

# *Quercus chrysolepis* Liebm.,

# Canyon Live Oak

Fagaceae Beech family

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Canyon live oak (*Quercus chrysolepis*), also called canyon oak, goldcup oak, live oak, maul oak, and white live oak, is an evergreen species of the far West, with varied size and form depending on the site. In sheltered canyons, this oak grows best and reaches a height of 30 m (100 ft). On exposed mountain slopes, it is shrubby and forms dense thickets. Growth is slow but constant, and this tree may live for 300 years. The acorns are important as food to many animals and birds. The hard dense wood is shock resistant and was formerly used for wood-splitting mauls. It is an excellent fuel wood and makes attractive paneling. Canyon live oak is also a handsome landscape tree.

## Habitat

### Native Range

Canyon live oak (fig. 1) is found in the Coast Ranges and Cascade Range of Oregon and in the Sierra Nevada in California, from latitude 43° 85' N. in southern Oregon to latitude 31° 00' N. in Baja California, Mexico (9,15). In southern Oregon, it grows on the interior side of the Coast Ranges and on the lower slopes of the Cascade Range. It grows throughout the Klamath Mountains of northern California, along the coastal mountains and the western slopes of the Sierra Nevada, and east of the redwood (*Sequoia sempervirens*) forest on the coast, except in the Ring Range, where it grows close to the coast. In central and southern California, canyon live oak is found on or near the summits of mountains. Scattered populations appear in the mountains of southern Nevada, Arizona, and northwestern Chihuahua, Mexico (17).

### Climate

Populations of canyon live oak receive more than 2790 mm (110 in) of precipitation in the northern portion of their range to less than 300 mm (12 in) in southern California. Interior populations receive from 810 mm (32 in) in the Sierra Nevada to 150 mm (6 in) in the desert mountains. Most of the annual precipitation in the Coast Ranges and the Sierra Nevada is winter rain. In the desert mountains, half

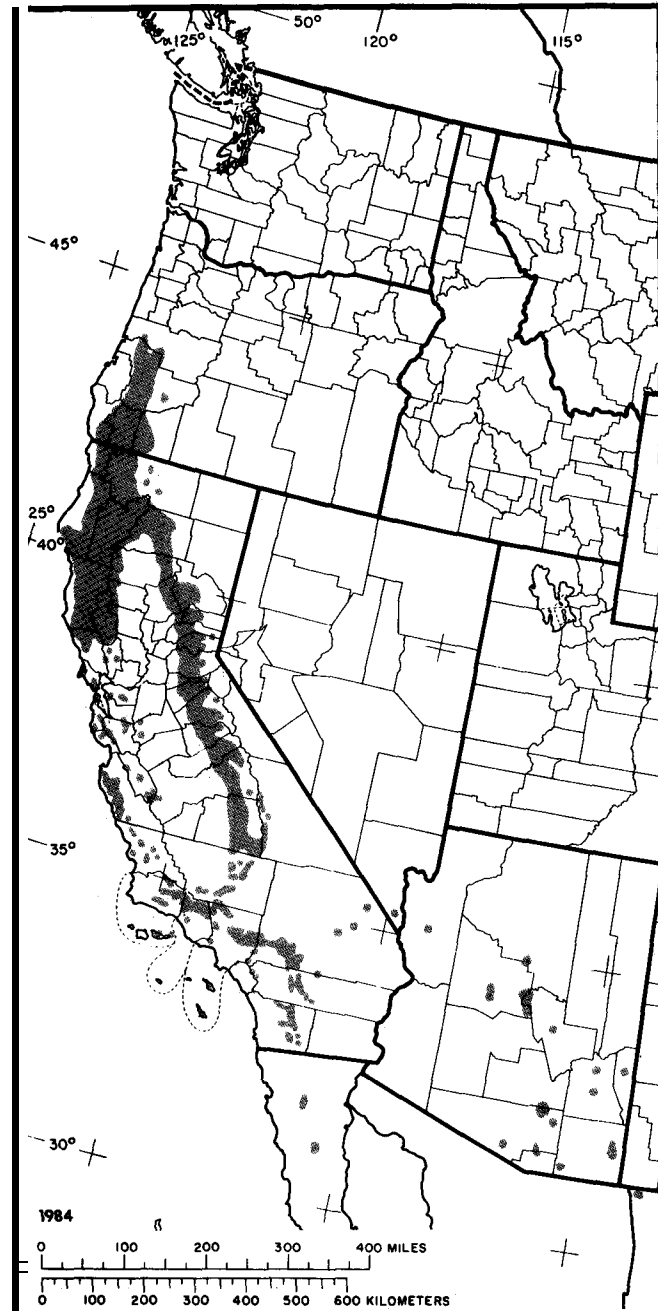


Figure 1—The native range of canyon live oak.

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the precipitation is received in summer, the other half in winter.

In the northern portion of the range of canyon live oak, the mean temperature in summer ranges from 20° to 23° C (68° to 74° F) and in winter, from 3° to 5° C (37° to 41° F); in the southern portion, from 21° to 25° C (70° to 77° F) in summer and from 5° to 7° C (41° to 45° F) in winter. The frost-free period varies from 160 to 230 days throughout the range (1).

### Soils and Topography

Canyon live oak is found on many types of soil. In the northern part of its range, this oak often dominates on steep, shallow, rocky, infertile soils having little soil development. On deep, coarse-textured soils, canyon live oak is usually secondary in importance to Douglas-fir (*Pseudotsuga menziesii*) and tanoak (*Lithocarpus densiflorus*). On deep, fine-textured soils, canyon live oak is normally a small shrub under an overstory canopy of associated species. In northwestern California, canyon live oak grows on sedimentary, metasedimentary, granitic, serpentine, and periodite parent materials. In southern California, it is a dominant on a broad range of soils from shallow and poorly developed to deep and well developed (13). Canyon live oak is most commonly found on soils of the orders Inceptisols and Alfisols.

Canyon live oak grows at elevations of 488 to 1525 m (1,600 to 5,000 ft) in southwestern Oregon; in northern California, from 90 to 1370 m (300 to 4,500 ft); and in southern California, up to 2740 m (9,000 ft). As its name implies, canyon live oak is often the dominant tree on steep canyon walls. In areas of moderate to high precipitation, it is found on southerly aspects, and in the drier parts of its range, on northerly aspects.

### Associated Forest Cover

In southwestern Oregon, canyon live oak is primarily associated with Douglas-fir, tanoak, giant chinkapin (*Castanopsis chrysophylla*), and Pacific madrone (*Arbutus menziesii*) in the mixed evergreen forests. In these forests it is a codominant tree and a shrub in the *Pseudotsuga menziesii*-*Quercus chrysolepis*-*Lithocarpus densiflorus* / *Quercus chrysolepis*-*Lithocarpus densiflorus* climax community type. On steep canyon slopes, it is dominant in the *Quercus chrysolepis*-*Lithocarpus densiflorus*-*Pseudotsuga menziesii* / *Rhus diversiloba* / moss community. On benches and ridgetops, canyon live oak along with tanoak occupies the lower tree canopy of the *Pseudotsuga menziesii*-*Pinus* spp. / *Lithocarpus den-*

*siflorus*-*Quercus chrysolepis*-*Castanopsis chrysophylla* / *Pteridium aquilinum* community. Canyon live oak also is a major codominant in the successional evergreen chaparral, along with hoary manzanita (*Arctostaphylos canescens*) and greenleaf manzanita (*A. patula*). In the mixed conifer zone of the western slope of the Cascade Range, canyon live oak primarily grows in semipermanent fire chaparral associated with snowbrush ceanothus (*Ceanothus velutinus*) (6).

In the Klamath region of northern California, canyon live oak is an occasional small tree or shrub throughout the *Abies concolor* zone of the montane or mixed conifer forest of the interior side of the Coast Ranges and Klamath Mountains. In the *Abies concolor* / *Arbutus menziesii* / *Corylus cornuta* type, canyon live oak is a codominant lower canopy tree under ponderosa pine, sugar pine, and white fir (*Abies concolor*). The associated codominant lower canopy trees are giant chinkapin, bigleaf maple, and Pacific dogwood (*Cornus nuttallii*) (10). It is also an understory tree in the *Abies concolor* / *Vicia americana*, *Abies concolor* / *Chimaphila umbellata*, *Abies concolor* / *Berberis nervosa*, and *Abies concolor* / *Ceanothus prostratus* types (1) and, at lower elevations, in the forest cover types Pacific Ponderosa Pine-Douglas-Fir (Society of American Foresters Type 244) and Pacific Ponderosa Pine (Type 245) (5).

In the Coast Ranges of northern California, canyon live oak is a major component of the mixed evergreen forest or Douglas-Fir-Tanoak-Pacific Madrone (Type 234). In these forests, it is associated with bigleaf maple, California-laurel, coast live oak (*Quercus agrifolia*), Douglas-fir, madrone, and tanoak. Canyon live oak is not usually found in the modal mixed evergreen community dominated by Douglas-fir and tanoak; however, it is dominant on steep, southwestern slopes associated with Douglas-fir and madrone in a *Quercus chrysolepis* / *Pseudotsuga menziesii* type. In the southern portion of the mixed evergreen forests, canyon live oak assumes more importance along with ponderosa pine. On serpentine soils, canyon live oak is a minor climax associate in the *Pinus ponderosa* / *Ceanothus cuneatus*, *Pseudotsuga menziesii* / *Corylus cornuta*, and *Lithocarpus densiflorus* / *Gaultheria shallon* types (20).

In the central Coast Ranges of California, canyon live oak is a codominant in the mixed hardwood forests (Blue Oak-Digger Pine, Type 250), associated with coast live oak, blue oak (*Quercus douglasii*), interior live oak (*Q. wislizeni*), California black oak (*Q. kelloggii*), madrone, tanoak, California laurel, and Digger pine (*Pinus sabiniana*). In this area, it also occurs in successional chaparral associated with Eastwood manzanita (*Arctostaphylos glandulosa*). At higher elevations, canyon live oak is dominant in the

canyon live oak-Coulter pine forest (Canyon Live Oak, Type 249).

In the Sierra Nevada of California, canyon live oak is found in several forest types. In the low-elevation foothill woodland forest, it is occasionally found on steep, north-facing slopes associated with interior live oak, blue oak, and Digger pine. In the mixed oak woodland, canyon live oak is a codominant with interior live oak, along with a prominent understory of manzanita, toyon, and western poison-oak (*Rhus diversiloba*). In the more mesic mixed oak forest, canyon live oak is a codominant with interior live oak, California black oak, bigleaf maple, and California-laurel (17).

Above the foothill woodland zone, canyon live oak is a codominant in the mixed oak-evergreen forest where it associates with ponderosa pine, Douglas-fir, and California black oak. Still higher in elevation in the mixed conifer forest, canyon live oak occurs in small groves with an understory of poison-oak and swordfern (*Polystichum munitum*), or in groves of mixed oak. It is also an understory small tree or shrub in the lower portion of the mixed conifer forests (17).

In the Transverse Range of southern California, canyon live oak is an important subdominant of the yellow pine forest on steep, south-facing slopes where it associates with ponderosa pine, Jeffrey pine (*Pinus jeffreyi*), and California black oak. In moister, cooler areas, canyon live oak is the major dominant in the stable bigcone Douglas-fir-canyon live oak forests (13). Canyon live oak is also found in the western juniper woodlands where it is associated with Jeffrey pine, singleleaf pinyon (*Pinus monophylla*), California black oak, and curleaf cercocarpus (*Cercocarpus ledifolius*). Woodland chaparral is the only chaparral type in which canyon live oak is consistently present; it grows with manzanita, ceanothus, birchleaf cercocarpus, interior live oak, and scrub oak (11).

Throughout California, canyon live oak is an associate in the cypress groves of Santa Cruz cypress (*Cupressus goveniana* var. *abramsiana*), Tecate cypress (*C. guadalupensis* var. *forbesii*), Sargent cypress (*C. sargentii*), and Cuyamaca cypress (*C. arizonica* var. *stephensonii*). It is associated with singleleaf pinyon in the eastern-southern Sierra Nevada. In the Mojave Desert, canyon live oak is a minor associate of the montane white fir forests (1).

In Arizona, canyon live oak is a minor climax species in the montane Douglas-fir and pinyon forests. It is an understory component in pure stands of Douglas-fir. At lower elevations, it is also a major shrub in oak-chaparral communities, associated with Gambel oak (*Quercus gambelii*), New Mexico locust (*Robinia neomexicana*), buckthorn cercocarpus, silk-

tassel bush (*Garrya flavescens*), Gregg ceanothus (*Ceanothus greggii*), and manzanita (17).

In Baja California, Mexico, canyon live oak is found in three habitats: in a scrub-chaparral type, as a shrub associated with manzanita and buckwheats (*Eriogonum* spp.); in groves on steep canyon slopes, as a small tree associated with Baja oak (*Quercus peninsularis*), buckthorn, manzanita, and ceanothus; and at higher elevations, as a small tree in Jeffrey pine forests (17).

## Life History

### Reproduction and Early Growth

**Flowering and Fruiting-Canyon** live oak trees begin to produce flowers at the age of 15 to 20 years. It is monoecious; both male and female flowers are borne on the same tree throughout the crown. The male flowers are in tawny, slender, tomentose catkins 5 to 10 cm (1.95 to 3.90 in) long. The female flowers are solitary or occasionally short, sparsely flowered spikes, tawny with bright red stigmas. The pollen is dispersed by the wind at the time the flowers are receptive. The uniform scattering of male and female flowers throughout the crown is apparently effective in inhibiting selfing. Flowering and pollination occur from May to June, usually later than associated conifers.

**Seed Production and Dissemination-The** acorns are ellipsoidal, light chestnut brown, 2.5 to 5.1 cm (1 to 2 in) long and 13 to 19 mm (0.5 to 0.75 in) wide. They are enclosed only at the base with a thick, shallow cup covered with golden tomentum. Cleaned seeds vary from 110 to 310/kg (50 to 150/lb).

Acorn crops vary from light to heavy (4). Dry weight yields of fallen acorns in dense stands of canyon live oak range from 10 to 2195 kg/ha (9 to 1,960 lb/acre). A few open-grown trees produce large seed crops, up to 181 kg (400 lb) of acorns per tree (23). Some trees bear acorns every year; the interval between good seed crops varies from 2 to 4 years. In dense stands, trees in sprout clumps usually produce fewer acorns than larger single trees.

The acorns mature in one season and fall to the ground in October. The large, heavy acorns are usually dispersed within a short distance of the tree (13). An occasional acorn, however, may roll a considerable distance down the steep canyon walls of its normal habitat. Animals and birds gathering food disseminate the acorn over wide distances.

**Seedling Development-In** stands of canyon live oak, seedling regeneration can be very dense and

evenly distributed. Seedlings show little seedbed preference, but they do best under an overstory or on the shaded overstory fringe. The best seedbed is moist soil covered with leaf litter. Few uncovered acorns germinate. Germination is hypogeal, and a short, cold stratification pretreatment helps to break dormancy. Germination occurs in early spring, and the percentage of seed germinating is moderate. The juvenile root penetrates moist soil rapidly, and survival is high under the shade of dense stands. Competition from grass can cause a complete failure in dry years.

Early seedling growth is slow, and large numbers of seedlings accumulate in some stands (7,13).

**Vegetative Reproduction-Canyon live oak** reproduces by sprouts that develop from dormant buds under the bark at the base of trees. Sprouts may form after a minor injury, such as browsing, or



**Figure 2**—Clumps of canyon live oak originating from sprouts in a 70-year-old canyon live oak-Douglas-fir stand. (Photo by author)

when the aerial parts of a tree are destroyed by fire or harvesting (21).

Sprouts develop from any size tree or shrub immediately after an injury. Older, less vigorous trees may produce only stool sprouts or none. The size and

vigor of the parent tree or shrub determine the early height growth and number of sprouts per clump. Sprout development is greater on larger, more vigorous parent trees. Sprout growth of 0.5 to 1 m (1.6 to 3.3 ft) has been measured the first year. The



**Figure 3**—Large canyon live oak and Douglas-fir in the *Pseudotsuga menziesii*-*Quercus chrysolepis*/*Rhus diversiloba* type of the mixed evergreen forests in northern California. (Photo by author)

number of sprouts per clump is gradually reduced as growth is concentrated on the dominant members. When nearly 100 years old, a parent tree may have three to five stems per clump (fig. 2). Individual stems in these clumps are seldom as large as single trees (13).

### Sapling and Pole Stages to Maturity

**Growth and Yield-Growth** from sapling stage to maturity is slow. In dense, mature stands where oaks are associated with conifers, heights of canyon live oak range from 18 to 30 m (60 to 100 ft), and trunks are straight and free of branches for 6 to 12 m (20 to 40 ft) (fig. 3). Trees may reach 152 cm (60 in) in d.b.h. (3). In open situations, canyon live oak grows less in height but has a large dome-shaped crown as wide as 38 m (125 ft).

In mature stands of canyon live oak, basal areas reach 125 m<sup>2</sup>/ha (545 ft<sup>2</sup>/acre); most stems are in the 50- to 70-cm (20- to 28-in) diameter class. The mean volume of sampled stands in California was 105 m<sup>3</sup>/ha (1,503 ft<sup>3</sup>/acre) with a maximum volume of 289 m<sup>3</sup>/ha (4,128 ft<sup>3</sup>/acre) (2).

**Rooting Habit**-Canyon live oak has rapidly growing, deeply penetrating juvenile roots. At maturity in coarse-textured soils, it is deep rooted with a pronounced taproot. In very rocky soils, the roots may be shallow and cover a large area, with occasional large roots extending for some distance near the surface.

**Reaction to Competition**-Canyon live oak is tolerant of shade and has a higher degree of drought tolerance than associated oaks. In the southern portion of its range, it has the ability to germinate and grow at a slow rate under dense stands of other species. Most stands free of recent major disturbance have trees of all sizes and all ages.

In the Coast Ranges of central California, canyon live oak reproduces under woodland stands of blue oak, valley oak (*Quercus lobata*), and coast live oak where fire is excluded (8).

In the northern portion of its range, canyon live oak is less tolerant of shade than its associates in the mixed evergreen forests-tanoak, giant chinkapin, and Douglas-fir-and is usually more tolerant than Pacific madrone. Canyon live oak occurs as an early successional shrub or tree on good sites but is soon outgrown by its associates and eliminated from a stand. On drier, more open sites, it persists in the climax forest as a subordinate tree and shrub (10,16,20). Only on very rocky, steep canyon walls does it occur as a dominant in the climax forest.

As sawtimber, canyon live oak is best managed in even-aged stands, mixed with different conifers: ponderosa pine in the northern portion of its range, Digger pine in the central Coast Ranges, and Coulter pine and bigcone Douglas-fir in southern California. Closed canopies should be maintained at all times, because open-grown canyon live oak tend to develop short boles, poor form, and excessive crowns with large branches. Maximum production of biomass for fuelwood can be achieved in pure, even-aged coppice stands.

**Damaging Agents**-Canyon live oak seedlings and saplings are browsed by deer. In some areas, as many as 40 percent of all seedlings were browsed (8). In most situations, however, growth is not seriously retarded. Young stands of canyon live oak are relatively vulnerable to ground and crown fires. The combustion of ground fuels and brush during light fires singes and kills the crown foliage and burns through the thin, flaky bark. Repeated fires tend to convert canyon live oak trees to shrubs (18). In southern California, crown-sprouting associates-such as coast live oak and bigcone Douglas-fir-remain as trees after repeated fires, whereas canyon live oak becomes a shrub (14).

Little insect damage has been observed on canyon live oak compared with other oaks. Occasional localized damage is caused by California oakworm (*Phryganidia californica*) in wet years; in dry years, the Pacific oak twig girdler (*Agrilus angelicus*) causes some damage. Other insects reported to do minor damage on canyon live oak are Pacific tent caterpillar (*Malacosoma constrictum*), western tussock moth (*Orgyia vetusta*), carpenterworm (*Prionoxystus robiniae*), ribbedcase maker (*Bucculatrix albertiella*), oak bark beetles (*Pseudopityophthorus* sp.), and a false powderpost beetle (*Melalgus confertus*) (3).

Acorns are destroyed by the filbert weevil (*Curculio uniformis*) and the filbertworm (*Melissopus latiferreanus*) (22). Often entire crops are riddled by insects. During some years an entire crop of acorns is used as food by squirrels, deer, and birds.

Numerous pathogens are found on canyon live oak throughout its range, the most serious being various heart rots. Diseases of canyon live oak are relatively unimportant under natural conditions. A rust fungus, *Cronurtium quercuum*, and the mistletoe *Phoradendron villosum* subsp. *villosum* cause witches' brooms.

### Special Uses

Canyon live oak was one of the woods most commonly used by early California settlers for farm implements, shipbuilding, furniture, and fuel. The

common name maul oak came from its use as a splitting maul (5). Canyon live oak has been considered a non-manageable hardwood; however, its high caloric value and rapid sprout growth make it an excellent source of fuelwood. Manufactured into paneling, the wood makes an attractive multicolored interior wall covering.

Open-grown trees with their wide crowns of evergreen leaves make attractive urban trees. The ability of canyon live oak to grow on steep, rocky, moving slopes makes it an excellent stabilizer of soils on steep slopes.

Montane hardwood forests dominated by canyon live oak provide habitat and food for a large variety of wildlife. The acorns are an important source of food for scrub and Steller's jays, acorn woodpecker, band-tailed pigeon, wild turkey, mountain quail, ground squirrel, woodrat, black bear, and mule deer. Deer also use the foliage as food. Many amphibians and reptiles are found in these forests (12,22).

## Genetics

Considerable ecological and morphological diversity has been reported for canyon live oak throughout its range. The ecological diversity has not actually been determined; however, its occurrence over a broad range of elevations and geographical, topographical, edaphic, and vegetational conditions indicates considerable ecological variability.

Throughout the Coast Ranges of California, a variety of canyon live oak has been recognized—*Quercus chrysolepis* Liebm. var. *nana* (Jepson) Jepson. Apparently this morphological variety is an ecotypic shrubby form of canyon live oak found in the fire chaparral types. At high elevations, the shrubby forms are hybrids between canyon live oak and huckleberry oak (*Q. vaccinifolia*).

On the California Channel Islands, canyon live oak hybridizes with the endemic island live oak (*Q. tomentella*), and in Arizona it hybridizes with Dunn oak (*Q. dunnii*) (17).

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