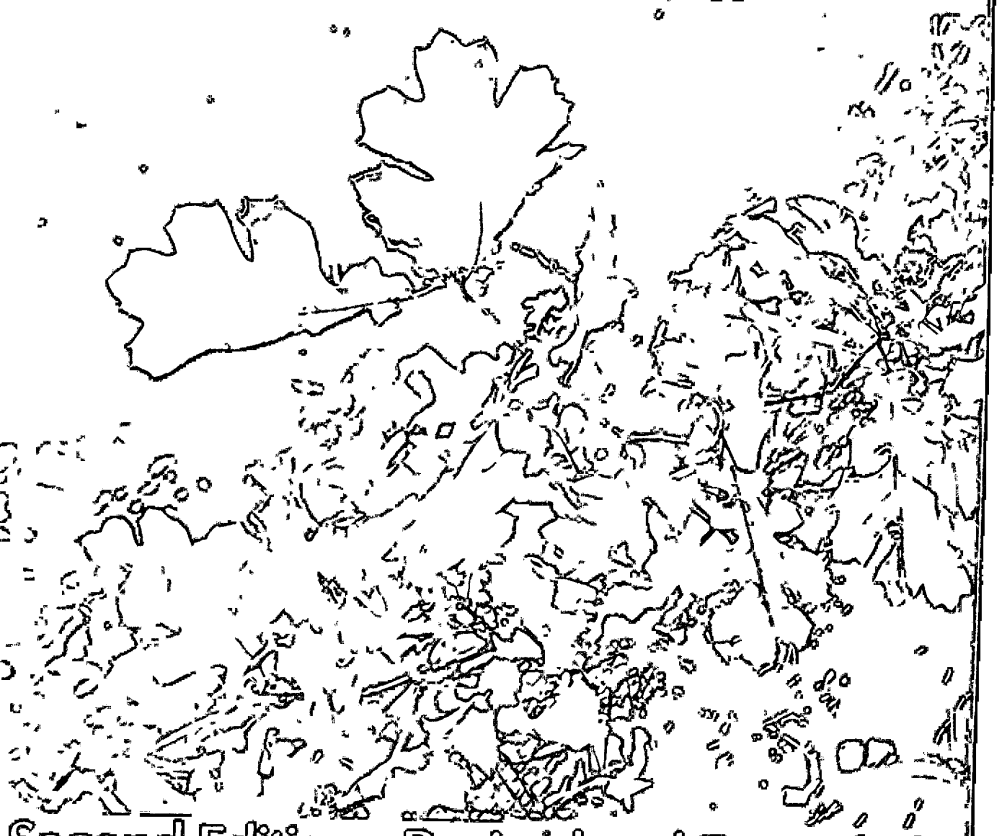
ELNA BAKKER

AN ISLAND CALLED CALIFORNIA

An Ecological Introduction to Its Natural Communities



Second Edition, Revised and Expanded

Summer Fog, Malibu Creek State Park

4. Patterns on the Hills

Anyone driving the 118 miles (190 km.) between Dubuque and Cedar Rapids, Iowa, on a summer day will see the following: some towns, several rivers, livestock, crop fields, other cars, people, billboards, buildings, and woodlots. They add up to a pleasing, prosperous-looking landscape or a deadly bore, depending on one's viewpoint. Central Iowa has its seasonal changes, but it does not have scenic variety. Considering its enviable position in the farming world, it probably doesn't care. Corn is King, and healthy stands of this crop are the best views possible to their owners.

In contrast, anyone driving the 15 miles (24 km.) from Mill Valley to Bolinas Lagoon (via Panoramic Highway) in Marin

County, just north of the Golden Gate, will pass through or alongside seven of the major natural communities found in California: chaparral, coastal scrub, grassland, coniferous forest, mixed evergreen forest, beach strand, and salt marsh. This mosaic of plant associations is quite bewildering to the casual observer. Why is grassland adjacent to a dense redwood forest? Why is there a patch of scrub here and a magnificent stand of Douglas-fir there? Common sense would suggest a reasonable uniformity of natural vegetation in the five crow miles between these two points. Marin County, however, is only a segment of many square miles of similar coastal landscape.

Two of the seven have already been discussed, salt marsh and coastal strand. Their most important determining features are obvious: the salt floods of the tide and the nature of their substrates. The other five are not as clearly self-explanatory. This chapter will deal with coastal scrub, grassland (or coastal prairie), chaparral, and mixed evergreen forest. The major coniferous forest types of this part of the transect deserve their own chapters as do other outstanding communities—foothill woodland, freshwater marsh, and streamside vegetation.

This crazy-quilt arrangement is characteristic of many California hillsides, not only sea-facing flanks. The inner Coast Ranges, those east of San Francisco Bay, for example, may have slightly different floras, but they share many species and communities with the fog-hooded mountains to the west. In many places man has seriously disrupted this natural patterning, and it is difficult to guess what the native vegetation was like. Eucalyptus and Monterey pine—the first from Australia and the latter, though a California native, once confined to isolated groves immediate to the sea—replace natural tree and shrub growth. Orchards and crops, to say nothing of urban sprawl, have all but obliterated any hints of the original plant cover. But enough wild country remains throughout much of central California, making it possible to surmise what was once there and bring it into ecological focus.

This part of the state, hill-and-valley California, engenders its own special kind of love and loyalty. To most people acquainted with the region the phrase "rural California" means tree-sprinkled hills and ranches snug in valleys reached by wandering dirt roads. Unless they are really familiar with the geography of the West, few people will think of the flat farm

acres of delta rice or Fresno orchard. Popularly, countryside California is pastoral California, the gentle topography of coastal range and foothill slope. Before we begin to discover some of the answers to the puzzle of their occurrence, it is appropriate to describe each of the four communities that lie in such curious patterns on the hills.

Coastal Scrub. To someone without botanical training this low-growing shrubby cover looks much like true chaparral, which often occurs above it on coastal bluffs. Many species are common to both communities, yerba santa, coyotebrush, and poison oak, for example; but coastal scrub is characterized by the predominance of subshrubs, 1 to 5 feet (.30–1.5 m.) in height with semiwoody stems growing from a woody base.

Two main types of coastal scrub have been described. The northern assemblage—called northern coastal scrub—spreads northward from Monterey County to southern Oregon in patches that are often interrupted by other communities described in this chapter and elsewhere. Its southern counterpart—coastal sage scrub—extends south to Baja California. A broad transition zone begins in northern San Luis Obispo County and continues northward to Marin County. Several southern species, with their characteristic summer drought leaf-dropping habit, contend with coyotebrush, the dominant plant of the northern community, creating a relatively open, one-storied cover on the coastal hills. California sagebrush is much in evidence as far as its northern limit in Marin County, but black sage loses ground in Monterey County though it persists inland to Contra Costa County. Such visitors from the south are gradually replaced by species more typical of northern coastal scrub until the community emerges as distinct, mesophytic (more moisture-requiring) vegetation near Point Reyes Peninsula. It has a low-growing cover of shiny-leaved salal, fronds of bracken and sword fern, snarls of poison oak and blackberries and other related berries, and a number of herbs, frequently rank in growth, including yerba buena, cow parsnip, golden yarrow, pearly everlasting, and a few grasses. Coyotebrush, the "beach bum" of the lot, blue blossom and other ceanothus, wax myrtle, and snowberry are often members of the shrub layer, though the whole collection may be understory to bishop pine and Douglas-fir.

As so often in California the community is a mixed bag of plants—contributions from grassland, chaparral, and forest whose input depends upon latitude and slope aspect as well as propinquity. In certain places along the northern coast several species of lupine are supreme, delighting us with their seasonal color that is in such contrast to the less showy coyotebrush. It appears that the prostrate varied lupine is successful near the lip of the sea bluff, coping with salt spray, strong winds, and perhaps higher summer temperatures, whereas tree lupine prefers a less extreme environment several hundred yards (meters) away from the bluff face.

California sagebrush and black sage are two prominent plants mentioned above and should not be confused. The sagebrush species belong to the daisy family and include the Great Basin sagebrush spreading over many miles of the arid West. The sages are in the mint family. Both groups usually have pungent, spicy odors. Everyone has personal tastes about smells, but to some the sagebrushes are more biting, almost acrid. The true sages have more a perfumelike essence just as their distant cousin lavender does. One of the delights of wandering through coastal scrub is its fragrance, as a number of plants of this community have leaves containing aromatic oils and resins. Whatever its local variations, coastal scrub is one of the typical vegetations of road cuts lining the hairpins of Highway One, in Marin County and south of San Francisco Bay, climbing over the bluffs above the beach, crowding in brushy fields between stands of evergreen trees.

Coastal Prairie. These bits and pieces of grassland on the outer ranges from Santa Cruz County northward contrast greatly with the shadowed groves of cone-bearing and broadleaf trees that are also a part of the coastal mosaic. In summer they look like scarves of gold velvet artfully draped over ridgetops and between the dark folds of redwood or Douglas-fir. Spring-green grasses, either native or introduced, blow in the onshore wind with grace and delicacy, but unless cropped by livestock, they are tawny tangles by summer. Wild bulbs such as Douglas iris, blue dicks, blue-eyed grass, and mariposa lilies, and other wildflowers embroider these open slopes, accompanied by sedges, rushes, and ferns.

Patches of prairie alternate with coastal scrub and forest on

maritime bluffs, extending inland some miles (kilometers) on warm slopes and ridgetop balds. Because of the relatively cool, humid climate along the north coast, the basic assortment is enriched by nodding trisetum, Pacific reedgrass, and tufted hairgrass, species common at higher elevations or in northern latitudes or both. A number of bentgrasses and a variety of melicgrass are found nowhere else than in these stretches of coastal prairie, accenting the uniqueness of these grassy "islands." The species more representative of northern habitats gradually lose ground southward along the coast, but many are common the length of the state. Most of the original prairie grasses are perennials; nevertheless, nonnative annuals such as wild oats and soft chess have encroached since livestock introduction, shouldering aside the old-timers and thoroughly altering the composition of the prairie. There is evidence, however, that the perennials are encouraged to return when grazing is restricted.

Like most meadowlands, these fields are tunneled by rodents. Meadow mice, sometimes called voles or field mice, are at home in the turf. They tunnel elaborate runway systems through the grass roots. Harvest and deer mice are plentiful in prairies. Harvest mice weave sheltering balls of dry grass; deer mice nests, lined with dry vegetation, are usually tucked in burrows or buried under logs and rocks. All of these small rodents eat seeds, berries, and other nutritious plant parts. Meadow mice are fond of green stems and leaves, and where the animals occur in large numbers they can be very destructive to crops and native vegetation alike. Mice are juicy feasts for keen-eyed and sharp-eared predators. Night-active habits protect harvest and deer mice somewhat, though owls and bobcats are constantly alert to their presence. Voles are busy at all hours. They are safe in runways, as long as their activities are undetected; but snakes, hawks, weasels, and the larger carnivores such as coyotes and gray foxes watch or listen for telltale movement and noises.

Chaparral. This is the typical brushy growth of the hillsides that means wild California to many people. It is the dangerous community in that so many destructive wildfires originate in

its highly flammable vegetation. It is also one of the most effective plant barriers against ground travel by the larger animals. Man and deer alike find mature chaparral with its profusion of stiff twigs almost impossible to enter. One can crawl through it, but this means of getting somewhere is fatiguing and painful. Imitate the deer and follow their trails if you go exploring.

The word *chaparral* has an interesting history. It comes from the Spanish, *el chaparro,* meaning the evergreen scrub oak. This in turn has a Basque root, *chabarra,* which also refers to scrub oak. The *-al* suffix is common to many of the Spanish place names throughout the West, being added to the root word to indicate the phrase "the place of." We get the cowboy's chaps from the leather pants or *chaparajos* he used when riding through this dense prickly cover. It must have been very gratifying to the Spanish settlers in California when they discovered a land so much resembling their own, even to the same type (though not the same species) of shrublike oak.

Though chaparral is one of our most distinctive natural communities, covering about 8 percent of the state, it is not confined to California. It occurs in southern Oregon, extends into Baja California, and even emerges as an upland island of brushy growth in central Arizona at about 4,000 to 5,000 feet (1,200–1,500 m.) in altitude. In southern California it spreads from nearly sea level to 5,000 to 6,000 feet (1,500–1,800 m.), wrapping around the Transverse and Peninsular ranges to mingle with the plants of the desert to the east and north. It continues up into the northern coastal mountains where it tends to remain in the inner ranges, and it is part of the foothill mosaic in some areas of the Sierra Nevada.

Chaparral consists for the most part of shrubs that are admirably adapted to a summer drought/winter rain climatic pattern. Its most active growth season is late winter and spring when soil moisture and air temperature curves meet for optimum growing conditions. Summer through early fall is the time for rest, unlike plants of regions having summer precipitation and cold winters where the frost season is the time of inactivity. Summer dormancy is shared by most chaparral plants, but some photosynthesis and other fundamental life processes continue throughout the dry months on a limited basis. This reduces both the need for water, an essential ingredient in foodmaking, and the gas exchange that though necessary in such processes unfortunately allows the escape of precious water vapor. In addition, the thick leathery nature of the leaves typical of these plants helps retard moisture loss. Evergreenness is also of survival value. It allows the plant to take advantage of rain whenever it arrives without having to produce a new set of photosynthetic equipment, that is, leaves. The fact that long-lived foliage uses nutrients more efficiently is important in less fertile environments as is the ability to store these necessary substances in leafy tissue for later growth.

All of these features are of great advantage when dry years hit, and the rainfall is less than normal. Brushy hillsides may suffer but are not put out of business; most mature, healthy shrubs manage to stay alive until the next rainy season. Many of these plants experience some leaf drop each summer, decreasing the amount of water-wasteful foliage, but during prolonged droughts the shrubs have recourse to another strategy. This is die-back—the loss of branches until only one or two life-sustaining limbs may remain.

In a subcommunity of its own, chamise, the most common chaparral shrub, often covers warmer, drier knolls and ridges with the uniform texture of broadloom carpetry, interrupted here and there by isolated clumps of other shrubs. Chamise has very small, needle-thin, water-conserving leaves, well adapted to its xeric (dry) sites. There is a rough correlation between leaf size and the aridity of the habitat—more mesic (moist) areas should support shrubs with larger leaves. Ceanothus, another genus of plants typical of brushy hillsides, tends to replace chamise on moister sites in northern California. A number of these species have leaves from 1 to 2 inches (2.5–5 cm.) long and half again as wide. Various manzanitas and scrub oak, other frequently encountered associates, also form chaparral communities of their own where local conditions permit. Mingling with these common brushy species are redberry, coffeeberry, silk tassel, hollyleaf cherry, chaparral pea, a number of currants and gooseberries, elderberry, and toyon, a handsome shrub that often becomes a small tree. A number of shrubs preferring more mesic places are winter deciduous—squaw bush and hazelnut among them—and drop their foliage during the cool season, but most of the species typical of xeric sites are faithful to the evergreen habit.

In addition to the water-conserving features discussed

above, other adaptations are characteristic of xerophytic (drought-adapted) plants. The steep, easily eroded slopes, so often home to chaparral, in general have soils that are thin, coarse, and incapable of holding much moisture during the drier part of the year. Most chaparral shrubs have two sets of roots, one long enough to tap moisture sources deep in fractured bedrock. The other is a system of lateral roots that takes advantage of moisture near the soil surface. Leaves of many species are cutinized, that is, have a varnishlike or waxy coating which serves to waterproof the leaf. Such leaves are often shiny, reflecting and thus reducing solar heating. The culprits responsible for most of the water lost from leaves are stomates, tiny openings in the leaf surface. The carbon dioxide for photosynthesis enters the leaf through these little pores, but transpiration, the escape of water in vapor form, takes place here as well. In idling away the long, dry summer, chaparral plants make less food, and the stomates need not remain open to permit the entry of carbon dioxide. Their closing obviously retards transpiration at the same time, an enormous benefit to these harassed plants. In many xerophytic species the openings are tucked down in pits, protected from drying air flow, or they are located on the under surface only. A few chaparral shrubs have leaves so oriented that just the edges of the blades receive sunlight rather than the broad leaf surface.

By no means is chaparral always the brown-green of the dry period. Urged along by the bounty of springtime, ceanothus sprouts little bursts of tender new foliage and blossoms in puffs of blue or white. Tree poppies display vivid yellow flowers that closely resemble those of herbaceous cousins. Vines like wild rose and wild peas, such as pride-of-California in San Diego County, spread pink blossoms over fence and shrub. Wild currants have sprays of rose and white. Pale lavender bells hang from yerba santa stems. The justly dreaded poison oak is one of the few coastal plants to turn a lovely crimson in late summer and fall before it loses its leaves completely. Toyon is aptly called Christmas berry. The clusters of its small beadlike fruit ripen to a brilliant scarlet in winter.

Herbaceous plants are not absent. These have juicy, in contrast to woody, stems and are usually what is meant by the term "wildflower." On the tops of road banks and in the more

open slopes, light and space encourage yellow mariposas and tidytips, star lilies, blue dicks, shooting stars, globe lilies, and the little pink and purple pagodas known as Chinese houses. In the rich wet soils of seepages and marshy places, look for yellow monkeyflower, miner's lettuce, buttercups, and cow clover. Lupine, fiddleneck, purple nightshade, bird's-foot trefoil, and tar-weed grow in roadside shoulders, while locoweed, clarkia, chia, paintbrush, several penstemons, and farewell-to-spring—that poetically named harbinger of summer—are at home in cracks and soil pockets of steep canyonsides and road cuts.

Though these brushy areas appear forbidding and formidable, they shelter a surprising number of animals within their concealing thickets, many with night-active habits. One well-known but seldom-seen mammal is the dusky-footed wood rat. Its stick-and-twig home may be several feet high and just as broad, containing a complex of runways and living quarters which it leaves at night to scout for house material and food such as leaves, bark, and fruit. Then it becomes interesting to nocturnal predators—owls, skunks, and ringtails. The wood rat's nest at times is more of an apartment house than a private residence. Lizards, insects, amphibians, and the commensal California mouse—one of the white-footed or deer mouse types—find the wood rat's construction efforts very convenient, and the mouse often robs its stored food. Gray foxes dig into wood rat lodges, tearing them apart with their front paws. Running skillfully through the stiff-twigged maze, these attractive members of the canine family are on the lookout for other small dwellers of the coastal shrublands. Heermann's kangaroo rat, California ground squirrels, brush and pocket mice, the Sonoma and Merriam chipmunks, and brush rabbits are among their victims. Gophers, rodents of more open country, rarely expose themselves to such attentions and are careful to plug the holes of their feeding tunnels. But gopher snakes and weasels are only too successful, from the gopher's point of view, in entering.

Reptiles are extremely common in the brushlands, partly because of the large number of rodents. Pacific rattlesnakes, racers, and gopher snakes slip through leaf litter and other debris. Alligator lizards, skinks, and fence lizards are frequently

encountered by hikers in brushy country. One can readily startle them out of their hiding places or from sunning spots while poking about rocky outcrops and under fallen limbs.

Several birds are so much a part of chaparral and scrub that they occur nowhere else. The wrentit, a shy bird with a long wrenlike tail, has a bouncing ball whistle that accelerates cheerily through the thickets. Scrub jays rasp raucously while diving in long bright blue glides from one vantage point to another. California thrashers sound like less talented students of their virtuoso cousin, the mockingbird, as they fuss about in the underbrush along with brown and rufous-sided towhees. A large number of birds typical of chaparral are neutral gray or brown in color. Thus they match the dull tones of the vegetative cover, which increases their chances of escaping predation. Goldfinches, rufous-crowned sparrows, kinglets, and bushtits work over the scrubby growth for tidbits on their way to other communities. California quail are common companions on a sunny morning hike through the chaparral. (A most interesting relationship between the breeding success of California quail and springtime annual plant abundance has come to light. It appears that during years of poor rainfall, the sparse and stunted herbaceous growth has certain compounds that when eaten by the quail inhibit brood production, a nice example of population controlled by the pressures of supply and demand.)

Mixed Evergreen Forest. Though lacking the imperial stance of an old-growth stand of redwood trees, these groves are delightful. Whereas most of their trees are not deciduous, they resemble in many ways the hardwood forests of the East. The streamside jungles of the interior California valleys share many of the same genera present in the eastern woods, but the mixed evergreen forest has the same sun and shadow interplay as groves of deciduous trees in Pennsylvania and Ohio. Most of the hardwoods of this community are broad sclerophylls, the technical term for plants having broad evergreen leaves (in contrast to the narrow-leaved conifers) with a stiff, leathery texture that, like foliage of chaparral plants, aids the tree in withstanding summer drought.

A digression here, for a moment. The word *genus* refers to the first of the two words of a Latin name of a plant or animal. It specifies to which branch of its family tree the organism belongs. The plural of genus is *genera.* A family of living things is made up of genera and their species, for example: family, Pinaceae (pine); genus, *Pinus;* species, *ponderosa.* This is the yellow pine so familiar in the mountainous West. No other plant in the world is named *Pinus ponderosa.* A specific name, such as *ponderosa* (heavy) or *albicaulis* (white-stemmed), may be repeated without limit; but the names of genera and higher groups are unique. The word *species* is both singular and plural. The word *specie* refers only to coin, not to an organism. One speaks of a species of ground squirrel as well as many species of ground squirrels.

To return to the forest trees, their leafy masses look as though they have been cut from a rich assortment of fabrics in every shade of green. The madroño has large, dark green leaves of heavy satin in pleasing contrast to its red and chartreuse bark. Tanoak, giant chinquapin, and the coast and canyon live oaks spread out swatches of coarse green homespun. The leaves of bay, or California laurel (Oregon's myrtlewood), are cut from deep green brocade. The most frequently encountered cone-bearing tree, Douglas-fir, drapes its branches with lacy strands whose green is tinted either yellow or blue depending upon location. Black oak foliage is fashioned from spring grass-hued taffeta. It and California buckeye are the deciduous members of this largely evergreen community, but they lose their leaves at slightly different times. Buckeye leaves begin to wilt, turn golden brown, and drop toward the end of summer. Black oak waits until fall. Where moisture concentrates in canyon bottoms and gully floors, other deciduous types—willow, big-leaf maple, and alder—contribute tawny brown, golden yellow, and even hints of crimson with the advent of the cold season.

Mixed evergreen forest extends the length of California's coastal hills and mountains, changing components to meet the various requirements of climate, soil, elevation, and topography. It needs less moisture than the redwoods or the mixed conifer forests of the Pacific Northwest but demands more mesic sites than foothill woodland, chaparral, coastal scrubs, and grassland, but all are interlocking pieces of a very complex Coast Range mosaic. From Marin County northward, the Douglas-firs stand parade-ground straight above the hardwoods, which undulate around them like exuberant hoop-skirted belles. Cluster-

ing under their taller associates, particularly in moister places, are salal, barberry, huckleberry, rose-bay, hazelnut, and ceanothus whereas poison oak, several manzanitas, and other shrubs tolerant of drier soils are typical of more xeric sites. Bracken and sword and other ferns enrich the shrub layer with both texture and color. In the most productive habitats trees and shrubs combine to form an often dense cover under which such herbs as oxalis, fairy bells, and heart's ease and other violets are sparse or rich as conditions permit.

This basic mixture of Douglas-fir, madroño, tanoak, bay, giant chinquapin, and black and live oaks is scattered in fragments on the outer coastal mountains but is more widespread on the inner slopes of the North Coast Ranges. In Siskiyou and neighboring counties a few members of the lush coastal forests of Oregon and Washington such as western yew and western hemlock venture onto moist, deep-soiled slopes and into draws. Sugar and yellow pines, more typical of California as they are found on all its major mountain ranges, accept somewhat drier sites. In its more xeric environment the forest is dominated by canyon live oak and other hardwoods. Though oaks are present throughout the entire range of mixed evergreen forest, each species has its own homegrounds. Canyon live oak probably has the broadest tolerance of site conditions. It is comfortable on moist stream banks as well as steep rocky slopes from southern Oregon down into Baja California. Coast live oak, the familiar *encina* (or *encino*) of coastal valleys and slopes, disappears just north of Sonoma County. Black oak is restricted to higher elevations south of the Bay Area. Interior live oak is locally present on Mount Diablo, Mount Tamalpais, the mountains of Santa Cruz County, and the Santa Lucia Mountains. As the northern dominants such as Douglas-fir and tanoak become less important and drop out, one by one, from the coastal hills southward from Santa Cruz County, coast and canyon live oaks continue to hold their own in the wooded landscapes of southern California. Scrubby forms of canyon and interior live oaks group in little hilltop thickets, miniforests, if you will, on Mount Diablo and other mountains in the Bay Area or mingle with other shrubs in both chaparral and woodland. Not only is the mixed evergreen forest an important as well as delightful piece of the coastal picture puzzle, it is often the transitional community, edging the coast redwoods on its wetter borders and sharing grassy patches with foothill woodland in its drier extensions.

The animal inhabitants of the wooded areas are much the same as those of the chaparral, with some differences. Mule deer readily move from one community to another, but tend to avoid the solid masses of thick chaparral. They prefer the more open brushy slopes. Favorite foods include the juicy tissues of herbaceous plants and spring-new sprouts of shrubs. They drift through the forest and along game trails, browsing as high as they can reach conveniently or nibbling at the grasses and forbs of the herb level.

Certain animals such as the gray squirrel are restricted to an arboreal life. One of the pleasures of exploring a patch of coastal forest is to see the down-feather tail of this tree squirrel flipping from side to side, or a bright eye peering over a limb. Since acorns are preferred food, oak trees are paramount in the life of this attractive animal, and its bulky nests are usually built in their limb crotches. A characteristic three-step food chain in oak groves is acorn/gray squirrel/hawk, but the tree-based life of the squirrel protects it from severe predation. If it eats the eggs of the black-headed grosbeak, common and typical bird of the broadleaf forest, a four-step chain ensues: seeds/grosbeak (in the form of eggs)/squirrel/hawk. The squirrel then moves to the rank of a second order consumer.

With this background of introduction to four of the many communities of the outer Coast Range, it is possible for us to pick up some of the pieces of our puzzle and attempt to fit them together, keeping in mind that five types of coniferous forest also flourish here: closed-cone pine, redwood, mixed conifer, yellow pine, and relict cypress. It should also be restated that no one really knows exactly why all these peculiar patterns exist where they do. There are many research problems still remaining for future ecologists.

Any understanding of the factors governing the distribution of biotic communities begins with climate, and California has several climates; the state's relief features and its position with regard to neighboring land and ocean have resulted in a series of climatic spectra almost as varied as its topography. Because of its latitudinal range, California experiences a grad-

ual increase in rainfall from south to north, from the near desert conditions of San Diego to the temperate rainforest of the Pacific Northwest. Its mountain ranges have heavier rainfall on their seaward sides and lighter precipitation on their eastern flanks because of what geographers call rainshadow (see Figure 5). Winds are forced to rise when confronted by a mountain barrier in their path. Any moisture-laden air masses they may bear become cooler during the upward journey. Such chilling increases condensation, and higher slopes are often soaked by resulting downpours or snowfalls. On descent the clouds are warmed and, already relieved of much of their moisture, may dry to the point of complete evaporation. Some major storms, particularly in winter, do continue on across the mountain ranges of the Far West, but by no means is this true for all. Most of California's winter rainfall comes from storms generated over the Pacific Ocean and carried east by winds known as the westerlies. The Coast Ranges are the first physiographic or relief barriers they meet; and rainshadow accounts for the fact that Santa Cruz, on the shoreline, receives roughly 24 inches (60 cm.) of rain a year while, across the ridge, San Jose may have only 13 inches (33 cm.).

So placed, maritime central California has what amounts to a moderate rainfall with many local differences based primarily on topography. Of equal if not greater importance is seasonal distribution. California shares what is termed the Mediterranean-type climate with four other regions in the world

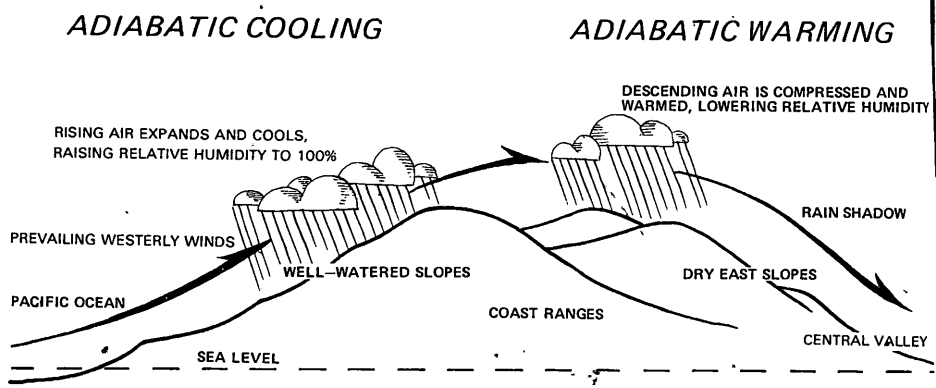


Figure 5. Precipitation pattern of central Coast Ranges

experiencing summer drought and winter rain. The extreme northwest corner receives occasional summer rain from storms that manage to slide down from Oregon, and higher ranges throughout the state have their share augmented by local thunderstorms. Masses of warm moist air, often associated with tropical storms, wander in from the south, bringing rain to the desert and even southern coastal areas in summer. In general, however, vegetation must be adapted to dry summers which are longer in the south and shorter in the north. Not only that, the Pacific High may deflect winter storms traveling east from the mid-North Pacific or down from the Gulf of Alaska. This pressure hump is a huge cell of air settling from aloft in what has been termed the Horse Latitudes, a subtropical belt of notorious calms in windjammer days. During the summer it bars from most of the state the rains that keep coastal Oregon and Washington green the year around. These two states, however, are on the edge of this great mass of high pressure, and rainfall decreases in summer here as well. The Pacific High usually weakens or moves south in the winter, following the sun, but sometimes it forsakes its customary course and continues to block off needed rain. At other times an extension of the Pacific High or a separate ridge develops, both circumstances having the same drought-producing effect. The causes of these changes are as yet not well understood, but there is some evidence that they are associated with anomalous patterns of sea surface temperatures. If such periods of lower than normal rainfall are set in train season after season, then California can have a series of dry years to worry farmers and forest rangers alike.

Another factor complicates matters. In summer, the northwesterly winds that prevail along the California coast—aided by the Coriolis force—push away surface water, resulting in the upwelling of cooler subsurface water. As moisture-heavy air flows landward from the ocean it passes over the cold water offshore. Enough condensation takes place to cause fog or drizzle, but not real rain. These summer mists, so disheartening to those who hope for a sunny day at the beach, are of extreme importance to coastal plant life—cropland and brush, Eucalyptus grove and redwood stand. This natural air conditioning forces many San Franciscans to wear coats in July while Bakersfieldians swelter in sports shirts. Anyone driving

in one June day from Market Street to Bishop, east of the Sierra, could have this temperature and weather schedule:

9:30 A.M. . . .San Francisco . . .55° F. (13° C.) . . .fog
11:30 A.M. . . .Manteca . . . . . .95° F. (35° C.) . . .cloudless sky
3:30 P.M. . . . .Tioga Pass . . . . . .40° F. (4° C.) . . .rain and sleet
6:00 P.M. . . . .Bishop . . . . . .90° F. (32° C.) . . .mostly clear skies

By now it will be obvious that there are many California climates. They account for much of the variety in its natural landscapes. Brushlands owe their scrubby growth and appearance to the summer drought experienced by most of the state. Such features as small leathery evergreen leaves and bushy habit are adaptations to regions of cool wet winters and warm dry summers. The same characteristics help the brush species live through periods of less than normal rainfall when the Pacific High is in stubborn command. The shrubs of the coastal scrub have many of these modifications. Some species, such as California sagebrush, have the ability to go dormant to the extent that their leaves desiccate and fall off during the dry season.

The evergreen trees of the coastal forests enjoy the same type of protection as chaparral in that they do not have to produce new foliage each year. One common species, buckeye, is deciduous, but to balance the energy needed for growing new leaves each year it loses them in late summer and remains inactive for the rest of the dry period. Its large thin leaves are ill-equipped for dry season dormancy, and their loss is another way to limit life processes during this critical time. Other trees of the broad-sclerophyll forest have many of the same evaporation-retarding leaf features as the brush species: waxy "waterproofed" leaf surfaces (cutinization), and stomata sunken to cut down on water loss.

Grasses have their own adjustments to the climate. Shallow rooted, they make use of surface soil water. When this disappears during drought, perennial grasses die back to underground runners, stem bases, and root masses, and the annuals live through the time of tension as seed. Most grasses are more xerophytic than brushland or forest plants and, in the coastal areas, often occur where conditions are dry. One such example is the Mattole River valley in Humboldt County where grassland persists though redwood forest might be expected. It is

assumed that the prevalence of local dry winds, the result of downdrafts peculiar to the inner face of the King Range, is responsible for the anomaly. In like situations, forbs—herbs, or green plants, minus grasses—react in much the same way.

In general, extensive chaparral is confined to summer-drought regions with an annual rainfall range of from 10 to 25 inches (25–63 cm.). Desert occurs where the precipitation range is roughly from 8 inches (20 cm.) downward. Forests need more moisture than either brushland or desert, but there is a fair amount of variation. Areas supporting redwoods can receive as little as 25 inches (63 cm.) per year or as much as 100 inches (254 cm.). Thus, rainfall accounts for the overall pattern of California's vegetation: fir trees on the Sierran slopes, creosote bush on the flats of the Mojave Desert, and manzanita on Mount Tamalpais. But it does not explain why a fern-carpeted tract of Douglas-fir should abruptly open out to the scruffy confusion of chaparral, nor why ponderosa pine, one of the dry-climate conifers, appears in the middle of a redwood forest. These sharp community shifts occur over and over in a region remarkably uniform in climate. This section of California enjoys moderate rainfall and maritime influences that keep temperature ranges small. Logically these sea-edge slopes should have but one type of vegetation, perhaps brush adapted to the lack of summer rain and making use of the summer fogs. If one were to envision a hypothetical vegetation diagram based solely on central California maritime climate, its moderateness and uniformity might indicate something like that shown in Figure 6.

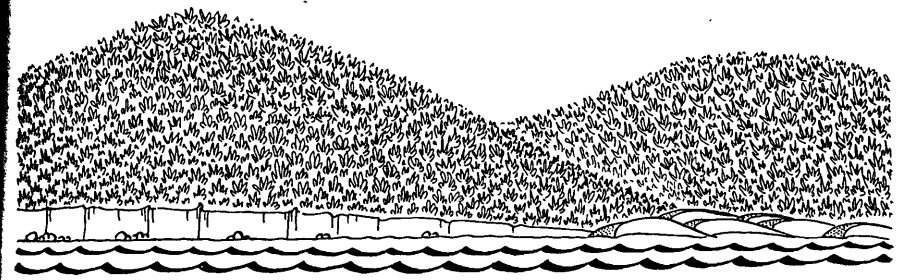


Figure 6. Hypothetical uniform chaparral-type vegetation

The famed redwood forest is a vegetation type commonly thought to be admirably suited to the coastal climate of California, but its distribution is by no means universal. In fact, in the San Francisco Bay region, these giants are held to pockets here and there. The extensive groves come into their own farther north. Man's inroads on the redwood stands in the transect aside, there are local restrictive climatic differences, more—and more influential—than one would realize. San Francisco is notorious for having its foggy streets and its sunny streets. The sea mists swirl in through natural draws and along channels formed by the valleys of this hilly city. In the warmer and more protected sections, housewives can garden in cotton dresses. In others, shoppers must button into wool coats against the chill and clammy winds. All along the coastal mountains, warm sheltered valleys huddle against exposed ridges, and a drizzly morning in Sausalito does not necessarily mean fog in Palo Alto.

Fog plays no unimportant role in central California's climate. According to Harold Gilliam's handbook, *Weather of the San Francisco Bay Region* (University of California Press, 1962), parts of the Berkeley Hills receive moisture equivalent to 10 inches (25 cm.) of rainfall each year from fog drip alone. Fog not only lowers air temperatures and raises humidity, it eases the effect of summer drought by forming drops that build up behind veins and other tiny dams on leaf surfaces. When heavy enough, they fall in sparse but noticeable showers. Since the redwoods are not as adjusted to summer drought as, for instance, the shrubs of the chaparral, they depend on both fog drip and its atmospheric humidity as a climatic "bridge" spanning the dry months between rainy seasons.

There are local differences in rainfall even in a relatively limited area. Mount Tamalpais creates its own small rainshadow. Its northeastern slopes receive less precipitation than its southwestern flanks which directly confront the storm-bearing winds. This is also true of many individual peaks and hills in the coastal ranges and accounts for some of the variation in plant cover.

The sea-facing bluffs and headlands of California seldom support thick tall forest. They are harassed by strong salt-laden winds that are essentially drying. Stunted scrub or prairie is typical of these exposed positions. What woody plants are present have the twisted and tortured habit of wind punishment. Clumped here and there on the seaward bluffs of Marin are hedgelike mounds of California bay and other broad-sclerophyll trees in more sheltered hollows or behind rocky outcrops. The appearance of these thickets is due directly to salty wind. It kills any exposed branchlet or twig venturing outside the protective masses of leaf and stem by dehydrating the vulnerable tissue.

But in the fog-visited and wind-sheltered canyons of the coastal hills, trees stand proud and straight. Just as mountain barriers cause rainshadow, passes and ridges channel and deflect wind which, when persistent in strength and consistent in direction, modifies the vegetation in its path. Where canyons open out to the sea, the benevolent bath of fog tempers the heat of summer. Such localized climatic units (microclimates) are due to the varied topography typical of many regions of California. Land and the great weather forces operate together in significant partnership.

In addition to affecting climatic patterns, features of the land exercise considerable control upon natural cover. The coastal hillscapes are rugged, broken by faulting and erosion. Ridge and gully succeed each other the length and width of the range system. Canyon bottoms are forested not only because of their sheltered positions; rainwater drains off the steep slopes above them and collects in permanent or seasonal streams on the ravine floors. Even where there is no visible flow, underground moisture concentrated here supports trees unable to live on drier substrates. We must now modify our hypothetical hillside to accommodate these additional situations (see Figure 7).

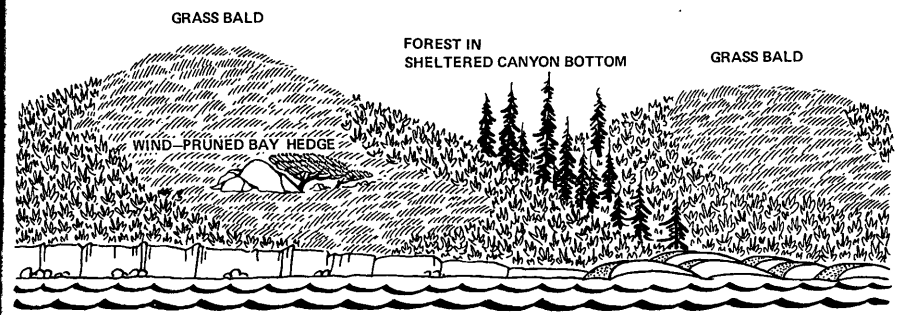


Figure 7. Exposed and sheltered sites in coastal hills

Another local variation of humidity and temperature must be taken into account. It, too, is due to rugged relief. In non-tropical regions, the direction of slope face or aspect, as it is sometimes called, is of great importance. As California is north of the equator, its southward-facing slopes get the benefit of the direct light of the sun, and those facing north are slighted. Solar radiation striking perpendicularly to a surface is more powerful in its effect than that which is oblique or glancing. Therefore northward-facing slopes are cooler than those facing south. Consequently, the soil retains moisture longer and can support more mesophytic vegetation. Southwest exposures are the most stressful for plants, warmed as they are by the lingering afternoon sun. Such xeric sites as these along the central California coast are predominantly chamise chaparral or elements of coastal sage scrub that are highly drought-resistant, for example, California sagebrush and black sage, whereas the north-facing slopes have a richer cover of less xerophytic shrubs or even trees. Coastal prairie is a typical occupant of both wind-blown ridgetop and dry south-facing slope while brushland and forest keep to either the cooler north-facing hillsides or deep-soiled valley bottoms. In moister places, chaparral takes the sunny slopes, and mixed evergreen forest keeps to the cooler shady hillsides. Such heavy growth in itself creates more mesic conditions. Wind is slowed and soil temperature and evaporation much decreased by the dense vegetation. Our diagram now undergoes another change; the shaded, humus-rich, north-facing slopes are cloaked with forest, and the warmer, drier south faces have brush or grass (see Figure 8).

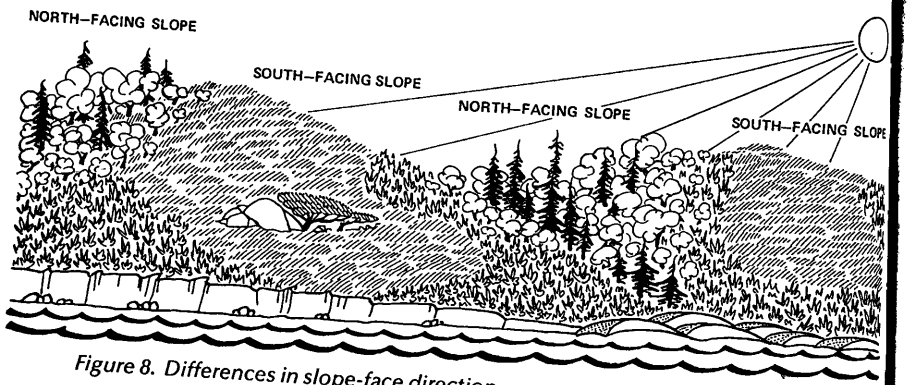


Figure 8. Differences in slope-face direction

These basic moisture patterns are further complicated by other influences. What ecologists call edaphic conditions are very much involved with the coastal mosaic. These have to do with the specifics of soil and are responsible for some of the abrupt changes in vegetation. Two such local substrate circumstances are noteworthy—outcrops of serpentine and exposed beds of ancient marine sands. The former occur in many places in California, particularly in the Franciscan rock series of the Coast Ranges where intrusions of molten material, at one time, forced their way into the earth's crust. Some of these, peridotite for one, were transformed into serpentine, a reddish or greenish rock, which usually weathers to very infertile soils. The outcrops are high in magnesium and heavy metals and poor in enriching substances such as phosphate, potassium, and calcium. They tend to be highly basic as well, that is, on the strongly alkaline side of the pH scale, another detrimental feature. Though some of these soils are waterlogged in winter, others are too thin to hold much moisture. Such conditions mean poverty for most plants and result in semibarren hillsides with widely spaced, starved-looking bushes or trees. Those that survive are short on branches and long on moisture-seeking roots. Many species found on serpentines seldom occur elsewhere. By enduring the unfavorable chemical ratio, they benefit from the absence of competing plants. There is evidence, moreover, that certain harmful soil organisms avoid serpentine sites; consequently, tolerant species such as leather oak and certain types of manzanita and ceanothus have several advantages in addition to their ability to live on a hostile substrate.

"Fossil" sand dune areas in the Santa Cruz Mountains are comparably infertile. Much eroded, these old loosely consolidated sand deposits have become badlands, and their coarse soils are poor water holders. Where they occur, the surrounding evergreen forest immediately changes to open woodlands of dry-climate pines such as knobcone and ponderosa. Manzanita and live oaks provide a sparse and casual understory.

The broken bedrock of the hillsides has encouraged another adaptation on the part of broad-sclerophyll shrubs and trees. Interstices or cracks allow roots to penetrate deep beneath thin soils typical of these communities for water that has percolated into the fracture system. With a crowbar and a little energy one can pry apart the exposed root-sundered rock slabs of a road-

cut or gully side and get an idea of the extent of this living network. Where ridgetops and hillsides are steep and heavily eroded, they may be too thin-soiled for either the larger trees or lush grassland. Then the aggressive brush with its moisture-miser leaves and enterprising roots comes into its own.

Talus faces of fractured rock are uneasy substrates and along with outcrops of bare rock account for barren patches appearing here and there on the hillsides. Only very hardy species such as digger and knobcone pines or the most drought-resistant shrubs can struggle along on the poor terrain. At the other extreme, seepages, springs, and local surfacing of the underground water permit more mesophytic species to intrude among those more spartan.

Soils differ in their ability to hold water largely because of texture. Sand, gravel, or cobble soils take in moisture quickly, but it rapidly sinks through these natural sieves, leaving the upper horizons relatively dry. Fine-grained soils, on the other hand, tend to take up water more slowly but retain it for a longer period of time. Soils of broad valley floors commonly contain much fine-grained clay and silt. Though deep, when underlain by impervious layers through which water is unable to percolate, these poorly drained basin bottom soils are waterlogged in the wet season. Since the moisture confined to upper horizons readily evaporates in summer, leaving baked surfaces, criss-crossed with cracks where it has stood the longest, such soils are usually dry. Chaparral shrubs rarely venture out onto these fickle substrates. They do better on the rocky soils of the steeper slopes where, with long exploring root systems, they can make use of reliable water sources deep in fractured bedrock. Shallow-rooted and quick-growing species such as grasses and weedy forbs are well suited to heavier soils of gentle slopes or valley floors, as they can take rapid advantage of seasonally available water held close to the surface. A number of clay-heavy soil types are responsible for grassy balds in the northern Coast Range conifer forests. Some of them are vertisols which expand and shrink in response to changes in soil moisture. Such movement discourages the root development of tree and shrub seedlings attempting establishment on these unstable substrates. The soils of the Yorkville series tend to slump and creep, particularly in the wet season. Another soil series, weathered from certain schists—highly metamorphosed rocks—that are in contact with serpentine, is high in magnesium. Both keep tree growth

at bay. Other patches of grassland occur on sandy soil, some surprisingly burdened with poor drainage. Some of the best soils in the area are thick, well-drained accumulations in the bottoms of ravines and canyons. When sufficiently moist a good part of the year they support forest or woodland incapable of growth on drier, thinner soils.

Soil organisms and chemical nature account for many specific plant associations. The rate of decomposition, or reduction of plant and animal debris to nutrients necessary for the growth of living things, depends on many factors—climate, the presence or absence of organisms responsible for such decay, vegetation, and the parent rock itself. If the process is slow because of the type of plant cover, drought, or long cold winters; if the bedrock resists disintegration; if certain soil elements are hostile to decay or if the substances so released are drained away through leaching or erosion, fertility suffers. Not only are pH values (acid-base ratios) of great significance in controlling decomposition rates, they determine the distribution of certain species. Some plants tolerate or do well on acid soils, whereas others grow best on those that are basic or neutral. Because of the evergreen nature of chaparral, duff accumulates slowly. Not only are the leaves small in size, but they drop infrequently. Decomposition proceeds quickly at the start of the rainy season when the soil receives reviving moisture and when the temperatures warm up toward the end of spring. Decay rates are slow the rest of the year. For these and other reasons, chaparral soils tend to be infertile. All of these features play their part in community placement, and our hillside should indicate an example or two (see Figure 9).

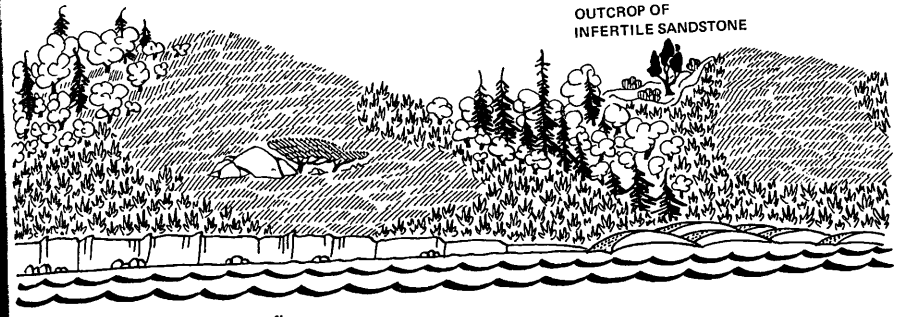


Figure 9. Edaphic influences

California's natural vegetation has another unusual aspect—its ability to survive the plant kingdom's most spectacular enemy, fire. Shocked and distressed as we are to hear of a disastrous fire, it is some comfort to know that the brushlands and forests of the state have built-in defenses against total destruction; it is poetic justice of a sort, because they are very fire-prone. Volatile oils, responsible for the pungency of scrub and chaparral, are highly flammable. Tinder-dry accumulations of discarded branches and other debris litter the thickets. Natural fires from lightning strikes have swept through the shrublands since their establishment far back in geological time (paleobotanical history, important to the understanding of the coastal mosaic, will be discussed in Chapter 5). When the American Indians entered what was to become California, they came as users of fire. With it they opened brushfields for hunting and seed gathering. It also escaped from campfires, as it still does today. Through millions of years a kind of equilibrium was reached between the native plants and fire. Fire is useful to chaparral because it clears out the dead wood and deposits ash, which is a rich source of nutrient material previously locked within living plant tissue as well as the slowly decaying debris. There is evidence that soil oxygen is increased by fire, and it removes toxins released by many chaparral plants that inhibit growth of possible competing species. Though the newly exposed soil dries out more rapidly, the plants in competition for its moisture are fewer in number and much reduced in size. Recently burned soil presents another problem in that it often becomes very water-repellant because of heat-concentrated substances from certain plants that tend to decrease moisture absorption. Under certain circumstances, however, fire leaves deposits of ash and charcoal that form protective crusts. In addition, the removal of litter and duff improves the seedbed considerably for plants whose seeds require bare, mineral-rich soil for germination. Many investigators report an increase in the soil organisms responsible for decomposition following fire.

A number of adaptations to the ravages of fire have evolved ensuring the survival of brushy species. Many of the most typical chaparral plants crown sprout after burning, that is, they start new stems from buds on the root crown which are activated when fire destroys growth-inhibiting hormones in the unburned stem. Such species as chamise are flourishing

shrubs again several years after fire has reduced them to black and lifeless-looking snags. Though chaparral shrubs are prolific seed producers, some species of manzanita and ceanothus are so adapted to periodic burning that their seeds readily germinate only when heated enough to scarify the seed coat. Then water can easily penetrate and initiate growth. Though the new burn provides an environment greatly to the advantage of the seedlings, there are potential threats—prolonged summer drought or an exceptionally dry year, and the reverse, herbaceous competitors flourishing with abundant rainfall. Young shrubs whose roots have nodules of nitrogen-fixing bacteria evidently have a better chance for survival. The root crown sprouters have a much easier time of it. Because they are already established plants with access to stored food and water and are equipped with well-developed root systems, they can begin new growth immediately after the fire. They also have an advantage over herbaceous rivals as they eventually shade them out or release toxic substances into the soil.

Grasslands are little damaged by most burning. They recover about as readily as they go up in flames. Annual species, by their very nature, assure renewal after fire. If the seed crop has fallen to the ground by the time of the burn, chances are it will escape injury and be ready to begin new growth in the next rainy season. Perennial grasses are almost as immune to fire damage. Their root masses are safe underground, and they will resprout as soon as weather conditions are favorable.

According to scientists who have studied the coastal mosaic, much of its seemingly inexplicable character is due to fire. Species and even communities may be shifted about when a vegetative cover is so destroyed. Each type of vegetation has its own route and rate of recovery. Forests may take a hundred years to return to former magnificence; brushlands can regain their previous aspect in a decade.

Almost all of the regenerating scrub and chaparral regions of California have an herb interval when quick-growing grasses and forbs, uncommon in developed brushland, dominate the postburn landscape. In many instances, the pioneering herbs are strictly fire types. The seeds have lain dormant underground since the previous burn, sprouting only when heat treated so that water may enter and awaken the embryo. Many spectacular wildflowers, including the delicately beauti-

ful fire poppies and pale yellow whispering bells, belong to this unusual group of plants. At any rate, newly opened brush areas with their ash-rich soils invite invasion by these quick-growing plants that require sunlight and space.

Postburn interaction between coastal sage scrub and chaparral is a prominent feature of many natural landscapes in southern California. Most of the scrub species such as California sagebrush and California buckwheat are somewhat weedy in nature. They propagate with ease because numerous seeds are readily dispersed by wind or other means. Once established on the burn, the semiwoody branches grow rapidly. There appears to be similar activity on the part of the elements of the scrub reaching central California. Yerba santa, black sage, and lotus (bird's-foot trefoil) are reported to be common invaders of recently burned chaparral on Mount Diablo. Seed-reproducing ceanothus and chaparral pea also pioneer following fire.

Throughout both herb and subshrub stages, chaparral recovers slowly by sprouting from seeds and root crowns, and eventually it reigns supreme. By denying light and producing toxic substances, it drives out the temporary species whose seeds lie dormant, waiting until the next great sweep of the fiery broom. Most trees of the mixed evergreen forest resprout, with the notable exception of Douglas-fir, but after a heavy fire the length of time necessary for a complete return from herb and shrub domination is much greater than that for brush.

The fire-induced herbaceous stage, under certain soil conditions, can be prolonged indefinitely by frequent burns. Many prairie balds exist for no other reason than recurrent fires staving off the return of shrubby growth. Any woody sprouts and seedlings attempting life in thick grass are subject to destruction in the next dry season. On the other hand, in the absence of burning, brush often invades grassland, extending its domain at the expense of the prairie.

The interested observer sees California's hillsides from but one point in time when he first asks about their puzzling vegetation patterns. A beginning student of plant ecology, given an introductory assignment of driving along Skyline Boulevard from San Francisco south to Santa Cruz and attempting to explain the hillside mosaic, is able to base his opinion only on what he sees during that drive. He does not have as yet the

background to interpret the landscapes from the point of view of passing time. After study and research he will gain this ability and remember that what he sees today is not necessarily what will be there in ten years (if man leaves it alone), nor what was there before disaster removed the stable community adjusted to meet certain conditions. Some of the prairies and brushed slopes, looking so out of place in the midst of a Douglas-fir or redwood forest, may be initial stages in the recovery, after destruction, of wooded landscapes.

Such changes as these fit other pieces into the puzzle. We must now amend the diagram to include the effect of fire, adding grassland that has replaced chaparral and forest burned a year or so ago. Patches of coastal scrub on the sea-facing bluffs complete the picture (see Figure 10).

The animals of these burned communities are much affected by the holocaust that has flamed through or over their homes. Since this type of catastrophe occurs more often in the less humid interior of California, a discussion of what happens to them during and after a fire may be found in Chapter 11.

Man, himself, has many ways of controlling the natural landscapes over which he has assumed jurisdiction. He can alter their composition and change their appearance, using such methods as deliberate burning or the bulldozer. He can plow a grassy field and bring a piece of Iowa's uninspiring but money-making cornland to California valleys. By introducing livestock or encouraging herbivorous wildlife he can prevent the natural shift from temporary meadow to brush or forest. Mule deer relish acorns and nibble here and there on tender

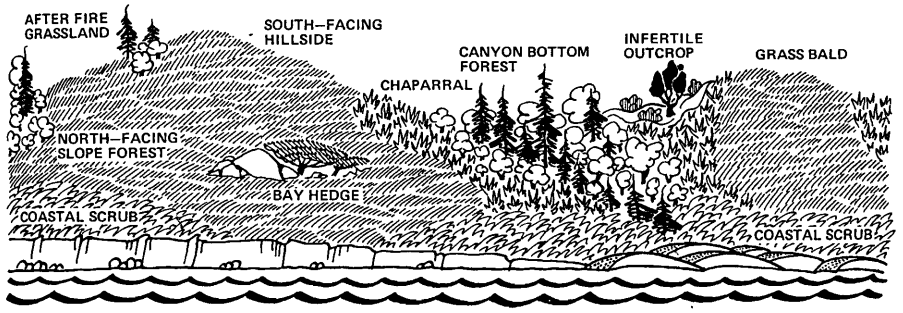


Figure 10. Typical vegetation mosaic

shoots of shrubs. By such feeding preference, large mule deer populations maintain grassland which would otherwise revert to woody vegetation.

Lumbering can be as disastrous an upheaval in the life of a forest community as fire or flood. If left alone, the normal transitional stages will return the cut-over land to the type of community for which it is best adapted. But man, the ever-active meddler, insists on manipulating nature, promoting those species most useful or worthwhile to him, eliminating those less profitable or desirable. By accident or on purpose, by carelessness or with considered reason, he has completely disrupted much of the orderly progression of cause and effect that for millions of years has played its drama upon forest and rangeland. Where the wilder areas are still tolerated, management has been substituted for the living world's own long-evolved controls—competition and the struggle for survival. To fire, climate, relief, and substrate we must add man as a determining factor in California landscapes which reflect a complex of interacting components, each exerting its influence, each contributing its answers to the puzzle of the patterns on the hills.