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Five Southern California Oaks: identification and postfire management

Timothy R. Plumb Anthony P. Gomez

The Authors:

TIMOTHY R. PLUMB was assigned to the Station's research unit studying the management of chaparral and related ecosystems in southern California, with headquarters in Riverside, California, at the time this study was done. He attended Oregon State College, where he earned a bachelor's degree (1954) in forest management, and the University of California, Berkeley, where he earned a master's degree (1959) in forestry. He earned a doctorate (1970) in plant physiology at the University of California, Riverside. He is now an associate professor of forestry at California Polytechnic State University in San Luis Obispo. **ANTHONY P. GOMEZ** is a scientific photographer assigned to the research unit studying the ecology of chaparral and associated ecosystems, with headquarters in Riverside, California. He earned an associate in arts degree (1974) in photography at Riverside City College.

Cover: (Left) This 60-foot tall coast live oak in Riverside County was heavily burned in the Soboba Fire in 1974. *(Right)* The same coast live oak 5 years later has made an amazing crown foliage recovery. It is an extremely fire-tolerant species.

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Oak trees are found on at least 20 million acres (8 million ha) in California. They comprise more than 9 million acres (3.6 million ha) of open woodland, are mixed with other evergreen broadleaf and coniferous trees in the mountains of California, and are also prominent members of the chaparral community. Although their current value as a timber resource is limited, oak trees provide a tremendous potential source of biomass for energy production and wood products. Perhaps even more significant are their roles in stabilizing soil for watersheds, and in providing wildlife habitats and forests for recreation and esthetic values.

All California oak trees are subject to partial or total killing by wildfire. Current efforts in southern California to use prescribed burning in oak stands to reduce fire hazard necessitate knowledge of the effect of fire on tree damage and survival. Effective management of oaks, therefore, requires an understanding of their response to fire.

Oak species vary in their susceptibility to fire. Individual species must be correctly identified before effective management plans can be made. Large, old trees damaged by fire should not be removed if crown recovery is possible. Some oak species are difficult to identify, especially when the trees are heavily charred and the leaves and acorns have been consumed.

This report provides a guide to identifying five of the prominent species of southern California oaks—coast live oak, interior live oak, California black oak, canyon live oak, and California scrub oak. It provides specific information for the identification of each of the five species; assesses fire damage for the trees on the basis of species, diameter-at-breast-height (d.b.h.), and degree of trunk charring; and, briefly outlines postfire management alternatives for fire-damaged trees.

IDENTIFICATION OF OAK SPECIES

Oaks native to California can be divided into three subgenera: white oaks (*Quercus*), intermediate oaks (*Protobalanus*), and black or red oaks (*Erythrobalanus*). The 15 native species, their common names, their subgenera (Tucker 1980) and growth habit are:

White oaks

Blue oak (*Q. douglasii* Hook. & Arn.)	Tree
Scrub oak (California scrub oak)[1] (*Q. dumosa* Nutt.)	Shrub
Leather oak (*Q. durata* Jeps.)	Shrub
Engelmann oak (*Q. engelmannii* Greene)	Tree
Oregon oak (Oregon white oak)[1] (*Q. garryana* Dougl.)	Tree
Valley oak (*Q. lobata* Nee)	Tree
Deer oak (*Q. sadleriana* R.Br. Campst.)	Shrub
No common name (*Q. turbinella* ssp. *californica* Tucker)	Shrub

Intermediate oaks	
Canyon live oak (*Q. chrysolepis* Liebm.)	Tree
Dunn oak (*Q. dunnii* Kell.)	Shrub
Island oak (island live oak)[1] (*Q. tomentella* Engelm.)	Small tree
Huckleberry oak (*Q. vaccinifolia* Kell.)	Shrub
Black or red oaks	
Coast live oak (*Q. agrifolia* Née)	Tree
California black oak (*Q. kelloggii* Newb.)	Tree
Interior live oak (*Q. wislizenii* A. DC.)	Tree

[1] Common names as listed in Little (1979).

Identifying some oak species is easy because of one or more unique characteristics, but other species are extremely difficult to identify because of diversity in the size and shape of the leaves, acorns, and trees themselves. Identification is further complicated by numerous varieties and hybridization among species. This is especially true for the shrubby species such as California scrub oak. Precise identification of shrub-sized oaks is probably unnecessary from a practical management basis, however, because small trees—those with stems less than 3 to 6 inches (7.6 to 15.2 cm) d.b.h.—will almost always be killed to the ground except by a light ground fire.

Most oaks have one or two key features that separate them from other species. These features are augmented in this guide by a detailed description of the bark, which is especially valuable for identifying burned trees when the leaves and acorns are missing. But because even bark varies within species with age, more than one illustration is provided to show some of its natural variation.

Three identification keys for leaf, acorn, and bark for two tree sizes are provided for the initial screening of the five species of southern California oaks. Once a species is tentatively identified, a more complete description is given in the next section, which includes a general description of the tree plus a detailed description of the leaves, acorns, and bark.

Leaf Key

A. Leaves conspicuously lobed, deciduous, leaf blade 2 to 8 inches (5.1 to 20.3 cm) long ..... California black oak.

AA. Leaves inconspicuously lobed to entire, evergreen, generally 1 to 3 inches (2.5 to 7.6 cm) long.

B. Leaves cupped downward, tufts of hairs on underside of leaf at the junction of the mid- and lateral veins ..... Coast live oak.

BB. Leaves not cupped.

C. Leaves shiny, pale green below, hairless ..... Interior live oak.

CC. Leaves not shiny, gray-green below.

D. Leaves with minute but conspicuous golden hairs beneath (when young), or gray-green or whitish beneath; lateral veins six or (usually) more on either side of midvein ..... Canyon live oak.

DD. Leaves never with golden hairs beneath; gray hairs below, never conspicuous; lateral veins commonly four or five (sometimes six) on either side of midvein California scrub oak.

Acorn Key

A. Inner surface of acorn shell (not the cup) densely to moderately woolly.
  B. Walls of cup often very thick; often covered with minute, golden hairs ..... Canyon live oak.

  BB Walls of cup thin, tapering to a very thin upper margin; never covered with minute, golden hairs.
    C. Acorns maturing in 1 year, that is, fully developed acorns on this year's growth .....Coast live oak
    CC Acorns maturing in 2 years, that is, they are on last year's growth.
      D. Nut (without cup) slender-ovate, tapering to apex ..... Interior live oak.
      DD. Nut (without cup) oblong, rounded at apex ..... California black oak.

AA. Inner surface of acorn shell smooth, not woolly ..... California scrub oak.

Bark Keys

Trees less than 6 inches (15.2 cm) d.b.h.

A. Surface smooth.
  B. Light gray ..... Coast live oak.
  BB. Dark gray ..... Interior live oak.

AA. Surface rough.
  C. No loose bark; shallow, vertical furrows ..... California black oak.
  CC Loose bark surface.
    D. Surface flakes irregularly shaped, no distinct furrow pattern, light gray ..... California scrub oak.
    DD. Surface flakes more or less rectangularly shaped, some vertical furrows .....Canyon live oak.

Trees larger than 6 inches (15.2 cm) d.b.h.

A. Surface smooth to furrowed, no loose surface bark.
  B. Furrow pattern (deep in old trees) divides bark into small black to reddish-brown, rectangular blocks ..... California black
  BB. Furrow pattern vertical.
    C. Surface smooth to wide-spreading, long, vertical furrows with light gray wide ridges between furrows ..... Coast live oak.
    CC. Surface smooth to shallow, short vertical furrows; dark gray ridges between furrows ..... Interior live oak.

AA. Surface furrowed; loose to somewhat firm outer bark.
  D. Mostly irregularly shaped, loose flaky bark; no definite furrow pattern; d.b.h. does not exceed 10 inches (25.4 cm) ..... California scrub oak.
  DD. Mostly narrow, vertical furrows; loose to more or less firm bark on ridges between furrows .....Canyon live oak.

FIVE SOUTHERN CALIFORNIA OAKS

Detailed descriptions of five, prominent southern California oaks are given in the following sections. At this time, comparable, descriptive information is not available for all five species. Much of the following information was obtained from Jepson (1909), Munz and Keck (1959), and Sudworth and others (1967).

Coast Live Oak

General description—*Height:* usually 20 to 40 ft (6 to 12 m), up to 80 ft. D.b.h.: 1 to 4 ft (0.3 to 1.2 m). *Age:* long-lived, 250 years plus. *Crown* (open grown): broad, dome-shaped, dense; may reach the ground (*fig. 1*); width up to two times height. *Crown* (closed stand): crown width may be less than one-half crown height (*fig. 2*). *Trunk* (open grown): short, 4 to 8 ft (1.2 to 2.4 m) long, forking into large, wide-spreading branches extending outward horizontally. *Trunk* (closed stand): clear trunk may extend 20 ft (6.2 m) before separating into two or three main branches extending upward at sharp angle. *Tolerance:* tolerant of shade throughout life. *Wood:* hard, heavy, fine-grained, but brittle and poor for timber as wood checks and warps badly. *Present uses:* esthetic and wildlife values, fuel, and charcoal.

Distribution—*Range:* coast ranges from Sonoma County to Lower California (*fig. 3*). *Elevation:* below 3000 ft (900 m) in Sonoma County, up to 5000 ft (1500 m) in San Diego County. *Site:* common on valley floors, not-too-dry, fertile slopes; often forms a narrow riparian woodland. *Associated species:* may form pure stands, but often associated with interior live oak, California sycamore (*Platanus racemosa* Nutt.), white alder (*Alnus rhombifolia* Nutt.), California bay (*Umbellularia californica* [Hook & Arn.] Nutt.). *Ground cover:* often sparse, but may have dense cover of shade-loving broad-leaved, herbaceous plants (Pacific poison oak [*Rhus diversiloba* T. & G.], skunkbush sumac [*Rhus trilobata* Nutt.], nettle [*Urtica holosericea* Nutt.]); grass sparse in dense stands but some present under open-grown trees. *Litter:* thick (5 inches [12.7 cm] or more) oak leaf layer common.

Leaves—*Persistence:* evergreen, drop in spring after new leaves formed. *Size:* 0.8 to 2.5 inches (2.0 to 6.4 cm) long, 0.5 to 1.5 inches (1.3 to 3.8 cm) wide. *Shape:* oblong to ovoid, usually strongly cupped downward (*fig. 4*), margins usually

Figure 1—Coast Live Oak: Open-grown trees have a broad, dense crown that may reach the ground. Usually, they have a single trunk with wide-spreading branches.

Figure 2—Coast Live Oak: Tree crowns in a closed stand may be narrow and irregular and the trunk maybe clear for 15 to 20 ft (4.5 to 6.0 m) with major branches rising at an acute angle.

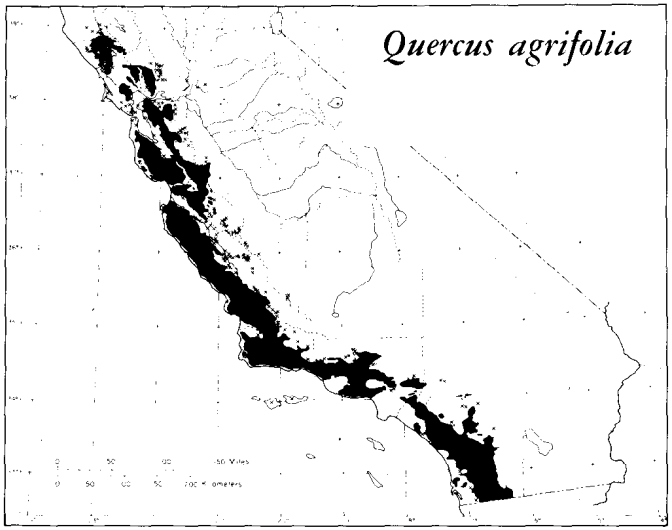

Figure 3—Coast Live Oak: The species is found in the coastal mountains and valleys from central to Lower California. (■ Group of stands more than 2 mi [3.2 km] across; x Stands less than 2 mi [3.2 km] across or of unknown size) (Griffin and Critchfield 1972).

spine-tipped but sometimes entire. *Surface* (upper): dark, shiny green, hairless to scattered star-shaped hairs. *Surface* (lower): paler green, somewhat shiny (*fig. 5*), tufts of hairs at junction of main and lateral veins.

Acorns—*Development period:* one season. *Size:* 1.0 to 1.5 inches (2.5 to 3.8 cm) long, 0.4 to 0.6 inch (1.0 to 1.5 cm) wide (*figs. 6* and *7*). *Shape:* slender, pointed, sometimes slightly curved. *Color:* tan. *Surface:* hairless.

Cups—*Size:* 0.3 to 0.5 inch (0.8 to 1.3 cm) deep, 0.4 to 0.6 inch (1.0 to 1.5 cm) across. *Shape:* cone-shaped. *Surface:* inside is silky or woolly. *Scales:* brown, thin edges turned in, minutely hairy. *Wall:* thin, tapering to thin upper margin.

Bark unburned—*Texture:* surface of young trees and older branches smooth (*fig. 8*); as trees mature (*figs. 9* and *10*), wide and often deep furrows develop that may extend up and down trunk; furrows usually separated by wide, smooth ridges; bark surface hard and firm with no loose outer, flaky material (unless previously damaged by fire). Considerable variation in bark texture, however (*fig. 11*). *Color:* both young and smooth mature bark light gray; rough surface furrows dark gray. *Thickness:* extremely thick bark comprised mostly of reddish inner bark. Live bark may extend to surface; outer bark thin and unevenly distributed over surface with greatest amount associated with edge of furrows.

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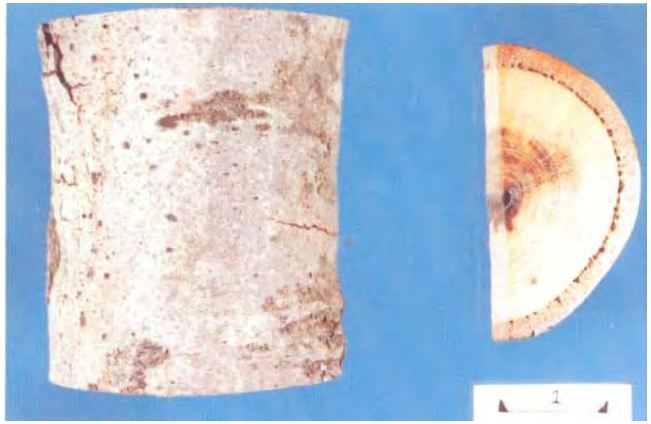
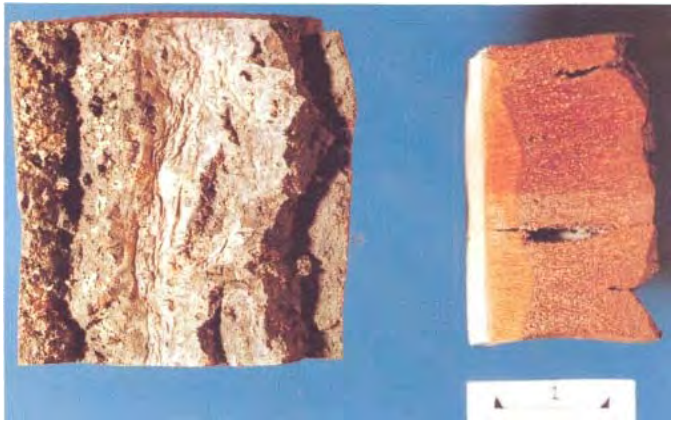
Coast Live Oak: **Figure 4** (left)—The leaves are evergreen, dark, shiny green above, and paler green below. The species is the only California oak with leaves that are strongly cupped downward. **Figure 5** (above)—The underside of a typical leaf shows hairs sparse, with clusters of hairs where lateral veins join the midvein.

Coast Live Oak: **Figure 6** (above)—Acorns of this species are 1.0 to 1.5 inches (2.5 to 3.8 cm) long, slender, and more sharply pointed than those of interior live oak. Cup walls are thin and taper to a very thin upper margin. **Figure 7** (right)—Acorns mature in one growing season and are either alone or in clusters. Often they are well hidden by the dark green, cupped leaves.





Coast Live Oak: **Figure 8** (above left)—The bark of young, 3-inch (7.6-cm) diameter stems is smooth textured and light gray in color. The inner bark is about 0.1 inch (0.3 cm) thick and there is little or no dead outer bark. **Figure 9** (left)—The bark of mature trees with 6-inch (15.2-cm) diameters has a range of texture from smooth to furrowed. The inner bark is about 0.5 inch (1.3 cm) thick and there is little dead outer bark. **Figure 10** (above)—The bark of trees with 12-inch (30.5-cm) diameters has a range of surface texture from mostly smooth to wide furrows with tapering sides. The inner bark is about 1.0 inch (2.5 cm) thick, with little dead outer bark.

Coast Live Oak: **Figure 11** (above)—The bark occasionally has narrow, steep-sided furrows (top). Young, mature bark is mostly smooth (bottom). **Figure 12** (right)—Burned bark, even when heavily charred, has only slight reduction in bark thickness. Surface features remain mostly unchanged. Vertical and horizontal cracks soon develop, exposing light reddish or white tissue underneath the damaged bark.

Bark burned: Even when entire trunk and all branches completely charred, reduction in bark thickness usually minor (*fig. 12*). Although charred, pattern of furrows and ridges remains. As burned bark dries, it separates into rectangular-like pieces separated by fine cracks. Even where heavily charred, damage usually extends only 0.5 to 0.8 inch (1.3 to 1.9 cm) into bark.

Interior Live Oak

General description—*Height:* 30 to 75 ft (10 to 22 m) tall, but sometimes only a shrub 8 to 10 ft tall. *D.b.h.:* 1 to 3 ft (0.3 to 0.9 m). *Longevity:* unknown, but at least 150 to 200 years when protected from fire. (Root system, like that of other oaks, may be several crown generations old.) *Crown* (open-grown): full, dense, rounded, with foliage to ground; not broad or with large limbs like coast live oak (*fig. 13*). *Crown* (closed stand): often irregular shaped, longer than wide. *Trunk* (open stand): branching begins low on trunk, branches fairly large and somewhat spreading. *Trunk* (closed stand): large trees may have straight bole 15 to 20 ft (4.6 to 6.1 m) long before separating into two or three main boles (*fig. 14*). Smaller trees often grow as clumps of several smaller boles (*fig. 13*). *Toler ance:* very tolerant of shade (Sudworth and others 1967); probably less tolerant in later life. *Wood:* similar to coast live oak, has thick, whitish sapwood. *Present uses:* fuelwood, wildlife, and watershed values.

Distribution—*Range:* Cascades in Siskiyou County south to Lower California, lower slopes of Sierra Nevada and inner Coast Ranges (*fig. 15*). *Elevation:* in northern part of range, from 1000 to 2000 ft (300 to 600 m), in southern California up to 6200 ft (1300 m). *Site:* wide variety of sites including valleys and foothills in coastal mountains but away from coast side, and especially foothills and broad alluvial banks of rivers of Sierra Nevada. In southern California, on sides of mountains, as riparian zone in chaparral, and as dense, shrubby thickets in mixed-conifer forest. *Associated species:* occasionally in pure stands, but more often mixed with blue oak, coast live oak, canyon live oak, digger pine (*Pinus sabiniana* Dougl.), scrub oak, and various chaparral species. *Ground cover:* dense tree canopy inhibits grass and other herbaceous development. *Litter:* thick litter develops under dense canopy.

Leaves—*Persistence:* evergreen, last 2 years. *Size:* 0.8 to 4.0 inches (1.9 to 10.2 cm) long (*fig. 16*). *Petiole:* 0.1 to 0.8 inch (0.3 to 1.9 cm) long. *Shape:* elliptic to oblong; leaf margins entire to spine-toothed; flat, never curled. *Surface:* hairless and shiny above and below, dark green above and pale green underneath.

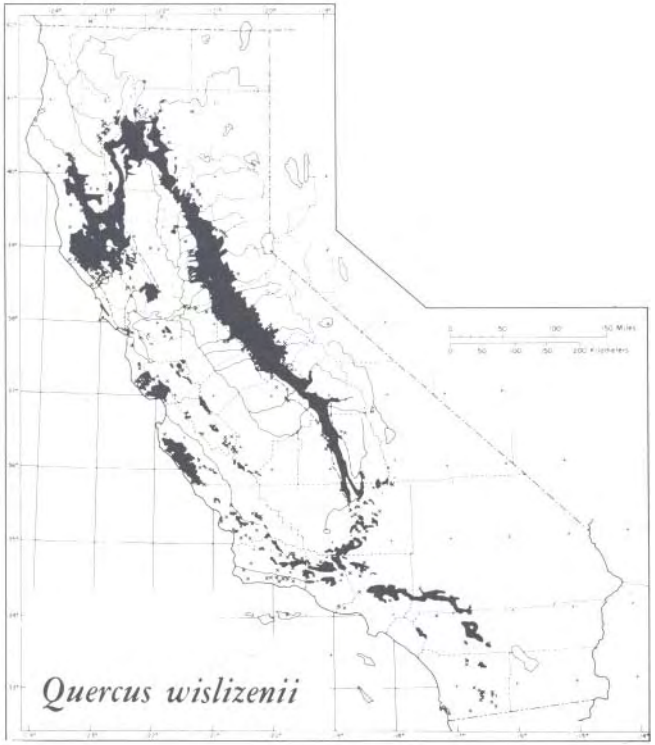
Figure 13—Interior Live Oak: Open-grown trees have full, dense, rounded crowns that reach the ground. Trees are often multi-stemmed and less than 15 inches (38 cm) d.b.h.

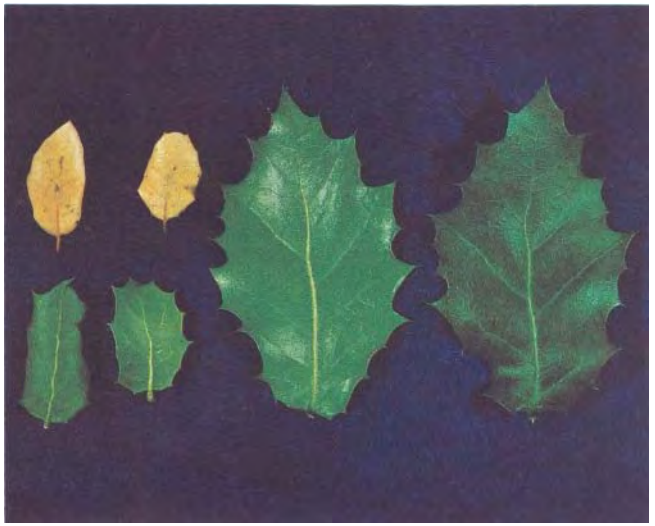
Acorns— *Development period:* mature second year. *Size:* 0.8 to 1.5 inches (1.9 to 3.8 cm) long, 0.3 to 0.5 inch (0.7 to 1.3 cm) wide (*figs. 17* and *18*). *Shape:* slender, cylindrical to conical. *Surface:* generally hairless. *Color:* tan when mature, often with thin, darker longitudinal stripes.

Cups—*Size:* 0.5 to 0.8 inch (1.3 to 1.9 cm) long, 0.5 to 0.6 inch (1.3 to 1.6 cm) wide. *Shape:* cup-shaped. *Scales:* thin, brownish-colored, covered with short downy hairs, fringed with hairs on scale margins. *Wall:* thin, tapering to thin upper margin.

Bark unburned—*Texture:* generally smooth in stems up to 6 inches (15.2 cm) d.b.h. although bark may be rough at base of tree (*figs. 19* and *20*). On old trees, shallow fissures develop separated by narrow ridges (*fig. 21*). Bark surface often covered with lichens (*fig. 22*). Surface of outer bark hard with no loose, flaky bark, although surface may become rough on large, old trees (*fig. 23*). *Color:* gray to dark gray, generally darker than coast live oak. *Thickness:* composed mostly of live inner bark, about one-third as thick as coast live oak.

Figure 14—Interior Live Oak: Tree crowns in a closed stand are often irregular and, for large trees, are much taller than they are wide, with trunks clear of branches for 15 to 20 ft (4.6 to 6.1 m).





Interior Live Oak: **Figure 15** (left)—This species ranges from Siskiyou County in northern California to Lower California. It is common in coastal valleys, foothills, and mountains, and in foothills and along rivers in the western Sierra Nevada. (■ Group of stands more than 2 mi [3.2 km] across; x Stands less than 2 mi 13.2 km] across or of unknown size) (Griffin and Critchfield 1972) **Figure 16** (above) —Leaves are evergreen, dark, shiny green above, pale, shiny green, and hairless below, with margins varying from smooth to spiny-toothed.

Interior Live Oak: **Figure 17** (above)—Acorns are 0.8 to 1.5 inches (1.9 to 3.8 cm) long, slender, two or more times longer than wide with darker, longitudinal stripes when mature. The cup has a distinct stem. **Figure 18** (right)—Acorns mature in two growing seasons. Cups, light tan, en-close about one-third of the mature acorn.

Interior Live Oak: **Figure 19** (above left)—Bark of young 3-inch (7.6-cm) diameter stems has a smooth, dark gray surface. The bark is about 0.1 inch (0.3 cm) thick and is mostly living, inner bark with a thin covering of dead, outer bark. **Figure 20** (left)—Bark of young 6-inch (15.2-cm) diameter trees is mostly smooth textured, but older trees may have shallow furrows. The bark is about 0.2 inch (0.5 cm) thick and is mostly live, inner bark. **Figure 21** (above)—Bark surface texture of 12-inch (30.5-cm) diameter trees ranges from almost smooth to well-developed shallow, narrow furrows. The bark is about 0.3 inch (0.8 cm) thick with a small amount of dead bark forming the ridges between the furrows.

Interior Live Oak: **Figure 22** (left)—The surface of trees with smooth outer bark is often covered with a dense array of colorful lichens ranging from gray to yellow and red. Although found on most oaks, lichens are especially common on interior live oak. **Figure 23** (above)—Large, old trees may have rather deeply furrowed bark with some loose, dead outer bark. Lichens are present but are not as thick as on smooth-surfaced trees.

Interior Live Oak: **Figure 24** (above)—The heavily charred bark of a smooth-surfaced tree trunk retains a smooth surface. Reduction of the bark is minimal. Vertical cracks develop as the bark dries, exposing reddish-brown damaged tissue. **Figure 25** (right)—The original pattern of furrows remains clearly evident even in heavily charred bark. Only a small amount of the bark surface is removed even during heavy burning.

Bark burned: though smooth outer bark chars, usually not much reduction of bark thickness; rarely burns through to wood (*figs. 24* and *25*). Even for large trees, bark provides only moderate protection to cambium from heat damage. In young stems, heat-damaged bark may turn dark reddish-brown (*fig. 26*). Surface of healthy, young bark when scraped off reveals green layer of chlorophyll-containing live bark. Damaged bark hard and tan under surface.

California Black Oak

General description: —*Height:* usually 30 to 80 ft (9 to 25 m) and, occasionally, more than 100 ft. *D.b.h.:* 1.0 to 4.5 ft (0.3 to 1.4 m). *Age:* up to 325 years, but probably less than 350 years. *Crown* (open grown): graceful, broad, rounded, near ground but rarely touching (*fig. 27*). *Crown* (closed stand): narrow, slender at top of young trees, irregularly broader in old trees. *Trunk:* if open grown, several forks common; if closed

Figure 26—Interior Live Oak: Cambium damage to young stems with smooth, gray bark may be indicated by a reddish tint on the bark. The damaged bark is very hard. Undamaged bark is green immediately under the surface.

grown, often straight, sometimes leaning or curving; trunk free of branches for 20 to 40 feet (6 to 12 m) (*fig. 28*); many old trees have decayed, hollow trunks. *Tolerance:* tolerates moderate shade in early life, needs full overhead sunlight for good growth. *Wood:* fine-grained, porous, brittle; heavy, large rays; strong tannin odor. *Present uses:* fuel, wildlife, and esthetic values; limited use for lumber and other wood products.

Distribution— *Range:* San Diego north through Sierra Nevada and Coast Ranges to Eugene, Oregon; also along eastern base of Sierra Nevada (*fig. 29*). *Elevation:* 1000 to 8000 ft (300 to 2400 m), 4000 to 9000 ft (1200 to 2700 m) in southern California. *Site:* mountain slopes, benches and coves, canyon bottoms, lower sidehills, and upper foothill slopes. *Associated species:* California bay, western dogwood (*Cornus occidentalis* [Ton. & Gray] Cov.), interior live oak, ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), and components of mixed-evergreen, mixed-conifer, ponderosa pine forests and oak woodlands. *Ground cover:* woody shrubs with various herbaceous plants including some grass under open-grown trees.

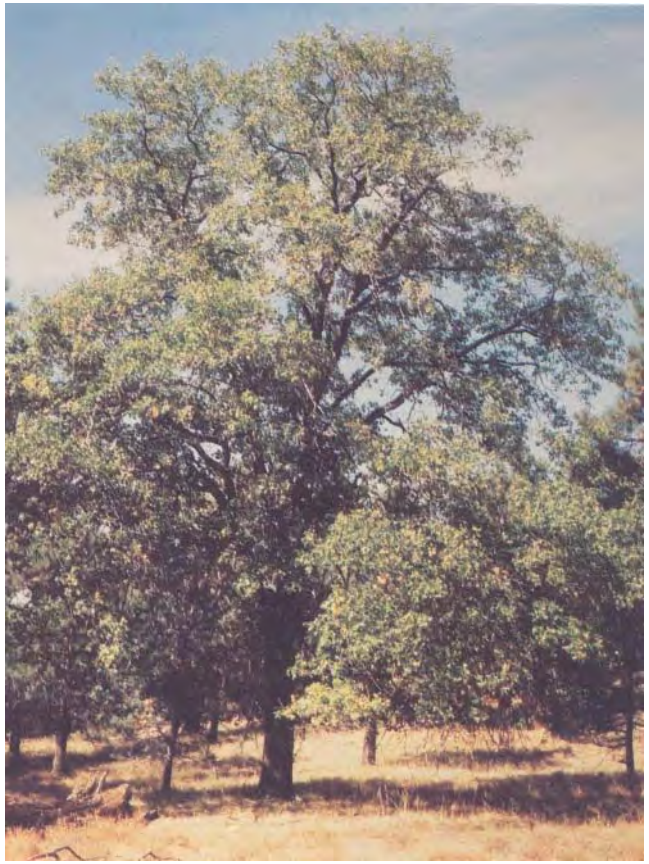


Figure 27—California Black Oak: Open-grown trees have a graceful, broad, rounded crown. The foliage is fairly open, the crown has an airy appearance and seldom reaches the ground.

Figure 28—California Black Oak: In a closed stand, the crowns are irregular and generally limited to the top one-half to one-third of the tree. The trees are mostly single- or double-trunked.

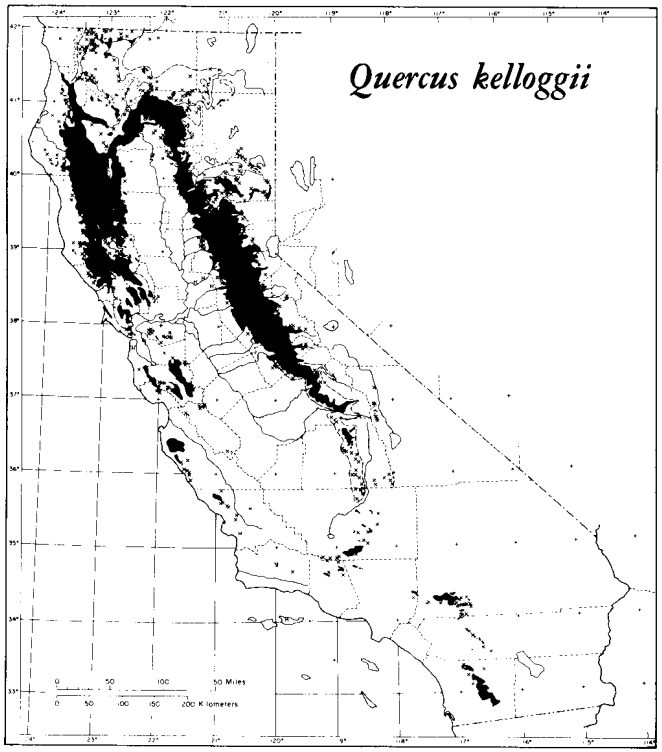


Figure 29—California Black Oak: The species ranges from Eugene, Oregon, south through the Sierra Nevada and Coast Ranges to San Diego County. (■ Group of stands more than 2 mi [3.2 km] across; x Stands less than 2 mi 13.2 km] across or of unknown size) (Griffin and Critchfield 1972).

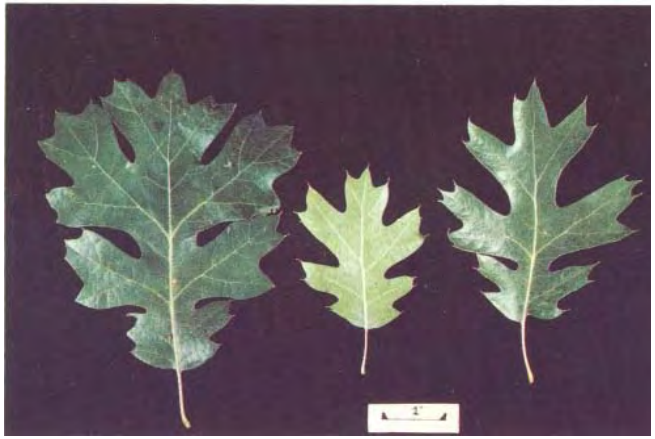
Leaves—*Persistence:* deciduous. *Size:* 2.0 to 8.0 inches (5.1 to 20.3 cm) long. *Shape:* elliptical, but variable; deeply lobed into three main divisions on each side, one to four coarse bristled teeth on each lobe (*fig. 30*). *Surface:* bright green top, mostly without hairs; pale green beneath with a sparse to dense mat of star-shaped hairs. *Petiole:* 1.0 to 2.0 inches (2.5 to 5.1 cm) long.

Acorns—*Development period:* 2 years. *Size:* 0.8 to 1.3 inches (1.9 to 3.2 cm) long, 0.5 to 0.8 inch (1.3 to 1.9 cm) wide (*fig. 31*). *Shape:* oblong, rounded at apex. *Color:* pale chestnut-colored when mature. *Surface:* covered with fine hairs; inside of acorn shell hairy. *Productivity:* variable, abundant crops produced every 2 to 4 years, above average every 7 to 8 years in a closed stand; acorns prominent, often in clusters of two to four (*fig. 32*). *Germination:* best in shade on exposed mineral soil.

Cups—*Size:* 0.6 to 1.0 inch (1.5 to 2.5 cm) deep, 0.8 to 1.1 inch (2.0 to 2.8 cm) wide. *Shape:* cup-shaped, enclosing almost one-half of the acorn. *Surface:* minute hairs within cup. *Scales:* thin, often thickened at base, somewhat ragged on margins, brown when mature. *Wall:* thin, tapering to thin upper margin.

Bark unburned—*Texture:* young, 3-inch (7.6-cm) diameter stems mostly smooth *(fig. 33),* some fissuring as grow

Figure 30 (below)—California Black Oak: The leaves are deciduous, deeply cleft into three main divisions with bristles at the tips of the lobes. Leaf surface is dark green above, and pale green below, with a light to dense mat of hairs.



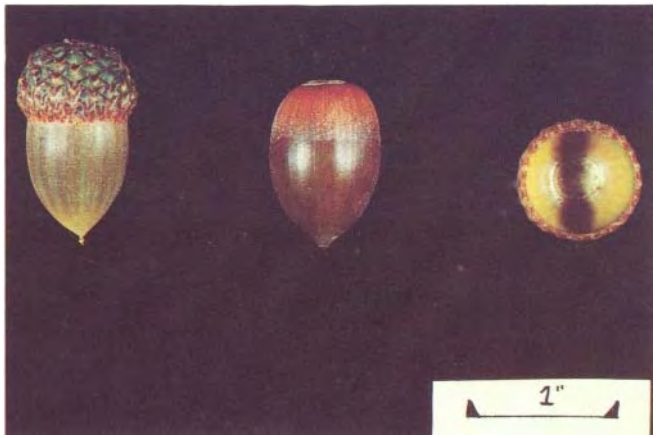
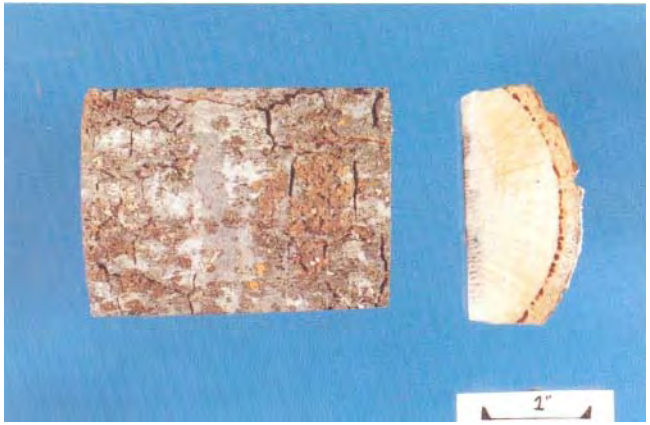


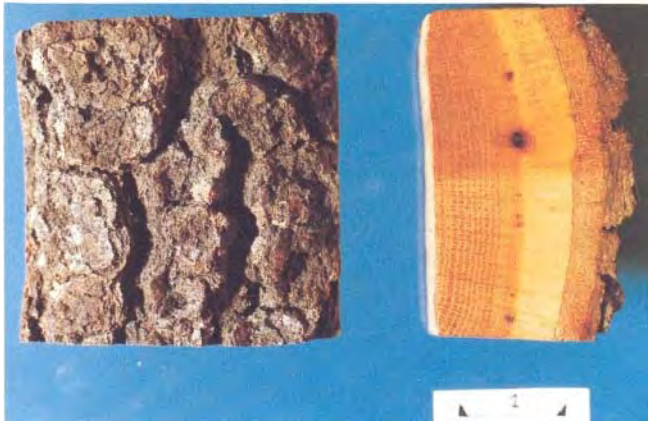
Figure 31 (above)—California Black Oak: The acorns are 0.8 to 1.3 inches (1.9 to 3.2 cm) long, 0.5 to 0.8 inch (1.3 to 1.9 cm) wide. The cups are thin-walled and minutely hairy within. Each cup encloses one-third to one-half of the acorn.

larger (*fig. 34*); fissures well-developed in mature 12-inch (30.5-cm) diameter trees (*fig. 35*); bark of old trees deeply furrowed or checked into small plates, surface hard with no loose flaky bark (*fig. 36*); upper limbs smooth. *Color:* young stems light gray where smooth, darker gray where rough; mature bark reddish to blackish-brown or weathered gray-brown. *Thickness:* moderately thick, about one-half live and one-half dead outer bark in older stems.

Bark burned: outer bark chars readily, but texture of furrows and ridges remains evident; bark does not burn through to wood (*fig. 37*). Cambium appears sensitive to heat damage even where bark is thick (see section on Species' Response to Fire). Overall California black oak is sensitive to fire.

Figure 32—California Black Oak: The acorns mature in 2 years and occur singly or in clusters of three, four, or more. Scales of the cups are thin and tan when mature. A fine whitish pubescence often covers the tip of the acorn.





California Black Oak: **Figure 33** (above left) —The bark of young 3-inch (7.6-cm) diameter trees is smooth and gray-colored. Older stems show development of shallow furrows. The bark is about 0.2 inch (0.5 cm) thick, with the outer one-third of it dead. **Figure 34** (left) —The bark of 6-inch (15.2-cm) diameter trees has a rough but firm surface. Small horizontal cracks occur between the furrows. The bark is about 0.4 inch (0.9 cm) thick and about one-half is dead, outer bark. **Figure 35** (above) —The outer bark of 12-inch (30.5-cm) diameter trees may be irregularly furrowed with the furrows extending vertically for about a foot. The bark is about 0.7 inch (1.8 cm) thick with about one-half dead, outer bark.

California Black Oak: **Figure 36** (above)—The outer bark of large trees may be divided into an irregular pattern of small, hard, rectangular blocks. The furrows are narrow, steep-sided, and extend to the inner bark. **Figure 37** (right) —Heavy charring will reduce bark thickness somewhat, but the pattern of the furrows remains clearly visible. Such heavy charring will almost always kill the trunk of even large trees.

Canyon Live Oak

General description—*Height:* variable, shrub to tree 15 to 70 ft (4.6 to 21.4 m) tall. *D.b.h.:* 2.5 to 5.0 ft (0.8 to 1.5 m). *Age:* upper limits unknown, but at least 250 to 300 years. *Crown* (open grown): wide-spreading, dense canopy reaching almost to ground (*fig. 38*). *Crown* (closed stand): small diameter crowns occupy top one-third to one-half of tree (*fig. 39*). *Trunk* (open grown): short, thick, rapidly tapering trunk with large, horizontal limbs. *Trunk* (closed stand): tall, slender trunk, fairly straight with little taper, clear of branches for 15 to 20 ft (4.6 to 6.1 m), top one-third to one-fourth separated into several branches forming canopy. *Tolerance:* endures considerable heavy shade especially when young, trees in closed stand seek top light. *Wood:* hard, stiff, and strong; often difficult to determine annual growth rings. *Present use:* wildlife, watershed, and fuelwood.

Distribution—*Range:* southwest Oregon to Lower California and east to Arizona; also on east slopes of central and southern Sierra Nevada (*fig. 40*). *Elevation:* 1000 to 5000 ft (300 to 1500 m) in the north, 2500 to 9000 ft (750 to 2750 m) in the south. *Site:* narrow canyon bottoms, steep side slopes, and sheltered coves; also common on exposed slopes in broken rocks and rock crevices; best growth on rich soils in canyon bottoms. *Associated species:* big-cone Douglas-fir (*Pseudotsuga macrocarpa* [Vasey] Mayr.), coulter pine (*Pinus coulteri* D. Don), ponderosa pine, digger pine, interior live oak, and various chaparral species. *Ground cover:* little herbaceous cover with buildup of litter under dense canopies.

Leaves—*Persistence:* evergreen, leaves can remain on tree for at least 3 years. *Size:* 0.5 to 2.5 inches (1.3 to 6.4 cm) long, about one-half as wide (*fig. 41*). *Shape:* variable oblong, margins usually smooth in older trees, spiny in young trees, and especially in vigorous shoots of young and old trees. *Petioles:* 0.1 to 0.4 inch (0.3 to 1.0 cm) long. *Surface:* dark green above; minute golden hairs underneath young leaves, hairs eventually fall off leaving pale gray-green or whitish underside. *Lateral veins:* six or usually more.

Acorns—*Development period:* two seasons. *Size:* variable, 1.0 to 3.0 inches (2.5 to 7.6 cm) long, 0.8 to 1.3 inches (1.9 to 3.2 cm) wide. *Shape:* variable, oblong to egg-shaped (*fig. 42*). *Surface and color:* pale chestnut when mature with downy hairs at apex, slightly hairy on inner surface of outer shell. *Productivity:* prolific seeder at irregular intervals with large prominent acorns in clusters or single (*fig. 43*).

Cups—*Size:* 0.8 to 2.0 inches (1.9 to 5.1 cm) across. *Shape:* variable in southern California, often saucer-shaped. *Surface:* silky on inside of cup. *Scales:* often small, triangular, pressed

Figure 38—Canyon Live Oak: Open-grown trees have a wide-spreading, dense crown that may almost reach the ground. They may have multiple or single trunks that are short and taper rapidly.

Canyon Live Oak: **Figure 39** (above)—The trees in a closed stand have a small diameter crown that occupies the top one-third to one-half of the tree. The trunks are tall, slender, and sometimes fairly straight, with 15 to 20 ft (4.6 to 6.1 m) free of branches. **Figure 40** (right)—The species ranges from southwest Oregon to Lower California and east to Arizona. (■ Group of stands more than 2 mi [3.2 km] across; x stands less than 2 mi [3.2 km] across or of unknown size) (Griffin and Critchfield 1972).

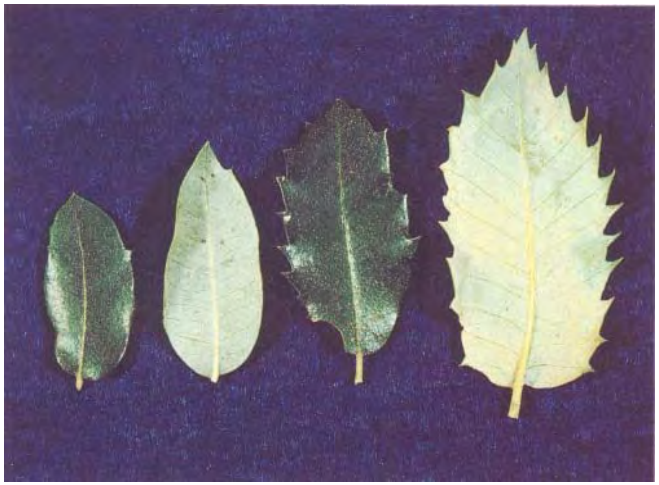


Figure 41 (above)—Canyon Live Oak: The leaves are evergreen and persist for 3 to 4 years. They are dark green above and covered with a golden down below, then become pale blue-green as hairs fall off. Leaf margins are smooth to spiny.

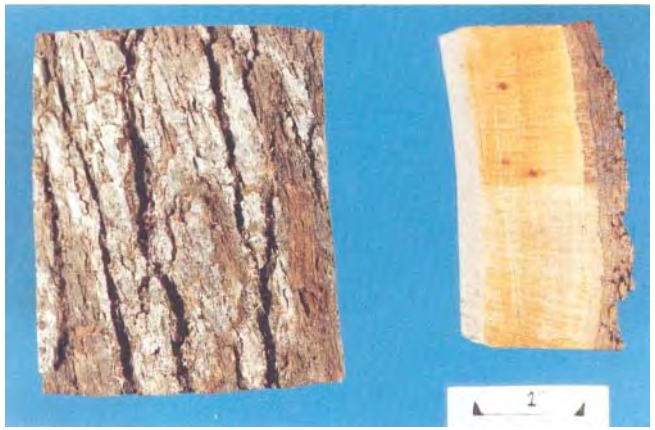
Figure 42 (below)—Canyon Live Oak: The acorns are 1.0 to 3.0 inches (2.5 to 7.6 cm) in length. The cup walls are often thick, with triangular scales often covered with golden hairs.

flat against cup wall and covered with dense layer of golden or white hairs. *Wall:* very thick-walled with a thick rim.

Bark unburned—*Texture:* surface fissured even in small stems; where tree is suppressed, well-established furrows present in 3-inch (7.6-cm) and larger diameter stems (*fig. 44*). Outer bark flaky; flakiness gives way to strips in larger, older stems, (*figs. 45* and *46*) but varies in older trunks (*fig. 47*). *Color:* ash gray where bark is undisturbed for long time, dark gray to brown where flaky bark has broken or sloughed off; young stems gray. *Thickness:* somewhat thinner than California black oak bark; about one-half live inner bark, one-half dead outer bark. *Flammable: will* carry fire up trunk, increasing injury even from low-intensity ground fire.

Bark burned: damage varies from light, scattered pitting where only small individual spots are charred to heavy damage where wood has been exposed (*fig. 48*).

Figure 43—Canyon Live Oak: Acorns take 2 years to mature and are prominent on the branches. Typical of this species, the cups are thick and covered with golden hair.



Canyon Live Oak: **Figure 44** (above left)—Bark of old 3-inch (7.6-cm) diameter stems is rough textured. Younger stems have a thin, flaky outer bark that becomes thicker and firmer with age. The bark is about 0.2 inch (0.5 cm) thick; one-half is inner bark, one-half is outer bark. **Figure 45** (left)—The bark of 6-inch (15.2-cm) diameter stems is rough textured and ranges from numerous, narrowly spaced, mostly long vertical furrows to a flaky surface of irregular furrows. The bark is about 0.3 inch (0.8 cm) thick. **Figure 46** (above)—The bark of 12-inch (30.5-cm) diameter trees varies in pattern from loose random flakes to definite, vertical furrows separated by strands of outer bark. The bark is about 0.5 inch (1.3 cm) thick, with one-half inner and one-half outer bark.

Canyon Live Oak: **Figure 47** (above)—The bark of some large trees is loose textured and flaky (top). In other large, old trees, the bark is aligned as long vertical furrows and is firmly attached to the tree (bottom). **Figure 48** (right)—The bark of heavily burned trunks is often burned through, exposing the yellowish colored wood underneath.

California Scrub Oak

General description—*Height:* mostly shrub, sometimes small tree; generally 4 to 10 ft (1.2 to 3.0 m) tall, sometimes up to 30 ft (9.2 m). *D.b.h.:* 2.0 to 10.0 inches (5.1 to 25.4 cm). Age: maximum age unknown; at least 100 years old where protected from fire, but most less than 75 years because of repeated burning. *Crown* (open grown): individual trees, depending on age, may vary from circular clump of several small stems to small tree with definite but somewhat irregular crown (*fig. 49*). *Crown* (closed stand): small trees may form dense thickets of rigidly branched crowns on short stems. Larger trees may form continuous canopy, like pigmy forest (*fig. 50*). Trees often multistemmed. *Trunk:* may be clear of branches for several feet before branching into crown; trunks rarely straight. *Tolerance:* shade intolerant. *Wood:* light brown, hard, brittle. *Present uses:* watershed cover and wildlife habitat; limited firewood potential.

Distribution—*Range:* central Sierra Nevada and Coast Ranges in Mendocino and Trinity Counties south through

Figure 49—California Scrub Oak: Open-grown trees have open, somewhat irregular crowns that reach the ground or surrounding vegetation. Most trees are multistemmed and of sprout origin.

California Scrub Oak: **Figure 50** (above)—Trees in a closed stand have a small open, irregular crown occupying the top portion of the stem. The trees are mostly multistemmed with trunks leaning outward from the base. **Figure 51** (right)—The leaves of scrub oak are variable in size, shape, and the nature of the margins that range from entire to toothed. The leaves are shiny, dark green above and pale, gray-green below.

coastal mountains of southern California into northern Lower California, also Channel Islands off southern California coast. *Elevation:* generally below 5000 ft (1525 m), sometimes to 7000 ft (2135 m). *Site: low* mountain and foothill slopes and sides of dry canyons, generally on poor quality soils. *Associated species:* found as individuals or in clumps, patches often pure or interspersed with chaparral. Major component of chaparral on better sites. Grows with chamise (*Adenostoma fasciculatum* H. & A.), manzanita (*Arctostaphylos* spp.), ceanothus (*Ceanothus* spp.), toyon (*Heteromeles arbutifolia* [Lindl.] M. J. Roem.), and others; in foothill woodland; mixes with interior live oak. Hybridizes with several oaks including Engelmann oak and turbinella oak (*Q. turbinella* ssp. *californica* Tucker). *Ground cover:* poison oak common, plus thick oak leaf litter. (Note: no distribution map currently available for scrub oak.)

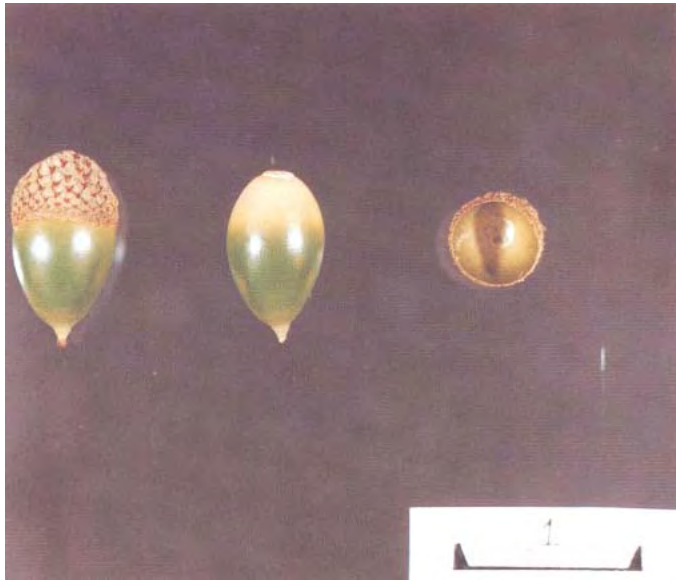
Leaves—*Persistence:* semi-evergreen, adhere until next spring when new leaves formed. *Size:* highly variable from 0.5 to 2.0 inches (1.3 to 5.1 cm) long. *Shape:* highly variable, roundish to oblong, margins usually toothed, but range from almost entire to spiny; leaf edges may be ruffled (*fig. 51*). *Surface:* leathery, dark green and shiny above; pale, gray-green underneath. *Lateral veins:* four or five (sometimes six). *Petioles:* short, about 0.1 inch (0.3 cm) long.

Acorns—*Development period:* mature first season. *Size:* variable 0.5 to 1.5 inches (1.3 to 3.8 cm) long. *Shape:* generally egg-shaped, extremely variable, broad at base, rounded at tip or acute (*fig. 52*). *Color:* tan. *Surface:* hairless, with some short hairs at tip of acorn. *Productivity:* large crops common on some trees yearly (*fig. 53*); others rarely have many acorns.

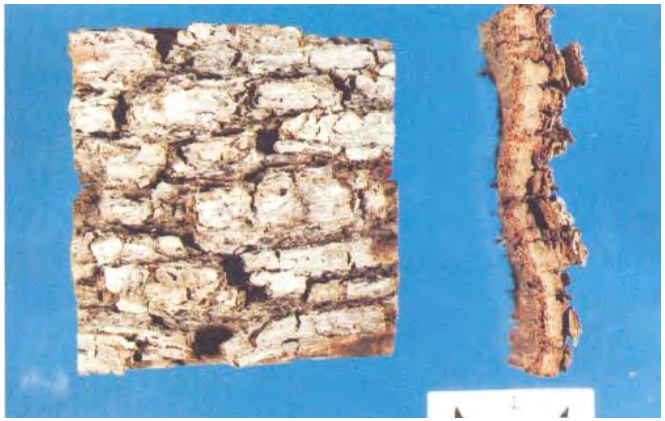
Cups—*Size: 0.4* to 0.6 inch (1.0 to 1.6 cm) across. *Shape:* one-half to two-thirds of sphere. *Scales:* mostly wart-like, especially at base of cup. *Wall:* thick with margin tapering inward.

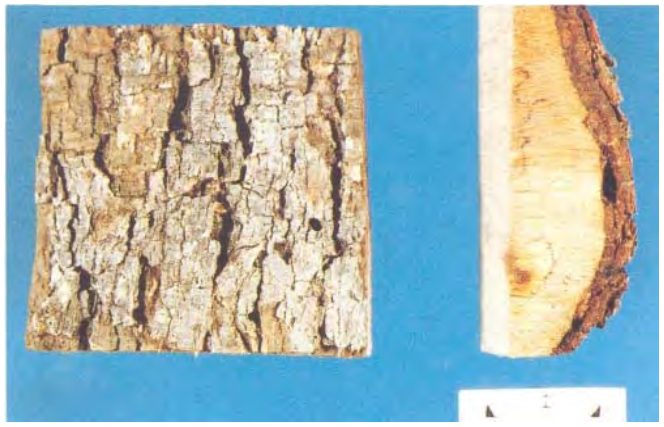
Bark unburned—*Texture:* young stems smooth. Stem of 3-inches (7.6-cm) diameter, has loose, flaky outer bark (*fig. 54*). On larger trees, loose flakes may be large (*fig. 55*) with irregularly developed furrow pattern (*fig. 56*). Large, flat flakes develop on some older stems, although bark becomes thick and lined up in narrow strips separated by narrow furrows (*fig. 57*). *Color:* light gray to tan, darker brown in furrows and where outer bark has peeled off. *Thickness:* bark never gets very thick because of small size of mature trees; about one-half outer dead and one-half inner live bark.

Bark burned: flaky bark contributes heat input into trunk during burning. Most fire-damaged trunks show medium to heavy char, with bark occasionally burned through, exposing wood. Charred surface rough and furrows remain evident (*fig. 58*). A small tree, component of chaparral, normally killed to ground by fire.



California Scrub Oak: **Figure 52** (above)—Acorns range from 0.5 to 1.5 inches (1.3 to 3.8 cm) long and are oval shaped. Cup scales are mostly wart-like and are pressed flat against the cup wall. **Figure 53** (right)—Acorns mature in 1 year and are displayed conspicuously. The cups enclose less than one-third of the acorn. Some trees produce a moderate to large crop every year, other trees rarely produce acorns.





California Scrub Oak: **Figure 54** (above left)—The bark of 3-inch (7.6-cm) diameter stems ranges from a smooth texture in young trees to light gray, flat, loose flakes in older stems. There is no obvious furrow pattern, just small cracks in the bark surface. **Figure 55** (left)—Bark of 6-inch (15.2-cm) diameter stems has a rough texture of thin, loosely attached plates of outer bark. Cracks and furrows are well defined. **Figure 56** (above)—Bark of 10-inch (25.4-cm) diameter stems has a surface of thick, narrow, loosely attached chunks of outer bark. The vertical furrows are deep and well-defined.

California Scrub Oak: **Figure 57** (above)—The outer bark of very old trees consists of a loose layer of thin plates. Large cracks are found between the plates. A heavy coating of lichens may be present. **Figure 58** (right)—In heavily burned trees, the loose outer bark is consumed and occasionally, the bark is burned through to the wood. A pattern of vertical cracks is apparent in the charred bark.

ASSESSMENT OF FIRE DAMAGE

Trees respond to fire immediately as well as later on. Immediate effects range from no obvious damage to complete consumption or heavy charring followed by long-term wood degradation by insects and disease. Delayed effects include sprouting from the tree base, trunk, and branches, and cambium regeneration.

The most common fire damage to the trunk of a tree is a basal wound resulting from death of the cambium (*fig. 59*). Small wounds less than a few inches across may eventually heal with no accompanying heart rot, but large wounds generally become larger because of disease and insects. The cambium attempts to close the wound but usually only curls inward as the damaged woody tissue disintegrates (*fig. 60*). Subsequent fires can enlarge the wound until all that remains is a

Figure 59—California Black Oak: Basal char of a 2-ft (0.6-m) diameter trunk from a low intensity surface fire (top). Damage to the cambium was not as extensive as the char area (bottom).

thin ring of live wood and bark (*fig. 61*). At this stage, the tree is a mechanical risk and readily subject to wind damage.

A small wound may greatly reduce a tree's value for lumber, but wildlife, watershed, and esthetic values may not be severely reduced even when a tree is completely hollowed out. In fact, value to wildlife may be improved. A wound that girdles the trunk, even if it is only a few inches wide (*fig. 62*), however, will eventually result in the death of the trunk and crown of the tree. But the crown may remain alive several years after girdling. Trees with healthy-looking crowns, but girdled trunks, may result in an underestimate of fire damage. The potential for a low estimate should be kept in mind during a postfire damage appraisal.

Visual Detection of Injury

To accurately assess fire damage, it is necessary to distinguish between live and dead tissue. The distinction is obvious

Figure 60—California Black Oak: Damaged wood eventually decays; meanwhile, live tissue curls inward as it attempts to cover the wound. Subsequent fires enlarge the wound even more.

when the leaves are burned or heat-killed, but damage to the buds, acorns and, especially the cambium, is not as obvious. Although several methods of detecting damaged and dead tissue have been developed, including chemical and electrical techniques, visual detection is simple, direct, and suitable for field use.

The first step in evaluating fire damage is to assess the condition of the trunk and categorize it into one of three char classes *(fig. 63):* light—spotty char or scorch with scattered pitting of the bark; medium—continuous charring with areas of minor reduction in bark thickness; heavy—continuous charring, pronounced reduction in bark thickness with the underlying wood sometimes exposed. The significance of these char classes in estimating trunk damage will depend on all of the variables listed in the next section on conditions affecting tree damage, for example, burning condition, season of the year, species, and tree characteristics.

Young, smooth stems may show heat damage by a color change from gray to reddish gray *(fig. 26*). The bark surface is

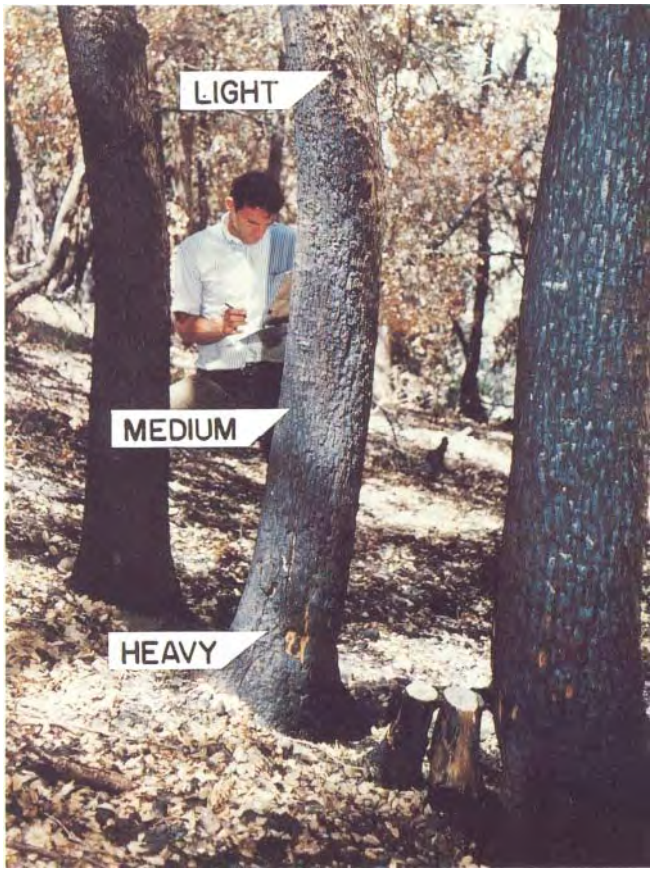
Figure 61—California Black Oak: After repeated fires, a tree may be hollowed out until only a ring of live tissue remains. Wind breakage is common in such trees.

hard and the underlying tissue tan or brown. This contrasts with the soft, gray bark surface of healthy trees that readily scratches off, revealing a soft, green, subsurface layer of bark. Occasionally, small desposits [sic] of dried sap are present that have oozed to the bark surface during the fire.

The second step is to estimate cambium damage. This can be based on the amount of charring, should be checked initially and periodically during a survey. If the bark was completely consumed, or if it has cracked or separated from the wood, it can be assumed that the cambium is dead. If the bark is intact and firmly attached to the wood, it is necessary to cut through the bark to determine the condition of the cambium (*fig. 64*). If the inner bark has a yellow tinge (*fig. 64*), not white or pink, the cambium is either dead or seriously damaged.

The cambium and wood may be stained dark brown or black, even though the inner bark appears healthy. It has not yet been determined if such stained tissue is dead or how long after burning the staining occurs. As a note of caution, it is

Figure 62—Canyon Live Oak: Even a low intensity fire can girdle the base of a fire-sensitive or small tree. Although the trunk and crown may live for several years after a fire, they will eventually die, because of girdling of the trunk. Note the narrow zone of white-colored, live bark at the lower edge of the old bark.



difficult sometimes to determine if the cambium is damaged, especially soon after a fire. Damaged inner bark may remain moist and healthy-looking for weeks after being burned. Often it will have a fermented aroma. The minimum time after injury that it takes this aroma to develop is unknown.

Immediately after a fire, the width of a wound is fairly well approximated by the width of the charred area; however, the height of the wound may exceed the height of the charred area by several feet. A small charred area at the base of a large tree with thick bark, like California black oak, however, may overestimate the amount of damaged cambium (*fig. 59*).

Guides for predicting the spread of butt rot in fire-scarred trees have not been developed for California oaks. Work on eastern oaks indicates that rot may spread upward at a rate of 1.5 to 2.2 inches (3.8 to 5.6 cm) per year, or about 1.5 ft (0.5 m) in 10 years.

Figure 63—Canyon Live Oak: Char classes: *Heavy*—(at base) yellow colored wood exposed through the bark. *Medium*—(at middle) continuous black char, some bark reduction. *Light*—spotty char (upper edge of burned area) with light tan to gray undamaged bark.

Figure 64—Interior Live Oak: Damaged cambium can best be detected by cutting into the wood. A dark or yellowish tone, as shown, indicates cambium kill.

Variables Affecting Damage

The amount of damage to trees exposed to fire depends on the interaction of many variables that directly or indirectly affect the temperature of the living cells. Lethal temperature range for most plant tissue is between 110° and 139° F (43° and 59° C), with 125° F (49° C) considered fatal to the cambium. The higher the temperature, the quicker death occurs.

Not all trees are equally sensitive to fire, however, although individual cells fall within the temperature range just noted. The trunk and branches are also protected by a corky layer of bark, which is an excellent insulator. Even a thin layer of bark will give good protection from high temperatures for a short time.

Fire Characteristics

Fire behavior—rate of spread, energy release rate, and duration in particular—affects the amount of damage that occurs. A slow moving fire of low intensity and long duration

may result in more damage to a tree trunk than a fast moving, high-intensity fire of short duration. The crown with its heat-sensitive leaves and small twigs will suffer greater damage, however, from the high-intensity fire of short duration.

Ambient Temperature

Initial bark temperature may determine whether the cambium is killed. Bark is damaged less in cooler temperatures.

Season of the Year

The amount of tree damage that results from fires has been correlated to the time of year that the fires occur. Conifers tend to be more sensitive to heat damage during the growing season than when dormant. The sensitivity of oaks and other broadleaf species to heat increases as season changes from winter through summer. The seasonal effect may result from (1) internal or physiological differences that affect tree sensitivity to heat, (2) differences in fire intensity, and (3) differences in ambient temperature, with lower temperatures in the spring than in the summer.

Tree Characteristics

Accurate prediction of tree response to fire requires knowledge of tree species, age, diameter, height, and bark characteristics.

Field studies have shown that all oak species do not have the same tolerance to fire nor the same recuperative capacity after being burned. Consequently, it is necessary that damaged trees be correctly identified. Specific fire responses of the species described in this guide are given in a subsequent section.

Variables directly correlated to age that affect fire tolerance are tree height, d.b.h., and bark thickness. Bark composition also changes with tree age and may increase or reduce a tree's fire tolerance.

Trunk diameter is correlated directly with age and stand density and is an important variable affecting tree survival. Large trees are more tolerant to fire than small trees because of thicker bark and a greater capacity to absorb heat and, more important, they have thicker bark. Trees of all species less than 6 inches (15.2 cm) d.b.h. will usually be topkilled by even a low intensity fire. Seedlings and small trees less than 2 inches (5.1 cm) d.b.h. will almost always be topkilled by all fires.

Amount of crown damage is related directly to height above ground. Trees that attain large size may suffer little or no crown damage from a low intensity surface fire if the bottom of the crown is 20 to 30 ft (6 to 9 m) above the ground. If the trunk is girdled, which is possible even from a light fire, however,

amount of crown damage is unimportant because the top of the tree will eventually die even though it may take several years.

Bark is the best protection the cambium has against fire damage and other injuries. A natural insulator, it develops into a complex structure as the tree matures. The bark changes from a thin layer of epidermal cells in young stems to a thick, complex, multilayered zone in old trunks composed of outer dead and inner live bark (*fig. 65*).

Surface texture—Surface texture of the outer bark varies from one species to another and is generally affected by tree age. A dry, flaky surface may contribute to the fire damage by carrying the fire up the trunk, for example, canyon live oak (*fig. 66*). Although a smooth surface may char, it actually inhibits the spread of fire.

Bark thickness—The most significant single variable influencing tree sensitivity to fire is bark thickness, and thickness is directly related to tree age and diameter. Thickness of the inner and outer bark also varies with species. Coast live oak not only has the thickest bark of the five southern California species, but its live inner bark is several times thicker than its dead outer bark. Interior live oak also has a large ratio of inner to outer bark, but its total bark thickness is less than that for the outer three species described, which have about equal amounts of inner and outer bark.

Bark thickness equations are based on average values from two sites in southern California and are plotted in *figure 67* (Plumb 1980).

Prediction equations for total bark thickness have the general form:

$$y = a + bx$$

in which

y = bark thickness in inches
a = y-intercept
b = slope
x = d.b.h. in inches

Intercept and slope constants for bark thickness equations are as follows:

Species:	a	b
Coast live oak	0.022	0.085
Interior live oak	.032	.019
California black oak	-.009	.060
Canyon live oak	.060	.041
California scrub oak	.031	.033

For example: bark thickness (y) for a 10-inch (25.4-cm) diameter coast live oak is:

$$y = 0.022 + 0.085(10)$$
$$= 0.022 + 0.850 = 0.850$$
$$= 0.872 \text{ inch thick}$$

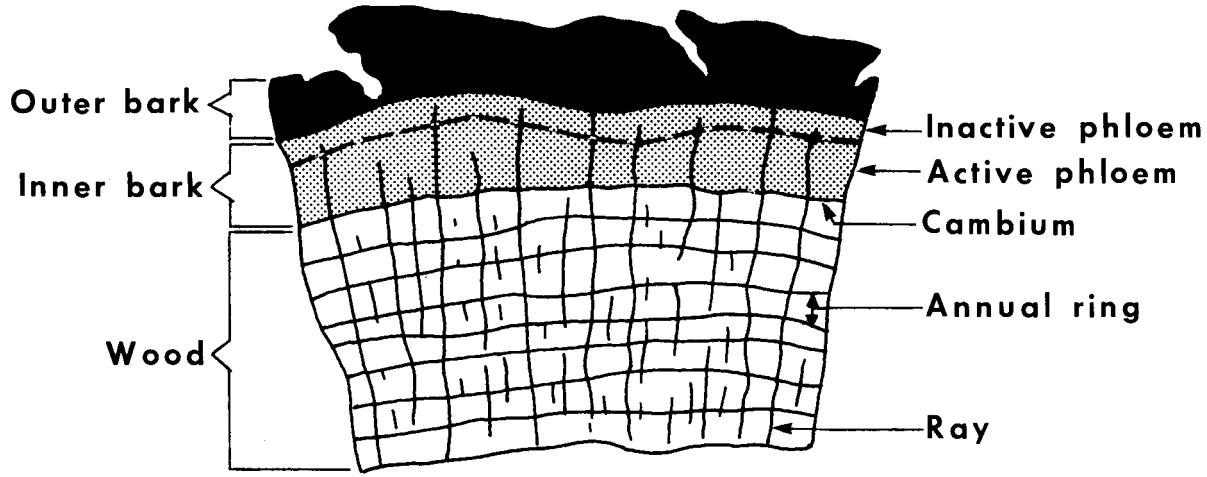
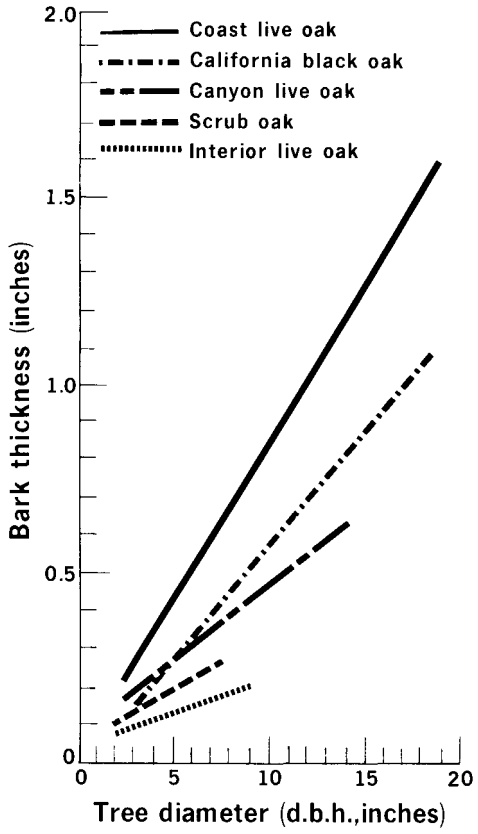


Figure 65—Major anatomical components of a woody oak stem.

Moisture content—Seasonally, and between the inner and outer bark, moisture content varies from species to species. The outer bark forms a zone of low moisture content and heat conductivity and the inner bark has high moisture content and high heat conductivity. Moisture content may be more important, however, because of its effect on bark flammability than on heat transfer.

Chemical composition—Of all bark characteristics, chemical composition varies most among species and between the inner and outer bark. The differences are related to the heat of combustion of the bark. High heat contents are associated with waxes and resins. With the exception of canyon live oak, the outer bark of other species has a higher heat content than the wood and, for all species, a higher heat content than the inner bark. The flaky, outer bark of canyon live oak, which burns so readily, has a low heat content and also a low density. The bark's low density and flaky configuration appear to contribute more to heat buildup around the trunk than does the heat or

Figure 66—Canyon Live Oak: Bark surface texture greatly affects potential fire damage. A loose, flaky bark like that pictured will compound the damage from fire. Note the smoother, tan-colored part of the trunk where the darker colored, flaky bark was scraped off.



Species' Response to Fire

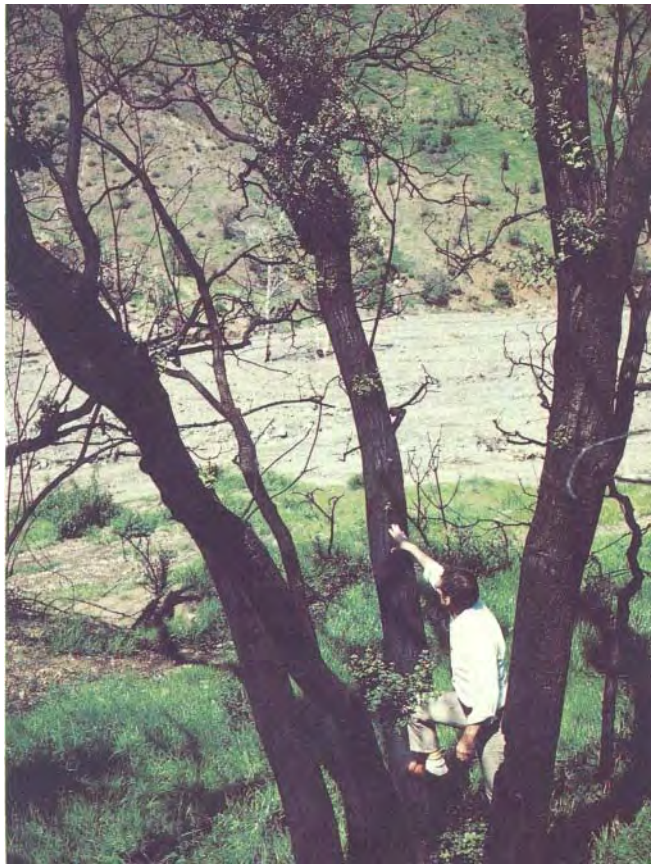
Coast Live Oak

The trunk and crown of coast live oak have a unique ability to survive fire damage, even after being completely charred. Resprouting along the branches and trunk may begin within a few weeks after burning (*fig. 68*) and most of the prefire crown area may be rejuvenated within 8 to 10 years. Small coast live oak trees less than 3 inches (7.6 cm) d.b.h. may be girdled by a low intensity fire. Although heavily charred trees 6 inches (15.2 cm) d.b.h. and smaller can be girdled, most trunks larger than 6 inches d.b.h. will survive. It is desirable, therefore, to postpone cutting of heavily charred coast live oak for at least 2 to 3 years after burning on the chance that most trees will recuperate.

Interior Live Oak

Although interior live oak is similar to coast live oak in that its bark is mostly live, inner bark, it is extremely sensitive to

Figure 67—The total bark thickness of five prominent southern California oak species. (Note: Bark thickness equations should not be used for d.b.h. values beyond the ranges plotted.)



fire, and is readily killed aboveground. Even large trees with bark 1.5 to 2.0 inches (3.8 to 5.1 cm) thick are sensitive to fire damage and may be girdled even though the bark appears to have only minor charring. The root crown sprouts vigorously after damage to the trunk and crown. Repeated fires keep interior live oak as a small, multistemmed tree.

California Black Oak

California black oak is much less fire tolerant than coast live oak, but somewhat more tolerant than the other species discussed. In a crown fire, the aboveground portion of all California black oak trees in a stand will be killed regardless of tree size. Complete crown kill is also common in fires where individual trees or isolated clumps of trees are surrounded by brush or are on the margin of a stand adjoining brush. The amount of damage from a surface fire depends on its intensity. But the cambium of even large California black oak trees with thick bark can be injured by a fire that results in only a small

Figure 68—Coast Live Oak: Sprouts from both the trunk and root crown often emerge from the charred bark within 2 weeks after burning. Within a year, they may be 1.5 to 2.0 ft (0.5 to 0.6 m) long. The light green, succulent sprouts stand out in marked contrast to the blackened, charred trunk.

amount of localized charring (*fig. 59*). New shoots develop along the trunk and branches where the cambium is undamaged. And vigorous root crown sprouting is common from badly burned trees.

Canyon Live Oak

Because of its loose, flaky bark that readily ignites, even a low intensity surface fire results in severe damage to the cambium at the base of a canyon live oak tree (*fig. 62*), and damage may extend far up the trunk above obvious charring. Delayed dying of the undamaged leaf crown is common in girdled canyon live oak trees, with some crowns remaining alive for at least 8 years after the trunks are girdled. Close investigation of the trunk is needed to confirm the extent of cambium damage. Both partially damaged and crown-killed trees soon produce a moderate to dense regrowth of root crown sprouts.

California Scrub Oak

Scrub oak is a shrub or small tree, usually mixed with chaparral; consequently, it is almost always topkilled during a fire. With a trunk that infrequently exceeds 8.0 inches (20.3 cm) d.b.h., the bark is quite thin (*fig. 67*) and offers little direct protection to the cambium. Like canyon live oak, it has a loose, flaky bark that reduces its tolerance to fire even more. The root crown usually sprouts vigorously soon after burning or at least by the next growing season.

MANAGEMENT OF OAKS AFTER FIRE

This guide provides some practical recommendations for postfire management of California oak stands. The decision to cut or not cut burned trees soon after a fire should be based on reliable information about anticipated tree survival. These recommendations only reflect the expected response of trees to fire and do not consider other factors that affect management decisions.

Harvesting of fire-damaged southern California oak trees should take into account tree species, size, and degree of trunk char (*table 1*). When possible, it is desirable to let at least one, and preferably three, growing seasons pass before making a final decision to cut large, valuable trees whose crown survival

Table 1—*Recommendations for harvesting fire-damaged southern California oak trees on the basis of tree size and degree of trunk char* [1]

Species	Tree size and char condition								
	Less than 6 inches d.b.h.			6 to 12 inches d.b.h.			More than 12 inches d.b.h.		
	Light	Medium	Heavy	Light	Medium	Heavy	Light	Medium	Heavy
Coast live oak	Leave	Leave	Cut	Leave	Leave	Leave	Leave	Leave	Leave
California black oak	Cut	Cut	Cut	Leave	Cut	Cut	Leave	Leave	Cut
Canyon live oak	Cut	Cut	Cut	Leave	Cut	Cut	Leave	Cut	Cut
Interior live oak	Cut	Cut	Cut	Leave	Cut	Cut	Leave	Cut	Cut
California scrub oak	Cut	Cut	Cut	Leave	Cut	Cut	([2])	—	—

[1]Assumes that 100 percent of the trunk circumference is affected, as follows: *light*—spotty char or scorch with scattered pitting of the bark; *medium*—continuous charring with area of minor reduction in bark thickness; *heavy*—continuous charring, pronounced reduction in bark thickness with underlying wood sometimes exposed (*fig. 63*). "Leave" means that the tree should be left uncut for 3 years; "Cut" means that the tree can be cut immediately.

[2]Scrub oak does not reach 12 inches (30.5 cm) d.b.h.

is uncertain. With the exception of a crown fire in which all trees are completely charred, degree of charring varies and individual tree evaluation is desirable. The suggestion to "cut" assumes that a tree is completely girdled with little or no chance that the trunk or crown will survive.

Coast live oak, which was found to be fire tolerant, can be left with the expectation that the trunk and crown will survive most fires. Some trees are killed under extreme burning conditions, and others are killed for reasons not yet identified. Only heavily charred trees less than 6.0 inches (15.2 cm) d.b.h. will probably be girdled and, for these trees, immediate cutting is suggested.

California scrub oak is at the other end of the tolerance spectrum—it is fire intolerant. Generally, it can be cut after most fires, however, lightly charred trees larger than 6.0 inches d.b.h. may survive and should not be cut immediately. In addition to being small, California scrub oak is usually part of a chaparral cover that burns with high intensity. Consequently, the trees are unlikely to survive most fires.

Recommendations for harvesting California black oak, canyon live oak, and interior live oak that have been fire-damaged are about the same for all three species. All trees less than 6 inches d.b.h. can be cut if they have received even light charring that encircles the trunk. Lightly charred trees 6 inches d.b.h. and larger should be left with the expectation that they will survive. Medium and heavily charred trees can be cut as they have little chance of surviving. Large California black oak trees with only medium charring as well as trees of all three species with d.b.h. of 24.0 inches (60.8 cm) or larger, probably can be spared with the hope that they will survive.

Many fire-damaged trees expected to survive have basal wounds that do not completely girdle the trunk. The crown can survive when less than 10 percent of the trunk is left ungirdled. Even in this condition, such a tree can provide all of the amenities of an undamaged tree, except for quality lumber. Consequently, what percentage of the trunk circumference must be damaged to recommend cutting? The prime consideration is whether the tree is currently or potentially a mechanical risk, especially trees in recreation areas. If a wound is narrow, the major portion of the trunk will remain intact, adequately supporting the crown. A tentative guide for cutting partially girdled trees is the following: for trees less than 6 inches (15.2 cm) d.b.h., cut them if more than 75 percent of the trunk is girdled; for trees greater than 6 inches d.b.h., cut them if more than 50 percent of the trunk is girdled.

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The Forest Service, U.S. **Department of Agriculture,** is responsible for Federal leadership in forestry. It carries out this role through four main activities:

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Plumb, Timothy R.; Gomez, Anthony P. **Five southern California oaks: identification and postfire management.** Gen. Tech. Rep. PSW-71. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1983. 56 p.

Oak trees in California are subject to periodic burning by fire, but their trunks and crowns vary in tolerance to fire. And once burned, oaks are difficult to identify by species. Fifteen oak species grow in California. This report provides keys to identifying five species of southern California oaks: coast live oak (*Quercus agrifolia* Née), interior live oak (*Q. wislizenii* A. DC.), California black oak (*Q. kelloggii* Newb.), canyon live oak (*Q. chrysolepis* Liebm.), and California scrub oak (*Q. dumosa* Nutt.). For each species, the characteristics of leaves, acorns, and bark; response to fire; and management alternatives for damaged oaks after fire are described.

Retrieval Terms: Quercus agrifolia Née, *Q. wislizenii* A. DC., *Q. kelloggii* Newb., *Q. chrysolepis* Liebm., *Q. dumosa* Nutt., oak taxonomy, tree injury, sprouting, oak management, fire management, southern California