter. Commonly in California, they are edaphic communities, where a sudden change in the chemistry of the soil or water eliminates some plant and animal species and allows others to successfully compete. (*Edaphic* refers to the nature of the soil.) Because great geologic diversity in this state has produced so many different types of adjacent rock outcrops, soil chemistry can radically change over very short distances. A good geographer or any other scientist *must* consider these factors when examining the distribution of plants and animals in California.

When more fertile soils grade into serpentine or other soils low in nutrients and high in heavy metals, or to highly acidic soils such as mountain spodosols (podzols) or clay oxisols, they present new challenges to plants and the animals that depend on them. More than 200 plant species and varieties are endemic on serpentine soils alone in California. In poorer soils, California's densest forests may become open, while more open forests may abruptly turn to woodlands or chaparral; woodlands may turn to grasslands or drier xeric environments in poor soils. Bald Mountain in northwestern California serves as a classic example. There are so many rare and endangered species in California partly because humans have so frequently modified or destroyed these isolated, unique habitats.

These ecologic islands are scattered in tiny patches throughout the state. Because they are found in some form in every region, and because they include so many endemic, interesting, and sometimes well-known and unusual species, we can focus on just a few of them. We will lump them with some other species which were otherwise skipped in our sweep through cismontane California communities.

Plants. Closed-cone coniferous forest communities are usually restricted to poor soils where lusher forests would otherwise thrive. The cones open after many years from the heat of fires to finally disperse seeds on freshly burned soil. These trees usually form a more open canopy and often have other characteristics linking them to drier habitats. They may grow with chaparral and coastal scrub capable of surviving more adverse conditions. Most of these trees grow in relic stands which were much more widespread when California climates were cooler and wetter thousands of years ago.

Knobcone Pine (*Pinus attenuata*) is probably the most widespread example and is scattered from the Klamaths to southern California. This species survives in some of the driest climates and poorest soils of any California pine, usually inland from the immediate coast. It is often surrounded with other forest species in northern California, but with non-forest species in southern and drier sites. There is a greater variety of coastal closed-cone pines—including Shore Pine (*Pinus contorta* ssp. *contorta*), which is a relative of lodgepole pine—growing on coastal dunes and cliffs in northern California. Other examples include Bishop Pine (*Pinus muricata*) and the sometimes twisted and scraggly-looking Monterey Pine (*Pinus radiata*) of central California and the Channel Islands. Interestingly, Monterey pine has been introduced as a timber crop to replant some Southern Hemisphere forests, where it grows taller and straighter than in its marginal California habitats. By the late 1990s, California's Monterey pines were proving how vulnerable they can be in such marginal environments. They were the first pines to be decimated by the spreading pine pitch canker. Some biologists warned that up to 80 percent of Carmel's pines could be wiped out by the fungus within 30 years.

Torrey Pine (*Pinus torreyana*) protrudes above the coastal scrub in northern San Diego County and is also found on Santa Rosa Island. It has that typical dry pine look but grows needles in clusters of five. It is probably saved from summer drought by the cool coastal fog and stratus. The approximately 9,000 trees only at these two sites make Torrey pine the rarest pine in the world.

Eight of the ten species of cypress (*Cypressus* spp.) in California are endemic (restricted to California). They are also divided into coastal and inland species and usually occur in isolated patches. These are the trees with scale-like leaves and fleshy cones which sometimes resemble tiny soccer balls. Monterey Cypress (*Cypressus macrocarpa*) is confined to the Monterey Peninsula on sites with granitic soil, persistent fog, wind, and salt spray. In spite of these restrictions, the contorted and tortured images of these trees appear in countless photographs and paintings as contrast to the scenic coastline.

ECOLOGIC ISLANDS (continued)

The most widespread inland cypress are the Sargent Cypress (*Cypressus sargenti*) of the Coast Ranges and the MacNab Cypress (*Cypressus macnabiana*) of northern California, which are usually restricted to serpentine soils. As the name implies, tecate cypress grows on poor soils in southern California past the Mexican border. Cuyamaca Cypress (*Cupressus stephensonii*) was originally thought to be endemic only to the southwestern slope of Cuyamaca Peak in San Diego County, until individuals were reported in Baja. Regardless, it is the rarest cypress in California, and it grows into higher elevations where chaparral turns to conifer forest. Before the taller of these trees was burned, they towered more than 14 m (46 feet) high. Occasional fire is an important factor in most of California's cypress stands, but if fires are too frequent, extinction of the rarer and more isolated species may follow.

Numerous other California species occur only in ecologic islands. Furthermore, shrubs common to chaparral, such as chamise, and different species of ceanothus and manzanita may be indicators of poor soils within otherwise more favorable sites. Even the California oaks include scrub species adapted to more adverse conditions, such as Leather Oak (*Quercus durata*), with its curled leaves. Because California Huckleberry (*Vaccinium ovatum*) is common on poor soils in central California, it should be no surprise that nearly pure stands of bishop pine (another dry habitat pine) grow on Huckleberry Hill near Monterey.

The Baldwin Lake Pebble Plains east of Big Bear Lake, Anticline Ridge near Coalinga, Corral Hollow Ecological Reserve southwest of Tracy, and Pine Hill in El Dorado County in the Sierra Nevada are famous for their ecologic island status. All have assemblages of interesting, rare, and endangered plants and animals adapted to unusually adverse conditions. Some of the most fascinating examples are in the dwarfed closed-cone conifer forests or pygmy forests on the Mendocino County ecologic staircase. Here, hardpan soils stunt tree growth and change the dominant vegetation from forest to shrubs.

Animals. As expected, numerous, mostly smaller, rare animal species are associated with specific soils or plants within these challenging ecologic islands. They include many insects, amphibians, and reptiles. The smaller and more unique habitats are often home to smaller and more delicate populations of rare animals. Other animals (especially larger mammals and birds) may live and are often more common in adjacent communities, but they may migrate through and sometimes settle in these patches of California. Many of them are considered in other sections of this chapter.

MONARCH BUTTERFLIES (*Danaus plexippus*) could be the only insects which make lengthy, round-trip migrations; they may travel up to 4,800 km (3,000 miles), but over several generations. Up to 5 million California monarchs winter mainly on the central and southern California coast; individuals have been known to migrate more than 1,000 km (650 miles). Most California monarchs spend their winters feeding on nectar, and many can be seen in Monterey pine and eucalyptus trees. A close look at some trees at locations such as Pacific Grove and Morro Bay might reveal many hundreds of monarchs covering the trees.

They begin their journeys toward the north and east in the spring. They return to the California coast each fall. The monarch's larvae feed off milkweed, then grow to larger caterpillars, and turn to butterflies in about two weeks. Though they are immune to the poisonous milkweed, otherwise potential predators recognize them as distasteful. This is just one example of how animals may migrate into or through California's ecologic islands.

The four species of alder in California may be important nitrogen fixers in nutrient-poor soils. The more common White Alder (*Alnus rhombifolia*) gives way to a shrublike Mountain Alder (*Alnus tenuifolia*) at higher elevations. Big-leaf Maple (*Acer macrophyllum*) is a valuable hardwood, while the yellow wood of Oregon Ash (*Fraxinus latifolia*) is used for furniture; both also grow in canyons up into higher elevations. Box Elder (*Acer negundo*), California Bay or Laurel (*Umbellularia californica*), several species of oak (*Quercus* spp.), and other trees may all enjoy wetter habitats found in riparian woodlands.

Western or California Sycamore (*Platanus racemosa*), like maple, has huge palmate leaves. It is restricted to riparian habitats and canyons of central and southern California. This is another relic species that was far more widespread until the warmer, drier climates after the Ice Age stranded and isolated it in these moist spots. It can look somewhat out of place as it turns color and then loses its leaves just in time for the mild rainy seasons in lower elevation southern California canyons.

Poplars require moisture and their different species are also separated by elevation. They include the Fremont Cottonwood (*Populus fremontii*) and the Black Cottonwood (*Populus trichocarpa*), which grows into higher elevations and up to 50 m (more than 160 feet) tall with its silver-bottomed leaves. Cottonwood gets its name from the cotton-like white hairs of the female flowers that drift in the wind. Quaking Aspen (*Populus tremuloides*) may dominate higher elevation riparian communities into eastern and northeastern California

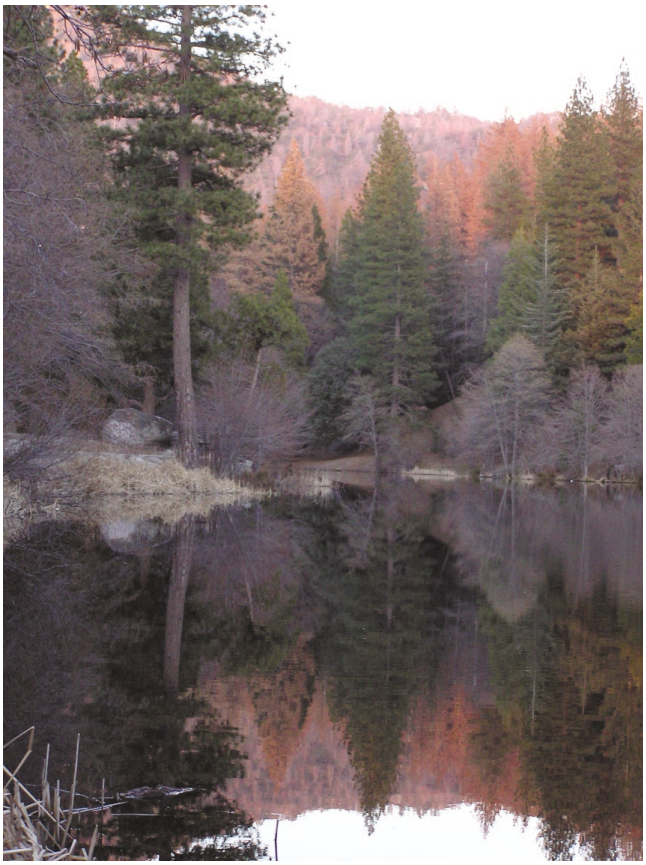


Figure 5-14 Wherever water appears in California, it seems to change everything. On distant slopes, bark beetles are eating their way through southern California's mountain forests. But, along the shores of little Lake Fulmor, deciduous trees have lost their leaves for winter and a variety of other water-loving species crowd around the water.

and in isolated stands as far south as the San Bernardino Mountains. It is difficult to miss the white bark behind light green leaves which wave and tremble in even the slightest breeze. After dropping their leaves, aspen will survive the coldest winter temperatures California can muster; they put on some spectacular fall colors in canyons north of Bishop and in higher terrain of the Warner Mountains.

Shrubs also often include willows. Mule Fat (*Bacharis glutinosa*) somewhat resembles willow. Like willow, sedges, and some other species that grow near flowing water, mule fat easily bends during and adjusts following major floods and submersions. A variety of other shrubs found in this ecotone between dry land and water include dogwoods (*Cornus* spp.), oaks (*Quercus* spp.), gooseberries and currants (*Ribes* spp.), other wild berries, and wild grapes. Herbaceous plants are more common in recently disturbed sites; rushes, sedges, cattails, and many different wildflowers are on this long list of riparian species often growing in areas where recent floods have reworked and deposited new sediment.

Animals. When larger animals and birds become thirsty and hungry, they often venture into riparian communities from other habitats, knowing where to go for water and more abundant food. Numerous bird species migrating many hundreds of kms (miles) stop to rest or winter along California's water courses. They join the great diversity and biomass of animals who spend their entire lives in the shelter of these productive ecotones between dry land and water.

Many aquatic insects live their entire lives in or near water. Others, such as mosquitoes, damselflies, and dragonflies, may fly away as adults. When temperatures warm, the riparian scene is busy with flying moths, butterflies, wasps, and bees, and crawling with ants and other insects, caterpillars, and worms. Because there is no shortage of nectar and fresh green shoots to choose from on the plants or in the soil during spring and summer, there is no shortage of primary consumers, including vegetarian birds.

The crawling and flying bugs become food for spiders, birds, bats at night, and other predators. Even fish dine on them when they venture too close to water. Flycatchers, warblers, wrens, and flickers are among the enormous list of birds frequenting riparian communities. Salamanders, reptiles, and rodents, such as mice and woodrats, become dinner for kites and hawks by day and long-eared and great horned owls at night. Several native and introduced frog species also represent tempting morsels to larger animals.

Raccoon commonly settle in riparian woodlands, where they feast on most of the edible aquatic and land animals and plants. California's native aquatic turtle, the Western Pond Turtle (*Clemmys marmorata*) lives in and around fresh water in valleys and mountains of cismontane California and locally along the Mojave River. Because their activity levels range somewhere between lethargic and comatose, their diets are restricted to juicy plants and occasional insects or dead animals that cannot escape. If it could not withdraw into its hard shell, this species would be easy prey for California predators looking for a scrumptious dinner. This is a very different species from the Desert Tortoise (*Xerobates* or *Gopherus agassizii*) of transmontane California and the many turtles introduced into the state.

Although beaver (*Castor canadensis*) were hunted for their pelts to near extinction by the 1900s, they may be found today mostly in northern California valley and mountain water courses, where they gather and

feed on native vegetation. In the mountains, they will chew and fell trees such as aspen and willow to make dams. Ironically, in lowland waterways, where they are called bank beaver, they are a nuisance when they excavate and burrow into river and stream banks designed to hold back water.

Coyotes, foxes, skunks, rabbits, and other larger mammals frequently visit riparian habitats. When it comes to animals, California's riparian communities are like bustling cities filled with busy consumers, especially during spring and summer months. Some animals take up residence in the city; others commute in from adjacent communities to do their business. If spring and summer in the riparian resemble a weekday lunch hour in one of California's downtown financial districts, could the winter lull resemble a weekend night in that same financial district? It is ironic that California's thriving cities and the agricultural land required to support their human populations have especially expanded, encroached upon, and destroyed more than 90 percent of nature's great riparian cities that once supported abundant California wildlife.

◆ TRANSMONTANE DESERTS

Here, we survey some of the most interesting and important features in the distribution of plants and animals living on the inland side of California's great physical barriers. Plant communities in the rainshadow deserts of California must be adapted to at least two climate extremes. First, temperatures are not moderated by marine air. Diurnal and seasonal temperature changes are extreme, so plants must adapt to extremely intense solar radiation and hot temperatures on summer days followed by extremely cold winter nights. The difference between recorded high and low temperatures in one year at one desert location could be more than 56°C (100°F)!

Second, winter's Pacific storms drop most of their water on the windward sides of the mountains, and as the drier air masses finally flow down the opposite rainshadow slopes, they are warmed and dried. Consequently, most California deserts have no trouble living up to this oversimplified definition: true deserts receive less than 25 cm (10 inches) of rain annually, while evapotranspiration rates greatly exceed precipitation. Death Valley receives an average of less than 5 cm (2 inches) of rain per year while potential evapotranspiration rates can be more than 380 cm (150 inches). Similar conditions are common in other lower deserts of southeastern California, where more than one year may elapse without recorded precipitation.

Even in the cooler, wetter semidesert conditions at higher elevations, dry continental air masses rule and continentality controls climates.

Poor soils (some with high salt content), fierce, desiccating winds, limited shelter, and dangerous exposure above ground are just some of the harsh conditions in the transmontane deserts. Plants and animals must adapt or die. Somehow, many species not only survive, but often thrive in these adverse environments. However, unlike our review of many cismontane California plant communities, this section is not about great size, diversity, or biomass. It is about how hardy species have adapted to the harshest of conditions in California's spacious desert communities.

Our review of California's biogeography has already skipped or spread into transmontane California on at least four occasions. You may recall the semidesert chaparral communities that spill over to the inland sides of the Peninsular Ranges and Transverse Ranges into the edges of the Colorado and Mojave deserts. These chaparral communities include manzanita, chamise, ceanothus, sugarbush, mountain mahogany, various scrub oak, bush poppy, yerba santa, and many other familiar plants.

Some of these and other more desert-like communities also creep along the edges of the southern Sierra Nevada and west into cismontane California's western Transverse Ranges and southeastern Coast Ranges. It is interesting that this geologic pivot point (where the Garlock and San Andreas Faults, three mountain ranges, and five physiographic regions meet) is also an ecological pivot point. The result is a fascinating mix of desert, semidesert, and cismontane plant communities with their plant and animal species. It is another example of the many connections between California's diverse geologic features and climates and the plants and animals adapted to these diverse settings.

We also surveyed the high pine forests of the Warner Range in northeastern California and the higher subalpine forests with the oldest trees in the Basin and Range east of the Sierra Nevada. Finally, we peaked at the surprising stands of White Fir (*Abies concolor* ssp. *concolor*) isolated on high north slopes of the Mojave's Clark, Kingston, and New York Mountains. These trees form an open forest with piñon pine and other species from above 1,900 m (6,200 feet) to nearly 2,350 m (7,700 feet). The total of nearly 1,200 white fir grow up to 20 m (65 feet) tall and some are more than 400 years old. At these lofty elevations, temperatures are cooler and winter snows and summer thundershowers are more frequent than in the hot desert communities below.

In this section, we remain mostly east of California's great physical barriers. We will gradually drop below previously mentioned and rare transmontane forests toward the warmer, drier, lower elevations. Plant communities will change from desert woodlands to desert scrub as we travel from the north and/or higher elevations toward the south and/or lower elevations. Remember that moving north in California deserts usually means higher

elevations and colder, wetter conditions, except for the few hot and dry deep valleys which finger north (such as Death Valley). Moving toward the southern deserts usually means lower elevations and warmer, drier conditions, with exceptions such as those isolated, high mountain forests poking up out of the Mojave.

Piñon Pine and Juniper Woodland Communities

Though less than 3 percent of California is covered with piñon and juniper woodlands, they are distributed throughout transmontane California above 1,200 m (4,000 feet) and below 2,400 m (8,000 feet). This places them below the wetter coniferous forests and above the warmer, drier desert scrub. These dwarf forests are found from the eastern Cascades and Modoc Plateau (where juniper usually dominate) south into the eastern Sierra Nevada (where piñon dominate) and into the Basin and Range, where they grow below the subalpine forests. Moving south, they are common on the eastern slopes of the Transverse and Peninsular Ranges and on those higher elevation desert slopes. They also creep west into drier portions of cismontane California's Transverse Ranges and southern Coastal Ranges, previously mentioned as an important natural pivot point, where they intermingle with species more common to cismontane plant communities.

Habitat and Structure

The trees in these dwarf forests are often mixed. They range from widely scattered stands of especially juniper less than 3m (10 feet) tall in lower, drier locations with poor soils to denser forests of mainly piñon pine up to 15 m (about 50 feet) at higher elevations with quality soils. The latter phase of these communities is clearly a cooler, wetter semidesert, where annual precipitation could be as high as 50 cm (20 inches) and winter snow is common. In these cooler, wetter environments, the juniper and mostly piñon woodlands have dense understories and may mix with species common in coniferous forests. In drier sites, the understory predictably consists of more widely scattered, smaller shrubs and mostly annual herbs common to California's true deserts. Regardless, it is often possible to observe from one location the forest-covered slopes above and desert scrub below; all of this standing within the usually dry, clean air of the transitional piñon and juniper woodland communities. Most of these California plant communities are related to similar communities throughout the Great Basin and Colorado Plateau to the east.

Plants. Junipers (*Juniperus* spp.) are small evergreen trees of the cypress family. They have scale-like leaves which resemble flat needles, small juicy cones commonly known as juniper berries, and aromatic, sometimes twisted and contorted wood. Different species may grow into stately trees or *krummholz* forms in some of California's highest forests; others grow as shrubs on the fringe of California's true hot deserts. Though species of widely spaced juniper are common in northeastern California and even in subalpine zones of the Sierra Nevada, they are usually associated with drier sites than piñon pine. Here, we focus on the more important transmontane species.

North of Bridgeport and often in the open, rolling countryside of northeastern California well into Oregon and Nevada, is Western Juniper (*Juniperus occidentalis* var. *occidentalis*). Its close relative, Mountain or Sierra Juniper (*Juniperus occidentalis* var. *australis*) is found on high mountain slopes, especially in the

Figure 5-15 We have traveled down to the eastern rainshadow side of the Klamaths. Though we are near the Oregon border, the climate is much drier here than on coastal slopes far to the west, on the ocean side of the mountains. Here, drier sage mixes with open woodlands and even the occasional conifer, just to remind us we are far to the north.

Sierra Nevada. It is also found in parts of the Transverse and Coast Ranges around that previously identified pivot point. California Juniper (*Juniperus californica*) grows from the southern Sierra Nevada into southern California, and Utah Juniper (*Juniperus osteosperma*) is found in the Great Basin, Mojave, and Transverse Ranges.

The One-Needle or Single-Needle Piñon Pine (*Pinus monophylla*) is the most common piñon pine in California, growing from the eastern Sierra Nevada and Basin and Range into that pivot point again and then south into Baja. Four-Needle Piñon (*Pinus quadrifolia*) grows from the Santa Rosa Mountains of the Peninsular Ranges into Baja California, while Two-Needle Piñon (*Pinus edulis*) is found only from the higher mountains of the eastern Mojave, east into the southern Rockies. Hybrid trees with one to five needles may be found where the single-needle piñon grow with other species.

Great Basin piñon and juniper woodlands often grow with high desert shrubs such as Great Basin Sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* spp.), and Bitterbrush (*Purshia tridentata*). In the Transverse and Peninsular Ranges, semidesert chaparral plants such as Desert Scrub Oak (*Quercus turbinella*) and yucca (*Yucca* spp.) are common. Moving into drier southern deserts, Joshua Tree (*Yucca brevifolia*) and even hotter desert shrubs such as Creosote Bush (*Larrea tridentata*) begin to appear in the scrubbier, sparse growth of piñon and juniper boundaries.

Animals. Animals may find fresh vegetation to browse and juniper berries, acorns, and other food in the piñon and juniper woodlands. Piñon nuts (sometimes called piñones) have been especially important for the wildlife and California Indians and are now considered a delicacy in some modern recipes. Several species of birds include hairy woodpeckers, chickadees, warblers, and nuthatches. Like Clark's nutcracker, the pinyon jay has been known to transport and bury seeds in caches more than 13 km (20 miles) from the producing trees. Unlike most jays, the pinyon jay has no crest and is duller gray and less blue. These noisy birds move in flocks between trees and are particularly important in spreading and planting piñon pine nuts that could grow to become the next seedlings in these woodlands.

Numerous rodents may live in and around these woodlands, including a typically large-eared, white-footed deer mouse called the pinyon mouse. Other mice, great basin kangaroo rats, wood rats, pocket gophers, chipmunks, and ground squirrels compete for available food. Usually nocturnal porcupines often hide in trees during the day. These spiny creatures are rarely seen, except as road kills, especially in northeastern California. They gnaw on young bark by winter and eat fresh buds, leaves, and herbs during summer. Gray foxes, coyotes, bobcats, and mountain lions are occasional predators in these communities, while mule deer and pronghorn antelope browse on the scrub understory. California Bighorn Sheep (*Ovis canadensis californiana*) often move down from higher Sierra Nevada terrain to escape winter cold and snow. Desert Bighorn Sheep (*Ovis canadensis nelsoni*) migrate to higher elevations to escape the desert's summer heat.

Joshua Tree Woodlands

Though a very small portion of California is covered with Joshua tree woodlands, they form some of the state's more distinct and celebrated plant communities. It is said that stands of Joshua trees (*Yucca brevifolia*) sometimes outline the boundaries of the Mojave Desert. They are scattered from the southern Owens Valley throughout the Mojave Desert and into southern Nevada and northwestern Arizona at elevations above 600 m (2,000 feet) to about 1,600 m (just above 5,000 feet). These communities are especially common north of the Transverse Ranges, around the Antelope Valley, and in eastern Mojave's ranges. In these cooler and wetter higher elevations of the Mojave, winter frost and some snow are common. Joshua trees do not grow in the hot, dry habitats of lower deserts to the south; they are a certain indicator of high desert in the Mojave.

Habitat and Structure

Like piñon and juniper woodlands, species from many other communities grow with them. At higher elevations, they may creep into piñon and juniper woodlands. Depending on geographic location, understory species from scrub communities such as sagebrush, blackbush, saltbush, or creosote bush scrub are common. Considering elevation and geographic location, discussion of Joshua tree woodlands should follow sagebrush scrub and perhaps blackbush scrub communities as we work our way down to lower elevations. However, because these towering, ghostly figures form open woodlands unique to the high deserts of the southwestern United States, they are addressed here.

During spring, especially following a good rainy season, grasses, herbs, and sometimes spectacular displays of wildflowers explode in new growth among the brush. Within weeks, these plants die back and go to seed, dried and brittled by the summer sun. Local, infrequent, and unreliable summer thunderstorms may deliver short-lived downpours. However, unlike the gradual soaking common during winter's cold rains and snowmelt, much of the water from summer's brief

storms may run off or eventually evaporate in the heat. Therefore, new growth and flowering usually peaks just when temperatures are warming in the spring.

Plants. This species of yucca got its common name, Joshua, from the Mormons, who associated its uplifted arms and old age with the biblical military leader. This member of the agave family is sometimes called tree lily and should not be confused with the smaller, scrubbier Mojave Yucca (*Yucca schidigera*). It also has smaller leaves than most other yuccas. The trunk, limbs, and size of *Yucca brevifolia* easily qualify it as a tree.

Younger trees grow for years as single poles up to 3 m (10 feet) before they bloom or feeding insect larvae cause them to branch out. Fresh new leaves are added to the branches as the tree grows at the expense of the lower old leaves, which wither and eventually fall to the ground. The long, thin, spear-like leaves added to the length of each branch are a reminder that this is a desert tree. The largest trees grow more than 10 m (32 feet) tall and wide, making them the largest flowering plants of the Mojave. Their large, white, lily-like blossoms are more numerous when favorable spring temperatures follow soaking seasonal rains.

Numerous species of shrubs and herbs common below the Joshua trees are usually members of desert scrub communities covered in the next section.

Animals. Joshua trees are recognized for supporting a variety of small animals, some of which are totally dependent on the tree for survival. A classic example is the mutualistic symbiosis which benefits yucca moths (*Tegeticula* spp.) and Joshua trees. At dusk, the yucca moth is attracted to the Joshua tree's white blossoms. It flies from tree to tree, gathering the sticky pollen until it lays its eggs in the flower and pollinates its targeted plants. As the larvae grow and mature, they feed off some of the developing fruit. These two species must occur together.

Meanwhile, larvae of the giant yucca skipper and yucca weevil eat from fresh growth, and termite colonies recycle nutrients as they feed off of and find shelter in the dried and downed wood at the base of these trees. Beetles and other insects are also common among the Joshua trees.

The desert or yucca night lizard is just one animal that feeds off these insects under the shelter of downed wood, while wood rats (also known as pack rats) pile their nests at the base of Joshua trees. Various snakes, including the night snake, slither among the debris sensing out many of these smaller animals for a meal. Woodpeckers also eat termites, but you will find many other birds here, including up to twenty-five species known to nest in Joshua trees. These include northern flickers, flycatchers, house wrens, and American kestrels. The colorful black and yellow Scott's oriole makes its nest from yucca fibers and feeds off the tree and its insects. On the hunt are red-tailed hawks by day and screech owls by night. Housing so many diverse, interconnected, and interdependent neighbors, the Joshua tree may display a unique microecosysytem, if not its own microgeography.

Desert Scrub Communities Overview

Various communities with vast, open expanses of desert scrub cover nearly 30 percent of California. Lack of water is the most important limiting factor. However, severe summer heat in the lower deserts, bitter winter cold in higher northern desert shrublands, and many other factors combine to create some of California's harshest environments. Climates are too harsh and dry and soils too poor to support even dwarf trees. These mostly transmontane communities are found in patches in northeastern California, become more widespread in basins east of the Sierra Nevada, and then completely dominate the landscapes of California's southeastern deserts.

These most challenging environments might be considered antithetic to California's north coast forest communities, where abundant water and mild temperatures rule for most of the year, producing relatively impressive accumulations of biomass and greater species diversity. Some desert scrub communities are also found in the southwestern San Joaquin Valley, behind the rainshadow of the Coastal Ranges.

Habitats, Plants, and Structures of Desert Scrub Communities

Sagebrush Scrub. Sagebrush scrub communities (sometimes known as Great Basin sagebrush scrub) are widespread at highest desert elevations, especially in California's northeastern deserts. Various rather evenly distributed sagebrushes cast their dull gray-green shades across the landscapes into several other Great Basin states. In California, these communities are common on well-drained soil from above 1,300 m (more than 4,000 feet) to about 2,300 m (7,500 feet), but locally they extend much higher into the subalpine of eastern ranges.

Sagebrush survive in many different habitats, from the understory of transmontane woodlands and forests to exposed range without a tree in sight. More common in northeastern California and the Modoc Plateau and east of the Sierra Nevada crest, they become more scattered toward the south and then isolated into the Peninsular Ranges. They even extend into the Transverse Ranges around that previously identified pivot point.

Most common and widespread from Canada to Mexico and east past the Rocky Mountains is Great Basin Sage (*Artemisia tridentata*). Its long light gray leaves end with three teeth, and it may grow more than 4m (13 feet) high, though it is usually a smaller shrub. Other sagebrush include the darker Dwarf Sagebrush (*Artemisia nova*), Black Sagebrush (*Artemisia arbuscula*), which is another dwarf species adapted to poor soils, and Silver or Hoary Sagebrush (*Artemisia cana*) in dry meadows.

Bitterbrush or Antelope Brush (*Purshia glandulosa* or *tridentata*) look like darker green Great Basin sage, but are often heavily overgrazed. Various saltbush (*Atriplex* spp.) become common in more alkaline soils in these communities. Also common and well-known in these communities are Rabbitbush (*Chrysothamnus* spp.), Hopsage (*Grayia spinosa*), and Mormon Tea (*Ephedra viridis*). Rabbitbush is also known as Mojave rubberbrush because small amounts of rubber can be extracted from it. It is a standout when its bright yellow autumn flowers protrude above this community. Meanwhile, stems of the leafless Mormon tea can be boiled to make a bitter drink with a stimulant.

Various bunchgrasses include Bluebunch Wheatgrass (*Agropyron spicatum*), and annual grasses are dominated by the introduced Cheat Grass (*Bromus tectorum*). Overgrazing has restricted distribution of many species, but greatly increased the abundance of less tasty sagebrush and rabbitbush, two plants that often dominate the scenery in these communities. Fire is also changing this community.

Blackbush Scrub. Blackbush (*Coleogyne ramosissima*) dominates these communities which are common at elevations just below sagebrush scrub, but above the lower desert communities such as creosote scrub (especially from about 1,200–1,800 m [3,900–5,900 feet]). Although their leaves are grayish green, these low shrubs look black from a distance, and they sometimes resemble antelope bush. Often found between high and low desert, they mix with many other communities and species, including Joshua trees. Such plants as yucca, Turpentine Broom (*Thamnosma montana*), Burrobush or Cheesebush (*Hymenoclea salsola*), Horsebrush (*Tetradymia* spp.), and Winterfat (*Ceratoides lanata*) are common. A conspicuous and interesting plant is the Paper Bag or Bladder Sage (*Salazaria mexicana*). Like Mormon tea, its skinny green stems are usually leafless, but it grows its seeds in thin, inflated, paper-like pods which easily float in wind or water. Like many of these species, bladder sage is common in other desert scrub communities.

Shadscale Scrub. These communities are also often found between the upper sagebrush scrub and lower creosote bush scrub communities. You may find them in more alkaline soils throughout the Great Basin and on higher, steep mountain slopes with rocky soils in the southern deserts. They are scattered in and north of the Owens Valley and on rocky slopes of the Basin and Range and Mojave. These communities are sometimes lumped with and considered a part of saltbush scrub communities. This is because the Winter Fat (*Ceratoides lanata*) member of the saltbush family occurs with the dominant Shadscale (*Atriplex confertifolia*). Joining them is a species common in saltbush communities, but not itself in the saltbush family—Bud Sage (*Artemisia spinescens*). Most of these species grow as small, compact plants less than 50 cm (20 inches) tall with light-colored leaves.

Saltbush Scrub. Though saltbush scrub communities are common in higher salinity soils of lower desert plains and basins, they are also established on rocky soils of higher desert slopes. Because they are found in various adverse conditions growing in poor substrates, they may occur above or below creosote scrub and other communities. We will look at them now and venture into the creosote and cactus scrub after we finish our descent into alkaline basins. Joining the previously noted shadscale shrubs and low-growing shrubs from other desert communities are other members of *Chenopodiaceae*, the saltbush family, including Allscale (*Atriplex polycarpa*) and Greasewood (*Sarcobatus vermiculatus*). Desert Holly (*Atriplex hymenelytra*) grows whitish leaves with pronounced edges resembling holly. These attractive compact bushes stand out against darker backgrounds as if planted in desert gardens. The list of *Atriplex* species which represent various saltbush is extensive. Saltbush scrub also shares a number of annual and perennial grasses and herbs with other plant communities.

Tumbleweed (*Salsola iberica*) is an introduced weed from Asia also called Russian thistle. It thrives in areas overgrazed and near disturbed and irrigated farmland. These roundish, thorny plants become dried and detached, rolling with the wind and spreading their seeds as they go. By the 1900s, they were widespread throughout the west and had become common nuisances in saltbush scrub and many other California plant communities. Annoyed California residents have used many colorful names (such as "Volkswagen Eaters") to describe these uninvited guests who roll into yards or across roads at the most inconvenient times and places.

Alkali Sink. By the end of the Ice Age, more than 10,000 years ago, California's great inland lakes were evaporating, leaving high concentrations of salt in the remaining trapped ponds and in the basin soils. Since then, floods have carried more minerals into inland drainage basins while still more water has evaporated from capillary action below the surface. Concentrations of salts are left behind and only halophytes—salt-tolerant plants—can survive.

Moving down the better-drained desert slopes toward the alkali sink, the vegetation gradually changes from saltbush scrub to the most salt-tolerant halophytes.

These communities are spotty in lower basins of the Basin and Range through the Mojave and into the Colorado Desert. They are closely related to, and share species with, their coastal marsh counterparts. Although these desert habitats experience much greater variations in temperature, it is interesting that we have traveled so far across California's plant communities only to find such similar plants and habitats.

More saltbush with light-colored and scaly leaves include Allscale or Cattle Spinach (*Atriplex polycarpa*) and Wingscale (*Atriplex canescens*). As salt content rises to near 1 percent, Seepweed, Inkweed, or Desert Blite, and Sea Blite (*Suaeda* spp.) splash dark gray shades just above the salt pans and once provided much of the black ink for Native American art work. In saltiest conditions approaching 2 percent, Pickleweeds (*Salicornia subterminalis*) appear with their leafless, sectioned, jointed stems. These succulents store water and drop excess salt with their dead stems. Iodine Bush (*Allenrolfea occidentalis*) resembles pickleweed and is another common halophyte in these salty brews.

Various rushes, reeds, and cattails grow in wetter locations. Where water is near the surface, phreatophytes such as Honey Mesquite (*Prosopis glandulosa*) can grow tap roots down nearly 10 m (33 feet) deep. These winter-deciduous legumes grow small leaflets during spring and long bean pods. They once represented an important staple food for California Indians and are still vital to local wildlife.

Scraggly but bushy Salt Cedar (*Tamarix* spp.) were introduced from Eurasia and have aggressively taken over near many water sources. They also have extensive roots which can tap and deplete underground water sources as their leaves transpire tremendous amounts of water. These species may also be found in or near sand dunes where groundwater may be tapped. Efforts continued in the twenty-first century to eradicate these water bandits where they were threatening local aquifers.

Creosote Bush and Cactus Scrub

The Oldest Plants Are Also Common. We now skip back above the salty basins but below the higher desert woodlands and sagebrush scrub, mostly on well-drained soils. Here, the most common shrub throughout the Mojave and Colorado Deserts grows. Because Creosote Bush (*Larrea tridentata*) survives in many different desert microenvironments, it is widespread and it may be the single plant most people associate with California's desert landscapes. It does not tolerate the extreme cold and prolonged frost of the higher desert terrain but, because it does tolerate extreme heat and prolonged drought, it is often dominant in middle- and lower-elevation deserts. This leaves it a wide range throughout transmontane southeastern California.

It also means that it may creep into and mix with other desert communities; myriad other species, including many cacti, may be associated with it throughout these various microenvironments. Creosote bush is common in areas of the Sonoran Desert, where precipitation peaks during the summer monsoon season. It also thrives into California's Mojave, where summer thundershowers are infrequent and unreliable, and peak precipitation occurs during the cool winter season.

Photo by Rob O'Keefe.

Figure 5-16 Around Anza-Borrego Desert State Park, you will find different species of cholla and barrel cacti, yucca, ocotillo, and other typical low desert plants. Here, extreme summer heat follows spring's wildflower displays.

The creosote bush grows small, dark green leaves with thick waxy coatings that provide pungent aromas during rainfall. The plant drops many of its leaves during drought, but after about 2.5 cm (1 inch) of rain, it grows fresh leaves and numerous yellow blossoms to attract pollinators. Its roots expand out away from the plant, robbing soil moisture from new growth which cannot compete.

The results are almost equally spaced bushes resembling a well-planned park environment. It has been discovered that rings of "clone" plants sprout from these extensive root systems. When botanists consider all the cloned shrubs growing out from an original plant's root system to be the same plant, they are the oldest plants in the world. One "King Clone" in Johnson Valley was found to be more than 11,000 years old and another near Yuma is even older.

Numerous other shrub species are associated with creosote bush scrub in the Mojave Desert, including plants more common in adjacent communities. Common and scientific names often reveal characteristics of these shrubs. White Bursage (*Ambrosia dumosa*) is a short gray bush with small leaves that often grows with creosote. The peculiar inflated stems of little Bladderstem or Desert Trumpet (*Eriogonum inflatum*) often line disturbed sites such as roads like so many holiday decorations. Burrobush (*Hymenoclea salsola*) and various saltbrush (*Atriplex* spp.) are other members of the long list of shrub species.

Moving into the Cactus Scrub. Other species are more common in the Colorado Desert and often associated with cactus scrub. Desert Agave or Century Plant (*Agave deserti*) grows thick leaves from its base. After about 20–25 years, it sends up a stalk which grows up to 30 cm (12 inches) per day to blossom with large yellow flowers that attract bats. Jojoba (*Simmondsia chinensis*) grow from California's lower Colorado Desert well into the Sonoran Desert of Arizona and Mexico. It has flat, waxy leaves. Female plants produce fruits with the high quality oil harvested in today's jojoba plantations scattered from southeastern California and beyond.

Brittlebush or Incienso (*Encelia farinosa*) drops its leaves and becomes brittle during drought. It grows fresh leaves and is covered with brilliant yellow sunflowers after heavy rains. Other *Encelia* species are common. The tall, dead-looking, thorny sticks that radiate out from the base of the Ocotillo (*Fouquieria splendens*) and point up to 5m (16 feet) high are also ***drought-deciduous***. After about 2.5 cm (1 inch) of rain, these stems erupt with small green leaves on the side and brilliant red tubular flowers at their ends to attract hummingbirds. Each ocotillo can repeat this cycle up to seven times/year.

The cactus family (*Cactaceae*) is represented so well in these California communities that many biologists place them in a separate community. They are well adapted to compete in the hot, dry conditions of the lower desert but are not tolerant of prolonged frost or severe cold. By growing shallow, widespread roots, they can gather water quickly during rare downpours. They survive by storing water, reducing leaf surfaces, and growing spines and thorns for protection from desiccating winds and intense sun. Their spines and the acidic nature of their stored moisture also protect them from hungry and thirsty animals. They are most common on rocky or other well-drained surfaces of California's lower Colorado Desert.

Barrel Cactus (*Ferocactus acanthodes*) is the largest, most robust of the common California cacti. It thrives in open, rocky locations. Various species of cholla (*Opuntia* spp.) are densely covered with spines and have common names which help describe them, such as Staghorn (*Opuntia echinocarpa*) and Teddybear Cholla (*O. bigelovii*).

Teddybear are sometimes called jumping cholla. When spiny sections break off, they might get caught in an animal's fur or in your clothes or skin. The painful barbs are difficult to pull out, but the attached cactus sections may grow to new plants after they have been transported and dropped—an effective method of dispersal. They don't really jump, but they can be annoying to careless travelers. Some of the most impressive and accessible stands of these cacti are at Cholla Gardens in southern Joshua Tree National Park, where some plants grow taller than the humans on the nature trail.

Beavertail Cactus (*Opuntia basilaris*) really grow big pads resembling beavers' tails. Different species of prickly pear cactus follow their showy flowers with scrumptious red fruits which serve as feasts for wildlife. The famous Saguaro Cactus (*Carnegia gigantea*), with its massive arms twisting majestically skyward, is found naturally only in a few spots in California just this side of the Colorado River. You will find them especially east of 114 degrees longitude in eastern San Bernardino County's Whipple Mountains. They become common on well-drained slopes in southern Arizona and northern Mexico, where annual precipitation peaks during summer. The exalted saguaro, often a symbol of the desert southwest, has been introduced into landscapes of the Coachella Valley and into films and pictures of southern California landscapes where it usually does not belong.

After it rains, most plants in these communities must display showy flowers to compete with other species for attention from pollinators. The list of ephemerals which contribute to colorful spring displays is far too long for this review. Lupine, brome, gilia, pincushion flower, desert star, fiddleneck, popcorn flower, and many other colorful names still fail to do these species justice after a wet winter. The few annuals that flower after late summer thundershowers become more numerous toward the southeast, across the Colorado River and the Mexican border.

Animals of the Desert Scrub. Desert animals are presented with a series of difficult challenges including extremes in temperatures, lack of reliable water sources, and limited food production during drought. Unusual adaptations allow a surprising variety of animals to survive and even thrive in these conditions. Many desert animals get their moisture from eating plants or other animals and excrete very concentrated waste, saving moisture. Larger animals and birds can move to water sources, while others must escape the heat and drought by burrowing or seeking other shelter. Ectothermic animals have an advantage in the desert because they gain much of their heat from the environment, rather than by metabolism, which uses more energy. Many animals will pant to cool off after overheating. Here is a partial summary of the busy animal world in a typical California desert scrub environment.

Ants, bees, beetles, butterflies, and moths are some of the pollinating insects that become more common when their targeted flowers are in bloom, especially during spring. Tent caterpillars live in colonies behind their webs, often feeding on desert plants in the rose family. Beetles and millipedes feed off decaying organic debris at the base of many shrubs. Black stink beetles will often point their abdomens upward and emit a foul liquid when threatened. Crickets, katydids,

and many kinds of spiders are also common. Scorpions wait for their prey (usually other arthropods and often other scorpions) at night, then sting and crush it. Tarantulas attack and eat prey that venture into their webbed burrows. The large, black tarantula hawk is a wasp which seeks out and paralyzes the tarantula so that its larvae may feed from the spider.

Reptiles usually eat insects and other animals, with exceptions such as California's largest lizard, the chuckwalla, which is a vegetarian. This usually dull gray or black lizard is already plump but wrinkled and it can store water under its skin. When threatened, it may lodge itself into rock cracks and inflate so that it cannot be pulled out. Numerous other lizard species are active in the desert scrub.

All snakes are carnivores. Rattlesnakes are pit vipers that sense out their prey, stun them with powerful venom, and then follow them until they drop. They can swallow mammals larger than their heads. The Mojave rattlesnake has some of the most potent venom. Though California rattlesnake bites cause painful swelling and illness, they very rarely are deadly to the careless humans who have forced snakes to defend themselves. The best advice to relieve symptoms is to get the victim to the nearest hospital.

The lethargic desert tortoise can store up to one liter (quart) of water. It is now a threatened species partially due to those who have taken them for pets, run them over with vehicles, or used them for target practice. However, the large aggressive raven populations that have exploded in recent decades are primarily responsible for the more than 90 percent decrease in desert tortoise populations, which occurred within 50 years ending in the late twentieth century.

Various toads become active after desert rains. Couch's spadefoot toad comes out of its burrow, mates, and lays its eggs in temporary ponds. Within a month, the larvae grow into tadpoles, grow legs, then leave the water just in time to burrow—as toads—to escape the drought with their stored water. They will emerge when the thunder and rain return.

Desert wood rats gather debris, including sections of cholla, to make their nests. They rely on such plants as prickly pear cactus for their moisture. Kangaroo rats scrape and discard the salt off saltbrush leaves, which have high water content, before eating them. They can live their entire lives without drinking water; with very concentrated waste, they are one of the best water conservers in the desert. Protected in their burrows by day from the desert heat, they even eat their waste to gain the moisture back. Like kangaroo rats, pocket mice and ground squirrels often feed off seeds from shrubs and make their burrows under protective canopies of those same plants. Grasshopper mice are deadly, aggressive predators. They eat insects and attack scorpions by first biting off their stingers. They even attack and eat other rodents. Bats use their sonar to feed at night when temperatures are lower.

Jackrabbits are the hares with giant ears that allow rapid heat loss. Cottontail rabbits have shorter ears; they live in burrows and become active at night in summer to escape the heat. Coyote occasionally feed on them after running them down, as they dart from bush to bush.

Desert Scrub Birds. Several birds, such as cactus wren, have learned to make nests in spiny chollas or other cactus for protection. Hummingbirds are important pollinators of specific tubular flowers. The phainopepla is a dark bird with a large crest which often rests on the top of branches when it is not consuming seeds of the desert mistletoe. These seeds are distributed to other plants in its droppings, disbursing the mistletoe.

Many birds (including verdins, swallows, flycatchers, gnatcatchers, swifts, and wrens) feed off desert insects. Some of these are gleaners, and all of them gain moisture from their food. Common raven populations increased more than 300 percent in parts of the California deserts during the 1900s and they pose a serious threat to native species, including the desert tortoise. Roadrunners rarely fly, but these cuckoos can run and glide with their long tails up to 24 km (15 miles) per hour. They will eat berries and insects, but they may be more famous for their attacks on small mammals, lizards, and even rattlesnakes.

This is just a sample of some of the activity among the many animals living in what unknowing visitors have labeled a desert "wasteland."

◆ DESERT WASH, RIPARIAN, AND OASIS COMMUNITIES

Habitat and Structure

Limited water is most responsible for restricting biomass and species diversity in California's transmontane deserts. Therefore, it is no surprise that ribbons of larger plants and lusher growth follow dry washes. Here, water may only briefly flow, then disappear below the surface but still within reach of root systems. As expected, the growth may become dense thickets or even strips of

gallery forests where surface water is found most of the year and where richer soils remain moist year-round. These conspicuous interruptions in the dry scrub represent just a tiny fraction of California's desert landscapes. They also represent vital watering holes and production zones for site-specific plant and animal species and for animals capable of commuting in from great distances from around the region.

There is great diversity in these plant communities. Where surface water flows rarely over impermeable bedrock of desert washes, there may be only subtle changes in the monotonous desert scrub, but where there is permanent surface water or thick sediment and abundant groundwater, there is an explosion of life and activity. Abundant growth is rarely established in the middle of braided channels that carry the most destructive flash floods. However, these events are often responsible for depositing rich sediment, dispersing seeds, and increasing species diversity from the wash channel to its outer banks. The common larger shrubs and small trees are often deeply rooted and deciduous.

Desert Wash Plants. Honey Mesquite (*Prosopis glandulosa*) is one of the most common of the tall shrubs or small trees to inhabit the desert wash. Joining the Honey Mesquite is a similar member of the numerous legumes, Catclaw Acacia (*Acacia greggii*). These legumes grow long seed pods that were important food sources for Native Americans and are still vital to the survival of so much wildlife. Roots of some young plants have been known to grow up to 10 cm (4 inches) per day until reaching soil moisture. Then, the plants can safely establish surface growth, sometimes years later. Numerous sharp barbs growing on its stems also earned catclaw its other name—wait-a-minute-bush.

Figure 5-17 California fan palms are only native to the state's southern desert oases. They often grow where water seeps out of upstream faults and flows down through canyons. You might find them from Joshua Tree National Park to Palm Springs and Anza-Borrego, but any palms you see on the coastal side of the mountains were imported.

Photo by Rob O'Keefe.

Other common members of the pea family include the Palo Verde (*Cercidium floridum*). It gets its "green stick" name from the chlorophyll in the bark that remains after it drops leaves during severe drought. Smoke Trees (*Psorothamnus spinosus*) rarely have leaves, but literally appear like ghostly gray puffs of smoke only along washes of California's lower, southeastern deserts. Like all the species named so far, the evergreen Ironwood (*Olneya tesota*) seeds rely on flash floods to tumble, scarify, and crack them to germinate. This further restricts them to desert washes.

There are many willows common to these communities, but Desert Willow (*Chilopsis linearis*) is often found lining washes of the Mojave, even though it is not a true willow. It does have long narrow leaves, but its pink flowers resemble snapdragons and its seed pods resemble beans.

Numerous desert wash shrubs may also be found in the open desert, but many species, such as Arrow-weed (*Pluchea sericea*) are usually restricted to these wetter sites. Arrow-weed stems were gathered by California Indians for making baskets and arrows. Chuparosa (*Justica californica*) is actually a tropical-like shrub with long, red tubular flowers. Burrobush or Cheesebush (*Hymenoclea salsola*) produces a rancid cheesy aroma when it is crushed between the fingers. Many other shrubs, such as Broom Baccharis or Desert Broom (*Baccharis sarothroides*) grow along with these plants. This nearly leafless plant with broom-like stems may grow up to 4 m (13 feet) high in wetter habitats.

The open sediments and sands of these washes are often splattered and sometimes covered with the spectacular colors of desert wildflowers in spring. The size and density of these ephemeral herbs often depends on temperatures and especially the amount and timing of seasonal rainfall.

Plants of Desert Riparian and Oasis Communities. Diversity and biomass often increase where more reliable water sources are available at or near the surface. Different species of willow (*Salix* spp.) become common and may combine with sedges, rushes, and cattails to form thickets. Various other willow-like shrubs join arrow-weed, including the similar Mule-fat or Seep-willow (*Baccharis glutinosa* or *salicifolia*). Joining and similar to desert broom is a common indicator of water, Squaw Waterweed, or simply Baccharis

CALIFORNIA DESERTS' ECOLOGIC ISLANDS AND SAND DUNES

Habitats and Structure

Transmontane deserts, like cismontane California, contain ecologic islands. These are sometimes islands of plenty, such as the oasis communities previously outlined. Often they are islands of even greater adversity, such as the alkali sinks with their halophytes or areas of poor soils, such as those weathered from limestone and dolomite, where specialized plants such as bristlecone pine grow. The formation of stark desert pavement, lacking surface soils, was a subject of Chapter 3 on California's geology and geomorphology. Spineflower or Spiny Herb (*Chorizanthe rigida*) is a tiny, spiny buckwheat annual that turns into a prickly, dried protrusion up to a few cms (inches) above the hot, stony surfaces. There are few competitors in these dried infernos!

We end our journey through California's plant communities in its desert sand dunes. The formation of such great dune fields—from the Basin and Range's Eureka, Death, Panamint, and Owens Valleys, through the Mojave to the Kelso Dunes and Devils Playground, to the Colorado Desert's Algodones Dunes—was a subject in Chapter 3. Though dune sand covers less than 5 percent of California's deserts, that is still a lot of land within such vast deserts of such a large state. Here, we examine some of the life within California's desert dunes.

It is fitting that these communities have so much—and so many plants—in common with the coastal dunes where we began our journey in this chapter. To recognize how plant communities so geographically detached can be so similar helps us to understand the connections between the many regions and diverse settings that make California such a fascinating state. Like their counterparts along the coast, many desert dune plants have fast-growing and extensive underground rhizomes which help anchor the plants and stabilize the dunes. Some are phreatophytes with deep tap roots that grow down to the water that first percolated through and was then trapped below the sand. When their roots find moisture, these normally small shrubs may grow much larger on and near the dunes. Herbaceous ephemerals may grow quickly following rare heavy rains, produce flowers, then seeds, and die back during the intense drought certain to follow.

Plants. Some of the most noticeable species also grow in other communities. They include creosote, saltbrush, indigo bush (*Psorothamnus* spp.), Mormon tea, mesquite, and desert willow in the Mojave and Palo Verde in the Colorado Desert. They are joined by perennial grasses which include endemics such as Eureka Dunegrass (*Swallenia alexandrae*), found only in Inyo County, where its expanding underground rhizomes follow shifting sands.

Most of the wildflowers are low-growing, spring-flowering, herbaceous ephemerals. These include Dune or Evening Primrose (*Oenothera* spp.), with its large white flowers, which open in evening hours to attract moths, and Sand Verbena (*Arbronia villosa*), which grows rose to purple flowers on a vine. Another vine-like plant is the Coyote Melon (*Curcurbita* spp.), which grows gourds known as Calabazilla or Buffalo Gourd. The white Desert Lily (*Hesperocallis undulata*) grows a large, deeply buried, onion-like bulb also known as the Ajo. Desert sunflowers,

Figure 5-18 Plants hold on to shifting sands at Kelso Dunes. Their roots anchor them and help stabilize the dunes. Months without rain and searing summer heat make this a challenging, dangerous habitat for any living creature. At night, the dunes come alive with prey and predators looking for dinner.

CALIFORNIA DESERTS' ECOLOGIC ISLANDS AND SAND DUNES (continued)

marigolds, dicoria, codenia, and spanish needles are just some of the common names within the longer list of wildflowers that may appear after rare rainfall. The Algodones Dunes alone contain six plants that occur nowhere else in the world. There are at least eighty-five species endemic to all of California's deserts, making their contributions to the state's diverse and unique natural settings.

Animals. Numerous pollinating insects gather nectar from dune wildflowers. Beetle tracks and the tracks of many small mammals are common on the desert sands, sometimes with the coyote in pursuit. Most of the animals found in these communities are common in other desert habitats and have been previously noted, but there are several animal species that are particularly successful in the dunes.

Fringed-toed lizards live in wind-blown sand and are built to dive so quickly into the sand, they are said to be sand swimmers. Zebra-tailed lizards have side bands and black zebra-like bars on the bottom of their tails. Their speed has been clocked up to 29 km (18 miles) per hour as they sprint on hind legs with their tails curled behind. Various rattlesnakes are found around the dunes. They usually don't rattle unless they are threatened by a larger animal. The sidewinder is an example of a rattler perfectly adapted to the sand. It hides its body in the sand with only the head up, waiting for a potential dinner, usually an unfortunate rodent. The sidewinder can accelerate to impressive speeds with its meandering or side-winding locomotion.

A hawk may soar near the dunes in search of its next victim among the activity below, while the vulture will wait for the desert to eliminate a weaker individual. The migrant birds and other species have left long before the days of severe heat and drought, and on those days when the sand gets blistering hot, the animals wait in shelter, mostly below the sand. At dusk, the desert again erupts in life. Birds such as poorwill and nighthawk hunt for insects well into the evening, and owls swoop down on unsuspecting prey. As the desert kit fox darts around the sand, it is certain that there will be tiny tracks leading only away from more than one little mammal's burrow. These are tracks of the latest victims of nature's grand cycle, victims that will never return to those burrows.

(*Baccharis sergilloides*). Joining honey mesquite is a similar legume growing to tall shrubs or small trees and producing twisted bean pods—Screwbean Mesquite (*Prosopis pubescens*).

Velvet or Arizona Ash (*Fraxinus velutina*) grow to small trees in riparian strips of desert mountains and into the Sierra Nevada. The larger Fremont Cottonwood (*Populus fremontii*) is a sure sign of more prominent and permanent sources of water; they even combine in strips of forests along the few more permanent water courses (such as the Mojave River) of California's deserts, where seedlings thrive in deposits of fresh, moist silt.

Introduced species, such as the previously noted Tamarisk or Salt Cedar *(Tamarix* spp.), may become problem invaders when they aggressively compete with natives for water. They were once planted as wind breaks, but one mature tamarisk can draw and transpire nearly 50 liters (14 gallons) of water per day. Their extensive roots grow rapidly. Today, aggressive thickets of tamarisk seriously deplete desert water sources throughout southeastern California. When tamarisks are removed, water returns, followed by natural vegetation.

California Fan Palm (*Washingtonia filifera*) is California's only native palm tree. It grows naturally in riparian and oasis communities from Twentynine Palms and Joshua Tree National Park south into Baja California. Some famous place names in California's deserts—including Thousand Palms, Palm Desert, and the Palm Canyons of Palm Springs and Anza Borrego Desert State Park—are identified by their impressive palm oases. These relic palms were stranded and isolated along and below desert springs—with desert species previously noted—thousands of years ago, as climates became drier. They are usually found along or downstream from faults where rocks have been crushed, ground, and weakened, allowing groundwater seeps and natural springs to erupt. Over millions of years, they have also been gradually dragged toward the northwest from Mexico on the west side of the San Andreas Fault.

Growing the largest leaves of any California desert plant, they require perennial sources of water. The seeds are distributed by birds, such as the American robin, and other animals, such as the coyote. Native Americans used their fibers, ate their fruits, and also distributed their seeds. Like so many other California plants, California fan palms benefit from fires that

clear the surface of competitors and allow seedlings to thrive. Along with other palms from around the world, they have been introduced especially into cismontane central and southern California, where they thrive when nurtured. The palm trees people often associate with Los Angeles, Hollywood, and the southern California coast have all been introduced into a Mediterranean region where they do not belong.

Animals of Desert Wash, Riparian and Oasis Communities. Many of the previously noted desert animals live within or frequently visit these water holes. They will not be repeated here.

Nearly half of California fan palms have tiny holes caused when giant palm-boring beetles lay their eggs. For years afterward, the larvae drill tunnels in the palm wood. Females of the southern California carpenter bee use the beetles' exit holes to raise their young.

Mule deer visit riparian and oases communities for water and fresh green meals. Coyotes come for the water and the abundant smaller prey living within the protection of the dense vegetation. Desert bighorn sheep come to eat leaves and shrubs and must drink regularly.

At least eleven different pupfish and five killfish were isolated in water bodies after the end of the last Glacial Period, when transmontane California's interior drainages began to dry and disconnect. These tiny species of fish have actually adapted to different temperature, chemistry, and other conditions unique to each of the remaining ponds.

Black-chinned sparrows, Gambel's quail, gnatcatchers, and ladder-backed woodpeckers may remain in California desert oases. Other sparrows visit for the winter, and warblers and others visit in spring, while grosbeaks, hooded orioles, and flycatchers fly in during summer to feast on oasis plants and insects.

If not permanent homes, these islands of food and water serve as crossroads, rest stops, and places of congregation for numerous animals.

◆ PLANTS AND ANIMALS INTRODUCED BY HUMANS

Throughout this chapter, we have reviewed some of the ***introduced species*** that have invaded, competed, and thrived in California's natural and not-so-natural plant communities. As the list of intruders grows, they often place more stress on organisms already challenged. These invaders become common and successful in disturbed sites, particularly where the human imprint is more pronounced.

Considerable attention has already been given to non-native invaders that have been particularly aggressive and successful in the state's grasslands. Mustards, thistles, and a mint called horehound are examples. Perhaps the most famous of all weeds is the notorious tumbleweed, another species that earned considerable attention in a previous section.

Of course, people have also purposely introduced and nurtured plants and animals that, for various reasons, they perceive as more attractive or useful than California native species. Even where invading beach and dune grasses haven't taken over our beach dunes, ice plant and other ground cover have often been purposely introduced to stabilize dunes. The saguaro cactus has been transported west of the Colorado River into the Coachella Valley and beyond. California's native fan palm now decorates landscapes throughout southern and central California, far beyond the confines of its original desert oases. With a little water, other palms from around the world are thriving, but only the fan palm is native to California.

We will end this chapter by listing a few of the more common non-native species that pose problems as they squeeze out the natives in California wildlands. They range from edible figs to various European brooms, from giant reeds to pampas grass (*Cortaderia* species). Fennel, with its strong licorice smell, is another example of an aggressive non-native. Biologists estimate that up to 20 percent of the plant cover in the state's open lands consists of introduced invaders. Even California farmers are battling opportunistic weeds that cut into agricultural production and profit.

The ubiquitous eucalyptus is a good example of what can happen when a non-native species is introduced for what seems to be a good reason. When this invader from Australia failed to provide valuable wood to a growing California, it was used for wind breaks and shade. It thrived in the Mediterranean climate, but it is a ragged tree that can, without warning, drop huge limbs. In groves, eucalyptus represents a serious fire hazard. Residents of the Oakland hills learned this fire lesson the hard way in the 1990s.

After burros used as pack animals broke loose from early California prospectors, they quickly multiplied and populated California deserts. Burros had overgrazed and damaged thousands of square miles of California desert scrub before government agencies from the Bureau of Land Management to Death Valley National Monument (now National Park) advertised their adopt-a-burro program during the 1980s. Many of the big-eared invaders were successfully rounded up and given homes by burro lovers, allowing some desert scrub to recover for bighorn and other natives and grazers.

Fire Ants and Killer Bees Threaten

Red imported fire ants from South America first invaded the southern United States during the 1900s. By the twenty-first century, they were established in many of the California valleys that do not experience long periods of below-freezing temperatures. From the Central Valley south, they were building mounds the size of basketballs as they crowded out established ant colonies and aggressively attacked any invaders. When disturbed, these red ants launch massive attacks that include painful stings laced with venom. They forced some families to abandon their backyards. As officials search for an efficient way to eradicate these pests, fire ants are expected to increase their range and become a greater problem in California well into this century. They are also threatening agriculture, including the state's nut and fruit trees.

Africanized "killer" bees arrived in southern California by the late 1990s. By 2005, they had colonized southern California and into the San Joaquin Valley. The similarity to the fire ant problem is striking. They first made their way north from warmer Mexican climates. Once established, they become hyper-defensive and hyper-aggressive. If disturbed or threatened, Africanized bees may launch aggressive attacks, inflicting hundreds of painful stings on their victims. Some of the attacks on humans and other animals have been fatal. They represent yet another example of how introduced species can be more than just a nuisance to Californians.

Wild horses have created similar problems by overpopulating and overgrazing rangelands. When non-native animals are introduced, it may be reasonable to consider any number of them as enough to overpopulate our wildlands. These are only examples of some of the dilemmas presented to those who manage our rangelands, wildlands, and wildlife each year.

The list of intruders goes on and is especially evident in or near California's waterscapes. They include crayfish consuming our California newts, habitat destruction and non-natives eating away at numerous native fish species, European green crabs munching their way along the coast, and Chinese mitten crabs burrowing in levees and clogging pipes in the Delta. Non-native frog and turtle species were considered in more detailed sections of this chapter.

One of the most notable controversies erupted after the aggressive northern pike was somehow introduced into Lake Davis in the northeastern Sierra Nevada in 1994. State wildlife officials poisoned the lake in 1997 to kill the pike before the fish could spread to threaten the state's aquatic industry. All other fish and insects in the lake—including its famous trout—were also destroyed by the poison; nearby Portola lost its water supply. The chemicals unexpectedly lingered for more than 9 months, well into the summer, resulting in painful losses to local businesses. Still, the northern pike rebounded. By 2004, officials had spent more than $14 million using nets, explosions, electric shock, and chemicals, but the California Department of Fish and Game still worried that it would spread to neighboring waterways.

Many of the scores of plants and animals introduced into the state by commercial agriculture are examined in Chapter 9 on primary industries. Accompanying the new plants and animals are a host of introduced pests, weeds, and diseases that threaten the state's agricultural production each year. These have also earned considerable attention in Chapter 9.

◆ HUMANS ENCROACH ON ANIMAL HABITATS

Throughout this chapter, we have examined scores of California's plant and animal species that are ***threatened***, more seriously ***endangered***, or even extinct. They range from some of the tiniest plants and insects to the long-extinct California grizzly bear. The introduction of foreign competitors and predators, encroaching developments, and other human activities are challenging the very survival of countless native species across the state. Debates about how to save these species involve which habitats to preserve and which developments and other human activities to curtail. Issues repeatedly fueling and complicating these debates involve private property rights and short-term economic profits.

Finally, we will focus on two more species that have not yet received the attention they deserve.

Thousands of bald eagles once soared free over California's coast and offshore islands. Their nesting numbers dropped to about twenty in the 1960s due to DDT, habitat destruction, and human encroachments. Extinction was a real possibility. Successful efforts by agencies such as the U.S. Fish and Wildlife Service and organizations such as the Predatory Bird Research Group at UC Santa Cruz (with help from legislation such as the 1972 Endangered Species Act) brought bald eagle nesting numbers to over 100 during the 1990s.

By the twenty-first century, a growing number of bald eagles were building their enormous nests near California's inland reservoirs, where stocked trout and other fish represent year-round food supplies. Up to eighteen eagles have been observed in their winter migrations to

Lake Cachuma. Nesting pairs were observed at San Antonio and Nacimiento Reservoirs near the Monterey/San Luis Obispo County border and at Skinner Reservoir in Riverside County. Officials upgraded the bald eagle's status from endangered to threatened in the 1990s and, by the end of the century, were urged to remove it from the listings under the Endangered Species Act. These are substantial improvements since the 1960s, when bald eagles had entirely disappeared from southern California.

The California condor's story is a similar one, except that it edged so close to extinction that there were finally no condors in the wild. The state's most famous vultures typically grow to about 20 pounds with a wing span of 3m (9 feet). But, California's largest birds became the most endangered. Costly efforts to save them included raising the remaining few condors in captivity, while teaching them to fear humans and survive in the wild. These painstaking efforts involved Ventura's Condor Recovery Program, the U.S. Fish and Wildlife Service, local zoos, and other organizations, such as the Audubon Society.

As their numbers grew in captivity (from less than 30 in the 1980s), condors were gradually freed. As expected, some never survived due to power lines, accidental poisoning, illegal shootings, and other incidents. By 2005, condor chicks had again hatched in the wild and for the first time in more than 20 years, one successfully flew out of its nest. By then, there were about 200 condors in California and a few other locations; about half were in the wild.

Notice the connections that must be made to understand and solve these problems that threaten and endanger our native plants and animals. Natural disasters, changes in weather and climate, water diversion and storage projects, increasing human populations, economic activities, cultural values, technologies, and growing urban areas all play important roles; each have earned entire chapters in this book. An understanding of the varied processes, cycles, and systems that are shaping California landscapes and how they are connected becomes extremely valuable.

◆ SOME KEY TERMS AND TOPICS ◆

beach
biomass
biome
climax communities
coastal sand dunes
drought-deciduous
ecologic islands
ecosystem
endangered/threatened species
food pyramid
habitat
introduced species
life zones
littoral strip
pyrophyte
sclerophyll
species diversity
succession
tree line
vegetation zones
xeric

◆ ADDITIONAL KEY TERMS AND TOPICS ◆

alpine
arctic-alpine
bighorn sheep
bristlecone pine
cactus scrub
California's Kansas
chaparral
cismontane communities
closed-cone forest
coastal coniferous forest
coastal sage scrub
coastal strand
creosote bush
desert biome
desert scrub communities
desert wash
Douglas fir
fire adaptations
grassland
indigenous
Joshua trees
limiting factors
meadow
Mediterranean scrub
mixed evergreen forest
montane coniferous forest
natives
oak woodland
oasis communities
piñon-juniper woodland
pioneer plants
red fir/lodgepole pine
redwood
riparian
sand dunes
scrub biome
sequoia
subalpine
temperate coniferous forest
temperate deciduous forest
transmontane deserts
tundra biome
vegetation structure
yellow pines