Lifhocarpus densiflorus (Hook. & Arn.) Rehd. Tanoak

Fagaceae Beech family

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Tanoak ***(Lithocarpus densiflorus),*** also called tanbark-oak, is an evergreen hardwood that, with other species in the genus, is considered a link between the chestnut, *Castanea*, and the oak, Quercus *(19)*. Tanoak has flowers like the chestnut and acorns like the oak. This medium-sized tree grows best on the humid moist slopes of the seaward coastal ranges. It usually occurs in a complex mixture with conifers and other hardwoods, but often forms pure even-aged stands. The wood is hard, strong, and fine-grained. Tanoak is designated a commercial species in California. Current major uses are for fuel and pulp. The acorns are a valuable food source for many kinds of wildlife.

Habitat

Native Range

A disjunct stand slightly north of the Umpqua River in southwestern Oregon has been reported as the northernmost limit of tanoak's natural range (fig. 1). The general northern limit of tanoak in the Coast Ranges, however, is farther south in the Coquille River drainage. Its eastern limit in Oregon extends from west of Roseburg to Grants Pass, and then southwesterly into the Applegate River drainage. Tanoak's range stretches southward through the Coast Ranges in California to the Santa Ynez Mountains north and east of Santa Barbara, CA. The range also extends northeastward from the Humboldt Bay region to the lower slopes of Mount Shasta, then intermittently southward along the western slopes of the Sierra Nevada as far as Mariposa County (7). In the Sierra Nevada, tanoak is most common between the Feather and American Rivers.

Climate

Tanoak grows in a climate broadly classified as humid. Annual precipitation, however, is seasonal and varies from 1020 to 2540 mm (40 to 100 in). Some precipitation is snow. Summer and early fall are dry and the winter rainy, From June through September rainfall totals less than 25 mm (1 in) a month. In fact, precipitation during these months amounts to only 5 percent of the year's total. Most of the precipitation-about 70 percent-falls between November and February.

Average mean daily temperatures range from 2" to 6" C (36" to 42" F) during January and 16" to 23" C (60" to 74" F) in July. The season free of killing frosts begins between March 8 and April 30 and ends between October 20 and November 20, varying in length between 160 and 249 days. Over a 30-year period the maximum temperature recorded at 183 m (600 ft) elevation in the center of tanoak's area of maximum development was 45" C (113" F).

Soils and Topography

Tanoak grows well on a variety of soils developed from igneous, metamorphic, or sedimentary rocks, or sedimentary rock alluvium. It grows best on soils that are deep, well-drained, and loamy, sandy, or gravelly. Tanoak also grows on soils derived from serpentine, which are intermediate between the moist and dry extremes, but is limited to a shrubby form. It is seldom found on heavy clayey soils.

High-site soils for redwood ***(Sequoia sempervirens)*** or Douglas-fir ***(Pseudotsugu menziesii),*** such as the Hugo, Sheetiron, Josephine, Empire, Larabee, Sites, and Melbourne (12) series, are also well suited for the growth of tanoak (28). These soils have been derived from either consolidated or soft sedimentary rocks. They are light grayish brown or light reddish brown to brown in color and are moderately to strongly acidic. Soil textures grade through gravelly loam, sand loam, fine sandy loam, loam, silt loam, to clay loam. Soil orders are mostly Inceptisols and Alfisols.

Besides growing well on deep soils, tanoak also thrives on stony and shallow soils that are less suitable for conifers. Yet tanoak requires more moisture than many other hardwoods. It will grow well on the shallow and stony soils of north slopes, for example, but will be supplanted by Pacific madrone ***(Arbutus menziesii),*** Oregon white oak ***(Quercus garryana),*** or California black oak *(Q. kelloggii)* on the warmer, drier south slopes.

Throughout the Coast Ranges from the northern limit of tanoak's distribution (lat. 43" 42' N.) to the Santa Lucia Mountains (lat. 35" 40' N.) tanoak grows from sea level to elevations of 1220 or 1525 m (4,000 or 5,000 ft). The terrain is rough, steep, and extremely dissected by both major streams and smaller

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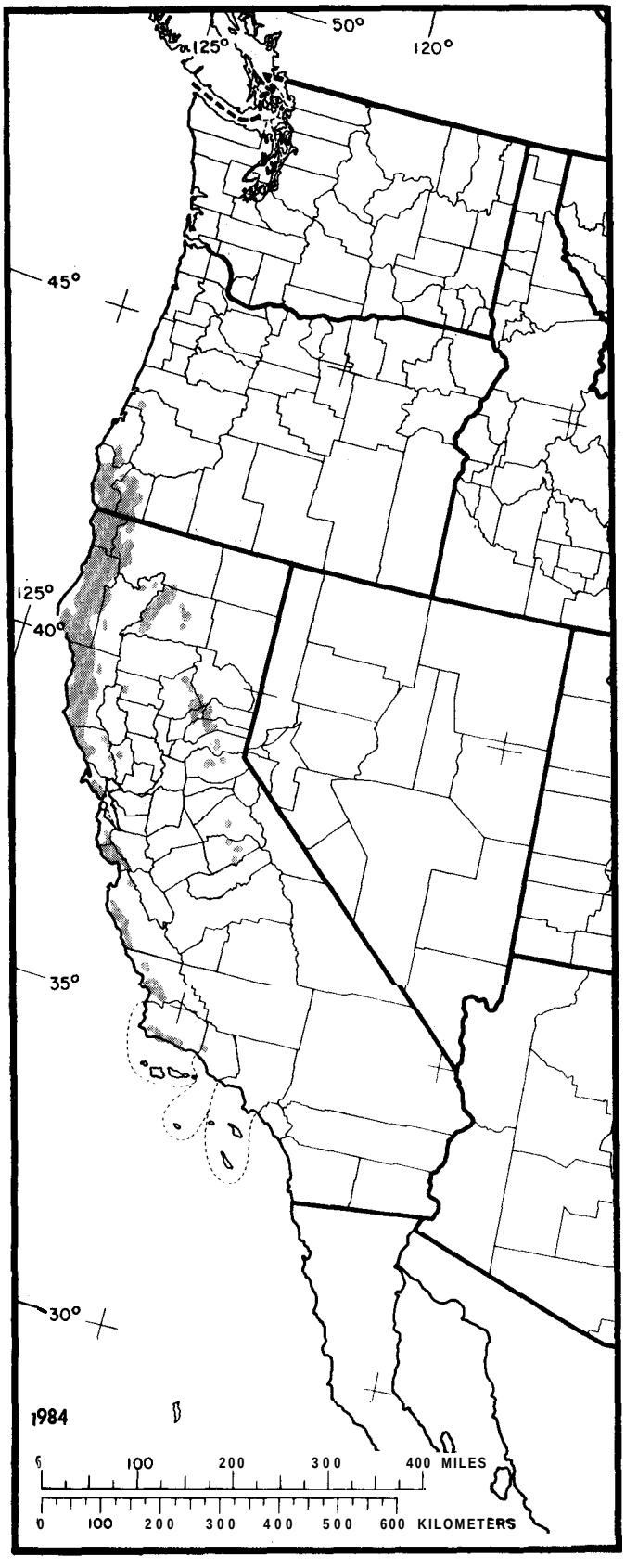

Figure 1-The native range of tanoak.

drainages. In the Santa Ynez Mountains, at the southern limit of its range (lat. 34" 34' N.), tanoak grows at 730 to 1435 m (2,400 to 4,700 ft). In the northern Sierra Nevada, it grows between elevations of 580 and 1220 m (1,900 and 4,000 ft) and in the central Sierra Nevada between 915 and 1525 m (3,000 and 5,000 ft). At its southern limit in the Sierra Nevada, tanoak is found between 1525 to 1980 m (5,000 and 6,500 ft) near Signal Peak (lat. 37° 32' N.) in the Sierra National Forest *(24)*.

Tanoak is most abundant and, in general, attains its largest sizes in Humboldt and Mendocino Counties, CA, between elevations of 150 to 915 m (500 to 3,000 ft) on northerly and easterly slopes and toward the summits of the seaward exposures of the Coast Ranges. In the southern Coast Ranges, tanoak is common in the Santa Cruz and Santa Lucia Mountains, particularly on the westerly slopes. And in the central Sierra Nevada, where the climate is less humid, it grows in valleys, coves, ravines, along streams, and on north slopes.

Associated Forest Cover

Tanoak grows within the life zones classified as the Canadian and Transition. It is the most abundant hardwood species in timber stands of the Coast Ranges of California *(6)* and southwestern Oregon. Tanoak is a common component in the following forest cover types (4): Redwood (Society of American Foresters Type 232), Pacific Ponderosa Pine (Type 245), Pacific Ponderosa Pine-Douglas-Fir (Type 244), Sierra Nevada Mixed Conifer (Type 243), and California Coast Live Oak (Type 255). It is a particularly important component of Pacific Douglas-Fir (Type 229) and Douglas-Fir-Tanoak-Pacific Madrone (Type 234).

The principal body of tanoak is a broad band along the inland side of the redwood belt. Here tanoak sometimes forms almost pure stands (6). More often it is an understory tree with Douglas-fir or is a component of hardwood stands or mixed hardwood-conifer forests (fig. 2). The most common hardwood associated with tanoak is Pacific madrone. Other frequent hardwood associates include giant chinkapin *(Castanopsis chrysophylla)*, canyon live oak *(Quercus chrysolepis)*, California black oak *(Q. kelloggii)*, and California-laurel *(Umbellularia californica)*. Tanoak is found most often with Douglas-fir and redwood. Other common conifer associates are California white fir (Abies *concolor* var. *lowiana)*, Sitka spruce *(Picea sitchensis)*, sugar pine *(Pinus lambertiana)*, ponderosa pine *(P. ponderosa* var. *ponderosa)*, California torreya (nutmeg) *(Torreya californica)*, and western hemlock *(Tsuga heterophylla)*.

Figure 2—*Tanoak growing as understory trees in a stand of* Douglas-fir *(SAF 229).*

A large variety of shrubs, forbs, grasses, sedges, and ferns are also associated with tanoak. Generally these plants are not abundant on forested land, but, with tanoak sprouts, often become aggressive on burned or cutover areas. Among the most common shrubs are blueblossom *(Ceanothus thyrsiflorus)*, California hazel *(Corylus* ***cornuta*** var. ***californica),*** salal ***(Gaultheria shallon),*** Pacific bayberry ***(Myrica californica),*** Pacific rhododendron ***(Rhododendron macrophyllum)*** , flowering currant ***(Ribes sanguineum),*** thimbleberry *(Rubus parviflorus)*, western poison-oak ***(Toxicodendron diversilobum),*** and California huckleberry *(Vaccinium* ***ovatum).***

Two smaller plants producing woody growth above ground are prince's-pine ***(Chimaphila umbellata*** var. ***occidentalis)*** and Oregon grape ***(Berberis nervosa).*** Many forbs and grasses are plentiful in the tanoak range. Among the most important forbs are bull thistle ***(Cirsium vulgare),*** New Zealand fireweed ***(Erechtites arguta),*** Australian fireweed *(E.* ***minima),*** and western whipplea *(Whipplea* ***modesta).*** Common grass species include California brome *(Bromus* ***carinatus),*** soft chess ***(B. mollis),*** California fescue ***(Festuca californica),*** and California sweetgrass ***(Hierochloe occidentalis).*** Western swordfern *(Polystichum* ***munitum)*** and western bracken ***(Pteridium aquilinum*** var. *pubescens)* sometimes grow abundantly with tanoak. Sedges *(Carex* spp.) also are represented in some places.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Staminate catkins are elongate and erect, 5 to 10 cm (2 to 4 in) long. Blossoms may appear in the spring, summer, or autumn. However, most tanoaks bloom in June, July, or August. Trees at lower elevations and near the coast bloom earlier than trees at higher elevations and farther inland. The plant is monoecious.

Almost all the flowers, both male and female, are borne on new shoots *(22)*, where they grow from the axils of the new leaves. Flowers also occasionally develop from buds found at the base of leaves of the previous year's growth.

Female flowers are borne at the base of erect male catkins. The profusion of yellowish blossoms that sometimes conceal the foliage suggested the tree's specific scientific name. The calyx is pale green; the stamen filament is white; and the anther yellow.

The seeds, which are similar to oak acorns, ripen in the second autumn. Seeds are usually borne singly, in twos, or in threes *(25)*, but sometimes more are clustered together.

Seed Production and Dissemination-Tanoak is a heavy seeder (3). In general, viable seeds are borne in abundance after the 30th to 40th year *(8)*, although 5-year-old sprouts also have produced fairly heavy crops. A long dry period at pollination time helps the setting of acorns. Trees are heavily laden almost every alternate year, and complete seed crop failures are rare. "Jayhawking"—peeling the bark from standing trees-has shown that girdling produces excessively large acorn crops before the trees die. Scanty crops generally are caused by frosts or by a dry year.

Mature trees produce the most acorns. One estimate places annual acorn production of a veteran tanoak 76 cm (30 in) in d.b.h. at about 454 kg (1,000 lb). Because about 110 acorns weigh 0.45 kg (1 lb), this production is more than 110,000 acorns. Other estimates showed that trees between 46 and 61 cm (18 and 24 in) d.b.h. produced 3,900 to 4,600 acorns.

Insects destroy a significant number of acorns. One study found insect larvae infesting 51 percent of the acorns. The insects identified were the filbert weevil

(Curculio uniformis) and the filbertworm *(Melissopus Zatiferreanus).* Other insect larvae that have been found in tanoak acorns are from the families *Gelechiidae* and *Pyralidae (5).*

Many immature acorns have been seen on the ground as early as August 25, but these were probably knocked down by heavy rains. Mature tanoak acorns drop between September 20 and November 15. The first acorns to fall are usually insect infested, whereas those falling later are usually sound. Indians in California placed a taboo on collecting acorns for food until their medicine women held a ceremonial festival that celebrated the falling of sound acorns.

Because the acorns are large-2.5 to 5.1 cm (1.0 to 2.0 in) long and 15 to 18 mm (0.6 to 0.7 in) in diameter-and heavy, most of them fall straight to the ground and are found under the tree crowns. Only a few bounce outward when dropping onto lower branches or roll for short distances on steep slopes. In one small study, acorns were counted under trees 46 to 61 cm (18 to 24 in) in diameter at rates of 194,000 to 226,000/ha (78,400 to 91,500/acre) *(24).*

Seedling Development-With suitable conditions, tanoak reproduces well from seed. Acorns germinate in a wide range of environments from old-growth stands to recent clearcuts *(31).* However, survival of unprotected seed is low in clearcuts due to heavy predation. The dense shade of virgin forests, and the thick litter found under tanoaks, madrones, or other hardwoods, do not hinder germination. Seedlings are common in these conditions. Tanoak germination is hypogeous.

A limited number of tests show that germination rates vary from 19 to 80 percent *(25).* When acorns were planted with pointed end up, germination was significantly greater *(13).*

Almost all natural seedlings emerge in the spring; some germination may occur in the fall, but only if the weather is mild and moist. To preserve their viability, tanoak acorns must either be planted immediately in the nursery in light soil, or be stratified until spring at temperatures just above freezing. Seedlings appear about 3 weeks after planting.

Natural tanoak seedlings have been counted under parent trees left after the Douglas-fir overstory had been cut. Although 1 year's acorn crop produced 395 to 940 seedlings per hectare (160 to 380 seedlings/acre) under trees 51 to 66 cm (20 to 26 in) d.b.h., the efficiency of sound acorns in producing seedlings was only 0.64 percent. Only one seedling grew from 156 sound acorns.

Many natural seedlings are found in the understory of conifer stands, which appears to be an ideal environment for reproduction (29). In southwestern Oregon, seedling survival after 4 years ranged from 44 to 49 percent in conifer stands whose ages ranged from 50 to 100+ years *(31).* In the northern Sierra Nevada, from 17 to 347 new seedlings per acre were present annually during an ll-year period *(13).* The annual appearance of new seedlings along with modest rates of mortality resulted in relatively stable populations of 570 to 3000/ha (233 to 1,215/acre) during these 11 years. However, attempts to establish a plantation of tanoak by artificial seeding on an exposed site, which had been prepared by removing vegetation and exposing mineral soil, were unsuccessful *(13).*

Biotic factors contribute to low seed crop efficiency. Although the acorns have hard seedcoats-the generic name, *Lithocarpus,* from the Greek "lithos" meaning rock, and "karpos" meaning fruit, alludes to the hard acorn-at least 38 species of animals eat them (2). Principal consumers include 4 bird species, 11 rodent species, deer, bears, and raccoons. Goats, hogs, and cattle also prevent seedling reproduction by devouring acorns and browsing tender seedlings.

Heights of first-year, natural tanoak seedlings, measured from cotyledons to growing tip, in one study varied from 5 to 21 cm (1.9 to 8.3 in) and averaged 13 cm (5.2 in), greater than first-year heights of natural conifers on the same site (24). After the first year, the seedling growth rate is moderate, less than 5.0 cm (2 in) per year.

Tanoak seedlings begin to produce burls below ground at 1 to 2 years of age. Burls develop more quickly on good sites and, in one study, averaged 25 mm (1.0 in) in diameter in 10 to 12 years (29). After 6 to 12 years, the original stem dies (even without browsing or other damage) and a new top is produced that tends to be more vigorous than the original one. Tanoak seedlings thus become seedling-sprouts. Top replacement is common, and seedling-sprouts may support several live stems (29). The tallest stem ranged from 25 to 150 cm (10 to 60 in) on 20-year-old seedling-sprouts in southwestern Oregon interior sites. More rapid development is likely in the coast range and northern Sierra Nevada forests. Tanoak seedling-sprout ages can be estimated by counting xylem rings in the stem below the burl, but there is no reliable relation between top age and/or size and total seedling-sprout age *(29).* The growth potential of seedling-sprouts is low. Forty- to fifty-year-old tanoak seedling-sprouts, for example, had burls that were only 5.0 to 7.5 cm (2 to 3 in) in diameter. Three years after removal of the overstory by cutting and

burning, they produced clumps of 4 to 6 stems that averaged only 51 cm (20 in) tall.

Records on the seasonal growth of tanoak are scanty. Some observations have been recorded in the vicinity of Salyer, CA. Here, in the Trinity River valley and on the low mountain slopes up to 610 m (2,000 ft) elevation, tanoak vegetative buds open in mid-April. From 610 to 1065 m (2,000 to 3,500 ft), buds burst in mid-May, and from 1065 to 1340 m (3,500 to 4,400 ft), foliage growth begins in late May. At its elevational limit near Salyer, which is about 1370 m (4,500 ft), buds open in early June. Leaves persist for 3 to 4 years *(24)*.

The growing season lasts 4 to 5 months in the mountains and somewhat longer at lower elevations and nearer the coast.

Vegetative Reproduction-Tanoak reproduces prolifically by vigorous sprouts that appear at practically any time under a wide variety of conditions (3). Sprouts may start to grow after a relatively minor basal injury, after bark has been stripped from the trees for tannin extraction, or when the aerial parts of the tree are destroyed by fire or logging (22). Even healthy trees sometimes sprout.

Sprouts develop from conical woody buds that lie under the bark at the base of the tree. Most of these buds are found on burls below the groundline. Because the number of buds varies from few to thousands, the number of sprouts also varies. As many as 1,400 have been counted on one large stump. The only mechanical damage that prevents sprouting is stripping the bark below the ground level to expose the buds.

Sprouts from burls grow rapidly in a wide range of environments. In clearcuts, they have reached 1.7 m (5.6 ft) the first year and 4.1 m (13.6 ft) after 5 years. The microclimate within sprout clumps is quite different from the microclimate immediately adjoining them (21). Sprout growth is reduced somewhat by a conifer overstory (13). The size of parent trees between 3 and 43 cm (1.3 and 16.8 in) in d.b.h. determined the height and diameter growth of sprout clumps, and the number of sprouts in a clump. The larger parent trees produced greater sprout development. Sprouts are reduced drastically in numbers early in their life and growth is concentrated on the dominant stems. In the first 15 or 20 years, sprouts grow an average of about 0.6 m (2 ft) in height a year. Often, a circle of four to eight slender 30-year-old poles grows around the stump of a parent tree. These poles may average 30 to 38 cm (12 to 15 in) in d.b.h. (24). Thinning all but 2 to 4 sprouts per clump of 3- to lo-year-old sprout clumps did not increase height or diameter growth of the remaining sprouts, largely

Figure *3-Mature tanoaks of* ***medium size. The tree on the*** *left is* ***51 cm (20 in) and the one on the right is 46 cm (18 in) in*** *d.b.h.;* ***both are 22.9 m (75*** *ft) tall.*

because rapidly growing new sprouts quickly replaced those that had been cut *(14).*

Leaf area, total above-ground biomass, height, clump width and area, and number of stems 1 to 6 years after cutting were statistically correlated with parent tree diameter at 1.4 m (4.5 ft) before cutting or burning (9). Thus, sprout clump size and total stand cover can be predicted from stand stocking tables before harvesting or burning either conifer stands with a tanoak understory or pure tanoak stands (30).

Although not growing as fast as sprouts of some associated hardwoods, such as bigleaf maple and madrone, tanoak sprouts are significant competitors because they are usually abundant, especially in conifer stands. Tanoak sprouts often quickly dominate the vegetational cover after logging or fire. Although this ability helps reduce soil erosion, tanoak sprouts often provide severe competition to conifer reproduction and may suppress it. The thick, stiff, flat, leathery leaves often cover young conifer seedlings or cover the ground so thoroughly that conifer seedlings cannot emerge above them (20).

Propagation of tanoak by grafts or cuttings has not been reported.

Tanoak sprouts can be controlled by herbicides applied to frills on the stems, to stumps of freshly cut stems, or to foliage of young sprout clumps (32).

Sapling and Pole Stages to Maturity

Growth and Yield-The form of tanoak varies greatly. In closed stands, particularly in dense coniferous forests, tanoaks develop one central axis, narrow crowns, ascending branches, and long trunks that are clear for 9.1 to 24.4 m (30 to 80 ft). In this form, tanoak is one of the most stately broadleaved trees in the West. In open stands, however, especially in association with Pacific madrone and California black oak, tanoaks are free branching, the crowns are broad, the limbs horizontal and large, and the trunks short and thick. The main trunk divides into several large branches and forms a rounded crown.

Tanoak is usually classed as medium in size (15). Mature trees (fig. 3) are generally 15.2 to 27.4 m (50 to 90 ft) tall but frequently grow to 45.7 m (150 ft) (26). The tallest tree reported was 63.4 m (208 ft) high and 137 cm (54 in) in d.b.h. It was found on the North Fork of the Little Sur River, Monterey County, CA.

Mature trees vary from 15 to 122 cm (6 to 48 in) in d.b.h. The largest diameter of record is 277 cm (109 in), measured on a tanoak near Kneeland, Humboldt County, CA. This tree was 30.5 m (100 ft) tall and the crown had a spread of 23.2 m (76 ft) *(1).*

Tanoaks with the largest diameters generally grow in open stands where tree heights are lower. Age-height-diameter relationships in Sonoma County, CA, were as follows (24):

Age	Height		D.b.h.	
yr	*m*	*ft*	*cm*	*in*
20 to 40	9.1 to 15.2	30 to 50	10 to 23	4 to 9
40 to 100	12.2 to 24.4	40 to 80	25 to 30	10 to 12
70 to 125	24.4 to 30.5	80 to 100	33 to 46	13 to 18
100 to 159	27.4 to 36.6	90 to 120	48 to 61	19 to 24
125 to 180	35.1 to 42.7	115 to 140	64 to 91	25 to 36
150 to 210	30.5 to 36.6	100 to 120	94 to 117	37 to 46
170 to 250	30.5 to 36.6	100 to 120	119 to 152	47 to 60

The growth of tanoak has been called slow, moderate, and fairly rapid. Knowledge about growth rate is limited, for only a few trees have been measured. Seven trees near Sherwood, Mendocino County, CA, which varied from 36 to 69 cm (14 to 27 in) in diameter at 0.61 m (2 ft) above the ground, had from 4 to 8 rings per centimeter (10 to 20/in). At another location, trees 48 years old averaged 25 cm (10 in) in d.b.h. and 10.7 m (35 ft) tall. Trees 36 to 46 cm (14 to 18 in) in d.b.h. were from 80 to 128 years old, and trees 51 to 152 cm (20 to 60 in) were from 150 to 250 years old.

It is difficult to ascertain the age of tanoak. As noted earlier, seedling sprouts in the understory were 50 to 60 years of age and less than 2 m (6 ft) tall. A tanoak taller than 20 m (60+ ft) had five stems ranging in size from 10 to 35 cm (4 to 12 in) d.b.h. and in age from 29 to 94 years (29). It also had four burls below ground 35 to 90 cm (1.5 to 2.5 ft) d.b.h. in diameter, with scars of large stems 50 cm (1.5+ ft) which had died, broken off, and decayed. This tree was likely older than the 240-year-old conifers in the overstory. When the overstory is removed, sprouting tanoak forms an even-aged stand above ground, regardless of actual age.

Growth of tanoak stands 50 to 60 years old above ground thinned to six different basal-area densities (19 to 32 m^2/ha; 85 to 141 ft^2/acre) grew about 6 m^3/ha/yr (85 ft^3/acre/yr) for 8 years after thinning (16).

Rooting Habit—Tanoaks develop deep taproots (22) and also develop intricate systems of lateral roots which may approach the soil surface and grow downhill, eventually emerging from the soil where they form burls that produce sprouts.

The sapwood of tanoak is extremely thick, reaching a high of 66 percent even on large trees. This condition helps trees to live after the bark has been stripped for tannin production or after trees have

been girdled for eradication. Some girdled trees have lived as long as 30 years.

Reaction to Competition-Tanoak generally is classed as tolerant of shade (22). It is aggressive and well fitted by its reproductive habits, vigor, and shade endurance to compete for possession of the ground *(31).* Although tanoak can endure considerable shade throughout life, it grows best with top light. In conifer stands where it has an equal opportunity to grow, it can compete with redwood and Douglas-fir (23). In dense stands, natural pruning produces long clear boles.

Tanoak can reproduce from both seed and sprouts and thus maintain itself in a wide range of forest types and successional stages. Under dense conifer stands it is often abundant (610 to 5300 stems/per hectare; 240 to 2,100/acre) *(29),* and continuous input of new seedlings can maintain or increase stocking *(13).* After the overstory is logged or burned, even small tanoaks can respond, and tanoaks of all sizes may dominate disturbed areas. Because of its ability to respond to disturbance and to reproduce and grow in the shade, it is considered to be a climax species in Douglas-fir, redwood, and mixed-conifer forests.

Damaging Agents-Fire is the principal enemy of individual tanoak trees (3). Ground fires, as well as crown fires, are sometimes fatal. More often, however, fires leave long vertical wounds reaching from 1.2 to 3.0 m (4 to 10 ft) up the trunks. Although the bark of mature trees is at least 3 to 8 cm (1 to 3 in), and occasionally 10 or 13 cm (4 or 5 in) thick, some trees are burned badly.

Fire injuries to small trees often heal over, but fungi usually enter the wounds on older trees. The exposed wood on these larger trees rots and the wounds do not heal. If decayed wood catches fire it burns readily and the original wound is enlarged. Sometimes one-third to one-half the diameter of the tree is destroyed as a result of repeated fires and decay.

Until injured by fire, tanoak is relatively free from insect attacks and fungal diseases and is windfirm (3). Injury to the trunk, however, allows fungi to enter. Wind and heavy snows eventually fell many trees originally injured by fire and subsequently weakened by decay.

Fire and fungi cause tanoak to be fairly defective. One study based upon cubic volume in 90 trees showed that the amounts of saw log cull were 39 percent in cull trees, 8 percent in noncull trees, and 13 percent in all trees.

Fungi found in living trees are the beefsteak fungus *(Fistulina hepatica),* which causes a brown cubical rot; the weeping conk *(Inonotus dryadeus),* a white root rot; and a necrophyte *(Schizophyllum commune),* which causes a sap rot on injured areas of standing trees. Tanoak is susceptible to the shoestring root disease *(Armillaria mellea).* The fungus *Ceuthocarpum conflictum* causes a commonly seen leafspot on tanoak *(10).*

Several insects have been found feeding on tanoak but, generally, the damage is not economically significant. Two of these are armored scales identified as the greedy scale *(Hemiberlesia rapax)* and the oak scale *(Quernaspis quercus).* The greedy scale chiefly infests the bark but also feeds on leaves. The oak scale feeds on the undersides of leaves. Another insect, the crown whitefly *(Aleuroplatus coronatus),* resembles soft unarmored scales and feeds on the undersides of leaves, sometimes causing the leaves to fall prematurely. Ehrhorn's oak scale *(Mycetococcus ehrhorni)* is found on stems and the white sage mealybug *(Pseudococcus crawi)* on stems and leaves *(5).*

In 1957, the California oakworm *(Phryganidia californica)* completely destroyed that year's foliage of tanoaks growing on Hennessey Ridge, near Salyer, Trinity County, CA. This damage was localized and was not observed at other places nearby Usually, the California oakworm causes little damage but irregularly becomes epidemic over large areas.

Other insects work under the bark. Adults of the Pacific oak twig girdler, *Agrilus angelicus,* feed on foliage, but its larvae mine spiral galleries that girdle twigs, small limbs and trunks, or sprouts. Adults of a false powderpost beetle *(Melalgus confertus)* prune twigs by boring at the fork of small branches *(5).*

Decline of tanoak sprout vigor was observed in mixed conifer-hardwood forests in the central Sierra Nevada *(18).* Affected clumps were wider and denser, but only one-fifth as tall as unaffected clumps. Reason for the decline is not known.

Tanoak is avoided by livestock if better feed is available. Mule deer rarely browse it. The current year's growth of tanoak leaves and twigs is protected by abundant stellate trichomes, which are unpleasant to inhale.

Special Uses

The Indians in California's North Coast Range obtained one of their principal foods from tanoak. In fact, the main fare of many Indian communities was salmon and tanoak acorns. The large acorns were ground, leached, and then prepared as a soup, cooked mush, or a kind of bread. After being leached, the acorns are said to have an agreeable acid taste. They also contain a comparatively large amount of oil. On

this account, tanoak acorns were preferred by local Indians over all other kinds. Ground tanoak acorns have also been fed to chickens.

Tannin from tanoak bark has properties intermediate between chestnut tannin and the usual oak tannin of commerce. The extract from tanoak bark, however, furnishes the best tannage known for the production of heavy leathers. For example, it gives excellent plumping when used to tan sole or saddle leather. The superiority of tanoak bark extract is attributed to the presence of certain other acids, such as gallic and acetic, with the tannic acid. Tanoak tannin has also been used medicinally as an astringent (24).

One successful attempt to graft European chestnut *(Castanea sativa)* scions to tanoak stumps has been reported from southern Mendocino County,

Genetics

Races

A shrubby variety of tanoak *(L. densiflora* var. *echinoides)* grows near Mount Shasta, on the west slope of the northern Sierra Nevada, in the central Trinity Alps, in the Salmon and Klamath Mountains, and northward through the Siskiyou Mountains into southern Oregon (28).

The shrub variety occupies a narrow elevational band just above that inhabited by the tree form. This variety is found on a wide range of soils including ultrabasics, but generally occurs only on moist sites (27). On deep, productive soils, especially in the Sierra Nevada, it forms a dense cover of large clumps that often become flattened by snow. Stems from such clumps may straggle downslope for 5 m (16 ft) or more. After cutting or burning, upright sprout clumps are formed that closely resemble those of root crown sprouts from tanoak trees in clearcuttings *(17).*

Small woody plants with slender, deeply toothed leaves were discovered in 1962 on the Challenge Experimental Forest, Yuba County, CA. These plants are believed to be a sublethal recessive mutation of tanoak and have been named *Lithocurpus densiflora* f. *uttenuuto-dentutus (33).*

Hybrids

No hybrids of tanoak are known. Although *Lithocurpus* comprises between 100 and 200 species, all but tanoak are native to southeastern Asia and Indomalaysia *(11).*

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