

Eucalyptus saligna Sm.

Saligna Eucalyptus

Myrtaceae -- Myrtle family

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Saligna eucalyptus (*Eucalyptus saligna*), also called Sydney bluegum, is a fast growing tree, valuable in plantation forestry. It grows in several warm temperate to subtropical countries, such as Brazil and the Republic of South Africa, and the state of Hawaii.

The name *Eucalyptus saligna* was given to type specimens in 1797. Another very similar but distinct species, found within the same geographic range, *Eucalyptus grandis*, was not named until 1918 (12). Before 1918, many introductions were made worldwide of seed collected from "*E. saligna*" that bore the characteristics of the type later to be called *E. grandis*. In most countries where introductions were made, therefore, considerable mixed planting and hybridization of the two species are present. Thus, in Hawaii, most saligna eucalyptus stands contain trees with a range of characteristics intermediate between those of *E. saligna* and *E. grandis*. *Eucalyptus grandis* is now preferred in South Africa because it self-prunes more readily and has smaller branches (28); and in Brazil because it is resistant to a canker disease and can be propagated vegetatively (6). *Eucalyptus saligna* has grown well where the climate is cooler; for example, in northern New Zealand (12) and in the uplands of Hawaii. Recent provenance tests of the two species in Hawaii suggest that *E. grandis* would be a better choice than *E. saligna* for most sites (26).

Habitat

Native Range

Saligna eucalyptus is native to the east coast of Australia from Bateman's Bay (lat. 36° S.) in southern New South Wales to the southeastern corner of Queensland (lat. 27° S.) (13). In the United States, it has been introduced into Florida, California, and Hawaii. In Hawaii it reproduces at the edges of planted stands. Although it was introduced into Hawaii in the late 1800's, the tree was not planted extensively until the 1960's, when it became the principal tree used for forestation.

Climate

In Australia, the tree grows from sea level to 300 m (1,000 ft) in the South and to 1220 m (4,000 ft) in the North. The climate within this range is warm-temperate to subtropical, with winter frosts to -15° C (5° F) at the higher elevations (12). In New Zealand, seedlings were frost tolerant to a minimum temperature of -7° C (21° F)

(21). Rainfall is evenly distributed, or has a summer maximum, and ranges from 890 to 1270 mm (35 to 50 in) annually (13).

In Hawaii, saligna eucalyptus grows well between elevations of about 150 m (500 ft) and 1100 m (3,600 ft) where the temperature is never below 4° C (40° F). One stand is at 1980 m (6,500 ft) where light winter frosts occasionally occur, and the average daytime temperature is about 16° C (60° F). Most of the saligna eucalyptus stands have been planted between 300 and 610 m (1,000 and 2,000 ft) elevation in locations with evenly distributed or winter maximum rainfall of 1520 to 7620 mm (60 to 300 in) annually. The tree achieves its best growth on sites with about 2540 mm (100 in) annual rainfall, rather than on wetter sites, possibly because sunlight is greatly reduced by the cloud cover on wetter sites.

Soils and Topography

In the northern part of its range in Australia, saligna eucalyptus extends to the slopes and ridges. In northern New South Wales and Queensland, it is usually on the slopes, while the closely related rosegum eucalyptus (*Eucalyptus grandis*) is usually near or at the valley bottoms. Saligna eucalyptus does best on clay loams derived from shales and requires good drainage (13).

In Hawaii, saligna eucalyptus has been planted extensively on Histosols and Inceptisols on the island of Hawaii, and also on the Oxisols and Ultisols of Maui, Molokai, Oahu, and Kauai. These soils have in common moderate to strong acidity, low to very low available nitrogen and phosphorus, and rapid to very rapid drainage. All are formed on basaltic parent material, either volcanic ash or rock. In other respects they differ considerably, but all are unsuited or only marginally suited for agriculture. Slopes are usually 10 to 20 percent.

Associated Forest Cover

In Australia, saligna eucalyptus is usually found in mixture with tallowwood eucalyptus (*Eucalyptus microcorys*) and blackbutt eucalyptus (*E. pilularis*), the main coastal species of New South Wales, and is also found associated with several other eucalypts. It seldom grows in pure stands, whereas the closely related rosegum eucalyptus is typically found in pure stands (13). The common names used follow those of Bryan and Walker (2).

In Hawaii, saligna eucalyptus has been planted in mixture with three species of eucalyptus-tallowwood, robusta (*Eucalyptus robusta*), and rosegum-with melaleuca (*Melaleuca quinquenervia*), Formosa koa (*Acacia confusa*), horsetail casuarina (*Casuarina equisetifolia*), silk-oak (*Grevillea robusta*), and a host of other species. On most sites, it has outgrown and shaded out or badly suppressed all of these species except the equally fast growing rosegum eucalyptus and the tolerant Formosa koa. In closed stands, about the only understory species found are strawberry guava (*Psidium cattleianum*) and occasional treefern (*Cibotium spp.*).

Life History

Reproduction and Early Growth

Saligna eucalyptus grown in Hawaii regenerates naturally on bare soil immediately after logging, or on cultivated land adjacent to planted stands. It rarely becomes established in undisturbed grass or brush cover and never in its own shade. Coppicing of stumps is variable. Usually about half to two-thirds of the stumps will sprout (26). Age, weather, and (probably) heredity influence coppicing. The tree also usually produces a mass of special bud tissue at the groundline known as a lignotuber. The lignotuber will sprout if the stem is killed back by fire or other injury.

Flowering and Fruiting- *Saligna eucalyptus* trees begin to flower at 3 to 4 years of age. Flowering in Hawaii is most prolific during January to March but occurs to some extent year round. In Australia, the tree also flowers from January to March; in California, from April to June. Flowers that consist of numerous stamen filaments surrounding a single shorter pistil occur in umbels of 4 to 9 flowers. Before opening, the flower buds are about 10 mm (0.4 in) long and 5 mm (0.2 in) in diameter with a short stalk (pedicel), and a blunt, rather pointed cap (operculum) enclosing the stamens. Flowers are perfect. The opened flowers are yellowish white and are insect pollinated. Pollen is generally shed before the style becomes receptive, so selfing is rare.

The fruit is a dark-brown, bell-shaped capsule 0.8 cm (0.3 in) long and 0.5 cm (0.2 in) in diameter. It is short stalked and has four pointed, rim level, or slightly exerted valves. The capsule ripens about 6 months after flowering but opens to release seed 1 or 2 months after ripening (12,13,20).

Seed Production and Dissemination- Seeds are black, irregularly shaped, and about 1.3 mm (0.05 in) in diameter. They are released along with a large amount of reddish-brown chaff when the capsule valves open. There are 460 viable seeds per gram (13,000/oz) of seed plus chaff (20).

Seeds are naturally dispersed by wind. They can be collected from ripe capsules dried to open after picking. Some unopened ripe capsules are always present on trees in Hawaii but are most common in August and September. Fresh seeds germinate readily in 10 to 20 days without pregermination treatment. Seeds can be stored in airtight containers for several years at 0° to 5° C (32° to 41° F) (20).

Seedling Development- The seedling has obcordate (inverse heart-shaped) cotyledons that are home epigeously as in all eucalypts. Juvenile leaves are opposite for 3 or 4 pairs, then become alternate, short stalked and lanceolate, and 2.5 by 5.0 cm (1 by 2 in) in size. The adult leaves are alternate, stalked and lanceolate, tapering to a long point, 2.3 by 15 cm (1 by 6 in) in size (13).

In Hawaii, nursery-grown seedlings in containers reach plantable size in 4 to 5 months. Although seedlings are hardy and will survive bare or open-rooted planting, planting of container-grown stock provides more assurance of success if the weather is dry just after planting. Under adverse conditions newly planted seedlings often desiccate and suffer leaf-drop, but such plants usually sprout from the lower stem and recover. When this dieback slows growth, additional weeding or maintenance usually is required to clear competition (32).

Around the world, seeds usually are germinated in flats containing light-textured medium, and seedlings are transplanted into other containers after 6 to 8 weeks when a third pair of leaves begins to appear (12). Seeds also are sown directly into beds or tubes, but thinning of seedlings is usually required with this method because the small seeds are difficult to handle individually. Thinning requirements can be overcome by using pelletized seed and seeding devices (15,31).

In Hawaii, *saligna eucalyptus* seedlings have been grown extensively in open beds. Because of their rapid growth, these seedlings usually are root pruned at 15-cm (6-in) depth at 6 months and top pruned at 8 months to a 30-cm (12-in) height. Bare root stock frequently has not survived well after field planting, and Hawaii's practice has now changed to growing seedlings only in polyethylene tubes (30).

On favorable sites in Hawaii, planted seedlings grow to about 3 m (10 ft) in height in 1 year, and 3 to 5 m (10 to 16 ft) per year for the next 10 years. After clear cutting of a 44-year-old *saligna eucalyptus* plantation, natural seedlings that became established grew to saplings that averaged 9 cm (3.5 in) in d.b.h., and 11 m (36 ft) in height, 22 months after logging. Several of these saplings were 18 m (59 ft) tall.

Vegetative Reproduction- *Saligna eucalyptus* can sprout prolifically from dormant buds located in the cambium throughout the stem. After a tree is cut, shoots sprout from many points on the remaining bark surface. Those highest on the stump suppress those lower down and, if not broken off by wind or by weak attachment, become coppice stems that overgrow the stump (12).

Sprouts will also grow from the lignotuber, a mass of bud tissue at or just below the groundline. Lignotubers are found on *saligna eucalyptus* from all but its northernmost provenances, but not on *rosegum eucalyptus* (12). In managing *saligna eucalyptus* for coppice, it is desirable to cut stumps 12 cm (5 in) or less in height, so that the sprouts will develop from near the lignotuber. Such sprouts generally are more firmly attached but are frequently suppressed by sprouts arising from higher on the stump. Lignotubers persist when stems are killed by shading, thinning, or fire and often sprout vigorously after a mature stand is cut (8).

Rooting of cuttings of *saligna eucalyptus* had been difficult (16) until a method was developed at the Aracruz Co. in Brazil (7). The method consists of collecting coppice sprouts that are just beginning to harden and keeping them constantly moist while 2-leaf-pair cuttings are prepared and end-dipped in rooting hormone. The cuttings are placed under intermittent mist in individual containers. In Hawaii, *saligna eucalyptus* has been easier to root than *E. grandis*, although most success elsewhere has been with *E. grandis* (3,7). However, just as was found for *E. grandis* in Brazil (6), cutting rootability is variable among coppice from individual *saligna eucalyptus* trees.

Tissue culture propagation has also been successful in Hawaii. The techniques used with *saligna eucalyptus* are essentially those reported by Boulay (1) for other *eucalyptus* species. Terminal and lateral shoot tips of greenhouse-grown rooted cuttings are multiplied, separated, and rooted in sterile culture, and afterwards grown to normal size in a mist chamber. A number of propagules of *saligna eucalyptus* produced by tissue culture are now being compared in clonal progeny tests.

Grafting success has been reported for *saligna eucalyptus* (24,27). Cleft, side, splice, and bottle grafting were all used successfully, but the tests were not observed for a long enough period to determine the extent of long-term incompatibility, a problem with many species of *Eucalyptus*.

Sapling and Pole Stages to Maturity

Growth and Yield- *Saligna eucalyptus* is a fast growing tree, well suited for producing high yields of wood fiber on short rotations. Measurements of a plantation spacing study on a good site at Kaumahina, Maui (29) provide an example. Four spacings were tested: 2.4 by 2.4 m, 3.0 by 3.0 m, 3.7 by 3.7 m, and 4.3 by 4.3 m (8, 10, 12, and 14 ft). At 2 years, trees averaged 9.6 cm (3.8 in) in d.b.h. and 10.7 m (35 ft) in height. At 5 years, they had grown to 20.8 cm (8.2 in) in d.b.h. and 22.9 m (75 ft). Mean annual volume increment had already peaked at the two closer spacings in the study and was rapidly leveling out at the wider spacings. At 15 years, the trees in this study averaged 26.7 cm (10.5 in) in d.b.h. and 39 m (129 ft) tall. The largest tree was 61 cm (24 in) in d.b.h. and 49 m (161 ft) tall. At 5 years, the trees at 2.4 by 2.4 m (8 by 8 ft) had produced 294 m³/ha (4,200 ft³/acre), or 58.8 m³/ha (840 ft³/acre) per year. At 15 years, these trees yielded 683 m³/ha (9,759 ft³/acre), or 45.6 m³/ha (651 ft³/acre) per year. Trees at 4.3 by 4.3 m (14 by 14 ft) yielded 33.1 m³/ha (473 ft³/acre) per year.

These figures are comparable to those of *Eucalyptus grandis*/*E. saligna* grown in other countries. In Kenya, a mean annual increment over 5-year periods of 21 m³/ha (300 ft³/acre) for the seedling crop followed by 32 m³/ha (457 ft³/acre) for the first coppice crop was obtained (11). Other mean annual increment figures cited for *E. grandis* are 14 to 45 m³/ha (200 to 643 ft³/acre) in Uganda, 28 m³/ha (400 ft³/acre) in Zambia, 50 m³/ha (715 ft³/acre) at 14 years in Argentina, and 22 m³/ha (314 ft³/acre) in New South Wales, the native habitat of both species (12).

In two 4-year-old stands in Hawaii, annual increment averaged 13 and 36 m³/ha (185 and 515 ft³/acre). The faster growing stand yielded wood with a specific gravity of 0.41 for an estimated annual dry-weight yield of stem wood of 15 tonnes/ha (6.7 tons/acre).

The tallest tree in Hawaii, thought to be the tallest hardwood in the United States, is a *saligna eucalyptus*. When last measured in 1979, the tree was about 50 years old, 137 cm (54 in) in d.b.h. and 82.3 m (270 ft) tall.

Rooting Habit- *Saligna eucalyptus* develops roots throughout the soil profile so that it is quite windfirm on deep soils, but easily windthrown on shallow soils. It does not produce a taproot. Roots are primarily from the stem below the lignotuber, although layering sometimes occurs a short distance from the lignotuber on buried stems. In plantations in Hawaii that are not subject to periodic short drought, about two-thirds of the root system is confined to the upper 61 cm (24 in) of soil where most of the available nutrients are found. In plantations subject to occasional drying of the surface soil, the shallow roots are killed and a deeper root system develops.

Reaction to Competition- Because the tree is such a fast starter, planted seedlings can frequently grow faster than surrounding grass and herbaceous vegetation and

shade it out. This is particularly true if the seedlings have an intact root system when planted, as in modern tube container planting, so that little or no "shock" occurs to delay new growth after planting. At the upper elevational boundaries of sugarcane fields, *saligna eucalyptus* grown from seed in the soil at the time of cane harvest actually outgrew the sugarcane ratoon crop.

In Hawaii, original plantings are made on completely cleared land. Pre-emergent herbicides, though effective, have rarely been used. If pre-emergents are not used, one cleaning around trees that require it is made after 3 months and, depending on the site, a second cleaning may sometimes be made at 6 months. Further weeding is seldom necessary. Coppice growth of *saligna eucalyptus* is so rapid that competing plants are rarely a problem after cutting.

Tests in Hawaii show that the leguminous tree *Albizia falcataria* outgrows *saligna eucalyptus* on some sites when planted row on row with both species equally fertilized. It is one of the few woody plants known that can grow this fast on sites that are suited for *saligna eucalyptus*. The trials of mixing the legume with *E. saligna* produced increased yields of the eucalypt on some wet sites, but reduced yields on other, drier sites (10).

In South Africa, thinning schedules have been developed for trees planted at 1330/ha (538/acre) that call for thinning 25 percent of the stems present at 6 years when the stems removed are 13 cm (5 in) in diameter, and 25 percent again at 10 years when they are 20 cm (8 in) (12). These thinnings are continued at 3- to 5-year intervals until a sawtimber harvest is made at age 30. In the interim, all stumps are allowed to coppice to keep the site free of competition and to supply fuelwood crops.

Saligna eucalyptus is classed as very intolerant of shade and the slower growing trees in a stand quickly become suppressed. In Hawaii, crown closure is usually complete and crown differentiation begins in 3 years in stands planted at 3 by 3 in (10 by 10 ft). In coppice stands where numerous stems grow from every stump, crown differentiation begins as soon as sprouts appear. Many studies have shown that the maximum yield of wood is obtained by not thinning coppice at all (12). However, if larger diameter and straighter stems are desired, thinning to one to three stems per stump is desirable.

Damaging Agents- *Saligna eucalyptus* grown in plantations in many parts of the world is susceptible to the eucalyptus canker disease, *Cryphonectria cubensis*. The disease kills young trees, deforms stems, and causes basal cankers that reduce the coppicing ability of stumps (19). Rosegum eucalyptus is somewhat resistant and *Eucalyptus urophylla*, perhaps, is immune to the disease, so these species are now being used in place of *E. saligna* in many Brazilian plantings. In Hawaii, the disease is present only on the island of Kauai. It attacks *E. grandis* in Florida but is not causing serious damage (18).

In Western Australia, two other canker diseases, *Botryosphaeria ribis* and *Endothia havaensis*, were determined to be pathogenic on *E. saligna* planted there, while another, *Cytospora eucalypticola*, was present but less damaging (14).

Phoracantha semipunctata, a wood-boring insect, degrades wood and reduces growth of eucalyptus in many places, including Hawaii, but is only a serious problem in trees that are stressed by severe drought. In Australia, saligna eucalyptus is subject to damage by *Spondylia* psyllids, which predispose the trees to attack by the wood-boring beetle *Xyleborus truncatus* (22).

In Hawaii, wind damage is a severe problem. In January 1980, a severe windstorm caused severe blowdown in 75 percent of the saligna eucalyptus stands planted during the 1960's (17).

Special Uses

In Hawaii, saligna eucalyptus has been used to some extent for sawtimber, but only with considerable difficulty and expense. Most of the milling and lumber quality problems are those associated with growth stress-severe end-splitting of logs, spring of cants during sawing, compression failures, and brashness of the wood near the pith (25). Because of this, the tree is now planted primarily for early harvest as pulpwood, or, if it proves economic in the near future, as industrial fuelwood to replace oil.

Elsewhere in the world, particularly in South Africa and Brazil, the trees and their close relative, *E. grandis*, are grown extensively for pulp, poles, and fuel.

Genetics

Population Differences

In an attempt to solve the problem of confused and probably mixed introductions of *Eucalyptus saligna* and *E. grandis*, differences between them have been noted for mature trees in South Africa (12), as follows:

<i>E. saligna</i>	<i>E. grandis</i>
Bark: smooth type bluish; rough type on lower stem	Bark: smooth type white; rough type often extends up stem
Flowering (South Africa): January to April	Flowering (South Africa): July to December
Valves of fruit: 3 or 4 pointed, straight or spreading	Valves of fruit: 4 to 6 blunt, incurved
Root crown: Lignotuberous	Root crown: Not lignotuberous
Branches: Persistent under shade	Not persistent under shade

These characteristics vary among provenances of each species. The northernmost provenances of *saligna eucalyptus*, for example, do not have lignotubers (12). When grown in some locations, for example, Hawaii, flowering seasons overlap and trees probably hybridize extensively. Among 6-year-old trees of provenances collected in Australia growing side-by-side at two locations in Hawaii, no consistent differences were observed between *E. saligna* and *E. grandis* in leaves, bark, or branching habit (26).

Saligna eucalyptus produces denser wood than *E. grandis*, but in Hawaii (26), and also in the Republic of South Africa (9) where yields of the two species growing on the same sites have been compared, the best performing *E. grandis* provenances for a particular site produce a higher total weight yield than *E. saligna*, despite the wood density difference.

Hybrids

Because of the wide international interest and the problems of hybridization and identification of the two species, a comparison of *E. saligna* and *E. grandis* populations representative of the entire range of each species was made in Australia (4). Distinct differences were found in seedling and mature-tree morphology and allozyme frequencies between core populations of the two, but intermediate types were found in some remote locations. Core mature *saligna eucalyptus* had smaller seed, upright valves (4 per fruit), and non-glaucous fruit and branchlets as compared with *E. grandis*, which had larger seed, incurved valves in 5's, glaucous fruit and branchlets. *Saligna eucalyptus* seedlings had lignotubers and were glaucous; not so, *E. grandis*. *Saligna eucalyptus* seedlings also had smaller cotyledons and narrower, longer leaves. The allozyme patterns found for native populations in Australia showed species differences and were later compared to patterns found for populations collected in the Republic of South Africa, which were thought to be hybridized (5). All the South African trees sampled fell within the allozyme patterns found in Australia for *E. grandis*, even though several were morphologically suspect.

In addition to the *Eucalyptus grandis/E. saligna* complex, *E. saligna* crosses with *E. robusta*, bangalay eucalyptus (*E. botryoides*), and probably with forest redgum eucalyptus (*E. tereticornis*) (12,28). In the southern part of its natural range, a region of introgression of *E. saligna* with *E. botryoides* exists (23).

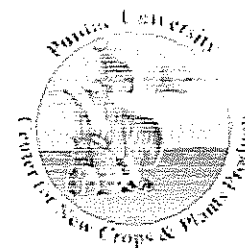
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Eucalyptus camaldulensis Schlecht.



Myrtaceae
Redgum eucalyptus

Source: James A. Duke. 1983. Handbook of Energy Crops. unpublished.

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Uses

Important timber, firewood, shelter belt, and honey tree. In the Sudan, it is planted to protect crops from blowing sands. The wood, durable, easy to saw, yet resistant to termites, is widely used in Australia for strong durable construction, interior finish, flooring, cabinetry, furniture, fenceposts, cross-ties, sometimes pulpwood. Australian aborigines made canoes from the bark. Survivalists in Australia and elsewhere might learn how the aborigines obtained water from the superficial roots, usually those ca 3 cm in diameter. The roots were excavated or lifted to the soil surface. Then the root was cut into segments ca 45 cm long, debarked, held vertically, and blown into, the water then draining into the receptacle provided.

Folk Medicine

Reported to be anesthetic, antiseptic, astringent, the redgum eucalyptus is a folk remedy for colds, colic, coughs, diarrhea, dysentery, hemorrhage, laryngalgia,

laryngitis, pharyngitis, sore throat, spasm, trachalgia, and wounds (Duke and Wain, 1981).

Chemistry

Leaves contain 0.1–0.4% essential oil, 77% of which is cineol. There is some cuminal, phellandrene, aromadendren (or aromadendral), and some valerylaldehyde, geraniol, cymene, and phellandral (C.S.I.R., 1948–1976). Leaves contain 5–11% tannin. The kino contains 45% kinotannic acid as well as kino red, a glucoside, catechol, and pyrocatechol. Leaves and fruits test positive for flavonoids and sterols. The bark contains 2.5–16% tannin, the wood 2–14%, and the kino 46.2–76.7% (Watt and Breyer-Brandwijk, 1962).

Description

Large evergreen tree 24–40(-50) m high with stout trunk often short and crooked, to 2 m in diameter; crown open, widely spreading, irregular. Bark smoothish, white, gray, or buff. Twigs reddish, long, slender, angled, drooping. Trunk can form air roots. Root system deep and spreading. Leaves alternate, drooping, narrowly lanceolate, 8–22 cm long, 1–2 cm wide, often curved or sickle-shaped, tapering to long point, short-pointed at base, entire glabrous, dull pale green on both surfaces or occasionally grayish. Umbels single at leaf base, ca 2.5 cm long on slender stalk 6–19 mm long. Flowers 5–10, each on slender stalk 5–12 mm long from ovoid buds 6–10 mm long, 4–5 mm wide. Stamens many, threadlike, white, 5–6 mm long; anthers with small round gland. Pistil with inferior, long-pointed, 3–4-celled ovary and long, stout style. Capsules several, clustered, hemiglobose or ovoid, 7–8 mm long, 5–6 mm wide, light brown, with wide raised disk and 3–4 prominent triangular teeth almost 2 mm long. Seeds many, tiny, 1.5 mm long, light brown (Little, 1983).

Germplasm

Reported from the Australian Center of Diversity, redgum eucalyptus, or cvs thereof, is reported to tolerate alkali, drought, fire, light frost, heat, high pH, poor soil, salt, savanna, and waterlogging. It is rather intolerant of weeds. The NAS catalogs four outstanding provenances, 'Katherine' and 'Petford' for tropical climates, 'Lake Albacutya' for Mediterranean climates, and 'Broken Hill' for arid climates. Some Provenances can tolerate -5°C and up to 20 frosts per year. ($2n = 22$)

Distribution

This is said to be the most widely distributed eucalypt, ranging over 23° lat. in most of arid and semiarid Australia but not the humid eastern and southwestern coasts. It is regarded as one of the most widely planted eucalypts in the world (ca 500,000 ha planted) (NAS, 1980a). Plantations occur in Argentina, Arizona, California, Egypt, Kenya, Morocco, Nigeria, Pakistan, Senegal, Sierra Leone, Spain, Sri Lanka, Sudan, Tanzania, Upper Volta, Uruguay, and Zimbabwe.

Ecology

Ranges from tropical through subtropical and warm temperate, and from arid to semiarid. Tolerates temperatures from 3° to 5°C in winter with 0–50 frosts according to locality. Annual rainfall from minimum of about 250–625 mm to as high as 1000–1250 mm (Little, 1983). In Duke's ecogeographic data base, redgum eucalyptus is estimated to range from Tropical Thorn Forest to Dry through Warm Temperate Desert to Dry Forest Life Zones, and is reported to tolerate annual precipitation of 10.3 to 20.6 dm (mean of 9 cases = 15.9) and annual temperature of 18.0 to 26.6°C (mean of 9 cases = 24.7). It is reported in areas with only 2 dm rainfall, but the lower limit for commercial plantations is 4 dm. Some provenances tolerate many different soil conditions, high calcium, high salt, periodic waterlogging. Occasionally pure stands may develop naturally along flood plains and stream banks. The mean maximum temperature of the warmest month where it grows well is ca 29°C. The dry season lasts 4–8 mos or more and may be severe. Frosts are rare (5–20 days/yr) (Mariani et al., 1981).

Cultivation

Seeds, long lived when sealed in dry cold storage, are usually started in nursery containers, then transplanted to the field (as close as 2 x 2 m for firewood). Extensive weeding may be mandatory. During the seedling stage, this species develops gall-like structures, at least in the Philippines, which offer resistance to drought and fire (Agpaoa, 1980).

Harvesting

Some provenances coppice well for six or more rotations, on good sites, plantations are managed on coppice rotations of 7–10 years.

Yields and Economics

According to NAS (1980a), annual wood yields of 20–25 m³/ha in Argentina, 30 m³ from Israel, 17–20 from Turkey in the first rotation, and 25–30 in subsequent coppice rotations. On poor arid sites, yields are only 2–11 m³ (ca 1–5 cords) on 14 or 15 year rotations. Litterfall ran about 3.6–5.8 MT/ha/yr in an Australian redgum swamp (Briggs and Maher, 1983).

Energy

According to the phytomass files (Duke, 1981b), standing biomass in an Israeli plantation is ca 110 MT/ha. At Calistoga, California, this was calculated to yield 4.3 m³/ha/yr or 2 cords and total energy yields of 15,000,000 kcal/ha/yr (Standiford and Donaldson, 1982). "As firewood, the timber from *Eucalyptus camaldulensis* has few equals. It is also a good charcoal wood, and the steel industry in Argentina, for example, relies on its charcoal for steel-making. The fuel value of the wood (sp. grav.

0.6) is 4,800 kcal/kg. In World War II, Australians used the charcoal for their producer gas plants." (C.S.I.R., 1948–1976).

Biotic Factors

According to Browne (1968), the following affect *Eucalyptus camaldulensis*: (Bacteria) *Agrobacterium tumefaciens*. (Fungi) *Cercospora eucalypti*, *Corticium salmonicolor*, *Fomes setulosus*, *Gymnopilus junonius*, *Hypholoma fasciculare*, *Inonotus chondromyelus*, *Polyporus portentosus*, *Sclerotinia fuckeliana*. (Angiospermae) *Tapinanthus* sp. (Coleoptera) *Alcidodes biangulatus*, *A. haemopterus*, *Anaemerus tomentosus*, *Apate monachus*, *Chrysolagria neavei*, *Dicasticus affinis*, *Gonipterus scutellatus*, *Opseotrophus sufflatus*, *Phoracantha recurve*, *P. semipunctata*, *Siderodactylus sagittarius*, *Sinoxylon transvaalense*, *Systates pollinosus*, *Xyleborus truncatus*. (Hemiptera) *Agonoscelis pubescens*, *Atelocera stictica*. (Hymenoptera) *Perga affinis*, *Phylacteophaga eucalypti*. (Isoptera) *Ancistrotermes amphidon*, *Odontotermes faec*. (Lepidoptera) *Archips occidentalis*, *Cleora dargei*, *Desmeocraera cyprianii*, *Eumeta cervina*, *Kotochalia junodi*, *Nadasia amblycalymma*, *Nola lugens*, *ophiusa tirhaca*, *Orgyia basalis*, *Parasa ananii*, *Strepsicrates rhothia*. (Orthoptera) *Staurocleis magnifica*. (Mammalia) *Lepus whytei*. Young and/or drought-weakened shrubs can be badly infested by the eucalyptus snout beetle, eucalypt borer, moth larvae, and termites. Even the young trees are not favored by livestock and wildlife. The tree is said to kill other tree species (NAS, 1980a). This is one of the few species whose leaves are eaten by sheep (Watt and Breyer-Brandwijk, 1962). The litter may provide an important food source for detritivorous invertebrates and hence for waterfowl in redgum swamps (Briggs and Maher, 1983).

Chemical Analysis of Biomass Fuels

Analysing 62 kinds of biomass for heating value, Jenkins and Ebeling (1985) reported a spread of 19.42 to 18.23 MJ/kg, compared to 13.76 for weathered rice straw to 23.28 MJ/kg for prune pits. On a % DM basis, the wh.plant contained 81.42% volatiles, 0.76% ash, 17.82% fixed carbon, 49.00% C, 5.87% H, 43.97% O, 0.30% N, 0.01% S, 0.13% Cl, and undetermined residue.

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Eucalyptus camaldulensis

Evergreen semi-hardwood tree, with very rapid growth rate, used as timber

Planting season

Spring/monsoon

Planting

400/ha with a spacing of 5m x 5m

Economics

They can coppice well for six or more rotations. Annual wood yields can range from 17-30 m³/ha. The fuel value of the wood is 4,800 kcal/ha

