

Eucalyptus globulus Labill.

Myrtaceae Myrtle family

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Bluegum eucalyptus (*Eucalyptus globulus*), also called Tasmanian bluegum, is one of the world's best known eucalyptus trees. It is the "type" species for the genus in California, Spain, Portugal, Chile, and many other locations. One of the first tree species introduced to other countries from Australia, it is now the most extensively planted eucalyptus in the world.

Habitat

Native Range

Four subspecies are recognized. The type tree, subspecies *globulus*, is largely confined to the southeast coast of Tasmania but also grows in small pockets on the west coast of Tasmania, on islands in the Bass Strait north of Tasmania, and on Cape Otway and Wilson's Promontory in southern Victoria, Australia (9). Other subspecies are found northward in Victoria and New South Wales (13).

The species was introduced into California in 1856 (1) and into Hawaii about 1865 (18) and has become naturalized in both States. It is also fairly common as an ornamental in Arizona but is not naturalized there. In California, it is now primarily used in line plantings along roads and as windbreaks, but formerly, extensive plantations were established. Plantings total about 16 000 ha (40,000 acres) (17). The planted range in California extends from Humboldt County in the north to San Diego County in the south, with best growth in the coastal fog belt in the vicinity of San Francisco. Numerous plantings are seen in the Central Valley from Redding, south through Fresno to Bakersfield, and San Bernardino. Hawaii has about 5000 ha (12,000 acres) almost all of them on the islands of Hawaii and Maui. In California and Hawaii the tree regenerates within and near the edges of plantations. In some areas of Hawaii it spreads fast enough to be considered a pest by ranchers.

Recently, the species has also been planted in its native Tasmania where it is an important pulpwood source (22).

Climate

Although bluegum eucalyptus has great climatic adaptability, the most successful introductions

Bluegum Eucalyptus

worldwide have been to locations with mild, temperate climates, or to high, cool elevations in tropical areas (8). The ideal climate is said to be that of the eastern coast of Portugal, with no severe dry season, mean annual rainfall 900 mm (35 in), and minimum temperature never below -7° C (20° F). In coastal California, the tree does well in only 530 mm (21 in) rainfall accompanied by a pronounced dry season, primarily because frequent fogs compensate for lack of rain. A similar situation is found in Chile where deep fertile soils as well as fogs mitigate the effect of low, seasonal precipitation (8). In Hawaii, bluegum eucalyptus does best in plantations at about 1200 mm (4,000 ft) where the rainfall is 1270 mm (50 in) annually and is evenly distributed or has a winter maximum. Seasonality of rainfall is not of critical importance to the species. Although it generally grows well in countries with a Mediterranean or cold season maximum rainfall, it grows well also in summer rainfall climates of Ethiopia and Argentina (8).

Soils and Topography

Bluegum eucalyptus grows well on a wide range of soils. It requires good drainage, low salinity, and a soil depth of about 0.6 m (2 ft) or more. Other limiting factors are few (8). In locations with a pronounced dry season, such as California, the tree grows best on deep alluvial soils because of the greater moisture supply.

In Hawaii, the tree grows very well on Typic and Hydric Dystrandepts, soils of the latosolic brown forest great soil group. These soils are generally 0.9 m (3 ft) deep, acid in reaction, and formed on volcanic ash. In California, the tree grows well on a much wider range of soils than in Hawaii, from the Ultisols and Alfisols developed on deeply weathered sedimentary deposits and sandstone to Inceptisols and Aridisols developed on a wide variety of parent materials.

In Portugal, almost 15 percent of the land area is planted to this species. Most stands are on soils developed from sandstone and limestone, which have been badly degraded by cultivation since ancient times. Best yields occur on the heavy texture clay-loams and clays (11).

Associated Forest Cover

In its native habitat, bluegum eucalyptus grows in pure stands and in mixture with messmate stringy-

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bark eucalyptus (*Eucalyptus obliqua*), mountain-ash eucalyptus (*E. regnans*), manna eucalyptus (*E. viminalis*), black peppermint eucalyptus (*E. amygdalina*), and white peppermint eucalyptus (*E. pulchella*). Although, for the most part, it has been planted in pure plantations in countries where it has been introduced, it has also been planted in mixture. In California, it has most commonly been mixed with forest redgum eucalyptus (*E. tereticornis*) and river redgum eucalyptus (*E. camaldulensis*) (19). In Hawaii, it has been planted in mixture with many other eucalypts.

Most of the dense bluegum eucalyptus stands in California and Hawaii are noted for being almost devoid of understory vegetation, except for a few hardy grasses. Although this condition is most likely related to the rather dry climate that provides the best site for the species, it has also been shown that the leaves of the tree produce water soluble phytotoxins that can prevent radicle growth of many herbaceous plants (7). In Hawaii, firetree (*Myrica faya*) is a species that sometimes invades bluegum eucalyptus stands. The noxious passion fruit vine (*Passiflora mollissima*) has also been found thriving in a young coppice stand.

Life History

Reproduction and Early Growth

Bluegum eucalyptus has a considerable competitive advantage as compared with most other tree species in that its juvenile foliage is seldom browsed



Figure 1—Bluegum eucalyptus, showing how it readily seeds into grasslands adjacent to planted stands. It spreads rapidly (if not controlled) because cattle do not graze the seedlings.

by cattle or sheep (fig. 1) (8). This condition not only caused it to be a popular tree for planting in open grasslands years ago, but it permits natural seedlings to survive in the presence of grazing animals alongside the planted stands. The tree reproduces by seeding into openings in planted stands and into fields adjacent to plantations.

Seed stored in the soil under older stands often germinates prolifically following logging and the resultant natural reproduction interferes with the management of the coppice stand (21).

Flowering and Fruiting—Bluegum eucalyptus in California flowers from November to April, the wet season (15). In Hawaii, some trees flower throughout the year, but flowering is heaviest in February to March. The flower buds have a warty cap or operculum about 2.5 cm (1 in) in diameter, which falls off, allowing the very numerous stamen filaments to extend in shaving-brush fashion above the cup-shaped base (hypanthium). The yellowish white flowers are pollinated by insects, hummingbirds, and other pollen and nectar feeders. As in almost all eucalyptus, pollen is usually viable before the stigma becomes receptive (8). The fruit, a distinctive top-shaped woody capsule 15 mm (0.6 in) long and 2 cm (1 in) in diameter, ripens in October to March in California, about 11 months after flowering (15). In Hawaii the fruit ripens throughout the year.

Seed Production and Dissemination—Bluegum eucalyptus seeds are relatively large for a eucalyptus. There are 18 to 320 seeds per gram (500 to 9,100/oz) of seeds and chaff, or about 460 clean seeds per gram (13,000/oz) (2,5,15). Capsules release seed immediately on ripening and the seed is dispersed by wind. Calculated dispersal distance from a 40-m (131-ft) height, with winds of 10 km/hr (6 mi/hr), was only 20 m (66 ft). Newly released seeds germinate within a few weeks if conditions are suitable. Trees usually begin to produce seeds at 4 to 5 years and yield heavy seed crops in most locations at 3- to 5-year intervals (23). Seeds can be stored for long periods in air-tight containers at 0° to 3° C (32° to 38° F).

Seedling Development—Newly germinated seedlings have inverse heart-shaped cotyledons, borne epigeously. The stems of seedlings, especially those grown in the shade, are usually square in cross section, often for as much as 3 to 5 m (10 to 16 ft) of stem length. These square stems usually have prominent ridges or "wings" at the corners. Juvenile leaves, which are opposite and broadly lanceolate, 9 by 9 cm (3.5 by 3.5 in), may persist for more than a

year (9). Trees in coppice stands 6 m (20 ft) or more in height are often entirely in the juvenile leaf form. These juvenile leaves bear a bluish gray, waxy bloom and are the reason for the common name of the tree, bluegum.

Nursery-grown seedlings in containers reach plantable size, about 30 to 40 cm (12 to 16 in) high, in 3 to 4 months. Seedlings can be established if planted with bare roots, but success is highly dependent on favorable wet weather after planting. Seedlings are, therefore, usually grown in containers and planted with a root ball. Seedlings are not frost resistant (23).

With favorable weather conditions on good sites in Hawaii, seedlings that germinate after logging and are not suppressed can be expected to be 1 m (3 ft) tall at 6 months, 2 m (6 ft) at 1 year, and 4 m (13 ft) at 2 years. Seedlings in four coppice stands in Hawaii grew poorly because they were generally suppressed by coppice shoots from stumps (21). Despite this, an average annual growth of 1.1 cm (0.4 in) in diameter at stump height and 1.4 m (4.6 ft) in height was recorded for all seedlings in stands 3, 4, 5, and 6 years old. Stocking of seedlings and coppice shoots in these stands was high, averaging more than 6,000 stems per hectare (2,400/acre). Measurements in six representative planted stands in California that were 5 years or less in age gave an average annual height growth of 2 m (6.7 ft) (19). In Victoria, Australia, unfertilized planted seedlings grew 1 m (3 ft) annually during a 4-year period, while fertilization of seedlings at three different levels nearly doubled the growth rate (6). Bluegum eucalyptus seedlings show a strong response to nitrogen and phosphorus fertilization on many soils (23).

Vegetative Reproduction—Bluegum eucalyptus coppices readily from stumps of all sizes and ages. Stumps should be cut 10 to 20 cm (4 to 8 in) high in stands managed for coppice (23). Low-cut stumps do not coppice well from the lignotuber, and coppice stems from stumps cut higher tend to break off easily in the wind. Because the buds that sprout are on the bark side of the cambium and initially weakly connected to the wood of the stump, it is essential that the bark be firmly attached to the stump if coppice stems are to survive. In four coppice stands in Hawaii, ranging in age from 2 to 6 years after logging, annual growth of stump coppice averaged 15 mm (0.6 in) in diameter at stump height and 1.8 m (5.9 ft) in height (21). This growth was considerably better than that of seedlings in the same stands referred to earlier.

Elsewhere than Hawaii, where foresters have had no experience beyond one rotation, bluegum eucalyptus

is normally carried for three coppice rotations after the first, or seedling rotation. Rotations range from 5 to 10 years in different countries and sites. Undesirable shoots are usually removed during the first 2 years of a coppice crop, but thinning is normally not done. In Portugal, coppice stands are sometimes managed by the system of "coppice with standards" so that a sawtimber crop of the straightest and best trees is retained between coppice harvests to be cut as sawtimber when of suitable size (8).

In Portugal, coppice rotations are 10 to 15 years with annual yields normally 15 to 20 m³/ha (214 to 286 ft³/acre) (11).

Sapling and Pole Stages to Maturity

Growth and Yield—Bluegum eucalyptus is considered a fast-growing tree in most countries where it is used, but a wide range of growth and yield figures are reported in the literature. We know of no data for natural stands in Australia, but some plantations in Tasmania, Victoria, and the Australian Capital Territory (A.C.T.) have done well (3). In Tasmania, a yield of subspecies *globulus* at 17 years of 35 m³/ha (500 ft³/acre) per year was reported, with the tallest trees averaging 30 m (99 ft). A plantation of ssp. *globulus* in Victoria averaged about 20 cm (8 in) in d.b.h. and 18 m (59 ft) in height at 14 years, while another (ssp. *bicostata*) at Canberra, A.C.T., at age 13 and somewhat lower stocking, averaged 21 cm (8.3 in) in d.b.h. and 15.5 m (51 ft) in height (3).

These data are well within the range of those reported for other countries (8). Annual growth in northwestern Spain averages 20 m³/ha (286 ft³/acre), but in southwestern Spain only 5 to 6 m³/ha (71 to 86 ft³/acre). In Uruguay, 25 m³/ha (375 ft³/acre) of annual growth is considered good. In Ethiopia and Portugal, at age 10 on the highest quality site, very good growth is 20 m³/ha (286 ft³/acre) per year.

In California, 67 different stands were measured in 1924 (19). The mean annual growth of all these stands ranging from 2 to 42 years in age, was 19 m³/ha (271 ft³/acre). Ten of these stands, ranging from 13 to 16 years in age and similar to the plantation in Australia, averaged 19.6 cm (7.7 in) in d.b.h., and 20.4 m (67 ft) in height, and had a mean annual growth of 21 m³/ha (300 ft³/acre). The tallest stand averaged 38.7 m (127 ft) at 23 years. The tallest stand in California is one planted in 1877 on the University of California campus at Berkeley; it contains trees that have been more than 61 m (200 ft) tall since 1956 (fig. 2) (1).

In Hawaii, 20 stands ranging in age from 2.5 to 35 years were evaluated in 1911 (18). Four of the stands were in the age range 11 to 20, somewhat similar to

the plantations in Australia. In these four, the average d.b.h. was 29.2 cm (11.5 in), and average height was 23 m (76 ft). The tallest stand averaged 30.5 m (100 ft) at 14 years. Seven stands ranging in age from 5 to 20 years had an average annual yield of 20 m³/ha (286 ft³/acre). The tallest bluegum eucalyptus trees in Hawaii were at Kukaiiau Ranch, on the Island of Hawaii, and were about 61 m (200 ft) tall until logged at age 70.

Rooting Habit-Bluegum eucalyptus generally does not form a taproot. It produces roots throughout the soil profile, rooting several feet deep on soils that permit it, or shallowly otherwise. On shallow soils, subsoiling to permit greater depth of rooting has markedly improved growth (8). On most trees all the roots are below the lignotuber, but occasionally, adventitious roots result from layering of the stem above the lignotuber. The tree is windfirm by the time it reaches sapling size, but because the root system develops slowly, it can be windthrown when a seedling.

Reaction to Competition-Bluegum eucalyptus is generally classed as intolerant of shade and planted stands quickly develop crown differentiation as soon as the crowns close. On sites for which it is best suited, other species cannot compete with it. In Australia, it frequently grows in mixed stands because of microsite variation that favors the competing species that have evolved in the area (23).

Although leaves of the species produce water-soluble toxins that may help prevent competition by larger trees (7), one or two maintenance cleanings are usually required shortly after planting to free seedlings from being overtopped by grasses. In Hawaii, sprouts from buried lignotubers often grow as much as 30 cm (12 in) horizontally through litter and grass before emerging to light.

Damaging Agents-Although bluegum eucalyptus is seldom browsed by cattle or sheep, seedlings are often severely girdled by rodents. This condition can be prevented by cultivating around the young trees to remove the protective cover the rodents require (19). Although grazing animals do not eat the trees, they do trample them and should be excluded from young plantations.

In California, bluegum eucalyptus stands are highly susceptible to fire during the dry season. The bark, which hangs in strips from the stems, readily carries fire into the crowns, and the leaves contain volatile oils that produce a hot fire. Trees are rarely killed by fire, however, as they sprout vigorously from the stems and bases (8). In the moister climate of Hawaii, fire has not been a problem in bluegum eucalyptus stands.

Seedlings are intolerant of frost and temperatures of -5° to -10° C (23° to 14° F) usually kill them. Frost resistance increases with maturity, juvenile foliage being less resistant than mature foliage (4). In 1972 a severe frost in the hills of Berkeley, CA, completely defoliated most of the mature bluegum eucalyptus. The trees were considered dead by several authorities and a salvage logging program was started to remove the fire hazard. A few months later, most of the "dead" trees sprouted from the stems and bases and began to grow again. This sprouting was judged undesirable and several experiments were undertaken aimed at preventing it. The most successful treatment found was to flood axe frills made at the tree bases with a 0.36 kg/l (3 lb/gal) solution of glyphosphate in water (10). This permanently killed the trees.

The tree is susceptible to drought, particularly on shallow soils. On such soils, subsoiling has been used effectively to permit deeper rooting and to overcome drought susceptibility.

Several insects attack bluegum eucalyptus, although none has been a serious problem in California.



Figure 2—Bluegum eucalyptus stand, planted in 1877 on the campus of the University of California, Berkeley.

or Hawaii. One that is common in many parts of the world is the wood borer, *Phoracantha semipunctata*, which has caused severe damage in South Africa and Western Australia. A scale insect, *Eriococcus coriaceus*, has caused high mortality in New Zealand. Several defoliating insects in the genera *Gonipterus*, *Chrysophtharta*, and *Mnesampela*, attack the species.

Fungi have generally not been a severe problem with bluegum eucalyptus. Damping off in nurseries caused by *Botrytis cinerea* has been a problem but is easily controlled. *Pythium* and *Rhizoctonia* spp. have also caused damping-off in containers and flats, particularly when old seed was used (16). *Fusarium* spp. have destroyed quantities of stored seed in Spain. Attack by *Diplodia* and *Armillaria* has been reported from several countries, but neither disease is considered serious (8,23).

Special Uses

Bluegum eucalyptus is one of the world's most valuable windbreak trees because of its windfirmness and the unpalatable nature of its seedlings to grazing animals (8,18,19). Because of its ability to sprout along the stem, it can be hedged, thereby making effective sight and sound barriers along highways. The horticultural variety *compacta* is a dwarf form widely used along California freeways. Bluegum eucalyptus windbreaks are most effective with an understory or adjacent planting of smaller trees and shrubs (20).

The species is a major source of fuelwood in many countries of the world primarily because of its ability to coppice after cutting. The wood burns freely, leaves little ash, and produces good charcoal (8). The tree shows promise for use as industrial fuelwood in place of oil. Closely spaced and fertilized plantings in Victoria, Australia, produced mean annual increments of 9 to 14 metric tons per hectare (4 to 6 tons/acre) dry weight of stem wood during a 4-year period (3). In Hawaii, untended 3- to 6-year-old coppice stands average stem wood dry weights of 5 to 7 t/ha (2 to 3 tons/acre) per year. One stand, during its fifth year of growth, produced 14 t/ha (6 tons/acre). Another, during its second year, produced 8 t/ha (3.6 ton/acre) (20).

Bluegum eucalyptus is much used for pulpwood, particularly so because its bark, acceptable in most pulping processes, adds greatly to the yield. It is used mostly for bleached products made by sulfate, sulfite, or bisulfite processes (8).

Other uses include the extraction of essential oils from the leaves, honey production from the flowers (that are also good pollen sources), plantings for erosion control, and roadside plantings to provide a noise and headlight buffer (8).

Because the wood is heavy and shrinks greatly in drying, it is unsuitable for lumber. Sawing of logs is difficult and the quality of lumber is poor because of growth stress problems. Main uses of bluegum eucalyptus are for mining timber, fence posts, and poles (23). In South America, the straight, uniform poles are used extensively in construction (17). Lumber and veneer are produced on a fairly large scale in Portugal and Spain where the wood is used for cooperage, furniture, and flooring (8). A small amount of lumber used to be produced in Hawaii.

Genetics

Population Differences

Several previously described species, southern bluegum (*E. bicostata* Maiden et al.), Maiden's gum (*E. maidenii* F. Muell.), and *E. pseudoglobulus* Naudin ex Maiden, have been reduced to subspecies of bluegum eucalyptus (*E. globulus* ssp. *globulus*) (12). Steep clines are found in many fruit and vegetative characteristics across the subspecies boundaries, and more gradual changes appear within the ranges of the four subspecies in Australia. The ssp. *pseudoglobulus* is central, grading on different borders into each of the other three subspecies. The most frost-hardy seedlings originate from populations above 450 m (1,475 ft) elevation in the ranges of ssp. *bicostata* and ssp. *maidenii*, but these tend to be the oldest growing (13). Tasmanian bluegum eucalyptus, ssp. *globulus*, originating near sea level in the southern part of the species range, is the most rapidly growing. Within taxa, drought tolerance of seedlings is associated with populations native to the driest sites. Variation in glaucous bloom of the leaves is correlated with elevation and the "bluer" forms are more frost hardy and more drought tolerant than the "greener" forms. Variations are known, such as California bluegum eucalyptus var. *compacta* (Hort.), a cultivar propagated in the nursery trade for its compact habit and widely used along California highways (2,20).

Hybrids

Natural or controlled hybrids of bluegum eucalyptus with *E. blakelyi*, *E. botryoides*, *E. cinerea*, *E. cypellocarpa*, *E. ovata*, *E. rudis*, *E. tereticornis*, *E. urnigera*, and *E. viminalis* are known (8,14,18).

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