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Study Group Leader
Warwick Varley
PO Box 456, WOLLONGONG, NSW 2520
Email: tallowwood@hotmail.com

Membership Officer
Sheryl Backhouse
Email: sheryl.backhouse@bigpond.com

Eucalyptus Study Group Website
Web address: http://anpsa.org.au/eucSG/EuSG-news.html

Eucalyptus Facebook page
Web address: http://www.facebook.com/pages/Eucalyptus-Trees/124249007754284?ref=hl

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Aerial Roots in Eucalyptus

By Warwick Varley

The formation of aerial roots in the natural environment within the Eucalyptus genus is a unique and uncommon occurrence. Restricted to a group of species, and referenced by a few diverse publications, they are often unknown as they are unseen. Although frequently a benefit, and likely a natural adaptation related to the environment, the formation in some circumstances can offer detriment.

Aerial roots are a type of adventitious root. They develop from tissues other than roots and are commonly prompted by symptoms of environmental stress, a process predominantly regulated by hormone crosstalk. Although this root type frequently initiates from different parts of the stem, it can also form from leaves and often relate to an adaptation to distinct environments. They perform specialised functions for example, prop roots, to aid support of crown structure, contractile roots assist with improving the growing environment for bulbous species, and some climbing plants, such as *Hedera* (English Ivy), have specialised stem roots for surface adhesion. Modified environments such as waterlogging and wounding can influence the formation of adventitious roots, and manipulation of this adaptation serves the varying methods of plant propagation, for example, layering.

***E. robusta* in Otford, NSW**

The types of aerial root formation have been based on the location of root initiation and the environments they form in. Root formation from fallen trees[2] provides for the majority of species capable of aerial root formation. Trees that have succumbed to windthrow, can result in new root formation where the stem is in contact with the ground. This is likely to be further influenced by the tree's habit, for example, the forest class. That is a tall slender straight stem, where the crown mass is restricted to the upper portion. Upon failure, this habit allows for an increased proportion of the stem to form contact with the ground, and in circumstances a new growth habit emerges, the 'Harp tree'. The first-order branching takes on apical dominance leading to a linear row of newly formed leaders.

Although the following species are attributed to this type of aerial root formation, not all are capable of naturally forming a forest class. Species referenced to have formed this root type include, *E. pauciflora subsp. niphophila*[1], *E. stellulata*[1], *E. stricta*[1], *E. botryoides*[2], *E. robusta*[1] , *E. blakelyi*[3] , *E. tereticornis*[3] , *E. melliodora*[1], and a single reference to *E. ovata*[3], although, unlike the remaining species, the root formation was limited to large branches in contact with the ground.

***E. botryoides*, Southern Sydney**

A further referenced type caters for trees subject to coppiced regrowth[2]. That is, the new shoot formation on a cut stump can allow for aerial root formation at the base of the new shoots, and over the cut face. The study by Gillison[2], of *E. botryoides* examined old stump bases and their matured root system and the formation of coppice stems. In circumstances where the stump and base of the coppiced stems had been partly buried with soil and/or detritus, the new stems displayed root growth into the new media. A number of the coppice stems had developed into large trees where the stump and coppiced shoot had each formed their own individual root system, although separated by the cut face. Species attributed to this include, *E. botryoides*[3], and *E. melliodora*[3].

The single most documented example of aerial root formation in the genus is *E. robusta*, although evidence of E. *botryoides* also exists in the natural environment. *E. robusta* has been referenced in several publications[1,4,5], and the extent of root proliferation is correlated to the environment. The aerial roots can emerge from several locations over the crown structure, including the stem, crotches and undersides of large branches. These roots can extend over the predominate tree height, forming dense curtains of roots ranging up to 200mm in diameter[6] .

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[1] Jacobs, M. R., 1955. Growth habits of the Eucalypts. Forestry and Timber Bureau Commonwealth of Australia, Canberra.

[2] Gillison A.N., Lacey C.J., Whitecross M.I., 1982, Root formation by stems of *Eucalyptus botryoides* Sm. in Natural Stands, Australian Journal of Botany, 30, 147-59

[3] Lacey C.J, unpublished data, cited in Gillison A.N., Lacey C.J., Whitecross M.I., 1982, Root formation by stems of *Eucalyptus botryoides* Sm. in Natural Stands, Australian Journal of Botany, 30, 147-59

[4] Boden, R. W., 1963, Adaptation in Eucalyptus to the waterlogged environment. MA. Thesis, University of Sydney.

[5] Pryor, L. D., Willing, R. R., 1963, The vegetative propagation of Eucalyptus; an account of progress. Australian Forestry, 27: 52-62.

[6] LeBarron, Russell K. 1962. Eucalypts in Hawaii: a survey of practices and research programs. U.S. Department of Agriculture, Miscellaneous Paper 64. Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. 24 p.

***E. robusta*, Madagascar**

This species caters to a thick, dense absorbent fibrous bark that extends to the small branches. Root initiation is referred by Lanner[7] to be controlled by moisture levels of the bark where natural water reservoirs form. Roots conform to a pattern followed by the naturally formed channels of water flow through the branch/stem structure and the underside of large branches and crotches[8]. Aerial roots are referenced to occur throughout the plantations of *E. robusta* in Hawaii[5] , with the further observation of this rooting referenced in Uganda and Argentina[9] and abandoned plantations in Madagascar. That is, aerial root proliferation exists in areas subject to high precipitation, in contrast to the endemic environment where the formation of these roots is often uncommon[10]. Aerial root formation of trees in the native environment appears reserved for gullies and transitional rainforest communities, that is locations that retain water.

Similar to the root formation of *E. robusta* yet significantly less prolific and akin to moist environments are the species *E. camaldulensis* and *E.deglupta*. The former poses the greatest natural widespread distribution throughout Australia (all states but Tasmania) and is primarily indigenous to riparian corridors. The River Red Gum is described to initiate aerial roots on parts of the lower stem, a consequence of periodic flooding[1]. While *E. deglupta*, which is endemic to parts of the Papua New Guinea rainforest is recorded to produce aerial roots[11] yet significantly finer and more sparsely arranged over the stem. Contrary to the habit of *E. robusta*, this species has an entirely smooth bark,

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[7] Lanner, Ronald M. 1966. Adventitious roots of *Eucalyptus robusta* in Hawaii. Pacific Science 20:379-381. 14.

[8] Penfound, W. T. , F. P. Mackaness., 1940. A note concerning the relation between drainage pattern, bark conditions, and the distribution of corticolous bryophytes. Bryologist 43:168- 170.

[9] M. R. Jacobs, in a letter to the Ronald M. Lanner in 1963

[10] King J.P., Skolmen R.G., *Eucalyptus robusta* Sm. Robusta Eucalyptus, cited in Silvics of North America, 1990, see Footnote 21

[11] Davidson J., 1973, Reproduction of *Eucalyptus deglupta* by cuttings, Forest Research Station, P.O. Box 134, Bulolo, Papua New Guinea

therefore removing the inference for the moist bark to be initiating root growth in this species. A study by Davidson[11] has replicated the ability for producing aerial roots on the stems of the Rainbow Gum seedlings with nearly one hundred percent success.

The formation of aerial roots within crotches is scantly referenced, and those integral to the included bark crotches are discussed further. This root type is found in several tree genera, that do not display aerial roots in any other part of the tree other than the crotch. Within this crotch type, the V-shaped structure captures the bark and forms an absorbing sandwich of moisture and detritus. Not unusual is a pocket-type structure to form in the base of the crotch, in particular, if a decay infection occurs and in other circumstances, a natural formation from adaptive growth in some tree species. This crotch type is structurally weak, and the formation of cracks is common (as is partial tree failure often attributed), resulting in a breach of the cambium. Combined, these elements form a suitable environment for root initiation and proliferation, which can render either a disadvantage or a potential benefit. That is, the weakened structure inherent to this crotch can be further hampered by the secondary thickening of a growing root mass, acting as a wedge and increasing the propensity for crotch failure. Yet in some, although uncommon circumstances, the root formation can anastomose, acting as a bridge or natural graft between the sides of the crotch, therefore stabilising the structure. Unfortunately, the formation of roots is often concealed until the crotch fails.

Aerial root formation (circled) in the failed crotch of *E.tereticornis*

Further anecdotal evidence of other aerial root formations has been noted for specific environments. Substantial woody root formation comprising a second tier of roots up to 80mm in diameter and 300mm above the existing root flare was recorded in *Eucalyptus punctata.* This was related to the aged deposit of composted mulch (garden refuse) around the base of the tree. An erroneous although common garden practice contrary to horticultural standards. Within this circumstance, the root initiation may be related to the lignotuber, for which related references are discussed for other tree species by Gillison[2] in *C. gummifera*[12,13] , *C. maculata*[3], *E. pauciflora subsp. niphophila*[1], *E. stellulata*[2], *E. stricta*[3], and *E. botryoides*[2]. A significant woody aerial root 100mm in diameter has been recorded protruding from a large decayed wound in the bole of a *E. piperita* subsp. *piperita*. Although this aerial root type has been recorded in several instances in other genera (*Casauarina, Melaleuca*), this is a single recorded occurrence in Eucalyptus. The formation of cavity-bound roots is estimated to have been initiated when an internal wound, decay pathogen or termites breached the cambium from inside the tree and moisture held in the decayed wood acts as a medium for root initiation. The growing roots track down the decay column typically reaching the ground. Within the situation of the Sydney Peppermint, the root has breached the thin decayed shell of the wound and continued on the outside of the tree into the ground. Much like crotch roots, this type of aerial root formation is often concealed.

***E. piperita subsp. piperita* cavity-bound root**

Fourteen species have been cited in this discussion for which the majority are referenced to occur in periodically waterlogged soils [14] . The formation of aerial roots is likely an adaptation related to the riparian environment. This is consistent with other native genera that naturally occur in similar environments that also have aerial roots, such as *Casuarina glauca, C. cunninghamiana, Melaleuca quinquenervia, M. decora*, and *Avicennia*. Species, such as *E. botryoides* and *E. robusta* that naturally occur in tidal environments where both additional loading and consistent water-logging exists present prolific formation of aerial roots over a larger area of the tree structure. That is, the natural extent of a species' exposure to riparian

[12] Lacey, C. J., and Whelan, P. I., 1976, Observations on the ecological significance of vegetative reproduction in the Katherine-Darwin region of the Northern Territory. Australian Forestry, 39. 131-9.

[13] Mulette, K. J., 1978, . Studies of the lignotubers of *Eucalyptus gummifera* (Gaertn. and Hochr.). I. The nature of the lignotuber. Australian Journal of Botany, 26, 9-13.

[14] Slee A.V., Brooker M.I.H., Duffy S.M., West J.G., 2006, EUCLID, Eucalypts of Australia, 3rd Edit. Centre for Plant Biodiversity Research, Australia

environments appears correlated with the quantity, mass, and location of aerial root formation and this supports the adaptive significance of this feature.

Aerial root formation occurs in Eucalyptus as it does in numerous genera. Although limited to a select number of referenced species, additional unreferenced species have been discussed, supporting, more species, are likely to offer this adaptation. The types of aerial root formation vary and likely environmentally related, where modified or foreign environments increase the propensity for root growth. Further work is required to elucidate the nature of aerial root formation in the genus, and related causes.

Species profile*: Eucalyptus robusta* (F.Muell., Fragm. 2: 33 (1860).)

Source: Adapted from EUCLID,

Plants For A Future Species Database Bibliography

Silvics of North America, 1990, James R King and Roger G. Skolmen.

Synonyms*: Eucalyptus multiflora* var. *bivalvis* (Blakely), *Eucalyptus rostrata* (Cav.)

Common Name: Swamp Mahogany, Swamp Messmate, Robusta Eucalyptus (US).

Classification: Eucalyptus | Symphyomyrtus | Latoangulatae | Annulares

Description: Tree to 30 m tall, Lignotuber absent.

Bark rough to small branches, thick, fibrous, spongy, reddish-brown to grey-brown.

Foliage: Juvenile growth (coppice or field seedlings to 50 cm): stems square in cross-section, sometimes winged; juvenile leaves always petiolate, opposite for 5 to 7 pairs then alternate, ovate to broadly lanceolate, 6–19 cm long, 2.5–8 cm wide, bases round to tapering, discolorous, dull, green.

Adult leaves alternate, petiole 1.5–3 cm long; blade broadly lanceolate to ovate, 8.5–17 cm long, 2.5–7 cm wide, base tapering to petiole, discolorous, glossy, green, strongly penniveined, moderately to densely reticulate, intramarginal vein parallel to and just within margin, oil glands mostly island or apparently absent.

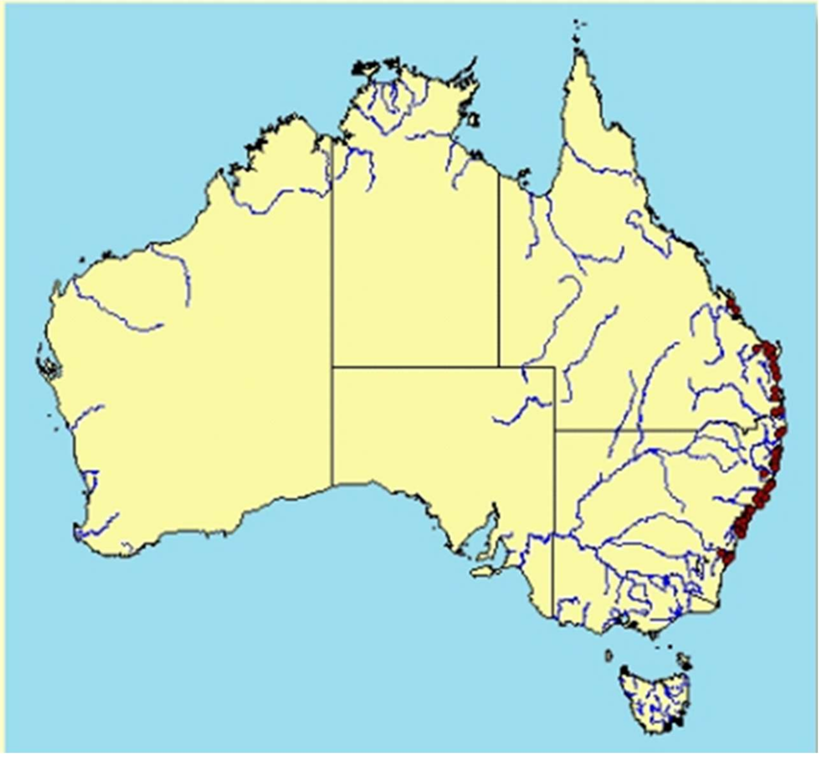
Inflorescence axillary unbranched, peduncle broadly flattened, 1.5–3 cm long, buds 9 to 15, pedicellate (pedicels 0.4–1.5 cm long). Mature buds fusiform to pyriform (1.6–2 cm long, 0.6–0.9 cm wide), yellow or creamy, scar present, operculum conical and beaked, stamens inflexed, anthers cuboid to oblong, versatile, dorsifixed, dehiscing by longitudinal slits (non-confluent), style long, stigma tapered, locules 3 or 4, the placentae each with (6)8 vertical ovule rows. Flowers white.

Fruit pedicellate (pedicels 0.5–1.2 cm long), cylindrical, 1–1.6 cm long, 0.7–1.1 cm wide, disc descending, valves 3 or 4, remaining joined at tips when fruit has dehisced, enclosed or near rim level, rarely slightly exserted.

Seeds light brown to yellow, 1.2–1.8 mm long, pyramidal or obliquely pyramidal, dorsal surface smooth, hilum terminal.

Cultivated seedlings (measured at ca node 10): cotyledons bilobed; stems square to winged in cross-section; leaves always petiolate, opposite for 5 to 7 nodes then alternate, lanceolate, 9–13.5 cm long, 3–5 cm wide, base tapering, margin entire, apex pointed, discolorous, dull, dark green above, paler beneath.

Species distribution in Australia



Source: Euclid

Flowering Time (Australia): Flowering has been recorded in May, July, August, September, and October.

Natural distribution: A small to medium-sized tree of coastal New South Wales from about Moruya north to north-west of Bundaberg in south-eastern Queensland, including North Stradbroke, Moreton and Fraser Islands.

Botanical notes: One of the red mahoganies, *E. robusta* is recognised by the thick fibrous rough bark, large, discolorous leaves with wide-angled side-veins, large buds and cylindrical fruit with the valves of the fruit remaining joined across the orifice, with this latter feature being unique in eucalypts in eastern Australia. *Eucalyptus robusta* usually occurs in swampy sites.

Taxonomy notes: *Eucalyptus robusta* belongs in Eucalyptus subgenus Symphyomyrtus section Latoangulatae because cotyledons are bilobed, leaves are discolorous and have side-veins at a wide angle to the midrib and buds have two opercula. Within this section, *E. robusta* is one of seven species forming series Annulares (the red mahogany group), as it has ovules in (6)8 rows, seeds pyramidal and bark rough over the trunk. The other six species are *E. pellita*, from coastal north Queensland and New Guinea; *E. urophylla*, from Timor and other islands to the north-west of Australia; *E. scias*, (with two subspecies) scattered in coastal and subcoastal New South Wales; *E. notabilis*, scattered in coastal and subcoastal New South Wales and south-eastern Queensland; *E. resinifera*, (with two subspecies) widespread in coastal New South Wales and Queensland; and *E. botryoides*, from coastal eastern Victoria and southern New South Wales.

Within this red mahogany group it is closest to *E. botryoides* and is distinguished by having larger buds and fruit, with the tips of the valves joined across the orifice.

The other red mahoganies are easily separated by having cup-shaped to funnel-shaped fruit (not cylindrical like *E. robusta*), and exserted valves on the dehisced fruit.

***E. robusta* buds**

Source: Euclid

***E. robusta* capsules**

Source: Euclid

Natural hybrids: Several natural hybrids involving *E. robusta* have been reported[8] . All of the known interspecific hybrids are between *E. robusta* and other species of the subgenus Symphomyrtus. Several have been assigned recognized botanical names. They are,

- *E. botryoides* var. platycarpa (*E. botryoides x robusta*),
- *E. grandis* var. grandiflora (*E. grandis x robusta*),
- *E. longifolia* var. multiflora (E. *longifolia x robusta*),
- *E. kirtoniana* (*E. robusta x tereticornis*),
- *E. patentinervis*, E. insizwaensis (*E. robusta x globulus*, probably),
- and an unnamed hybrid (*E. robusta x saligna*, probably).

Origin of Name: *Eucalyptus robusta*: Latin robustus, robust, referring to the appearance of the trees.

Introduced distribution: *E. robusta* is one of the most widely planted Eucalyptus species outside of Australia. Jacobs[15] refers to the species to have been grown in Hawaii, Uganda, Brazil, Sri Lanka, Fiji, Madagascar, Congo, South Africa, Mozambique, Papua New Guinea, Argentina, Comoros, Ethiopia, Malaysia, Philippines, Tanzania, Colombia, Cyprus, Ghana, Greece, Israel, Nigeria, Kenya and America. A reference by CABI included numerous more locations, including China and several countries throughout South America[16].

In Hawaii, *E. robusta* grows well from near sea level to 1100 m (3,600 ft) where annual rainfall ranges from 1000 mm (40 in) to 6350 mm (250 in) and temperatures rarely if ever reach freezing.

E. robusta in Florida grows mainly in the southern portion of the State where frosts may occur annually. Mean annual rainfall averages 1320 min (52 in) with 70 to 80 percent of rain falling during the May to October wet season.

In Puerto Rico the species makes its best growth in mountain regions about 460 m (1,500 ft) where annual rainfall averages 2540 mm (100 in) (17).

In Madagascar, plantations were planted by the French occupation for construction of a railway which never came to fruition. These were planted in cleared areas of rainforest on the east coast and northern Madagascar.

In southern California and along coastal northern California, plantings of *E. robusta* have been subject to several unseasonal cold spells where temperatures reached -9° C (16° F). In every instance severe foliage damage was initially observed (more than 80 percent of the crown foliage killed), but the stems recovered within 3 months.

Although *E. robusta* can recover from occasional severe frost damage, the limiting variable in its distribution seems to be low temperature. If the temperature drops below -9° C (16° F) annually, introduced *E. robusta* will seldom be successful. In Yunnan Province, China, -7° C (19° F) damaged *E. robusta*, but to a lesser extent than *E. globulus*.

Medical uses

Antiasthmatic, Antibacterial, Antifungal, Antirheumatic, Epilepsy, Febrifuge, Malaria.

The tree is reported to have significant antimalarial activity[17]. An infusion of the leaves is used in both Africa and China for treatment of malarial fever[18]. In Mauritius and Réunion the leaves are used for baths, inhalations and infusions to treat fever, colds, cough and influenza. Inhalation is also recommended for treatment of asthma and sinusitis, and infusions are taken against diabetes[18]. A decoction of the leaves is used in baths to treat stiffness, rheumatism and epilepsy[18]. In Madagascar a handful of buds is rubbed and squeezed, and the sap is applied to the nostrils to relieve headache[18]. The essential oil has shown antibacterial and antifungal activity[18]. Ethanol extracts of the leaves have shown antioxidant activity[17]. Phenolic compounds with activity against the malaria-inducing protozoan Plasmodium berghei have been isolated from the leaf[18].

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[15] Food and Agriculture Organisation of the United Nations, edited by M.R. Jacobs, 1979, Eucalypts for planting 2nd edit., Rome
[16] Cited at CABI, https://www.cabidigitallibrary.org/doi/10.1079/cabicompendium.22843
[17] Oxford Tindall. H. D., 1983, Vegetables in the Tropics, MacMillan, UK
[18] Protabase - Plant Resources of Tropical Africa, Website: http://www.prota.org

Agroforestry: The tree is used in reforestation schemes and is also sometimes planted to stabilize dunes. It is suitable for planting in coastal areas as shelterbelts. Although intolerant of salt spray, it is quite wind firm. It is often used as a windbreak, even though the trees often become deformed by continuous exposure to wind[17,18]. Because of their rapid growth, Eucalyptus species use a relatively large amount of water and can be used as pumps to lower the water table and help dry wet sites[17,18]. This species has been used very successfully in to dry swampy ground, making it possible to grow less flood-tolerant species on the same site[17].

Other : The gum in the trunk contains about 30% tannin[17]. The bark contains over 8% tannins[19]. The dried leaves yield up to 41% tannin[18]. The essential oil yield from the leaves is 1.7%, with the characteristic constituents being piperitone, rho-cymene, linalool, 1,8-cineole, terpinen-4-ol, citronellyl acetate and alpha-terpinol[17]. The heartwood is pale red when freshly cut, turning orange-red or red-brown with age; it is clearly demarcated from the up to 5cm wide band of pale brown sapwood. The grain is interlocked, texture coarse. Quartersawn surfaces sometimes have a ribbon figure of light and dark stripes. The wood is fairly heavy, moderately hard, strong, durable and able to be used in moist conditions, resistant to attacks by fungi and most insects, including marine borers, and moderately resistant to termite attack. The high shrinkage, coupled with the interlocked grain, means the wood requires careful drying. During drying distortion and splitting may occur; serious degrade can be avoided by air drying to a moisture content below 30% before kiln drying. The wood is not stable in service. The wood works well and takes a good polish. It is somewhat abrasive, and planing may be affected by interlocked grain. Therefore, slow speeds and a cutting angle of 20° are recommended. Sawing and working properties are generally good, although gummy exudates may clog up saws. The wood holds nails well, but pre-boring is necessary to avoid splitting. It turns well, and paints and waxes satisfactorily. Gluing is fairly difficult. The wood is not suitable for steam-bending. It is used for general construction and for poles, fencing, and wharf and bridge work. Other uses include pallets, house siding, flooring, ordinary furniture, interior trim, and panelling. Because of its strength and durability, it is also commonly used for mine props, railway sleepers, fence posts, stakes and gates. The stakes last a long time in the ground and can be driven repeatedly without splitting. The timber is also used for pulpwood, but the pulp is dark reddish-brown and is not as good for this purpose as some other species of Eucalyptus[17, 18]. The wood makes an excellent fuel and is good for making charcoal[17, 18]. It has an energy value of 19,600 - 20,500 kJ/kg[2]. The species is also used for honey production, and sometimes grown as an ornamental or windbreak tree.

Cultivation details: A plant of the lowland subtropics, remarkably, swamp mahogany adapts to a wide variety of conditions, from equatorial regions with maximum temperatures of about 35°c, to more temperate climates where it can endure frost, provided the frosts are not severe. It grows naturally at elevations up to 100 metres in areas where the mean maximum temperature in the hottest month is 30 - 32°c, and the mean minimum of the coldest month is about 3 - 5°c[20]. Throughout its native range, from 5 to 10 light frosts occur each year[20]. It has proved to be very adaptable in the tropics, where it can grow from sea level to elevations of 1,100 metres with a mean annual rainfall that ranges from 1,000 - 6,350 mm[20]. Requires a sunny position[19]. Succeeds on a range of soils, but prefers stiff clays and

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[19] Maiden J.H. , The Useful Native Plants of Australia, Turner & Co.; London, Website; http://www.biodiversitylibrary.org

leached sandy loams. The tree is exceedingly tolerant to prolonged flooding, so it is extensively planted in swampy areas and along rivers[21]. Tolerant of very acid soils[20]. Trees start flowering when they are 3 - 5 years old. Seed dispersal is mainly by wind. The tree regenerates freely, and dense thickets of saplings can be found near old stands[21]. A fast-growing tree, it has reached a height of 27 metres in 15 years from seed in tropical plantations[21]. The annual growth in height is usually 1.8 - 2.4 metres during the first few years, slowing down to 1.5 - 1.8 metres later[21]. The plant grows well in plantations on good sites, but because of its ability to grow on both poorly drained and draughty locations, it is usually planted on adverse sites[20]. It regenerates in areas flooded with fresh water, and its roots appear to be able to penetrate the heavy clays found in these conditions to reach the aerated soils below[19]. The growth habit also helps it to establish on difficult but not necessarily flooded soils in localities widely different from its normal habitat[20]. The tree can send out aerial roots from its trunk[1]. Plants coppice well up to the age of 25 years[20]. It recovers well from fire, sending out shoots from relatively small branches a few centimetres in diameter[1]. Under optimal conditions, the tree begins flowering by the end of its third growing season. More commonly, trees begin flowering when they are 5 years old[20]. In tropical areas, such as Hawaii and Puerto Rico, flowers may appear at almost any time of the year[20]. Planted seedlings are susceptible to competition and shading, and generally require two weedings in the first six months[20]. The length of rotation is largely determined by the product desired. For fuel wood, the tree is sometimes grown in plantations on a 4 - 5 year rotation; for pulpwood an 8 - 10 year rotation is appropriate; whilst saw logs can be produced in plantations or natural stands using 30 - 60 year rotations[20]. Most *E. robusta* plantations are regenerated from coppice shoots. The leaves are aromatic and, when crushed, have a spicy, resinous odour[19]. Eucalyptus species have not adopted a deciduous habit and continue to grow until it is too cold for them to do so. This makes them more susceptible to damage from sudden cold snaps. If temperature fluctuations are more gradual, as in a woodland for example, the plants have the opportunity to stop growing and become dormant, thus making them more cold resistant. A deep mulch around the roots to prevent the soil from freezing also helps the trees to survive cold conditions. The members of this genus are remarkably adaptable however, there can be a dramatic increase in the hardiness of subsequent generations from the seed of survivors growing in temperate zones[22].

Propagation

Seed Production and Dissemination- Seeds are small and like all eucalyptus contain no endosperm. The viable seed is difficult to separate from the chaff (unfertilized or aborted ovules) in the ripe flower capsules. There are 200 to 400 viable seeds per gram (5,700 to 11,300/oz) of seed and chaff.

Seed dispersal is largely by wind and may begin within 6 weeks after the seed capsule ripens. In Florida, most trees retain seeds in closed capsules for more than 1 year after ripening.

Seed - surface sow in a sunny position and make sure the compost is not allowed to dry out. Species that come from high altitudes appreciate 6 - 8 weeks cold stratification at 2°c. Germination can take only 4 days, but in cooler conditions can take 1 month or more. Pot up the seedlings into individual pots as soon as the second set of seed leaves has developed, if left longer than this they might not

20. Medicinal Plants in the Republic of Korea World Health Organisation, Manila 1998
21. Burns. R.M. & Honkala. B.H. 1990, Silvics of North America. Agricultural Handbook No. 654. USDA Forest Service; Washington DC.
22. Huxley. A. 1992, The New RHS Dictionary of Gardening. , MacMillan Press

move well. The seedlings are ready for planting in the field when they are 25 - 30 cm tall, usually after 3 - 4 months. The seed has a long viability.

Vegetative propagation by grafting and rooting stem cuttings has been done with young trees, but it is not a common method of reproduction.

The majority of new stems in logged stands of *E. robusta* are of coppice origin. These coppice shoots arise from dormant buds in the cambium of the stump. All parts of the stem surface under the bark contain dormant buds that sprout rapidly after crown injury.

E. robusta is one of the Eucalyptus species that produces lignotubers. A lignotuber consists of a mass of vegetative buds and contains substantial food reserves. It begins forming in the axils of the cotyledons and the first three pairs of the seedling leaves. Eventually these organs are overgrown by the main stem and remain as tuberous bulges just above the root crown.

When the species is logged, therefore, the source of the coppice is usually the dormant buds in the stem cambium surrounding the stump. But if the entire stem is killed through fire, or in young seedlings through grazing, new coppice shoots may arise from the lignotubers. In a Florida test, *E. robusta* coppicing proved to be less influenced by season of cutting than either *E. grandis* or a hybrid E*. grandis x robusta*, but was reduced during the hot, dry summer.

No rooted cuttings of *E. robusta* have been used on a commercial scale, but cuttings taken from young seedlings and young coppice shoots have been successfully rooted [23].

ABSTRACT

Chemical composition and herbicidal potential of essential oil of *Eucalyptus maculata* Hook

Khammassi Marwa, Amri Ismail, Mouna Souihi, Mabrouk Yassine, Ferjeni Dhaouadi, Hanana Mohsen, Hamrouni Lamia

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In continuation of the search of eco-friendly and safe alternatives for chemical pesticide for weeds management, essential oils (EOs) of forestry tree may be a good candidate. Here, the EOs of *Eucalyptus maculata* were extracted by hydrodistillation and the study of their chemical composition was carried out by GC and GC/MS analysis. The allelopathic effects of *E. maculata* EOs was tested against two common weeds in Tunisia: *Sinapis arvensis* (dicot) and *Phalaris canariensis* (monocot) and *Triticum durum* as cereal monocot cultivated crop. The application of EOs has been carried out in two stages of growth: pre-emergence and post emergence. Analysis of the EOs resulted in the identification of 46 components representing 97.7% of the total oil. 1.8-Cineole was detected as the principal compound accounted for 42% of the oil totality and oxygenated monoterpenes (61.5%) was the major subclass that characterize *E. maculata* growing in Tunisia. On pre-emergence stage, *Eucalyptus* EOs significantly reduced germination and seedling

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23. Kelly, S., 1969, Eucalypts. (Text by G. M. Chippendale and R. D. Johnston.) Thomas Nelson Ltd., Melbourne, Australia

growth of all tested species in a dose dependent manner and the phytotoxic effect of the EOs was differently effective depending on doses and tested species. On post-emergence stage, volatile oil induces a phytotoxic effect against all tested plants, a decrease in relative water content, an increase of relative electrolyte leakage percentage and levels of proline and malondialdehyde contents which explain their significant phytotoxic potential. Thus, *E. maculata* EOs inhibits germination and seedling growth of tested herbs in pre-emergence stage and post emergence stage, therefore *E. maculata* EOs shows potential towards weed management.

Tasmanian Herbarium keeps *Eucalyptus regnans* from Styx Valley, state's tallest grove of flowering plants

Source: May 2021, ABC Radio Hobart By Lucie Cutting

Yoav Daniel Bar-Ness says ancient trees are at significant risk due to climate change.*(ABC Hobart: Lucie Cutting)*

Yoav Daniel Bar-Ness knows he is only a "mega-fire" away from losing clues to Tasmania's past.

That is why the forest ecologist is creating an archive of specimens of the state's tallest grove of flowering plants, *Eucalyptus regnans*.

He says the Tasmanian Herbarium collection will help future scientists to research the trees with tools that have not been invented yet.

"We know [fires are] going to come … the real scary obvious one is yet another mega-fire," Mr Bar-Ness said.

"This is a way to face the future and do something. Once it occurred to me that we could, I realised we should."

The near loss of the world's tallest known flowering plant, a *Eucalyptus regnans* in the far south of Tasmania named Centurion, has partly inspired the project.

In 2019, Mr Bar-Ness had planned to collect a physical specimen from Centurion to sequence the tree's genome but could not proceed because of road closures from recent bushfire damage.

The focus point of the project is Styx Valley of southern-central Tasmania, an area with a notable concentration of the tallest grove of flowering plants in the world.

A *Eucalyptus regnans* towers above other flora in Styx Valley.*(ABC Hobart: Lucie Cutting)*

Threats to Tasmania's flowering trees

Mr Bar-Ness says, for many years, Tasmania's trees have been places to explore, study biodiversity, and gather digital data, such as height measurements.

Now his attention has turned to creating an archive of physical specimens for future scientists and their research.

Although unsure of how specimens will be used, Mr Bar-Ness said the window of opportunity to collect specimens was closing.

He points to climate change, drought stress, fire, and a declining number of ancient trees as significant risks to tall trees.

"We hear all of these warning bells," Mr Bar-Ness said.

"For me, this is an opportunity to do something practical in response to that.

To the best of my knowledge, nobody else had volunteered or was equipped to do [this]."

A warning bell rang loud for the forest ecologist in 2019 when bushfires struck southern Tasmania, threatening the world's tallest known flowering plant Centurion.

"One of the things I sat with during that period was, I may have missed the chance," Mr Bar-Ness said.

"This project, in part, came from the realisation that we've missed the chance on so many of them.

"There are stories we can get from these trees if we just remember to go and do something about it before [they perish]."

Fire natural part of *Eucalyptus regnans*

Although the idea of losing ancient trees to fire may be confronting, Mr Bar-Ness says some eucalyptus trees welcome it for ideal conditions for regeneration.

Eucalyptus regnans harness fire to kill off competition and then dominate a landscape through rapid growth.

The samples collected from the Styx Valley will help future research.*(Supplied: Yoav Daniel Bar-Ness)*

Fire creates favourable conditions for the growth of seeds, which are protected from the heat of the fire by a woody capsule.

Although the tree has a small amount of fire protection in the form of bark at its base, a *Eucalyptus regnans* is built to burn.

"It accepts it might go out in a blaze of glory," Mr Bar-Ness said.

"When these trees die from fire, they die happy because they wanted a fire."

For Mr Bar-Ness, the likelihood of fire in the tree's future provides further impetus to collect physical specimens from the ancient flowering plants now.

"We know [fires are] going to come," Mr Bar-Ness said.

"This is a way to face the future and do something. Once it occurred to me that we could, I realised we should."

Yoav Daniel Bar-Ness says it is necessary to preserve specimens before fire destroys them.*(Supplied: Anna Brozek and Ramji Creations)*

Stories written in flowers and leaves

Using tree climbing gear, Mr Bar-Ness pulls a *Eucalyptus regnans* branch from 20 to 60 metres above to select leaf and floral samples from it.

A sample taken by Mr Bar-Ness.*(Supplied: Yoav Daniel Bar-Ness)*

Occasionally a windstorm or gust of wind results in a fallen branch that can be used.

Mr Bar-Ness places the specimen on a plant press and later will take it to the Tasmanian Herbarium in Hobart.

Once there, samples are transferred to archival sheets, catalogued and included in the world's most comprehensive record of Tasmanian flora.

Alongside more than 312,000 plant specimens, the tall trees add to the many stories a single leaf or flower can tell.

"Their structures are holding signs of the past," Mr Bar-Ness said.

"Even in their genetics, they tell us something about the population structures of the past"

He said in their physical forms, they held chemistry and biological clues to conditions of the past.

"We're creating the ability for future scientists to investigate these [trees] with technologies that have not been invented yet," Mr Bar-Ness said.

"How am I going to feel, how will any of us feel, if a fire comes through this season and I knew that all I had to do was put the leaf on the press and bring it in safe?"

Species profile*: Eucalyptus erythrocorys* (F.Muell., Fragm. 2: 33 (1860).)

Source: EUCLID

Eucalyptus erythrocorys, Source: Euclid

Habit: Tree or mallee to 8 m tall. Forming a lignotuber.
Bark: smooth, grey or grey-brown to cream or white, rarely developing a short stocking of loose thin brown box-bark on the lower trunk.
Leaves: Juvenile growth (coppice or field seedlings to 50 cm): stems round in cross-section, not glaucous, hairy; juvenile leaves opposite, petiolate, lowest leaves deltoid, becoming broadly lanceolate to ovate to cordate, 5–13 cm long, (2)3–6 cm wide, base lobed to rounded to truncate, apex acute, green, hairy. Regrowth glabrous by 1 m tall.
Adult leaves opposite to sub-opposite, petioles 1.5–3 cm long; blade lanceolate to falcate, 9–20 cm long, 1.2–3 cm wide, base tapering to petiole, concolorous, glossy green, side-veins at an acute or wider angle to midrib, tertiary venation moderate, intramarginal vein present, oil glands mostly island.
Inflorescences axillary single, peduncles 1.2–2.6(3) cm long; buds 3 per umbel, pedicels 0.2–1 cm long. Mature buds obovoid, 2–2.5 cm long, 2–2.6 cm wide, hypanthium green, outer perianth whorl minutely sepaline, inner whorl operculate, operculum red, flattened with four lobes, stamens grouped in four clusters, inflexed, anthers oblong, versatile, dorsifixed, dehiscing by longitudinal slits (non-confluent), style long, stigma tapered, locules usually 3 or 4, the ovules arranged in 4 or 6 distinct vertical rows on the placentae. Flowers bright yellow to yellow-green.
Fruit pedicellate, rarely sessile (pedicels 0–1 cm long), broadly campanulate, four-lobed at the apex, 2.8–4

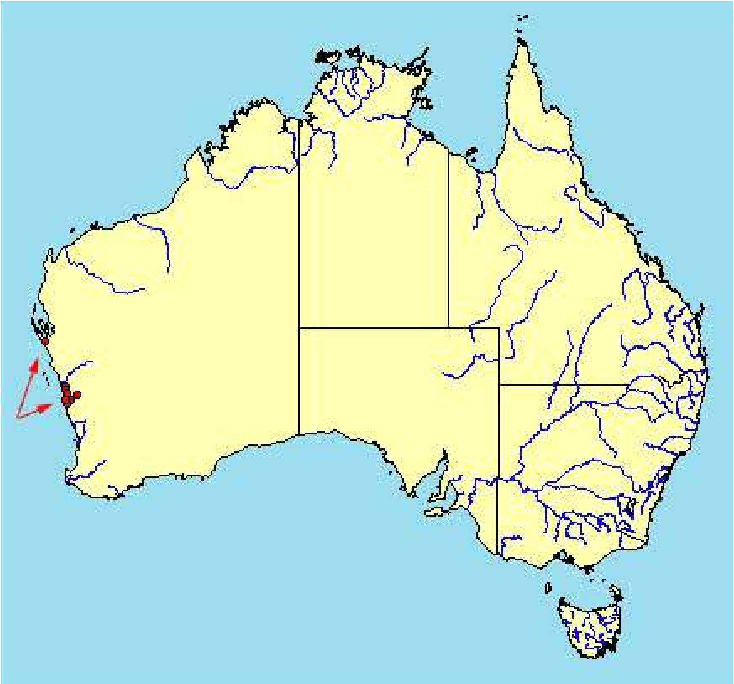
cm long, 3–5.5 cm wide, disc ascending, valves 3 or 4, enclosed.
Seed dull brown to black, obliquely pyramidal, sides ribbed, 2–4 mm long, surface smooth not deeply pitted, hilum ventral.

Flower/buds of *Eucalyptus erythrocorys.*

Source: Euclid

Capsules of *Eucalyptus erythrocorys.*

Source: Euclid



Natural distribution of *Eucalyptus erythrocorys*

Source: Euclid

A small tree of subcoastal areas north of Perth, on undulating lime stony sites from Cockleshell Gully to Dongara, with a further occurrence north of Kalbarri National Park where it grows as a mallee. The bark is smooth and the adult leaves are opposite, petiolate, falcate, glossy, dark green.

E. erythrocorys is one of the morphologically most remarkable species in the genus. It is easily recognised by the large buds in 3s, the brilliant red operculum, the bright yellow flowers and the grossly sculptured fruits with massive undulating disc.

Eucalyptus erythrocorys belongs in *Eucalyptus* subgenus *Eudesmia* because of the combination of cotyledons reniform in shape and folded and clasping in embryo, buds with the calyx free and evident as four small teeth around the midline of the bud (Sections *Ebbanoenses* and *Reticulatae* in this subgenus have the calyx fused to the corolla and evident as four small teeth at the apex of the bud). Within subgenus *Eudesmia, E. erythrocorys* belongs in the Section *Limbatae,* series *Heteropterae,* subseries *Tetraedrae,* that is further characterized by having seedling leaves with stellate hairs, the presence of oil glands in the pith of the branchlets, stamens arranged in four bundles, flanged ± pyramidal seeds and buds and fruit square in cross-section. The other species in subseries *Tetraedrae* are *E. gittinsii, E. pleurocarpa, E. extrica, E. eudesmioides, E. conveniens* and *E. roycei. E. erythrocorys,* with its large red buds and bright yellow flowers and large sculptured fruit, should not be confused with any of these.

A very popular species in cultivation in warmer temperate areas where it forms a decorative small tree.

Flowering has been recorded in January, February, April and September.

Eucalyptus erythrocorys is a popular ornamental and is commonly used as a street tree, particularly in Perth but also in many South Australian and Western Australian country towns.

Origin of Name: *Eucalyptus erythrocorys*: Greek *erythro-*, red and *korys,* helmet, referring to the operculum.

Eucalyptus erythrocorys or Illyarrie

Source: Wilcannia News, 14 March 2023

At the presentation of the Shire's Wilcannia Community awards on Wednesday 22nd February, the tables were decorated with vivid yellow flowered gum branchlets, which also carried bright red gum nut caps. These attracted lots of comments.

So for those interested – here is the story.

They came from the front of Christine Smiths house, the old Bushman's Home, previously the Cricketers Arms Hotel.

The tree is *Eucalyptus erythrocorys* or Illyarrie. It was first noticed in 1851 growing along a stock route between Geraldton and Perth. Another early observer of the tree, Augustus Oldfield, reported that the local Noongar people called it Illyarrie, claimed by some linguists to mean 'outback'. The botanical name comes from two Greek words, erythro for red and korys for helmet. And the story continues, or rather the research did.

The tree was voted the 2020 Eucalyptus of the year, the vote being announced on 23rd March, which is National Eucalyptus Day (NED), (who knew?), which commemorates the birthday of Norwegian born Klaus Bjarne Dahl.

Eucalyptus Erythrocorys Tree
Photo courtesy Wilcannia News

Klaus came to Australia in 1928 and was employed by the Victorian Forestry Commission as a Forestry Assessor. In this role, he travelled through the states forest, mapping and assessing the volume of standing timber.

After leaving State Forests in 1948 he was employed by Australian Paper Manufacturers, where one of his jobs was to buy abandoned farmland for forestry plantations. Some of the land was deemed unsuitable so he bought it himself, thinning the already growing timber, selling the timber and then sometimes the land as well. When he died in 1993, he left his whole estate of $2.5 million to Forestry Commission of Victoria to establish the KBD trust to ensure the perpetuation of eucalyptus forests.

Held by the Department of Energy, Environment and Climate Action, the KDBTrust, through Eucalypt Australia, promotes NED and awards the Bjarne K Dahl Medal, in honour of their benefactor, to publicly recognise and reward those who have made a significant and sustained contribution to eucalypts.

Since 2018 there has been a competition to name the Eucalyptus of the Year. To vote for the 2023 Eucalyptus of the Year go to https://www.eucalyptaustralia.org.au/eucalyptoftheyear/.

The winner of the first competition was the tree well known in Wilcannia, the river red gum or *Eucalyptus camaldulensis.*

Eucalyptus erythrocorys **flowers**

Photo courtesy Wilcannia News

ABSTRACT

The spatial distribution and expansion of Eucalyptus in its hotspots: Implications on agricultural landscapes

Amare Tesfaw , Ermias Teferi, Feyera Senbeta, Dawit Alemu

Heliyon, Volume 9, Issue 3, March 2023

Fast coppicing plantations like Eucalyptus are becoming an ever increasingly important land use system globally, including the Eucalyptus hotspot highlands of Northwestern Ethiopia. However, comprehensive information regarding species composition is essential for proper planning and policy decisions. The current study mapped the spatial distribution of Eucalyptus globulus (hereafter referred to as Eucalyptus) and identified the key push factors for its expansion. The study used a mapping procedure that uses Landsat imagery together with ground truth data based on supervised training of a pixel-by-pixel classification algorithm within image regions to distinguish areas of Eucalyptus plantations from other classes. High-resolution multispectral and multi-temporal remote-

sensing images were combined with ground truth data to produce robust features of Eucalyptus plantation distribution maps. Heckman's Two-Stage econometric model was also employed for determining the major driving factors of Eucalyptus expansion. The results of the mapping algorithm were Eucalyptus plantation distribution maps of 30 × 30 m resolution that showed temporal changes from 1999 to 2021. The findings revealed that Eucalyptus coverage increased by 55% during the period from 1999 to 2010 and the change expressively increased to 69% in 2021 with respect to the reference period. The study also found that a number of push factors influenced the size of land planted with Eucalyptus. The developed maps showing the spatial distribution and expansion of Eucalyptus will help policymakers properly manage the ecosystems and agricultural landscapes of Eucalyptus growing areas.

Severe droughts devastate eucalyptus trees that pre-date Ice Age

Source: The National Tribune, 12 Apr 2023

South Australian scientists have documented the catastrophic decline of a stand of Red Stringybark in the Clare Valley, a tree species that has survived in the region for 40,000 years but is now at risk of extinction due to climate change.

Researchers documenting the loss of Red Stringybark trees in the Clare Valley, SA.

Two severe droughts driven by climate change since 2000 are blamed for "staggering losses" of an isolated population of the South Australian species *Eucalyptus macrorhyncha* in the Spring Gully Conservation Park.

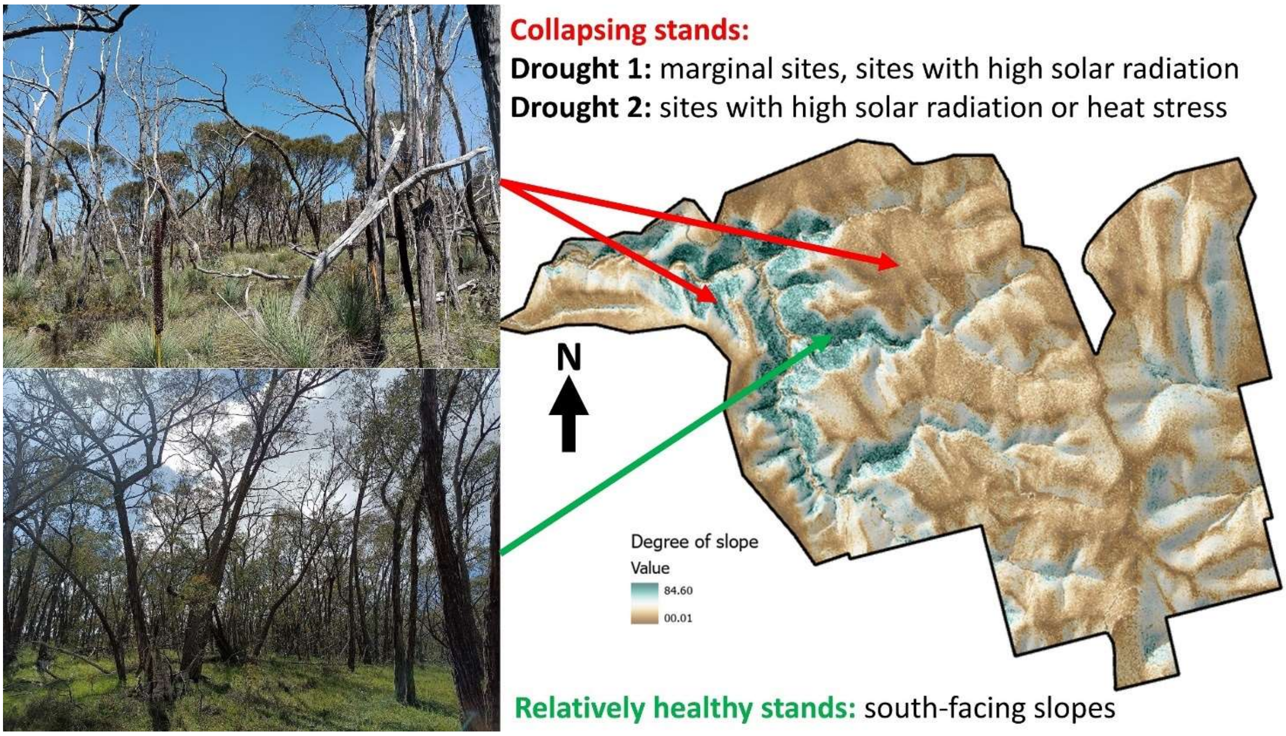
Multiple surveys led by University of South Australia environmental biologists Associate Professor Gunnar Keppel and Udo Sarnow have recorded tree and biomass losses of more than 40 per cent, during the Millennium Drought from 2000-2009 and the Big Dry from 2017-2019.

More than 400 trees were monitored over 15 years, within two years of their dieback first being reported in 2007.

The scientists say that approximately 250 tonnes of biomass per hectare have disappeared.

“In areas that experienced complete dieback, drooping she-oaks remain as the only trees, suggesting that the red stringybark ecosystem could be replaced by a more open woodland,” Assoc Prof Keppel says.

The research team, which included scientists from the State Herbarium of South Australia and University of Adelaide, has published their findings in the journal Science of the Total Environment.



A diagram illustrating where the red stringybark trees have died back and where they have thrived.

A diagram illustrating where the red stringybark trees have died back and where they have thrived.

Genetic data show that the red stringybark trees in the Clare Valley have been isolated from their closest relatives in the Grampians National Park in Victoria for about 40,000 years. This predates the Ice Age when Australia was much drier and cooler.

“The Clare Valley provided a safe haven that facilitated the survival of the red stringybark during this arid period. However, current climate change is different from the last glacial age. It is associated with much hotter temperatures compared to the preceding time periods, which were cooler but much drier.”

The team used trees marked by the Department of Environment and Water to document the progress of the eucalyptus dieback in the Clare Valley.

During the Millennium Drought, sites with less water and on flatter ground were most severely affected, while sites subjected to the greatest heat stress were most susceptible during the Big Dry.

Dieback is further compounded by intensive agriculture and viticulture in the Clare Valley, potentially adding more stress and preventing migration to sites that may facilitate the species' survival.

But there is hope, researchers say. "Mortality was much lower on the south and east-facing slopes – sites that received less sun and therefore less heat and drought-stress," Sarnow says.

"In these locations, some regeneration was also evident. Hopefully, the population can persist in pockets that provide milder microclimates.

"If we can manage the population in Spring Gully Conservation Park, protecting these microclimates, we may be able to save this unique element of Australian biodiversity."

Notes to editors

"Population decline in a Pleistocene refugium: Stepwise, drought-related dieback of a South Australian eucalypt" is published in Science of the Total Environment.

Udo Sarnow completed this research as part of his Master of Environmental Science.

ABSTRACT

A systematic and comprehensive review on current understanding of the pharmacological actions, molecular mechanisms, and clinical implications of the genus Eucalyptus.

Nikhil Chandorkar , Srushti Tambe, Purnima Amin, Chandu Madankar

Source: Phytomedicine Plus, Volume 1, Issue 4, November 2021

Background

The interest in the use of *Eucalyptus* genus members, in parallel with preclinical studies has been steadily growing over the last few decades in the field of pharmaceuticals, agriculture, cosmetics, food, etc. Eucalyptol (1,8-cineole or cineole), the main terpenoid constituent in *Eucalyptus* species, has been studied in both preclinical and clinical settings for its various pharmacologic activities. Investigations into the pharmacological activities of the genus *Eucalyptus* revealed that it manifests astounding potential in the treatment and management of respiratory disorders, COVID-19, pain, oral health, infectious diseases, cancer, etc.

Purpose

This review congregates and discusses the hitherto scattered data on *Eucalyptus* species morphology, chemical composition, some of its profusely investigated multifaceted therapeutic applications with insights into their molecular mechanisms, and clinical studies. The current understanding of the molecular mechanisms arising from cell lines, animal models, and clinical trials are emphasized. Lattermost, this review sheds light on various reported *Eucalyptus*-based formulations and relevant patents. Overall, this review aims to summarize and bridge the lacunae in the current research and offer a plethora of opportunities for the researchers engaged in the validation of the traditional claims and development in *Eucalyptus* utilization for safe and effective treatment of various diseases

Method

The systematic and comprehensive review was carried out by adhering to the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statements. PubMed, Scopus, ScienceDirect, Google Scholar, and Google patents databases were used to explore literature published till April 2021 by using relevant keywords.

Results

The systematic search retrieved 306 papers that were potentially relevant and after the selection procedure, 103 studies were included in this review and discussed. The evidence reviewed herein suggested that several *Eucalyptus* species possess anti-inflammatory, anti-microbial, anti-viral, anti-oxidant, anti-nociceptive, anti-cancer, anti-diabetic, etc., activities.

Conclusion

Preclinical and clinical studies have shown that the *Eucalyptus* plant and its chemical constituents have enormous potential for disease prevention and treatment. *Eucalyptus*, an ancient and underutilized ally with its diverse therapeutic applications can give rise to a paradigm shift in the treatment regime of several diseases in this era of modern science.

ABSTRACT

In vitro bioefficacy of *Trichoderma* species against two *Botryosphaeriaceae* fungi causing Eucalyptus stem canker disease in Ethiopia

Wendu Admasu, Assefa Sintayehu, Alemu Gezahgne, Zewdu Terefework

Journal of Natural Pesticide Research, Volume 4, June 2023, 100037

Phytopathogenic fungi, which are leading to significant economic and production losses, pose a serious threat to global forestry. Field surveys were carried out on *Eucalyptus* trees in Ethiopia between 2019/20 and 2020/21. The *E. camaldulensis* predominantly grew in the surveyed fields and was severely affected by progressive stem canker disease. The diseased stems and branches exhibiting symptoms were collected, and the *Lasiodiplodia theobromae* and *Neofusicoccum parvum* fungal pathogens were identified via

morphological and DNA sequence analyses of ITS1 and ITS2 from rDNA. The objective of this research was to assess the in vitro growth inhibition potential of *Trichoderma* species against *Lasiodiplodia theobromae* and *Neofusicoccum parvum* fungal species. Researchers are now exploring alternate eco-friendly management strategies due to the hazardous effects chemical fungicides have on human and environmental health. The use of biocontrol agents, such as *Trichoderma* species, is one of the potential approaches employed today. The antagonistic activities of *Trichoderma asperellum* (T4), *Trichoderma asperellum* (T5), *Trichoderma atroviride* (T1), *Trichoderma atroviride* (T11), *Trichoderma longibrachiatum* (T3), and *Trichoderma longibrachiatum* (T31) were tested in vitro against *Lasiodiplodia theobromae* and *Neofusicoccum parvum* that cause canker disease symptoms in *E. camaldulensis*. In all antagonism tests, *T. asperellum* and *T. longibrachiatum* effectively inhibited the growth of *L. theobromae* and *N. parvum*. This implies that the *Trichoderma* species could be useful to control *E. camaldulensis* canker disease.

Scientists Discuss the Role of Eucalyptus in Climate Mitigation

Source: Telesur: 19 August 2022

Eucalypts dominate over 75 percent of Australia's bushland, a testament to their adaptation over millions of years to an arid and fire-prone climate.

As part of Australia's National Science Week, a panel of experts held a discussion on the eucalyptus, which is both at risk and a potential solution in the face of climate change.

The discussion, titled "The Eucalyptus: Sentinels of a Changing Climate", took place on Thursday in Sydney's Powerhouse Museum. The eucalyptus is a family of over 800 species of native trees. They dominate over 75 percent of Australia's bushland, testament to their adaptation over millions of years to arid and fire-prone climate.

Belinda Medlyn, a professor at the University of Western Sydney who works on modeling how the trees will be impacted by climate change, said this seeming high-degree of resilience is masked by each species' adaptations.

"They're all over the country, but most of them have their own little niche. They have a small area that they need, which would tend to suggest that they are quite vulnerable to climate because they're really quite specialized."

In 2018 Medlyn started the Dead Tree Project, which seeks to view trends of how and the rates at which Australian trees are dying. The ongoing research has found that while droughts and fires are a natural part of Australia's ecosystem, their frequency and intensity could see entire species of the tree wiped out or even prompt ecological collapses.

One study from the University of Canberra found that in a worst case scenario, a three degree rise in temperature would see a 50 percent reduction of 90 percent of eucalyptus species. Beyond the trees' ability to sequester large amounts of carbon dioxide, they are also the basis on which Australian ecosystems thrive.

Rebecca Jordan, CSIRO Research Scientist, brought her focus on genetics to the discussion, and how it might help conservationists ensure the trees survival.

"I like to think of genetic diversity like a tool kit, the more tools we have in that tool kit, the more options that an organism might have to deal with whatever challenges are coming into the future with these changing climates."

For instance, eucalyptus trees growing in Australia's southern states have specific adaptations to wetter cooler conditions, and those in the north hotter and drier conditions. She said by breeding these species scientists could create trees that have both genetic defenses. All panelists agreed that collaboration would be key to preparing Australia and its trees for climate change, but the challenge of integrating vastly different practices remained in the air.

ABSTRACT

Phytophthora alticola and *Phytophthora cinnamomi* on *Eucalyptus globulus* in Portugal

Eugénio Diogo, Helena Machado, Ana Reis, Carlos Valente, Alan J.L. Phillips & Helena Bragança

European Journal of Plant Pathology volume 165, 255–269 (2023)

Eucalypt, mostly *Eucalyptus globulus*, is the exotic tree species occupying the largest area of Portuguese planted forest. Eucalypts were introduced in the country more than one hundred years ago, but it was only in the second half of the twentieth century that the area of plantations grew with the onset of their use in the paper and pulp industry. As an exotic species, it was free from pests and diseases but gradually the number of insects and pathogens affecting these plants increased. In recent year, a new disease causing root rot and dieback has been detected with increasing frequency. In this work, two *Phytophthora* species, *P. cinnamomi* and *P. alticola*, were identified associated with these symptoms. Koch’s postulates were fulfilled, proving that these two species are pathogenic to *E. globulus*. This is the first report of *P. alticola* outside South Africa. Although presently unknown, the possible factors associated with the increased occurrence of this disease are discussed..

That lone, craggy gum tree on a farm? It's a lifeline for Koalas

Source: Phys Org, by Loren Smith, University of Sydney, July 2022

A koala used in the study in the Liverpool Plains, NSW. Credit: Mathew Crowther/USYD

Certain eucalyptus trees on farms have added nitrogen due to the fertile soil. Despite dangers, koalas will travel from bushland to reach these trees and feed on their nutritious leaves. Farmers should pay heed to this, the University of Sydney researchers say.

Scattered, isolated farm trees may be postcard-perfect, but they also serve a crucial function: feeding and protecting koalas.

Declared endangered in February this year, the iconic marsupial, native to eastern Australia, relies on eucalyptus leaves for food. On farms, due to fertile soil, eucalyptus trees tend to be more nitrogen-rich and have fewer toxins and are therefore more nutritious for and appealing to koalas.

Despite the potential to become exhausted or be attacked by predators such as dogs, koalas will travel more frequently from patches of bushland on farms to reach isolated nitrogen-rich trees, new University of Sydney research has found. They also spend much more time in these nitrogen-rich trees, and in larger trees, for shelter.

Lead author Associate Professor Mathew Crowther from the University's School of Life and Environmental Sciences says farmers should try to preserve these trees at all costs.

"Land clearing resulting in fragmented habitats is the largest contributor to koala population decline—followed by climate change and disease," he said.

When their habitat becomes fragmented, koalas are more likely to move through developed areas where they have to cross roads. Less tree cover makes them vulnerable to dog attacks and being hit by cars and hurt by livestock.

"Loss of valuable farm trees will further fragment koala habitats," Associate Professor Crowther said.

A 2022 NSW government report, reviewed by Associate Professor Crowther, found that since 2015, land clearing in that state has increased roughly threefold to 35,000 hectares per year—equivalent to the same number of football fields.

"The latest NSW biodiversity protection legislation and policy represents a backwards step for koalas," he said.

Save the trees

The nitrogen-rich trees are all Eucalyptus species, including the Poplar Box; White Box; River Red Gum; Yellow Box; Tumbledown Red Gum; Fuzzy Box; and Black Box. The farmers in the area studied—the Liverpool Plains in NSW—care about the local koalas and can generally identify these trees, Associate Professor Crowther said.

"To protect koalas, farmers should preserve these trees, particularly the older ones which are larger and supply shelter from the shade during the day," he said.

"Farmers can also help koalas by keeping cattle out of tree regrowth areas and planting more trees on their properties."

About the study

The researchers tracked 23 koalas by GPS within an agricultural landscape on the Liverpool Plains near Gunnedah, northwest NSW, to determine why they would return to the same trees or groups of trees.

They collected data on the number of times the koalas revisited trees, how long they spent in the trees, and how long it took them to return to a specific tree.

They also measured tree characteristics including food quality (nitrogen and toxin levels in leaves), tree size, and tree connectedness.

Lastly, they modeled the costs of koalas moving between trees, accounting for exhaustion and predation.

They found koalas spent more time in trees with high leaf nitrogen, as well as in large trees, which they used for shelter. Their results are published in Behavioural Ecology

ABSTRACT

Effects of Successive Planting of *Eucalyptus* Plantations on Tree Growth and Soil Quality

Qiongling Dai, Tianhui Wang, Penglian Wei and Yunlin Fu

Sustainability 2023, 15(8), 6746

The ultra-short-cycle successive planting of *Eucalyptus* plantations has caused environmental and social problems, and changing the rotation cycle is a very good option to solve this issue. However, the effects of successive planting on *Eucalyptus* growth and soil quality after changing the cultivation period are unclear. This study evaluated the effects of successive *Eucalyptus* planting on growth, soil nutrients, and bacterial and fungal community structure with an eight-year cultivation period. *Eucalyptus* plantations with different succession generations (first, second and third generation) were selected, and tree height and diameter at breast height were measured. Ten indicators of soil nutrients in different soil layers (0–20 cm and 20–40 cm) were measured, and soil bacteria and fungi were sequenced in high throughput. Results show that there is an upward trend in tree growth after three successive generations, reaching the highest timber yield in the third-generation plantation. Soil nutrients also showed changes, in the 0–20 cm soil layer, with decreased TN, NH_4^+-N, NO_3^--N and AK and increased AP, particularly for OM and TP content. In the 20–40 cm soil layer, the content of NH_4^+-N and NO_3^--N increased slightly and the soil's OM, TP, and TK content increased significantly. The diversity of bacterial and fungal communities in different soil layers increased significantly, and the community structure composition changed. Bacterial and fungal community structures were mainly driven by pH, NH_4^+-N, TP and AP factors and by OM, NH_4^+-N, TP and TK factors, respectively. Thus, successive plantings of *Eucalyptus* plantations with a cultivation period of eight years is conducive to the growth of trees. Some nutrients of the soil were returned, and the soil microbial diversity increased. Successive planting has brought efficiency and economic benefits while maintaining the soil's fertility.

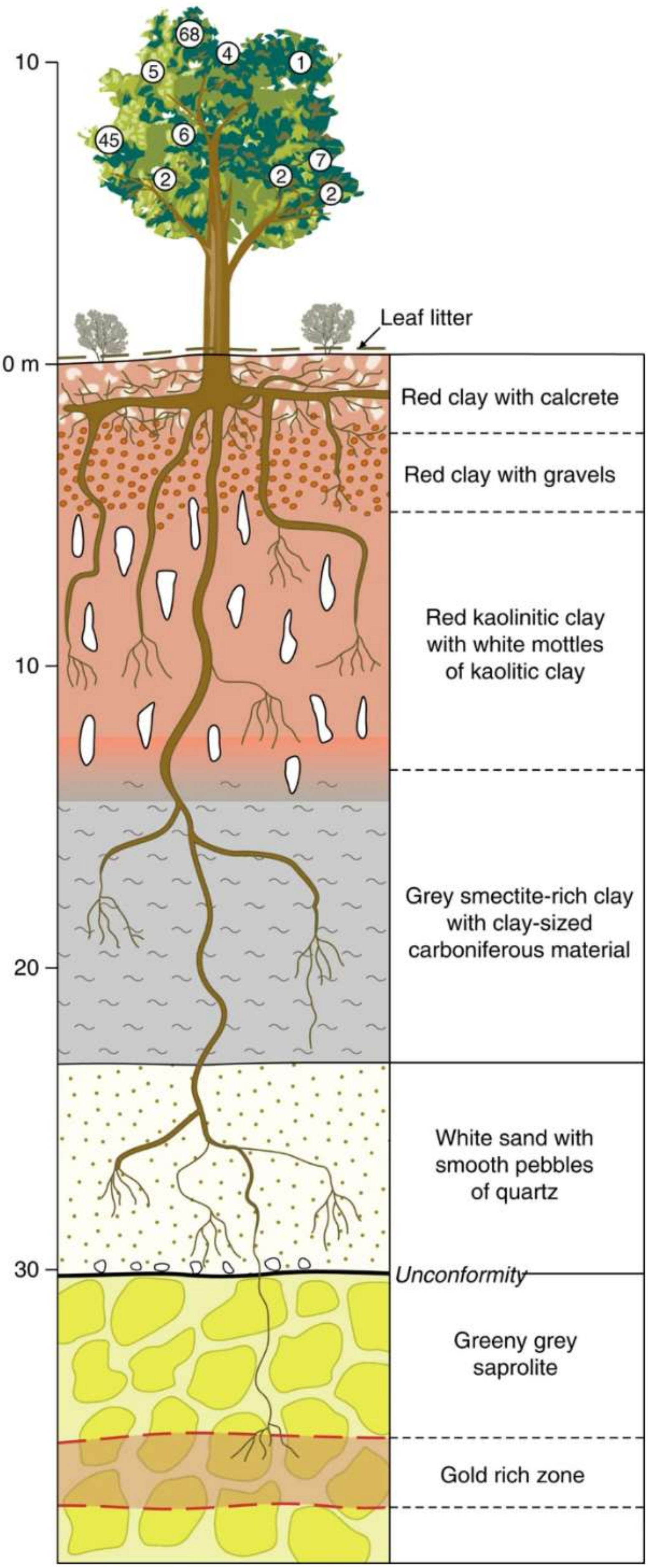
Gold Literally Grows On Trees In Australia

<u>Source:</u> IFL Science; Rachael Funnell, March 2023.

Gold hunters need only consult the trees if they want to track down some of that sweet Au. Why? Because when certain trees strike gold with their roots, the chemical element ends up in their leaves. It seems in Australia, gold quite literally grows on trees.

The gold leaves are found on eucalyptus trees that are able to transport microscopic particles of gold from deep deposits thanks to their incredibly long roots. The roots of *Eucalyptus marginata* can stretch 40 meters (130 feet) into the ground in search of water in an arid landscape, and it seems they pick up a few things along the way.

We've known about Australia's gold-leaved trees for a while now thanks to a 2013 paper that explores the use of vegetation sampling as a means of searching for minerals. At one point it was thought that detecting gold in plant samples was to do with surface contamination rather than it



having been absorbed from the environment, but their research showed it's possible for particular Au to ride the eucalyptus root trains all the way to the surface.

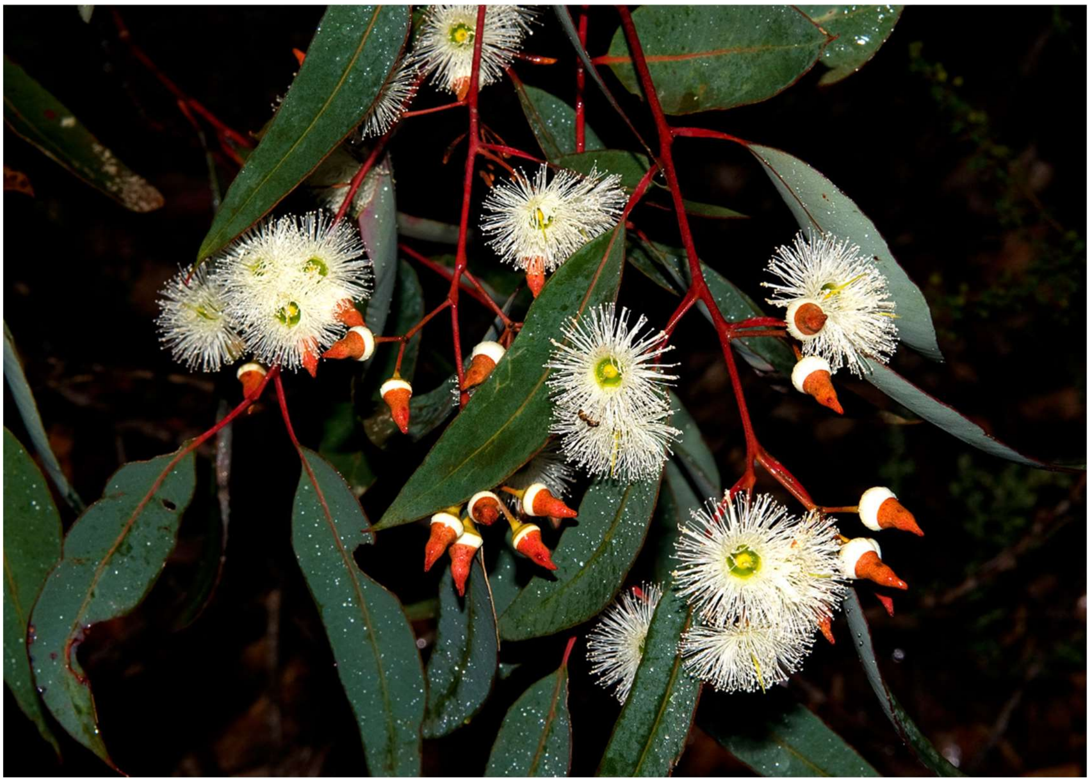
As this slinky long boy of a diagram demonstrates, the roots of eucalyptus trees are uniquely positioned at a depth where gold lurks. Image credit: M Lintern et al 2013, Nature Communications, CC BY-NC 3.0 (cropped)

Proving that eucalyptus trees could do this meant finding gold country, so they headed for the Freddo Gold Prospect north of Kalgoorlie in Western Australia. On top of its deep-dwelling gold layer are large eucalyptus trees whose leaves, twigs, and bark revealed significantly high Au (the chemical element symbol for gold) content.

The findings were mirrored in a greenhouse experiment that grew seedlings in sand pots dosed with gold. Just like their wild relatives, scanning electron microscopy revealed Au particles in their leaves.

In 2019, a company struck gold in South Australia thanks to a tip-off from trees that it was hiding deep below the surface. The 6-meter (20-foot) vein of Au was packing 3.4 grams of gold per ton, according to New Scientist, at a cumbersome depth of 44 meters (144 feet). It was a remarkable find as the deposit was 450 meters (1,476 feet) away from any other known gold sources.

It might not be the weight-of-a-man nugget that hunters dream of, but finding trees with expensive leaves is a less invasive way to go prospecting. At least, until the digging begins.



Flowers/buds of *Eucalyptus marginata*

Source: https://en.wikipedia.org/wiki/Eucalyptus_marginata

ABSTRACT

Hybrid vigor in *Eucalyptus* increases resistance against *Phytophthora* root rot

Tanay Bose, Almuth Hammerbacher, Wayne Jones, Jolanda Roux, Bernard Slippers & Michael J. Wingfield

Mycological Progress volume 22, Article number: 24 (2023)

Eucalyptus nitens is a cold-tolerant eucalypt that is native to Eastern Australia. Pure *E. nitens* as well as its hybrids, such as *Eucalyptus grandis* × *Eucalyptus nitens*, is propagated commercially in various regions of the southern hemisphere, including South Africa. In a plantation environment, *E. nitens* is susceptible to a variety of native and invasive pathogens, including *Phytophthora alticola* and *P. cinnamomi*. Recently, there have been increasing reports of root and collar rot in *E. nitens* in South Africa. The severity of this disease was substantially lower among interspecific hybrids of *E. grandis* × *E. nitens* compared to purebred *E. nitens*. In South Africa, the susceptibility of commercially propagated provenances of pure *E. nitens* and varieties of hybrid *E. grandis* × *E. nitens* to *Phytophthora* species is unknown. Therefore, we conducted greenhouse trials to evaluate the pathogenicity of *P. alticola* and *P. cinnamomi* to two families of pure *E. nitens*, one self-fertilized and the other outcrossed, as well as a single clonal variety of the most widely planted interspecific hybrid, *E. grandis* × *E. nitens*. The outcomes from these trials revealed that both self-fertilized and outcrossed families of *E. nitens* were highly susceptible to the tested *Phytophthora* species. The severity of root rot was greatest among plants inoculated with *P. cinnamomi.* The tested interspecific hybrid was tolerant to both *Phytophthora* species and developed new lateral and fine roots to offset the effects of root rot.

How the Eucalyptus Came to California; A Cautionary Tale

By Teisha Rowland,

Source: Santa Barbara Independent, Inc

It seems harmless enough; how can releasing just a few plants or animals into a new area hurt anything? But again and again, we've seen just how devastating introducing a foreign organism can be, whether it was on purpose or inadvertent. This has led to declining populations of bats, honeybees, and amphibians, among others, and explosive population increases among garden snails in California. Even when it doesn't look like the non-native organism is doing any harm, it's still tilting a biological scale that had carefully balanced itself over millennia.

The blue gum (*Eucalyptus globulus*) has become embedded in much of California's scenery, though how this came to be is a cautionary tale that emphasizes the importance of thinking before planting.

When we think of organisms being introduced to new lands and wreaking havoc upon the natives, animals more readily come to mind than plants do. But the often over-looked plant invaders have significantly sculpted the California landscape to become what we know it to be today. Europeans started to settle in California in the late 1700s, and soon many non-native plant species made their way to California as well. By the early 1800s, there were 16 non-native plant species, but this jumped to about 134 species by 1860. The number has been increasing ever since; today, there are over 1,000 non-native plant species living in California (and nearly 5,000 native species). While less than 10 percent of these non-native plants are considered to be a "serious threat" to native organisms, every new plant affects its environment in ways both subtle and profound.

Introducing "aliens": Just how much damage can a few non-native plants do? A great deal. For example, they compete with native plants for nutrients. They can in some cases alter nutrient levels in the soils (such as nitrogen levels) such that the entire local environment becomes changed and undesirable for native plants and animals. This can in turn prompt even more non-native plants, animals, and microorganisms to become established in these "disrupted" areas. The entire ecosystem's balance can be thrown off.

While not all non-native plants and animals cause such noticeable damage to their new environments, the potential for serious disruption is always present, and each should be introduced with premeditation and educated planning. The story of how the eucalyptus came to be embedded in much of California's scenery is a great example of lack of forethought when introducing a plant to a new area.

Australian roots: In 1770, eucalyptus specimens made their way to Europe for the first time. On his first Pacific Ocean trip, Captain James Cook explored part of the Australian coast. Botanists onboard catalogued and collected several different species along the way, taking them back to London. European botanists gave the trees the name “eucalyptus” because of how the flowers are in hard, protective cup-like structures: The Greek root “eu” means “well” and “calyptos” means “covered.”

Soon, interest in the eucalyptus swelled in Europe. In the early 1800s, wealthy merchants and aristocrats were excited about rare or “exotic” plants and, together with people in the plant business, made cultivating eucalyptus trees popular. Horticulturists also wanted to better study such novelties, to understand them scientifically and see what their potential economic value might be. And of course, the new European settlers in Australia were eager to make some money selling the abundant eucalyptus. Promoters touted the trees as not only aesthetically pleasing, but as capable of satisfying many practical needs. The eucalyptus quickly spread in Europe.

Eucalyptus is a very large genus that consists of over 600 species, which natively live in Australia, Tasmania, and some surrounding islands, in a range of soil conditions and temperatures (though prolonged frost is usually detrimental). They do very well in Australia; 80 percent of Australia's open forests are eucalyptus trees. With some aromatic species majestically soaring over 300 feet tall, as a hardwood tree their height is second only to California's coastal sequoias. It's easy to see their appeal.

On an economic level, many early promoters believed the eucalyptus could be used for making a number of materials: timber, fuel, medicine, wood pulp, honey, and both medicinal and industrial oils. Not only could eucalyptus grow quickly in many conditions, but, in several species, when the tree's cut down even to the roots new stems sprout back up. It all seemed too good to be true. Later, it turned out, it was.

The eucalyptus goes to California: Following its spread throughout Europe, northern Africa, India, and South America, settlers in California became increasingly interested in the eucalyptus. Not only was eucalyptus a fascinating novelty, but the California Gold Rush of the late 1840s and early 1850s created high demand for wood for constructing buildings and for fuel. Deforestation had become a serious concern, so much so that the California Tree Culture Act of 1868 was created to encourage people to plant more trees, particularly along roads. Many entrepreneurs rushed to capitalize on the situation.

Ellwood Cooper's role in spreading eucalyptus: Ellwood Cooper, educator, entrepreneur, and one of the key individuals who helped the eucalyptus take off in California, is a local legend here in Santa Barbara. After seeing eucalyptus in the San Francisco area, Cooper settled down in Santa Barbara in 1870. On his ranch, among many different types of produce trees (including olives, walnuts, and figs), he grew over 200 acres of eucalyptus. The eucalyptus forest he started lives on to this day at the Ellwood Bluffs. Cooper became a vocal advocate for the eucalyptus, emphasizing its unique, aesthetically pleasing appearance, as well as its useful qualities. He even wrote the first book in the

U.S. on the trees. Eucalyptus became very appealing to foresters in the 1870s and 1880s as native hardwoods were being severely depleted.

Starting in the 1870s, the first large-scale commercial planting of the blue gum eucalyptus (E. globulus) began. The blue gum, a mid-sized eucalyptus reaching around 150 to over 200 feet tall, is the most common eucalyptus in California. These trees are easily recognized by their waxy blue leaves and a grayish bark which reveals a smooth, contrasting yellowish surface when the bark sheds off in long strips. As with many other eucalyptus species, sprouts can grow back from a fallen tree stump.

By the early 1900s, the get-rich mindset had caused many aspiring forest tycoons to plant countless acres of eucalyptus in hopes of selling the timber for a tidy profit. It's estimated that there were over 100 companies involved in the eucalyptus industry at this time, and they changed the landscape of much of California.

But investors were soon to discover that the eucalyptus weren't all they'd hoped them to be.

Sadly, most of these schemes went the way they infamously did for Frank C. Havens. Havens was an Oakland developer who opened a mill and planted eight million eucalyptus trees in a 14-mile-long strip from Berkeley through Oakland. But when he came to sell the timber, it was found that the trees were too young to make suitable wood; the young wood had an irregular grain and it bent, cracked, and shrank when dried. It is true that eucalyptus trees from Australia could make good timber, but those trees were decades or sometimes centuries old. It was soon found that eucalyptus trees would need to be at least 75 or 100 years old for good lumber. The young wood didn't even make useable fence posts or railroad track ties, both of which decayed rapidly. Havens closed shop.

Other options for selling California-based eucalyptus products were grim. In the early 1920s, it was realized that California eucalyptus oil wasn't nearly the same quality as foreign-made oil, again mainly from Australia. The wood became increasingly sold just for fuel, but cheap electricity and gas soon replaced it. By 1950, eucalyptus trees were primarily grown in California as ornamentals or windbreaks. The trees had failed to live up the many premature claims and hopes.

Eucalyptus recently: Today, millions of acres globally are covered by eucalyptus, as forests, shade trees, anchors along canals, ornamentals, windbreaks, or plantations. Their adaptability allows them to grow where other plants can't, such as lands that have been ruined by mining or poor agricultural practices. They're still used in medical products (including antiseptics, decongestants, and stimulants), foods (such as cough drops and sweets), perfumes, toothpastes, industrial solvents, menthol cigarettes, and more. (But be careful, because eucalyptus bark and leaves, and consequently eucalyptus oil, are toxic if ingested or absorbed through the skin at high doses. It's especially poisonous to cats.) Eucalyptus is also a source of quality pulp. In a controversial case of history potentially repeating itself, these factors have caused eucalyptus plantations to crop up in many developing countries, particularly in Thailand. Due to the contentious social and environmental impacts of this, much criticism has been cast upon the international corporations spearheading these projects.

In addition to these new plantations, there are other divisive issues surrounding the eucalyptus today. Blue gum can be invasive in California, aggressively spreading from its original planting if enough water is present, such as in the form of fog. The bark strips dropped by the blue gums are extremely flammable, which can lead to intense fires, such as the Oakland Firestorm of 1991.

Additionally, in eucalyptus groves outside of their native homes, ecosystem development faces many challenges. Because most eucalyptus trees were grown from seeds from Australia, few eucalyptus insect pests traveled with the eucalyptus to their new homes. Fifty-seven Australian mammal species that normally live in eucalyptus groves, including koalas, wallabies, and pandemelons, as well as over 200 bird species, didn't make the voyage either. Because the eucalyptus leaves and bark are poisonous, the mammals that feed off it had to evolve mechanisms to deal with these toxins. Other mammals won't eat the eucalyptus. Overall, this results in a small degree of species diversity in eucalyptus groves. Australian plants and animals never arrived; native plants and animals are pushed out. While the eucalyptus is certainly not as devastating to its new home as some non-native plants and animals have been, its story should still serve as a cautionary tale: Think before you plant.

For more on eucalyptus and non-native plants, see Robin W. Doughty's book The Eucalyptus: A Natural and Commercial History of the Gum Tree, Carla C. Bossard, John M. Randall, and Marc C. Hoshovsky's book on Invasive Plants of California's Wildlands, California Invasive Plant Council's website on Invasive Plant Inventory, the University of California's Agriculture and Natural Resources' website on Invasive Plants, California's Department of Fish and Game website on Invasive Species Program, a previous Santa Barbara Independent article on Ellwood Cooper and other Santa Barbara Pioneer Horticulturists, and Wikipedia's article on Eucalyptus.

ABSTRACT

Insights on the Impact of Arbuscular Mycorrhizal Symbiosis on *Eucalyptus grandis* Tolerance to Drought Stress

Sijia Wang, Ying Ren, Lina Han, Yuying Nie, Shuyuan Zhang, Xianan Xie, Wentao Hu, Hui Chen, Ming Tang

Plant Microbiology, 16 March 2023

Drought stress has a negative impact on plant growth and production. Arbuscular mycorrhizal (AM) fungi, which establish symbioses with most terrestrial vascular plant species, play important roles in improving host plant mineral nutrient acquisition and resistance to drought. However, the physiological and molecular regulation mechanisms occurring in mycorrhizal *Eucalyptus grandis* coping with drought stress remain unclear. Here, we studied the physiological changes and mitogen-activated protein kinase (MAPK) cascade gene expression profiles of *E. grandis* associated with AM fungi under drought stress. The results showed that colonization by AM fungi significantly enhanced plant growth, with higher plant biomass, shoot height, root length, and relative water content (RWC) under drought conditions. Mycorrhizal plants had lower levels of accumulation of proline, malondialdehyde (MDA), H_2O_2, and $O_2^{\cdot-}$ than seedlings not colonized with AM fungi. In addition, mycorrhizal *E. grandis* also had higher peroxidase (POD), superoxide dismutase (SOD), and catalase (CAT) activities under drought conditions, improving the antioxidant system response. Eighteen MAPK cascade genes were isolated from *E. grandis*, and the expression levels of the MAPK cascade genes were positively induced by symbiosis with AM fungi, which was correlated with changes in the proline, MDA, H_2O_2, and $O_2^{\cdot-}$ contents and POD, SOD, and CAT activities. In summary, our results showed

that AM symbiosis enhances *E. grandis* drought tolerance by regulating plant antioxidation abilities and MAPK cascade gene expression.

IMPORTANCE Arbuscular mycorrhizal (AM) fungi play an important role in improving plant growth and development under drought stress. The MAPK cascade may regulate many physiological and biochemical processes in plants in response to drought stress. Previous studies have shown that there is a complex regulatory network between the plant MAPK cascade and drought stress. However, the relationship between the *E. grandis* MAPK cascade and AM symbiosis in coping with drought remains to be investigated. Our results suggest that AM fungi could improve plant drought tolerance mainly by improving the antioxidant ability to protect plants from reactive oxygen species (ROS) and alleviate oxidative stress damage. The expression of the MAPK cascade genes was induced in mycorrhizal *E. grandis* seedlings under drought stress. This study revealed that MAPK cascade regulation is of special significance for improving the drought tolerance of *E. grandis*. This study provides a reference for improving mycorrhizal seedling cultivation under stress.

Eucalyptus grandis **photo via Sydney Botanical Gardens**

Source: https://canopy.org/blog/tree-spotlight-flooded-gum/

Articles, requests and questions are needed. Please send all correspondence to;

tallowwood@hotmail.com or sheryl.backhouse@bigpond.com
or postal address; PO Box 456, WOLLONGONG NSW 2520

New members wishing to subscribe to the Eucalyptus Study Group, please fill in the following application and forward to Sheryl Backhouse:
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