

Arbutus menziesii Pursh

Pacific madrone

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Other common names. madrone, arbutus, madrono.

Occurrence and growth habit. Pacific madrone *Arbutus menziesii* Pursh is 1 of 3 species of *Arbutus* native to the western United States (Little 1979). It is an evergreen tree that occurs in coastal mountains from southwestern British Columbia to southern California, and also in the Sierra Nevada of north central California. It often is found as a single tree or in groves, only rarely occupying extensive areas (McDonald and Tappeiner 1990; McDonald and others 1983). Seldom does Pacific madrone form pure stands; usually it is found in mixture with several conifer and hardwood species. It also competes successfully in both overstory and understory canopies (Sawyer and others 1977). Although some trees originate from seed, most begin life as root crown sprouts. Tree height and form vary widely: height from 8 to 38 m, and form from straight to crooked (Sudworth 1908). Stand density is a prime determinant of form and also affects tree height. In general, the more dense the stand, the better the form and the greater the height. On good sites with well-stocked stands, plentiful moisture, and some shade, the tree grows straight and tall with a narrow crown. On poorer sites with lower stocking and inadequate soil moisture, the tree becomes short and crooked, with a relatively wide crown. Clumps of trees are prevalent and increase as stands become more open. The species seems to be phototropic and trees are often observed leaning into gaps in the canopy. Asymmetric bole development is common. Over the entire range, the majority of Pacific madrone trees have some lean and some crook. Forking also is common.

Use. The strong, smooth, fine-grained wood has been utilized for many purposes, ranging from lumber, veneer, and fuelwood to furniture, flooring, interior trim, and paneling (EDA 1968; Overholser 1968). In the past, the wood of Pacific madrone was prized for making charcoal for gunpowder (Koch 1973) and was found to be without peer when made into bobbins and spools. This species was first cultivated in 1827 and has been planted occasionally as an ornamental tree in Europe and the United States (McMinn and Maino 1959).

Flowering and fruiting. Flowers, which bloom from March to June, are formed on a panicle 12 to 15 cm long. The 8-mm flowers consist of 5 sepals fused at the base with 5 fused urn-shaped petals and 10 stamens. The anthers split open when ripe, the awns are elongate, and the superior ovary is rough and bumpy with 5 chambers (Hickman 1993). The fruit is a berry, also rough and bumpy, less than 12 mm in diameter (figure 1). The generic name derives from "arboise," a Celtic word for rough fruit (Roy 1974). The thin-skinned berry has rather dry, mealy flesh and generally is 5-celled (figures 1 and 2). McDonald (1978) found that, in northern California, the

number of seeds per berry ranged from 2 to 37, with an average of 20. The berries ripen in September through November but often remain on the trees through December. Fully ripe berries are bright red or bright reddish orange (Peattie 1953). However, the smaller numbers of yellowish orange or yellowish green berries that are usually present at the same time also furnish viable seeds (McDonald 1978).

The minimum seed-bearing age (from root crown sprouts) is 4 years but more commonly at least 8 years. Older trees have tremendous capability to produce seed. On a good site in northern California, the number of berries produced during a light seed year for 3 representative trees that were 23, 36, and 41 cm in dbh ranged from 13,320 to more than 107,000/tree and related best to amount of living crown (McDonald 1978). On this same site, annual records showed that during a 24-year period (1958-1981), Pacific madrone produced 2 medium to heavy and 10 very light to light seed crops (McDonald 1992). In years when the overall seed crop is poor or nonexistent, madrone trees may be stimulated to produce heavy crops by logging and thinning. Apparently, the reduced stand density provides additional water and nutrients that become manifest in reproductive material.

A recent phenomenon that has greatly reduced seed production (Thornburgh 1994) is dieback and death of Pacific madrone trees infected by the madrone canker (*Botryosphaeria dothidea* Moug.:Fr.) Ces. & De Not. which is virulent in northern California (McDonald and Tappeiner 1990).

Collection, extraction, and storage. Berries of Pacific madrone can be collected during the ripening period, dried thoroughly, and stored at room temperature for 1 or 2 years (Mirov and Kraebel 1939). Separating the seeds from the pulp after soaking and maceration of the berries probably is best (McDonald 1978). Only dry seeds should be stored, probably in sealed containers at temperatures just above freezing (Roy 1974). Fresh berries picked in the northern Sierra Nevada numbered 1,390 to 2,490/kg (630 to 1,130/lb), and the yield of cleaned seed was 1.6 to 2.0 kg/45 kg or 3.6 to 4.4 lbs/100 lbs of fruit. The number of seeds ranged from 434,310 to 705,470/kg or 197,000 to 320,000/lb (McDonald 1978). Dried berries from an unknown source numbered 900/kg (2,000/lb) (Mirov and Kraebel 1939).

Pregermination treatments. Because the seeds exhibit strong embryo dormancy, stratification is critical. McDonald (1978) found that only 1 of 400 sound seeds germinated without stratification. For stratification, much evidence shows that storage in a plastic bag containing a small amount of moist paper or peat moss at temperatures just above freezing for 35 to 45 days is all that is needed to break dormancy (McDonald 1978; Roy 1974). With this treatment, 78 to 90% of seed will have germinated in 10 days.

Germination tests. Only sound seed should be used in germination trials. For red berries, darker color and slight rounding at the pointed end proved diagnostic for separating sound from unsound seed; for yellowish berries, only seed size was a worthwhile indicator. Larger seeds were more likely to be sound than small ones (McDonald 1978). Extensive trials in laboratory and field have shown the perils of germinating seed in berries. If berries were present, so were virulent fungi and consumers. Indeed, in a field trial, snaptraps baited with a single red madrone berry caught more white-footed deer mice (*Peromyscus maniculatus*) than those baited with peanut butter and wheatflakes.

Nursery practice. Pacific madrone can be propagated by germinating seeds in flats and

transplanting the seedlings to individual containers. Losses from damping-off fungi, however, can be huge. Hundreds of seedlings die overnight and the number available for planting often is small. Van Dersal (1938) noted that a yield of about 450 usable plants/kg of seed (1,000/lb) was the best that could be expected. Although this species has been propagated vegetatively by grafting, layering, and rooting of cuttings (Roy 1974), no operational application of these techniques is known.

Seedling care. The problem of fungi does not end after the germinants become seedlings. Even after transfer to peatpots or other containers, the seedlings need to be protected from fungi. And even after great care, survival and growth in a conventional (sunlit) plantation is poor. In a trial on a high site in the northern Sierra Nevada, survival of seedlings in large containers (plugs) on competition-free ground was 33% after 6 years (McDonald 1978). All seedlings died back at least once, developed multiple stems of poor form, and grew poorly. Natural seedlings developing in the wild also have a dismal establishment record, with first-year survival rates of 0 to 6%. Damping-off fungi, drought, predation by invertebrates, and litterfall, often interacting together, seriously limit the reproductive efforts of Pacific madrone (McDonald 1978; Pelton 1962; Tappeiner and others 1986). Based on this evidence, the best environment for establishment of both natural and planted seedlings is bare mineral soil and moderate shade (McDonald and Tappeiner 1990). However, the rate of seedling growth and its consistency in this environment is unknown.

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