FagaceaeCBeech family

Lithocarpus densiflorus (Hook. & Arn.) Rehd.

tanoak

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Occurrence and growth habit. This evergreen hardwood species, the sole representative of its genus in North America, is considered a link between the chestnuts (*Castanea*) and the oaks (*Quercus*) (McMinn 1939). Tanoak (also known as tanbark-oak)C*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.Chas flowers that resemble those of the chestnuts, but acorns that resemble those of the oaks. Tanoak is found from just north of the Umpqua River in southwestern Oregon southward throughout the coastal ranges to the eastern end of the Santa Ynez Mountains in western Ventura County, California. Its range then extends eastward to near Grants Pass, Oregon, and the lower slopes of Mt. Shasta, and then intermittently southward along the western slopes of the Sierra Nevada to Mariposa County, California (Griffin and Critchfield 1972).

A striking characteristic of tanoak species is that, throughout its range, the tree form is found where moisture is presentCfrom the soil, from fog, or from high relative humidity (McDonald and Tappeiner 1987). Another characteristic of the species is that shade is a requirement, but the amount varies by reproductive mode. Seedlings from acorns need shade to become established and grow. Sprouts from root crowns, which are often found in burned or otherwise severely disturbed areas, grow best in full sunlight, but only until the crowns close. From then on, and whether from acorns or sprouts, only toplight is needed. Indeed, full sunlight is then deleterious.

Because partial shade is necessary, tanoak is often found in dense stands, usually in mixture with several conifer and hardwood species. Pacific madrone (*Arbutus menziesii* Pursh) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) are its most common associates. The species is particularly abundant in a belt surrounding the redwood forest in northern coastal California and in Yuba and Butte Counties in the Sierra Nevada (Sudworth 1908). But even though abundant, it is reported to Anever@ form pure stands (Jepson and others 1911). However, extensive pure stands of tanoak, 40 to 50 years old, have developed in northwestern California after logging and fire (Thornburgh 1994). Tanoak often forms part of the overstory, but almost always in a codominant position. It is rarely found in a dominant position, except possibly when part of a ragged overstory with Douglas-fir.Because tanoak cannot withstand sudden exposure to full sunlight, leaving scattered mature tanoak trees after heavy logging is a sure way to cause blighted tops and decreased acorn production (McDonald and Tappeiner 1987). Tanoak also is abundant in the understory in intermediate and suppressed crown positions.

As a codominant forest tree, the crown of tanoak is shaped much like the tapering cone of its

principal conifer associate, Douglas-fir. It has a long, straight bole, often clear of branches for 9 to 24 m (Roy 1974); narrow crown; and slender upright branches. Leaning, forking, and crooked trees are uncommon. In stature, tanoak is best described as medium, with most trees falling into the 13- to 47-m height range.

Tanoak also has a recognized shrubby form—*L. densiflorus* var. *echinoides* (R. Br.) Abrams—and possibly another, unrecognized one. The recognized form is reported in northern California in Shasta, Siskiyou, and Trinity Counties and on the lower slopes of Mt. Shasta. In these areas, Griffin and Critchfield (1972) state that it is restricted to rocky exposed ridges intermixed with tanoak trees that reach heights of 17 m in protected spots. They also describe the shrubby form at the end of the species= southern range in the Sierra Nevada. Roy (1974) states that the northern California variety has a typical shrub form, low stature, and Asmall, thin@ leaves. The unrecognized form is found in the northern Sierra Nevada in a narrow elevational band just above that occupied by the tree form (McDonald and Litton 1987; McDonald and others 1989). Here large clumps, often flattened by heavy snow, are found with stems straggling downslope for 5 m or more (Tappeiner and others 1990). In addition, the thick, dark-green leaves of these plants are as large or larger than those of the tree form. Sudworth (1908) was doubtful about classifying this shrubby form as a variety. He stated that it was A...not to be worth of separation because it is connected with the larger tree forms by numerous intermediate ones.@

Use. The hard, strong, fine-grained wood has a long but intermittent record of use in California and Oregon (Huber and McDonald 1992). It has been used for flooring, railcar decking, paneling, veneer, plywood, gunstocks, pallets, crossties, baseball bats, pulpwood, and fuelwood (EDA 1968). In the past, tannin was extracted from the bark for tanning heavy leathers (Jepson and others 1911), hence its common names.

Flowering and fruiting. Tanoak produces flowers in the spring and irregularly during autumn. Most flowers arise from the axils of new leaves, occasionally from buds at the base of year-old leaves (Peattie 1953). April, May, and June are the months of heaviest flowering. Pistillate (female) flowers form at the base of the catkins, below the spike of the staminate (male) flowers (Hickman 1993). The pistillate flowers are 5 to 10 cm long and form crowded clusters in such profusion as to conceal the foliage. Initially, their color is white, eventually turning to yellow.

The fruit is a fairly large, heavy acorn (figures 1 and 2), maturing at the end of the second season, and numbering about 242/kg (110/lb) (Mirov and Kraebel 1937). Acorns are borne singly or in clusters of 2 to 4. They ripen in September to November, with peak fall occurring when the relative humidity is low, often when a dry north wind is blowing (McDonald 1978). Generally, the first and last acorns to fall are unsound. The minimum seed-bearing age (from root-crown sprouts) is 5 years, with abundant production occurring after age 30 to 40. On a good site in northern California, annual records showed that, during a 24-year period (1958B1981), tanoak produced 4 medium to heavy and 9 very light to light seed crops (McDonald 1992). The number of acorns per mature tree is reported to range between 3,900 and 110,000 (Tappeiner and others 1990). Soundness of just-fallen acorns varies from 49 to 79%.

Collection, extraction, and storage. Although it fairly Arains@ acorns in the fall of a bumper seed year, few remain by spring. Consumption by a host of birds, rodents, and other animals typically is heavy. In a study in several clearcuttings in southwest Oregon (Tappeiner and others 1986) and in studies in northwestern California (Thornburgh 1994), consumption after 3

annual sowings was over 99%. Many acorns are killed by insolation and freezing but, even though they are embryo-dead, they are still prime food for birds, rodents, and other animals. Acorns should be gathered during or shortly after the time of maximum seed fall, preferably from shady, covered locations. Those that fall in an exposed environment overheat and become embryo-dead in a few days, possibly even in a few hours. Freezing temperatures also kill embryos of exposed acorns (McDonald 1978).

Tanoak acorns generally are stored without the cups. Storage for any length of time can be risky. Death or germination often occur. Acorns can be stored in sacks in cool shaded places or in plastic bags containing a small amount of moist material at temperatures just above freezing. The most effective and efficient technique is to place sound acorns in wire containers buried near the planting site and covered with soil and dead leaves. Here, they stratify in tune with the local environment and produce tiny radicles in the spring. Seeding germinated acorns almost guarantees a high initial seed-to-seedling ratio.

Pregermination treatments. Stratification in moist peatmoss at temperatures just above freezing is all that is needed to give high germination values (97% and 6 days). Germination is hypogeal (figure 3).

Germination. Acorn position is a major influence on germination and subsequent seedling survival and development. Reversing polarity (placing acorns so that the pointed end is up) enhances the speed and completeness of germination, as well as seedling development. In a test in a conventional plantation (clearcutting) with 840 acorns placed point-up and 772 point-down, germination was 53% for point-up acorns and 21% for point-down acorns. Germination rate was 12 versus 41 days, respectively (McDonald 1978). Early germination, however, subjected the just-emerged (7-day-old) seedlings to late spring frost and many were frozen. It is of interest that 75% of these seedlings eventually sprouted from the root crown, but with multiple stems. Perhaps shade from the outer stems provides the inner stems with a more favorable environment and is at least part of the reason for this phenomenon.

Nursery practice. Tanoak seedlings are difficult to grow in the nursery. The emergent seedling produces a fast-growing taproot that quickly exceeds the depth of conventional containers and should not be clipped.

Seedling care. Extensive trials on a good site in northern California involved seeding sound acorns and outplanting container seedlings. In spite of the utmost care in site preparation—yearly removal of competing plants, loosened soil at each seed spot, careful seeding, use of acorns known to be viable when seeded, rodent protection, fertilization, and irrigation—seedling survival and growth were poor. Survival of 4- and 6-year-old seedlings was about 34% and mean height was 30 cm (12 in). Many plants had multiple stems from repeated dieback and sprouting (McDonald 1978). Most eventually died. The fate of container-grown seedlings that were given extensive care and artificial shading was little better. Survival after 2 growing seasons was 46%; height growth after outplanting was essentially nil (McDonald 1978). Most seedlings eventually died. The clipped taproot did not renew and the depauperate seedling root system did not extend beyond the already loosened soil. When that dried out, the seedlings died. Survival and growth of natural tanoak seedlings is best described as fair and slow, respectively. We cannot grow tanoak seedlings in conventional sunlit plantations. An environment of moderate shade and plentiful organic material seems necessary for survival and establishment of both artificial and natural

seedlings. How to achieve consistent and reliable seedling growth remains a mystery.

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Figure 1—*Lithocarpus densiflorus,* tanoak: acorns, × 1.

Figure 2—*Lithocarpus densiflorus,* tanoak: longitudinal section through an acorn, × 1.7.

Figure 3—*Lithocarpus densiflorus,* tanoak: seedling development 2 months after germination.