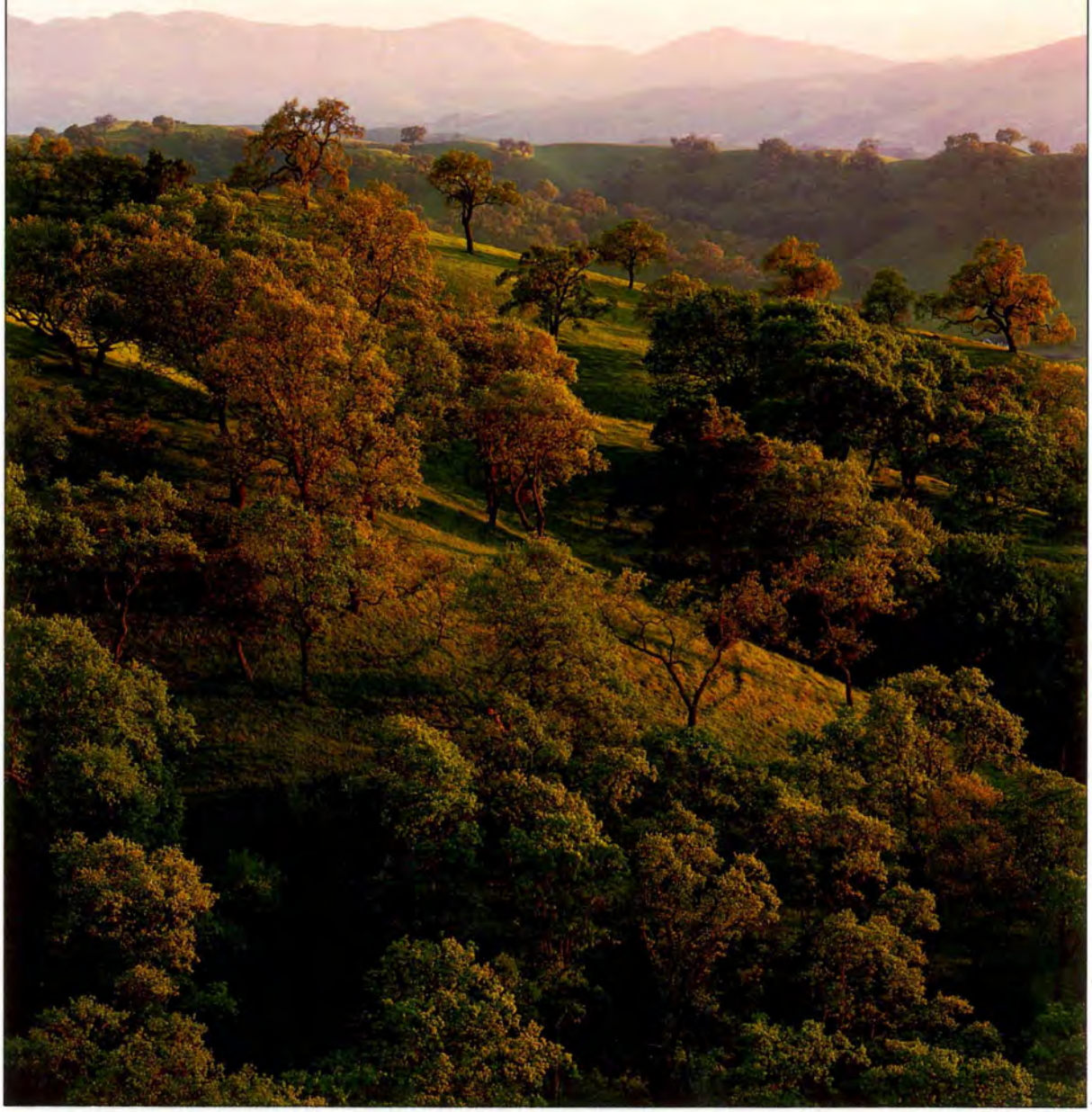
OAKS OF CALIFORNIA



By Bruce M. Pavlik, Pamela C. Muick, Sharon G. Johnson, and Marjorie Popper

Above: Spring winds ripple grasses and new leaves in a blue oak savanna, Madera County. BILL EVARTS
Right: Blue oaks, Santa Barbara County. JOHN EVARTS

Blue Oak *(Quercus douglasii)*

On the hot, dry foothills of California's interior, blue oak endures. In a landscape where midday temperatures exceed 100° F for weeks at a time, and annual precipitation is a scant 15 inches, blue oaks number in the millions. Every year, from April to October, they withstand drought and tolerate parched winds that sweep the grasslands en route to cooler elevations above.

Anyone who drives the foothill highways sees evidence of this special endurance—blue oak is usually the only tree species that extends onto the lowest, sunniest slopes and plains. This was apparent to geologist Clarence King, who rode through Madera County more than a century ago.

> Riding thus in the late summer along the Sierra foothills, one is constantly impressed with the climatic peculiarities of the region. With us in the East, plant life seems to continue till the first frost; but in the Sierra foot-hills growth and active life culminate in June and early July, and then follow long months of warm stormless autumn wherein the hills grow slowly browner, and the whole air seems to ripen into a fascinating repose,—a rich, dreamy quiet, with distance lost behind pearly hazes, with warm tranquil nights, dewless and silent. This period is wealthy in yellows and russets and browns, in great overhanging masses of oak, whose olive hue is warmed into umber depth. . . . —these are the conditions of the vegetation.

How does blue oak endure? What unique features does it possess that allow establishment and growth on shallow soils in hot, dry climates? Although other oaks are resistant to drought, few of them combine all the mechanisms of opportunism,

conservation, tolerance, and resiliency that are known in blue oak. Moreover, these mechanisms are integrated into all stages of the blue oak's life, from germinating acorn to mature tree.

Blue oak acorns rapidly germinate when conditions become favorable. Unlike some other oak species, blue oak embryos do not wait until spring to become active. The cool rains of late October are enough to stimulate root emergence from the just-ripened acorns. Blue oak roots grow much more rapidly than those of other oaks that inhabit deeper, more moist soils (e.g. valley and coast live oak). Despite cool soil temperatures during the winter months, growth is sustained so that the roots of blue oak seedlings have a chance to extend below the dense, competing roots of grasses and herbs.

An effective root system would be futile if seedlings also developed large, leafy shoots that used water lavishly. Water conservation mechanisms have evolved in blue oak that are similar to those observed in the hardy shrubs of chaparral and desert communities. Blue oak seedlings begin with much more root than shoot compared to other arboreal oaks, and this pattern is maintained through the sapling and adult stages of life. The mature root system is not especially deep or extensive. Rather, the canopy of leaves remains proportionally smaller in blue oak than in other, less drought-tolerant species. The leaves are also moisture conserving, covered on their upper surface by a waxy coating that gives the tree its characteristic bluish cast.

When water from the soil becomes very scarce, a remarkable array of drought tolerance mechanisms is exhibited. Leaves become reinforced with cellulose and lignin (the chemical component of wood) to withstand the physical stresses imposed by progressive dehydration. Photosynthetic cells adjust their internal salt content so that wilting is prevented even if the leaves lose up to 30% of their water to the bone-dry atmosphere. This ability surpasses that of some desert trees, such as mesquite and ironwood.

Drought-deciduous leaves are a common feature of chaparral and desert shrubs, but rare among oaks and trees in general. In extremely hot and dry years, blue oaks resort to dormancy. They drop their summer-weary leaves and take on a skeletal look. Nevertheless, drought-stricken blue oaks continue to fill their acorns with previously stored food. Under these circumstances, most of the trees do not resume growth with the arrival of fall rains; instead, they wait until spring to produce a new flush of bright-green leaves and tender shoots.

The ability to endure allows blue oak to dominate nearly half of all oak-covered lands in California. At low elevations, blue oaks are scattered in a sea of grasses and herbs, forming a distinctive savanna vegetation. Inhabited by herds of deer and other native grazers, as well as predators such as mountain lion and coyote, California's blue oak savannas have been called the Pacific Coast version of Africa's Serengeti Plain. At higher elevations, the stands of oaks are denser and include many other kinds of trees and shrubs. Known as blue oak woodland, this community is even richer in animal species than the savanna, and its fate will determine much about the future of California wildlife.

Identifying Characteristics

GROWTH FORM: Blue oak is a small or medium-sized, deciduous tree. In moist sites it may retain most of its leaves nearly year-round. It reaches a

Above: Blue oak leaves and acorns. ALLISON ATWILL
Opposite: Blue oak bark. DAVID CAVAGNARO

Chapter Three

Wildlife and Oaks

Native oaks and oak communities profoundly affect the variety and abundance of California wildlife. The 20 oak species figure significantly in producing food and providing shelter on more than 30 million acres (30%) of the state's land. Hundreds of vertebrate species and thousands of invertebrate species are associated with California's oak landscapes.

Oak acorns, leaves, wood, and sap are sustenance for a myriad of insects, birds, and mammals. Among these animals are insects so specialized that they feed only on the photosynthetic cells of blue oak leaves. Other insects dine on almost anything that is *Quercus.* Some vertebrates, such as bear and deer, depend on the nutritious acorn crop for food while others have an indirect dependence on oaks. Reptiles and amphibians, for example, do not consume oak products but prey heavily on insects that do.

While food is a primary resource produced by oaks, of greater overall significance is the fact that oak communities contain the nooks, crannies, perches, and passages where animals live, breed, or rest. The physical structure of those communities, especially the way different plant species are arranged in time and space, determines the availability of shelter, nesting sites, and corridors for travel. An oak woodland with complex structure—an overstory of old, middle-aged, and young trees, along with understory canopies of shrubs and herbs—forms a wealth of micro-habitats for animals to occupy. Such an oak woodland can support far more wildlife species than simpler communities with few plant species and canopy layers.

The branch of synecology dealing with plant-animal interactions is relatively young, and so there are many gaps in our knowledge of oaks and wildlife. Drawing upon a recent body of studies, this chapter describes how wildlife utilize native oaks and oak communities for food and shelter. The discussion then summarizes specific ways that insects, amphibians, reptiles, birds, and mammals interact with California's oaks. The text also profiles several animals closely associated with oaks.

Oaks as a Food Resource

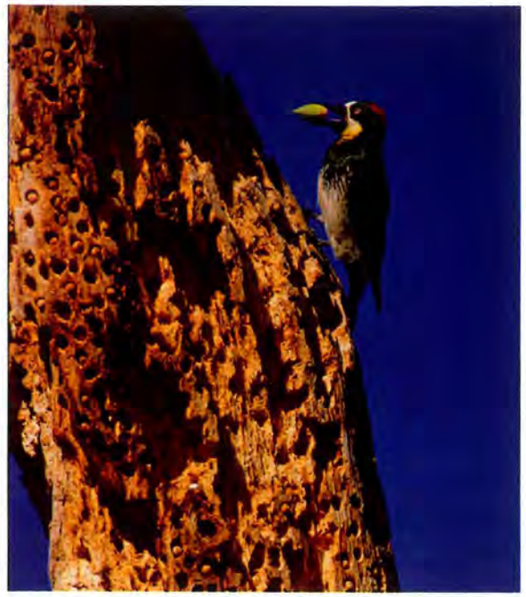
Oaks produce a cornucopia of wildlife foods, including acorns, leaves, twigs, sap, roots, and pollen. They form the basis of an elaborate food web, with herbivores eating the oak products, and carnivores eating the herbivores. Enriching the

Above: A baby dusky-footed woodrat. BILL FILSINGER
Opposite: A great horned owl and her chick perch in their nest high in a valley oak. MICHAEL SEWELL

bounty of oak-associated foods are fungi, lichens, and mistletoe, all of which are relatively abundant in oak communities.

Acorns are the most widely recognized food resource identified with oaks. Consumed by insects, mammals, and birds, they are a seasonal, high-energy food, rich in carbohydrates and fats. While insects feed on both immature and ripe acorns, mammals and birds strongly prefer the latter. Acorns ripen in late summer and autumn, and depending on the species, mature at slightly different times. In communities with more than one oak species, the harvest may last from August to November. Because different species produce "bumper crops" during different years, a diverse oak woodland or forest rarely experiences a year without acorns.

The fall acorn crop comes when many animals must put on fat for the long winter. Other sources of food, such as grasses and deciduous leaves, are usually dry and of low nutritional value at this time of year. A mule deer, for example, may eat over 300 acorns per day during October; for weeks this single source may constitute over half of its daily food intake. The deer's heavy consumption of acorns, which helps it accumulate a fatty layer for insulation and energy, may confer additional benefits as well. Studies of deer and other mammals

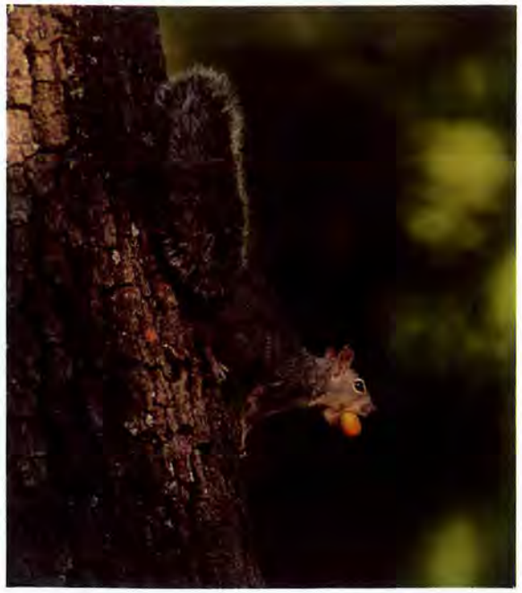


Acorn woodpecker and granary tree. TIM DAVIS

suggest that the size of the mast crop—a term that includes all acorns, nuts, and berries in a community—is linked to reproductive success during the following year.

Harvest season allows black bears, feral pigs, and band-tailed pigeons to feast on the available acorns. Gray squirrels, woodrats, scrub jays, and acorn woodpeckers spend much time and effort caching the nuts for later consumption. (See "The Acorn Woodpecker" in this chapter.) Acorns keep well because their hull protects the enclosed seed from desiccation and deterioration. An acorn cached in a nest, burrow, granary, or other protected site can remain edible until the next harvest.

The foliage of oaks is another important food resource. Although oak leaves may be tough and contain bitter chemicals known as tannins, many animals consume them readily. Dusky-footed woodrats gnaw off and eat the leaves of oaks. (See "The Dusky-footed Woodrat" in this chapter.) Deer and domestic livestock browse extensively on oak leaves and twigs, especially in summer and fall when green grasses and forbs are less available. California oak moth caterpillars, tent caterpillars, and western tussock moths ingest large quantities of oak leaves, sometimes denuding whole trees. Aphids, whiteflies, mites, and leafhoppers suck sap from leaves and tender shoots.



A western gray squirrel races down the trunk of a valley oak with an acorn. MICHAEL FRYE

Mule deer doe and fawns travel under the cover provided by an oak woodland. B. "MOOSE" PETERSON

Oak branches, trunks, and roots also furnish food. Western harvest mice strip the bark from saplings. Pocket gophers eat the roots of seedlings and young trees. A host of burrowing insects consume woody twigs and limbs. The oak pit scale and several species of birds imbibe sap from phloem tissue beneath the bark. Larvae of California prionus (a longhorn beetle) tunnel into food-storing roots. Even the flowers of oaks are a food resource: bees and other insects gather pollen, while larvae of at least three species of moths and two species of birds feed on whole catkins.

Oaks as Shelter

The structural diversity of California's oak communities provides many kinds of shelter to wildlife. Differences in the number and height of canopy layers, the density of branches and foliage, and the variety of plant species in the community determine many of the environmental conditions important to animals. The shady, spacious interior of northern mixed evergreen forest bears little resemblance to the dense, sun-drenched thickets of desert scrub oak chaparral. As a result, different assemblages of animals will characterize these two communities. Structural diversity within and among California's oak communities offers a wide range of sites for wildlife activity.

Nest of endangered least Bell's vireo. B. "MOOSE" PETERSON

From the treetops to the root tips, every part of an oak community is utilized for shelter. Leaf canopies moderate light, temperature, moisture, and wind to the community as a whole. Within the canopy, birds and mammals find branches for supporting nests and insects locate suitable twigs and bark for depositing their eggs. Beneath the canopy, trunk cavities are important for nesting and hiding even if the tree has long since died and fallen over. Understory shrubs shield prey from predators and form protective thickets for raising the young. A litter layer of dead leaves, twigs, and branches on the soil surface retains enough moisture for

Top: A mountain lion leaps to catch its prey in an oak woodland. MICHAEL SEWEL
Bottom: Feral pigs forage for acorns during the autumn harvest. MICHAEL SEWEL

Mammals

Of California's 169 terrestrial mammal species, at least 60 utilize oak landscapes for food or cover. From demure, insectivorous moles to imposing, carnivorous grizzly bears, oak communities were brimming with fur-bearing creatures when the first Europeans arrived. Many of these species were ruthlessly trapped, hunted, and poisoned, and some driven to extinction. The fates of large, roving mammals such as elk and mountain lion are still uncertain as oak-dominated habitats vital to their survival continue to shrink and disappear as a result of land development.

Acorns are the most important oak food utilized by mammals and are found in the diets of at least 37 California species. Squirrels, gophers, and wood rats are typical consumers, but at one time so were grizzly bears. (See "Acorns and Grizzly Bears" in this chapter.) Although no mammal depends entirely on acorns, studies have shown a correlation between acorn availability and reproductive success in western gray squirrels, bears, feral pigs, and deer. New generations of these animals are, therefore, linked to new generations of oaks.

After the year's supply of acorns has been exhausted and quality spring herbage becomes scarce, mule deers often turn to oaks for browse. At such times, foliage and twigs from black, blue, canyon, and other species constitute as much as 40% of the mule deer diet. Stump-sprouts and low-growing branches are easy to reach, but when the low browse is gone, these nimble animals stand on their hind legs, with neck and chin extended, and stretch up into the canopy.

Oak-associated plants such as mistletoe and lichens are also elements of the mule deer food supply. In feeding experiments designed to test deer preference among 31 species of browse, mistletoe and lichen occupied the top two positions. These plants offer a relatively high year-round crude protein resource and are especially important to deer during the winter.

Many carnivorous mammals spend time in oak communities searching for prey. Oak woodlands and forests often contain a higher density of animals than adjacent, non-oak communities and are very attractive to predators. The large numbers of mule deer that inhabit blue oak woodland and scrub oak chaparral, for example, attract and sustain significant populations of mountain lions. Ecologically,

A young mule deer browses on the leaves of an oak sapling. IAN C. TAIT

animals such as the mountain lion exist on the outermost edges of the oak-based food web.

Dens and nests are often located in oak communities. Raccoons and squirrels utilize cavities in standing trees, while deer mice and striped skunks reside beneath fallen trees and limbs. Overstory trees and understory shrubs help conceal den sites, reduce exposure to harsh weather, and provide cover for escaping from predators. Gray fox and bobcat seek shelter from summer heat beneath dense stands of scrub oak chaparral. Squirrels and woodrats use the network of limbs and trunks in oak woodlands for travel and escape routes.

The ecological characteristics of oaks and oak communities attract and sustain mammal populations for a variety of reasons. Researchers conducting studies on the denning behavior of black bears in the San Bernardino Mountains, for example, concluded that the bears preferred to den in southern mixed evergreen forest where canyon oak dominated. (Black bears were introduced to Southern California in the 1930s when a group of 16 bears was transported from Yosemite National Park.) They concluded that black bears chose this plant community because it was relatively undisturbed by humans, contained a supply of acorn and berry crops, and had cool winter temperatures. The cool temperatures, required for successful denning, were maintained by the dense canopies of canyon oak on north-facing slopes and in steep canyons with cold-air drainage.

Of all the vertebrates that interact with oaks, mammals probably have the greatest impact on oak regeneration. Although there is no simple explanation for the lack of regeneration, introduced and native mammals may contribute to the problem. Browsing and foraging by sheep, cattle, and deer are thought to be especially detrimental. These herbivores browse on oak leaves and twigs of mature trees and feed on young seedlings that have little or no chance of surviving frequent defoliation. Feral pigs also destroy seedlings and disturb established oaks by rooting for subterranean bulbs and fungi. All of these animals consume large quantities of acorns that might otherwise germinate and grow.

Smaller mammals, especially rodents, affect oak regeneration as well. Pocket gophers are probably the principal predators of buried acorns, and the extensive systems of underground tunnels they construct disrupt and sometimes kill the roots of young oaks. Gophers and mice also prey on surface acorns, seedlings, and young saplings. Some rodent activities, however, can enhance oak dispersal and regeneration. Gray squirrels and ground squirrels consume large numbers of acorns, but their tendency to cache supplies at some distance from the parent tree is an important mechanism for oak dispersal. Acorns which end up buried beneath a layer of soft soil are less susceptible to desiccation or predation than those on the surface. Some cached acorns are not retrieved, and these will germinate with the fall rains.

Top: In many areas of California black bears rely on the fall acorn crop to put on winter fat. KENNAN WARD
Bottom: The gray fox frequently hunts and seeks shelter in scrub oak chaparral. MICHAEL SEWELL

The Oaks of San Simeon

In April 1919, newspaper publisher William Randolph Hearst met with his architect, Julia Morgan, to begin designing an elaborate estate for his rustic property in the Santa Lucia Mountains north of San Luis Obispo. As they discussed Hearst's plans, little did they know that the building project would eventually span three decades and become a California landmark and major tourist attraction: Hearst Castle.

The estate was to be situated on an oak-shaded hilltop overlooking the Pacific near the seaside community of San Simeon. As construction began, Hearst's utmost concern was the preservation of the native trees that dotted the building site. He decreed that numerous coast live oak and bay trees be incorporated into the landscaping, and under no circumstances were live oaks to be removed.

Many of the oaks were 150 to 200 years old, with huge trunks, thick, twisting branches, and massive roots. Julia Morgan had no choice but to move some of the oaks—but how? At her drafting table, she devised a method for excavating, boxing, and moving the trees, and later described the procedure in a letter to Hearst:

> The program [of moving an oak] consisted of tunneling under the tree and casting three or four parallel reinforced concrete girders under the main root area of the tree. A more or less circular trench was then dug around the tree and a reinforced concrete band was poured in this ring against the earth containing the roots. A bottom was then placed in this ring by undermining and lagging, using the concrete girders to support the lagging. Timbers and rollers were then placed under the girders and the tree was then ready for either jacking up or moving laterally.
>
> In some cases the moving was done by means of rollers, and in at least one case, where the movement was downhill, the moving was effected by means of greased skids.

Moving mature coast live oaks during construction of Hearst Castle. HEARST MONUMENT ARCHIVES

From 1926, when the first oak was moved to make way for the main building, until 1948, when construction at Hearst Castle was completed, six mature coast live oaks were relocated. Hearst also ordered an oak to be rotated so that its low-hanging branches would not disturb a walkway.

The relocation of oaks at Hearst Castle set a precedent in landscape architecture: prior to that time, oaks and other large specimen trees were rarely moved to make way for developments. Visitors to Hearst San Simeon State Historical Monument now come to enjoy the beauty of the man-made environment and the impressive art collection that Hearst used to furnish his home. They also appreciate the ancient coast live oaks that grow here, some of which were moved during construction of the castle. Four of the specimens are still alive and continue to provide shade, color, and habitat, thanks to the efforts of Julia Morgan and William Randolph Hearst.

—Robert C. Pavlik

Vineyards, such as this one in San Luis Obispo County, have replaced tens of thousands of acres of native oak woodlands. KAREN AND ROLAND MUSCHENETZ

Using Oaks in the Modern World

As California's human population exploded in the 20th century, the trend towards consumptive rather than sustained uses of oaks and oak communities was rapidly accelerated. In 1900 the total population of the state was 1.5 million people; by 2000, the number had surpassed 33 million. Most of this growth took place after 1940, during which time the oak stands throughout the state declined precipitously. In San Luis Obispo County, the reduction in hardwood (mostly oak) acreage was 27%, in Los Angeles County it ranged up to 38%, and in Tuolumne and Santa Barbara counties it was 42%. The increased demand for land to raise crops, and to build houses, commercial centers, and roads, has had a great and irreversible impact. Other uses of oak communities, such as fuelwood cutting, timbering, grazing, recreation, and scientific study, have also been important in modern California. These types of resource utilization appear to be sustainable if they do not severely inhibit oak germination and growth.

Consumptive Uses

Within this century, agricultural clearing has been the single most consumptive use of oak woodlands and riparian forests in the state. Oak communities with level topography and rich soil were among the first areas converted to large-scale farming operations by California's modern agricultural industry. The woodlands of the San Fernando, San Gabriel, and Santa Ana valleys were exchanged for vast orchards of oranges, lemons, and walnuts. More than 70% of all riparian forests in the Central Valley were cleared for plantations of stone fruits, olives, almonds, pears, and a wide variety of vegetables. Rich bottomlands in the Napa and Sonoma valleys were planted with grapes. Row crops and orchards replaced the woodlands and savannas of Tehama, Mendocino, Santa Clara, Monterey, and Riverside counties. Although there is no doubt that California farmers have built one of the most productive and profitable agricultural industries in the world, there is also no doubt that it was established at great expense to the native oaks.

Since the 1940s, more than one million acres of oak woodland, and perhaps as many as two million acres, have been cleared of trees in order to make range improvements for livestock. Rangeland clearing took place in 42 of the 58 counties, but was concentrated in and around the Central Valley. Blue oak was the species most often removed, but interior live, coast live, and canyon oak were also affected.

Following World War II, California's economy and population entered a period of unprecedented expansion. Intensive land development for homes, commercial buildings, reservoirs, roads, power transmission lines, and pipelines has consumed oak communities in both coastal and inland counties. The growth of cities such as Redding, Sacramento, San Jose, Fresno, and San Diego, and the many suburbs of Los Angeles and San Francisco, occurred in oak-covered areas or on lands previously converted from oaks to agriculture. Since the early 1970s these developments have taken place on 92,000 acres of oak woodland, averaging about 7,400 acres per year. Recent projections indicate that by early this century an additional 244,000 acres will be affected, including communities of blue oak (160,000 acres), coast live oak (50,000 acres),and valley oak (34,000 acres). Whether the oaks will be removed entirely or a few left as stately

Top: Livestock grazing is one of the most important commercial uses of California's oak savannas and woodlands. DAVID CAVAGNARO
Bottom: Oak woodlands furnish much of the state's firewood. PAUL R. JOHNSON

remnants amidst a sea of houses, the overall effect will be the same: a population or community of oaks will be depleted once and for all.

Sustainable Uses

Oak wood has long been recognized as a superior source of fuel and charcoal because of its density and lack of flammable resin. Commercial harvest of oak fuelwood dates back to the mid-19th century. In recent years, oak cutting—as opposed to clearing—has increased dramatically: in 1980, the California State Board of Equalization determined that more than 12,000 cords (1 cord = 128 cubic feet) of hardwoods (primarily oaks) were cut for use as fuel in homes and industry; by 1985 this figure had nearly tripled to 35,000 cords per year. This still amounts to a very small fraction of the total available wood and has involved less than 14% of California's woodland acreage. In many areas of the state, oak fuelwood commands a price that provides considerable economic incentive for commercial harvesters. Blue, interior live, and Oregon oak account for more than 75% of the productive acreage.

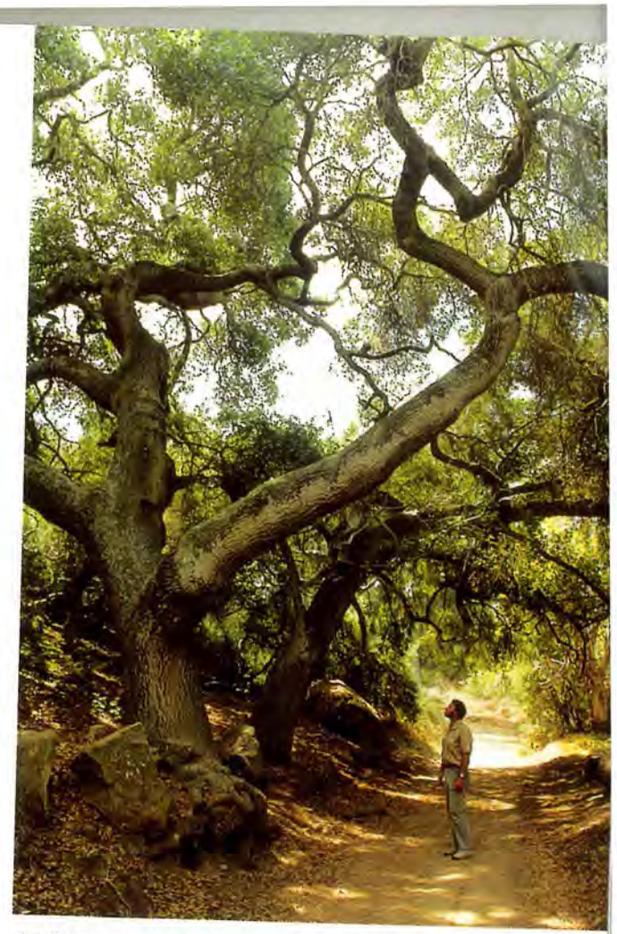
Until very recently, lumber production from California oaks has been insignificant when compared to lumber production from pines, firs, and cedars. In 1982 only 10 million board feet of hardwood lumber passed out of California's sawmills, or about 0.4% of the total 2.6 billion board feet produced. Despite the fact that demand for quality oak products is high and that suitable hardwoods are abundant (there are about 25 billion board feet of hardwood sawtimber in the California inventory), there have been few attempts to utilize the resource. The primary reason is that the technology of harvesting and processing timber has always been adapted to the characteristics of softwood species and communities. Softwood trees, which often grow in dense, single-species stands, have long, wide, straight trunks which can be efficiently converted into lumber. Oaks, by contrast, grow in scattered stands, which makes harvesting more difficult; the irregular trunks of oaks are also more difficult to mill. New technologies have recently been developed, however, and at least one company, Cal Oak of Oroville, has succeeded in producing oak paneling, flooring, furniture stock, and doors. In 1985 this one operation produced 3.3 million board feet of high-grade lumber, 80% of which was from black oak. Black oak lumber compares favorably with oak lumber from the eastern United States in terms of beauty and ease of woodworking. Having overcome some of the technical and economic problems associated with oak timber production, it is possible that some expansion of the industry is likely in the future.

One of the most important contemporary uses of oaks and oak communities is for livestock grazing. Acorns are highly regarded as a food source for domestic cattle, sheep, and pigs. They ripen and fall at a time of the year when quality forage is scarce and are, at the same time, a good source of carbohydrates and crude fiber. Sheep fed a diet of 30% blue oak acorns and 70% standard feed gained an average of 0.32 pounds per week, compared to an average loss of 0.86 pounds per week in control animals given 100% standard feed. Oak leaves are also browsed for their protein and tend to be available during a large portion of the year.

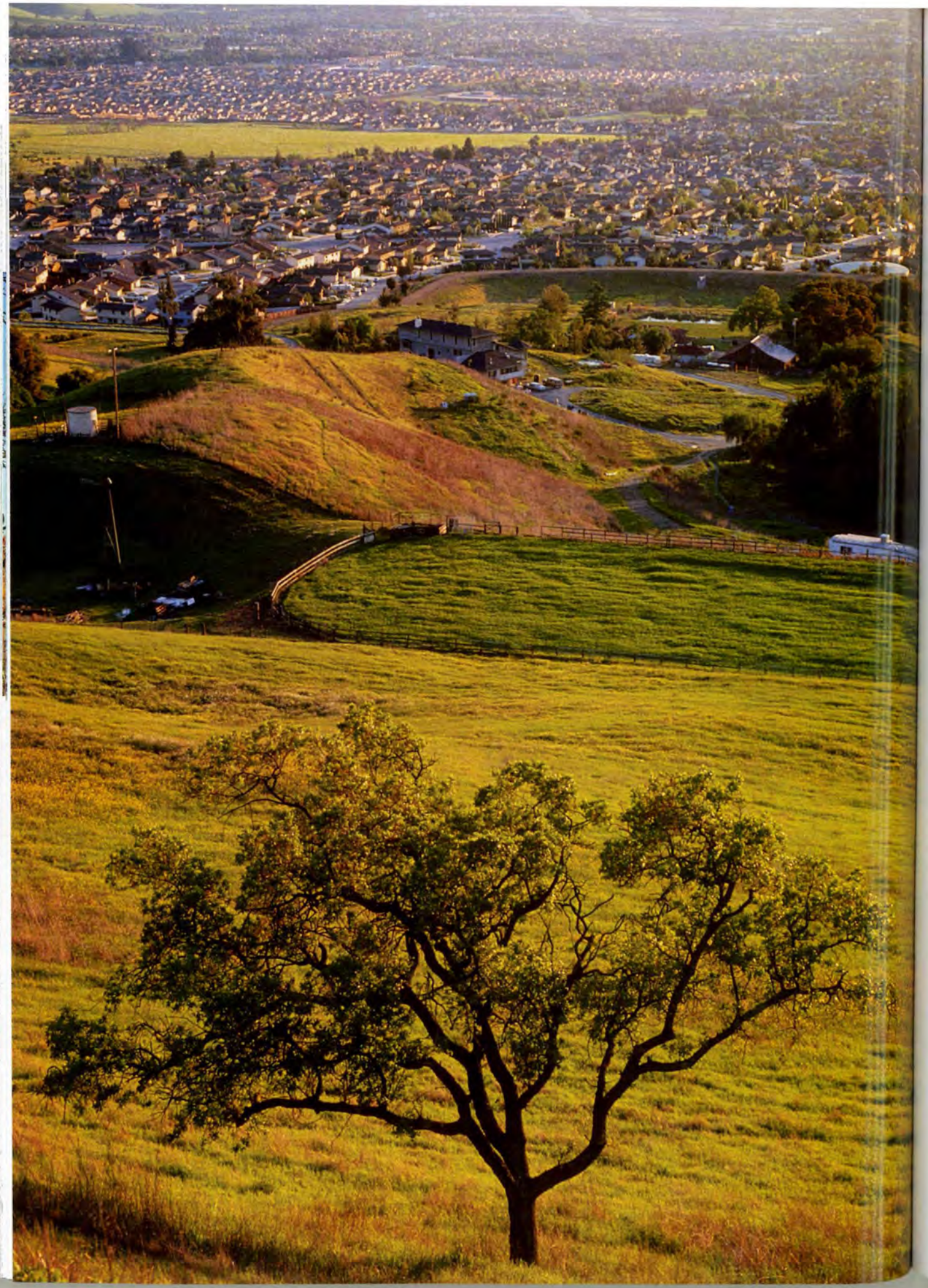
More important, however, is the fact that oak communities, especially blue oak woodland, have a productive understory of annual and perennial grasses that forms the basis of the multi-billion dollar livestock industry in California. About 60% of the state's rangelands, or 10.5 million acres, are oak woodlands that provide meat and dairy products for millions of people. From the standpoint of the oaks, however, livestock grazing is a double-edged sword. On one hand, moderate grazing acts as a substitute for wildfire, eliminating annual grasses and shrubs that compete with oak seedlings as well as with established trees. But grazers can also be detrimental to oaks by consuming acorns, browsing foliage, trampling or eating seedlings, and compacting the soil. In addition, the conversion of oak woodland into annual grassland by extensive clearing represents a consumptive use of oaks with only short-term economic benefits at best. Between 1945 and 1975, about 32,000 acres of oak woodlands were cleared every year, but the benefits to range and livestock production lasted only about 15 years at a given site. This implies that clearing for purposes of range improvement may not be as desirable as once thought and, indeed, the rate of clearing since the 1970s has declined to less than 2,500 acres per year.

Recreation is an important part of today's use of California's oak communities. Often beautiful and serene, they provide opportunities for wildlife study, plant identification, hunting, camping, hiking, and quiet reflection. A great number of county, regional, state, and even national parks preserve small pieces of oak landscapes across California. Examples include Placerita Canyon Park and Nature Center near Los Angeles, the East Bay Regional Park District near Oakland, Cuyamaca Rancho State Park near San Diego, and Pinnacles National Monument near Salinas. (More than 100 places to view native oaks on public lands are described in Chapter Six.)

Finally, the scientific uses of California's oak landscapes cannot be ignored. In addition to parkland, oak reserves have been established by the Nature Conservancy, the U. S. Forest Service, the Bureau of Land Management, the State of California (Department of Forestry and the Department of Fish and Game), and the University of California. The reserves are essential for studying the basic biology of oaks and their communities and for conducting research on the preservation, use, and restoration of these invaluable California resources.



A hiker marvels at the massive limbs of a coast live oak in Crystal Cove State Park. BILL EVARTS



Chapter Five

Preserving Oaks for Future Generations

When California entered the 20th century, the state's agricultural and livestock industries were expanding. Patterns of land use established in oak woodlands during the 1800s, including agricultural clearing, woodcutting, and urban expansion, continued and intensified. Cities grew with the pulse of prosperity and spread into the countryside, displacing oak landscapes with the sprawl of houses, industry, roads, and other symptoms of a burgeoning economy.

As oaks fell before the ax and the plow at the turn of the century, California's fledgling conservation movement was fighting to protect other tree species—the redwood and its cousin, the giant sequoia. Organizations such as the Save-the-Redwoods League and the Sierra Club sought new or expanded parklands to protect these majestic conifers. While battles over redwoods and sequoias captured the headlines, the first skirmishes to save oaks were beginning to take place. During the opening decade of the 20th century another concern about oaks surfaced: botanists noted an absence of oak seedlings in areas grazed by livestock. Seventy years passed, however, before the intertwining issues of oak protection and regeneration shared the agenda at scientific symposia devoted to the ecology and management of California's oaks. The symposia, publication of new research, and related public events signalled a growing interest in oaks and marked the beginning of a new era of environmental activism and research on their behalf.

This chapter explores the complex problems that face California's oaks and describes a strategy for oak conservation. It then profiles several oak preservation and habitat restoration efforts.

Oaks in Trouble

In the 230 years that followed the founding of the first Spanish mission at San Diego, California's human population increased from about 300,000 to over 33 million. This staggering growth and the concurrent introduction of ranching and farming to the state's oak-covered valleys, plains, and foothills brought dramatic and irreversible changes to the natural landscape. Among the first to recognize the relentless loss of California's oaks was botanist Willis Linn Jepson, who wrote in 1909:

> In some regions where the horticultural development has been rapid or the needs of an increasing population urgent, extensive areas have been cleared to make room for orchards or gardens, and scarcely a [valley oak] tree remains to tell the story

Above: A small remnant of valley oak riparian forest is preserved at Caswell Memorial State Park. JIM BARRY
Opposite: Homes have displaced the oaks that once graced this valley, Santa Clara County. FRANK BALTHIS

A valley oak is removed from farm land in the upper Salinas Valley, circa 1915. ATASCADERO HISTORICAL MUSEUM

of the old-time monarchs of the soil; in other regions the destruction has not been so complete.

The observations of scientists like Jepson were shared by a growing legion of citizens, some of whom mounted the first efforts on behalf of endangered oaks. Early campaigns, such as the one in Visalia to preserve a valley oak grove in 1909 or the fight in Glendale in 1927 to save a venerable coast live oak from road construction, were harbingers of the widespread concern for native oaks that began to coalesce in the 1970s and 1980s.

Researchers in California's universities and colleges, as well as biologists at state and federal agencies, had become increasingly aware of oak issues by the 1970s. This was evident in the workshops and papers offered at the first oak symposium held at Scripps College in Claremont in 1979. The proceedings of this meeting, along with those of two subsequent symposia at Cal Poly State University, San Luis Obispo (1986) and UC Davis (1990), were published by the U.S. Forest Service's Pacific Southwest Forest and Range Experimental Station in Berkeley. These reports broadened the concern about oaks within the scientific community and helped stimulate much of the oak research that is being conducted today.

A cooperative effort to study the management, regeneration, and enhancement of oaks and other hardwood trees was launched in 1986 when the California State Legislature established the

The Giant Oak near Visalia, photographed about 1900, stood 178 feet high. ALAN GEORGE COLLECTION

Integrated Hardwood Range Management Program (IHRMP); the program is conducted by the University of California and the California Department of Forestry and Fire Protection. Provided with state funding and a mandate to study oak resources, the IHRMP sponsors oak research and disseminates oak management information to agencies and citizens throughout California.

The surging interest in oaks during the 1980s also gave rise to the California Oak Foundation. Formed in 1988, the foundation promotes the statewide protection of oaks, and stresses the "conservation, restoration, and management of our native oak heritage."

At the city and county level, proponents of urban forestry have played a growing role in oak protection. By 1991 more than 100 California municipalities had enacted oak tree preservation ordinances. In addition to citizen activism, public acquisition of lands for recreation and wildlife preservation has augmented the protected acreage of oak landscapes. In 1990, for example, Californians passed a bond measure (Proposition 117) that makes $30 million available each year for 30 years for the enhancement and purchase of wildlife habitats, including oak communities.

Despite a growing mantle of protection, California's oaks remain at risk. The vast majority of the state's oak woodlands and savannas are found on private property; many of these oak communities are located in suburban and semi-rural areas destined to be transformed by land development. Since the 1940s, California has lost more than one million acres of oak woodland as a result of rangeland clearing and agricultural conversion. Projections indicate that population growth—and the inevitable suburbanization that accompanies it—may claim another quarter million oak-covered acres by the year 2010.

The Regeneration Problem

While concern for oaks among the public has centered around the need to save individual trees or woodlands, the efforts of the scientific community have largely focused on the issue of oak regeneration. In many areas of the state, particularly in savannas or woodlands with low annual rainfall, oak populations are experiencing little or no tree replacement. Although these populations periodically have seasons of good acorn germination and seedling establishment,

Top: A plant scientist closely inspects the annual rings of a blue oak to determine the tree's age and growth characteristics. CAROLINE L. SHUGART
Bottom: Oaks are converted to firewood during range clearing in Amador County. DANIEL D'AGOSTINI

there is a persistent failure of the seedlings to be "recruited"—to make a transition into saplings and pole-size trees. Communities dominated by valley, blue, or Engelmann oaks are especially devoid of trees established in the last 75 to 125 years. In the absence of vigorous seedlings and saplings to take the place of aging and fallen monarchs, the nature and persistence of many oak landscapes is in jeopardy.

The first scientist to detect poor regeneration among oaks may have been dendrologist George B. Sudworth. In describing blue oak in his 1908 book, *Trees of the Pacific Slope,* he wrote: "Prolific periodic seeder. Seedlings scarce in ground usually

Introduced annual grasses often form a dense ground cover in valley oak savannas. JOHN EVARTS

grazed or cultivated, where much seed is destroyed or has little chance of germination; rather abundant elsewhere." For the next 60 years, however, practically no mention of the oak regeneration problem appears in print—a notable exception being the observations of rancher, botanist, and author Ernest Twisselman, who suggested in 1956 that livestock grazing and introduced annuals were both detrimental to oak recruitment on Kern County rangelands.

In 1971 research ecologist James R. Griffin published the results of his landmark study of oak regeneration in the upper Carmel Valley. Despite good acorn germination and the complete exclusion of livestock, Griffin's seedlings experienced a poor survival rate for a variety of reasons, including browsing by deer, predation by pocket gophers, and competition for soil moisture on grassy slopes. Two years later, Griffin sounded the alarm over the future of valley oaks in Central California in *Fremontia,* the journal of the California Native Plant Society. In an article titled "Valley Oaks—The End of Era?" he stated:

> Where are the young trees under the big oaks? At first glance there seem to be none. One can drive through literally tens of thousands of acres and not see a single Valley Oak sapling. The alert observer can poke around and find a few young trees, to be sure, but the conclusion is clear: under present circumstances, large portions of the savanna [on the Hunter Liggett Military Reservation] will not be adequately replaced by Valley Oaks.

The lack of blue oak regeneration and the wholesale clearing of blue oaks to improve rangeland forage was addressed by plant ecologist V. L. Holland in his resonant 1976 article in *Fremontia* titled "In Defense of Blue Oaks." He began by warning: "California may be in danger of losing an important part of its biotic heritage, the picturesque blue oak trees that dot the scenic foothill woodlands." Holland implicated livestock grazing, deer browsing, acorn predation by rodents, and changes in the makeup of California's grassland vegetation as the chief reasons for low recruitment in blue oak stands. The work of researchers like Griffin and Holland raised troubling questions about the myriad causes of poor oak regeneration and set the stage for future scientific and policy debate on the issue.

The widespread lack of oak regeneration is a complex problem with origins that can be traced back to the arrival of the Spanish fathers. Although Indians altered and managed the landscape with fire for hundreds, if not thousands, of years, it was the Europeans who wrought the most profound ecologic changes to California. With permanent settlements came the weeds, livestock, predator control, and fire suppression that would impact the state's flora, fauna, and natural communities forever. We are just beginning to understand how these factors complicate and hinder the establishment of oak seedlings and relate to the problem of oak regeneration.

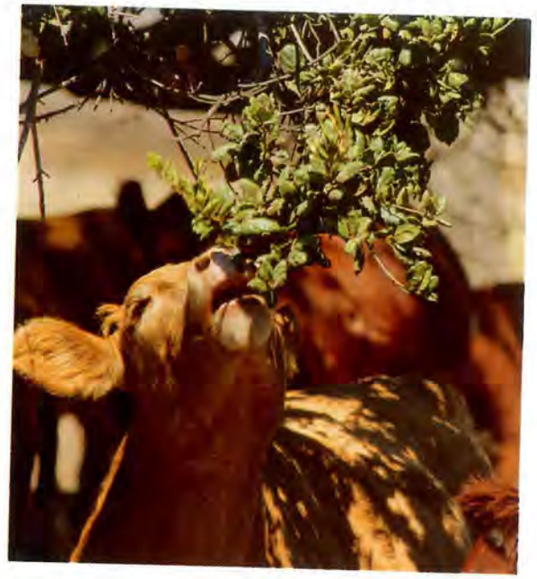
Since the arrival of the Spanish in the late 1700s, native grasses and wildflowers have been largely replaced by weedy plants that came from the Mediterranean Old World. The seeds of these

A herd of sheep gathers beneath a winter canopy of oaks in the Sacramento Valley. RON SANFORD

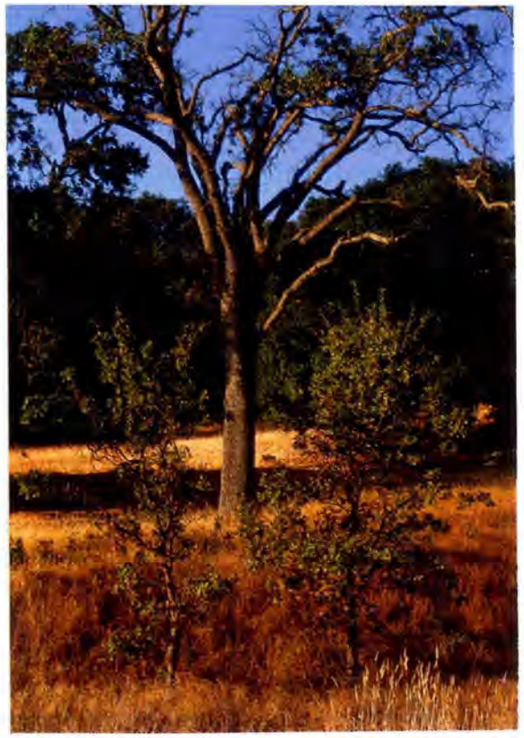
weeds, especially those of annual grasses, arrived as stowaways in the hay bales and grain sacks that supplied Spanish settlements and were casually dispersed throughout the territory on the hides and in the feces of roaming cattle and wildlife species. Other weed seeds, such as those of filaree, were sometimes intentionally sown by colonists to ensure plentiful forage for sheep. Livestock preferred to graze on the palatable and nutritious native plants that often lack the barbs, bitter juices, and ephemeral foliage of the European weeds. The weeds, thus avoided, grew with relative impunity for they evolved with these grazers in the Old World. But in the New World they have escaped the diseases, insect pests and other organisms that kept their homeland populations in check. The weedy grasses and herbs spread rapidly, forming a dense, competitive cover that now dominates the California grasslands.

This complete change in the flora of the grasslands has brought other broad ecologic changes that affect oak regeneration. Recent research has shown that introduced annual grasses, which grow rapidly during spring, deplete surface water much earlier in the season than the displaced perennial grasses. This diminishes water supplies to oak seedlings. Although the ultimate effects of grassland composition on oak regeneration are not fully understood, observations such as these suggest that grasslands dominated by introduced species do not provide an environment that is conducive to natural oak regeneration.

In addition to facilitating the spread of competitive, non-native plants, livestock grazing directly impacts oak regeneration. Stock eat leaves, acorns, seedlings, and saplings as they move through the savannas and woodlands. The growth of saplings is suppressed when branches and leaves are browsed, and these saplings may never make the transition to tall adult trees. The extent to which livestock are detrimental to oak regeneration has been the subject of heated debate. Research conducted at a number of locations in California has challenged the assumption that sheep and cattle are the sole culprits in poor oak regeneration. In some cases, sites that have been free of livestock for decades show the same low rates of oak recruitment as lands still being grazed. However, some plant ecologists feel that changes brought about by prior grazing can so alter an environment that the effects of grazing can endure well beyond



Top: Cattle browse on oak leaves, especially when grasses are dry in late summer and fall. RICK PHILLIPS
Bottom: Native bunchgrasses are scattered across this prairie in Tehama County near Corning. TOM GRIGGS



Pole-size saplings, such as the pair pictured here, are rare in many valley oak woodlands. JOHN EVARTS

the point that livestock are removed from the area.

The arrival of Europeans and the introduction of widespread grazing brought other changes to California's oak woodlands that, in aggregate, may contribute to poor oak regeneration. Rangeland soils, for example, are compacted where livestock travel, congregate, and rest, making it difficult for rainfall and oak roots to penetrate. This may be particularly critical in areas as hot and dry as those occupied by the blue and Engelmann oaks.

Domestic livestock are not the only animals that eat oaks, and dramatic changes in populations of oak and acorn predators also accompanied European settlement. Deer populations grew explosively as mountain lions were hunted to protect livestock. Abundant deer place great demands on acorn crops and on oak saplings for nutritious forage. Where herbivore browsing is intense, young oaks may take the form of shrubs or bushes. At the University of California's Hastings Reservation, for example, observations of a group of coast live oak seedlings that became established prior to 1940 showed that by 1969, less than half had begun to make the transition into saplings—the rest remained shrubby because of browsing.

Pocket gophers, mice, and ground squirrels also multiplied in the absence of bobcats, gray fox, coyotes, and badgers. Large populations of these and other rodents voraciously consume acorns as well as the now-abundant seeds of non-native grasses and herbs. Studies in Carmel Valley have shown that even when valley oak acorns are protected from deer and cattle, fewer than 1% escape consumption by pocket gophers. Many that eventually germinate succeed only to have their fleshy roots devoured from below. In a San Luis Obispo County study less than 1% of the blue oak seedlings left unprotected from herbivores survived for three growing seasons. This research would indicate that reestablishing predator populations may be necessary in order to reduce herbivore populations in some stands of blue and valley oak.

There are some animals that clearly foster oak regeneration, including the scrub jay and western gray squirrel. These species cache acorns by burying them—and then recover only a portion of their harvest. This behavior can benefit oaks in at least three ways: first, buried acorns are less susceptible to predation by deer and other grazing animals; second, seedlings from buried acorns have much higher survival rates than those that emerge from acorns on the surface; and third, buried acorns are often placed outside the shady canopy of the parent trees in sites that may favor germination and seedling development.

Alterations in the rangeland fire cycle also influence oak regeneration. Widespread Indian burning of oak landscapes was common when the Spanish arrived. As explained by a Karok woman in 1933, her people used fire for several reasons:

> Our kind of people never used the plow. . . . All they used to do was to burn the brush at various places, so that some good things will grow up. . . . And sometimes they also burn where the tan oak trees are lest it be brushy where they pick up the acorns. They don't want to burn too hard, they fear that the oak trees might burn. . . . Some kinds of trees are better when it is burned off; they come up better ones again.

Burning was practiced by ranchers until the mid-1950s but declined dramatically due to concerns about liability and air quality. It has all but disappeared from modern-day oak communities.

If fires are suppressed over long periods of time, the non-native understory may overwhelm any seedlings that are not yet well-established. Similarly, light ground fires help control weedy annuals and favor the growth and reproduction of native perennial grasses. The fast vertical growth of

oak sprouts following a wildfire may help young trees more rapidly achieve heights that put upper leaves and vulnerable shoots beyond the reach of browsing herbivores (about five to seven feet). On the other hand, if fires become too frequent the young oaks may be eliminated in spite of their ability to sprout. Although fire undoubtedly plays a critical role in the ecology of California's oak woodlands, its role is not yet well understood. A detailed study of tree ages and fire scars conducted in the Sierra foothills, for example, showed a high correlation between episodes of fire and successful establishment of blue oak saplings during the last 200 years. This relationship was associated with about 70% of the burns.

The growing body of published research on the subject of oak regeneration has identified various agents that inhibit seedling recruitment. More importantly, much of this literature proposes that successful regeneration only occurs when several natural factors coincide, such as a summer ground fire, large acorn crop, wet winter, and decline in the deer population. Seedling recruitment appears to be a somewhat irregular event, with "pulses" of regeneration taking place when and where the right combination of conditions exist. An example of such a regeneration pulse was documented at the Nature Conservancy's Kaweah River Preserve in 1983: a good acorn crop was followed by a wet winter and on-site flooding that reduced populations of ground-dwelling acorn predators. The preserve now supports an abundance of saplings that date back to that year.

While episodic regeneration may be the norm in many oak communities, it is unclear if this has always been the case. Age studies of blue oaks in Tulare and Kern counties indicate that prior to the mid-1800s some woodlands had a relatively steady rate of recruitment. Since species of *Quercus* typically live for 200 years or more, sporadic and sometimes widely spaced regeneration pulses could still be expected to produce sufficient saplings to replace the trees in aging stands. As Griffin concluded in his 1971 *Fremontia* article:

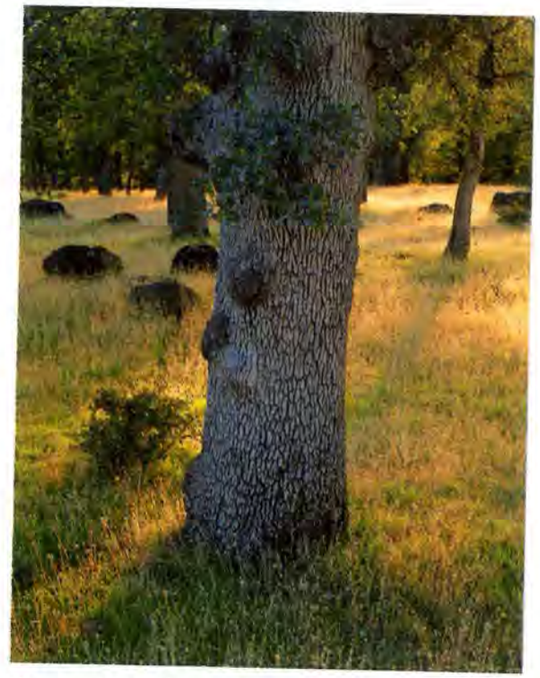
> Where grazing and browsing pressures are low during a combination of good acorn years and wet winters, new Valley Oaks may replace the veterans. These conditions seem hard to achieve, but we must remember that such a long-lived tree can afford to wait a long time for the winning combination to arrive.

Oaks of Special Concern

The combined impact of poor regeneration and habitat loss has particularly affected three tree oak species: valley, blue, and Engelmann. These are oaks of special concern.

Valley oak must compete with farmers and developers for prime lands in valley bottoms and on low foothills. Valley oaks in streamside habitats have been especially hard hit; as much as 90% of California's valley oak riparian forests were destroyed by the beginning of the 20th century. Compounding this loss of trees and habitat has been an alarming failure of valley oak seedlings to make the transition to saplings. Recruitment rates in valley oak communities, especially in savannas, are very low or nonexistent.

Blue oak is found on more than 10,000 square miles of land and therefore cannot be considered endangered. But the widespread absence of regeneration in blue oak savannas and woodlands, coupled with the escalating conversion of blue oak communities to ranchettes and subdivisions, has raised concern for the species in some parts of its range.



The growth of a blue oak sapling (left of tree trunk) has been stunted by browsing. WILLIAM M. SMITHEY, JR.