



Australian Essential Oil Woody-plant Species Profile

Narrow-leaved Peppermint (*Eucalyptus radiata* Sieber ex DC subsp. *radiata*)

- Species: *Eucalyptus radiata* Sieber ex DC subsp. *radiata* (cineole variant, formerly called 'Type')
- Common name: Narrow-leaved Peppermint
- Principal source of oil: Plantations of the cineole variant of *E. radiata* outside of Australia and chiefly in South Africa.

Species description

Narrow-leaved peppermint varies from a small bushy tree 10–15 m tall to a medium sized to tall tree of moderately good form of 20–30 m tall and occasionally much taller with diameter at breast height (dbh) up to 1.5 m (Figure 1; description adapted from Slee *et al.* 2020).

Features:

- bark – rough to small branches, dark grey or grey-brown, finely fibrous (peppermint type), small branches covered in dark grey smooth bark.
- juvenile leaves – opposite and sessile for many pairs, narrow lanceolate to linear, 3.3–10 cm long, 0.5–2 cm wide, mostly green but occasionally bluish-green.
- adult leaves – alternate, petiolate, lanceolate to falcate or almost linear, 5.5–12 cm long, 0.6–1.5 cm wide, glossy or dull, green to blue-green or blue-grey (Figure 2), concolorous, and giving a strong peppermint smell when crushed.

(For more details refer to texts given under 'Further Reading' below).

Natural occurrence

The entire range of *E. radiata* with its three subspecies extends from the NSW–Queensland border to the Otway Ranges of Victoria with an outlier in northern Tasmania (Figure 3). Range in Elevation ranges from <100 to >1000 m.

Provenances of *E. radiata* subsp. *radiata* (cineole variant) are relatively few in number. Locations where oil of this

type was produced historically are listed in the Importance of Biodiversity section.



Figure 1: *E. radiata* subsp. *radiata* stand at Isabella, NSW, (N. England 2023).



Figure 2: Herbarium specimen of *E. radiata* subsp. *radiata* from Kinglake, Victoria (Ladiges 1981).

Climate

Narrow-leaved peppermint is mostly from the temperate climatic zone with relatively mild winters and cool summers with rainfall fairly uniformly distributed throughout the year. The mean maximum temperature of the hottest month ranges from 24–27°C and the mean minimum temperature for the coolest -1–5°C. Frosts are few at low altitude but up to 70 per year can be received at higher elevation. Rainfall averages 650–1100 mm per year.

Topography, soils and vegetation

These peppermints occur largely on tablelands where they prefer hill and mountain slopes. Low altitude, near-coastal occurrences are known in Victoria and southern NSW. They grow on a wide range of free-draining soil types including sands and skeletal types, volcanic loams and weakly differentiated reddish loams derived from a range of parent material such as shales and granite. They usually occur in open or tall eucalypt forest and are associated with a wide range of other eucalypt species (Boland *et al.* 2006).

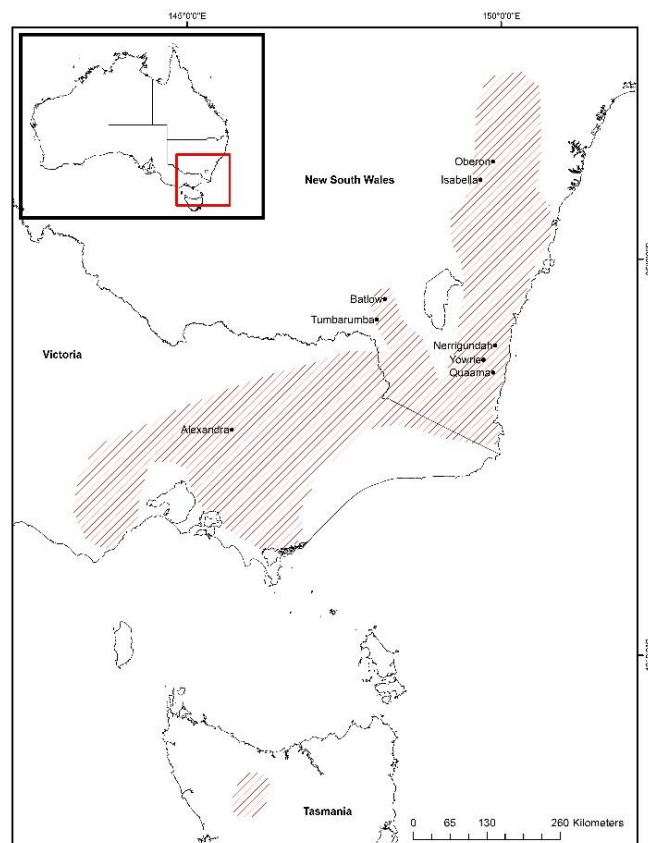


Figure 3: Distribution of *E. radiata* subsp. *radiata* (hatched area) based on edited points taken from Atlas of Living Australia (www.ala.org.au).

Importance of biodiversity

Eucalyptus radiata exhibits significant intraspecific variation in its essential oils. Four chemotypes ('Type' and 'Vars A, B and C') were first identified, each differing in the amounts of 1,8-cineole and phellandrene and the presence or absence of piperitone (Penfold and Morrisson 1935, 1937, 1940). The principal component of 'Type' oil is 1,8-cineole (62–72%). Later, the number of chemotypes reported was increased to six (Johnstone 1984). The 'Type' variant is the only chemotype discussed further in this leaflet.

It is very important, in acquiring seed for plantation establishment, that the seed has been collected from the desired cineole-rich chemotype. Certain provenances have consistently yielded high-cineole oils and should be the focus of seed acquisition for production of *E. radiata* subsp. *radiata* (cineole variant) oil. They are:

1. In NSW: Tumut/Batlow/Tumbarumba/Rosewood area, the Nerrigundah/Reedy Creek/Yowrie/Quaama region of the south coast, and the Oberon/Isabella River area of the southern high country.
2. In Victoria: near Alexandra.

These provenances will generally withstand frosts down to -5°C with minimal damage. On sites experiencing more severe frosts, then the Isabella River provenance is

recommended, although expect slower growth from this high elevation source compared to provenances from lower elevations. Reedy Creek is the most hardy of the southern NSW provenances (Doran *et al.* 2005).

Essential oils

Rectified oil from steam distillation of leaves and twigs is colourless to pale yellow, with a fresh, very powerful, peppery-camphoraceous odour (Weiss 1997).

Leaf oil concentration averages 3.9% and ranges from 2.7–5.4% (Fresh Weight) (Penfold and Willis 1961).

The following datasheet gives the percentage ranges for compounds in typical commercial *E. radiata* subsp. *radiata* (cineole variant) oil and the oils physical properties.

Uses

It is considered to be one of the finest eucalypt oils for medicinal purposes (Penfold and Willis 1961), primarily as a cough and cold remedy as well as for helping relieve muscular aches and pains. The high content of 1,8-cineole (\pm 70%), in association with α -terpineol and some other components, imparts a sweeter and less harsh odour when compared to other 1,8-cineole-rich oils, and is favoured in aromatherapy.

Oil Quality

Mainly based on presence of 1,8-cineole which ideally falls in the range of 65–75% of total oils. It is thought that higher levels of 1,8-cineole in the oil mask the sweeter aromas for which the oil is famous (Richard Davis pers comm. 2023).

Production and markets

Most oil of the 'Type' cineole chemotype of *E. radiata* subsp. *radiata* is produced from plantations in South Africa where the species grows well and produces high quality oils under suitable conditions, e.g. in Western Cape Province and KwaZulu-Natal. Coppen (2002) estimated total production of *E. radiata* subsp. *radiata* (cineole variant) in South Africa to be in the order of 35 tonnes annually, although this has likely grown in recent years with the establishment of new plantations. The main markets are to EU countries and Australia.

Production of modest amounts ('Farmers-Market' quantities) of *E. radiata* subsp. *radiata* ('Type' cineole variant) oil from native stands in NSW by independent distillers continues but this is neither substantial nor regular. Attempts over the years in Australia to establish major plantings of the cineole chemotype of *E. radiata* subsp. *radiata* for oil production have failed due to economics and choice of inappropriate planting sites.

Plantations for oil production

South Africa – Propagation is universally by seed with an average germination rate of 200 germinants per gram of seed and chaff (ATSC records). Standard forestry techniques for ground preparation and silviculture are usually employed. Formerly, most *Eucalyptus* oil plantations in southern Africa were established at a spacing of 2.74 m x 2.74 m (stocking of 1332 stems/ha) allowing mowing for weed control between trees. In more recent years closer spacings (e.g. 3.0 m x 1.5 m, 2222 stems/ha) are being employed.

Australia – Plantings on the Northern Tablelands of NSW employed spacings of 1.5 m x 1.5 m (4444 stems/ha) and 2.0 m x 1.35 m (3750 stems/ha) while another in southern NSW used 3.0 m x 1.5 m. (2222 stems/ha) for oil production with adequate results. Clearly some well-designed spacing trials are needed to determine the optimum planting density for this species.

Harvesting techniques vary between growers. It is common to allow the trees to grow for two years and cut at 0.6 m above ground level. Harvests thereafter are on an annual basis with best yields in the late summer.

Average yields and distillation times

Average oil yields are typically about 100 kg/ha (J. Owen pers comm. 2023). In a provenance/family trial of the cineole chemotype of *E. radiata* subsp. *radiata* in southern NSW, Doran *et al.* (1998) estimated a mean oil yield of 131 kg/ha at age 23 months (first harvest) with the best provenance (Big Belimbla, NSW) giving 156 kg/ha equivalent to a 20% increase due to higher survival and greater oil concentrations. Extraction times can be as short as 1.25 hours with application of suitable distillation techniques (J. Owen pers comm. 2023).

Research

New growers are encouraged to consult the following studies: Donald (1980) reports on success with the vegetative propagation of *E. radiata* by rooted cuttings and micropropagation. Harris (2002) demonstrated that key commercial traits in the cineole chemotype of *E. radiata* subsp. *radiata* are amenable to improvement through selection and breeding and that the use of selected stock to achieve a high yield of oil per unit area of land could be crucial to economic viability. Kar (2003) researched management strategies for the cineole chemotype of *E. radiata* subsp. *radiata* to produce high foliar biomass with maximum oil concentration on the northern tablelands of NSW. This author presents the results of studies of fertilizer rates, season of harvest, harvest frequency, height of harvest and leaf age for maximum oil production.

Eucalyptus radiata subsp. *radiata* (cineole variant) Essential Oil Data Sheet

1. Chemical composition of *E. radiata* subsp. *radiata* (cineole variant, formerly known as 'Type') oils. All five oils sampled were distilled from progeny of south coast of NSW provenances growing in an experimental planting in their zone of occurrence. The oils are representative of the products of commercial harvests from young plantations.

Compound	Range in % relative abundance in total oil
α -pinene	2.5–3.3
β -pinene	0.6–0.7
sabinene	0.2–1.2
myrcene	0.9–1.6
α -phellandrene	0.1–1.2
α -terpinene	0.1–0.4
limonene	6.0–6.9
1,8-cineole	67.6–70.6
γ -terpinene	0.2–0.9
<i>p</i> -cymene	0.4–1.2
terpinolene	0.1–0.3
linalool	0.1–1.2
terpinen-4-ol	1.0–1.7
δ -terpineol	0.1–0.6
α -terpineol	5.6–11.5
γ -eudesmol	0–0.3
α -eudesmol	0–1.2
β -eudesmol	0–1.3
other	0.2–4.6

2. Physical properties of *E. radiata* subsp. *radiata* oils (Penfold and Morrison 1988 and GRD Specification*)

Specific gravity at 20°C	0.916 to 0.930
Refractive index at 20°C	1.463 to 1.465
Optical rotation	+1° to +5°
Flash point (GRD spec*)	+48 °C
Solubility in 70% Ethanol [% by weight]	1.2 to 1.5

*GR Davis Pty Ltd specification

References

Boland DJ, Brooker MIH, Chippendale GM, Hall N, Hyland BPM, Johnston RD, Kleinig DA, McDonald MW and Turner JD (2006). *Forest Trees of Australia* (5th ed.). CSIRO Publishing: Victoria, Australia.

Coppen JJW (2002). *Eucalyptus: The Genus Eucalyptus. Medicinal and Aromatic Plants – Industrial Profiles*. Taylor and Francis: London and New York.

Donald DGM (1980). The production of cineole from *Eucalyptus*: a preliminary report. *South African Forestry Journal* 115: 64–67.

Doran JC, Arnold RJ and Walton SJ (1998). Variation in first-harvest oil production in *Eucalyptus radiata*. *Australian Forestry* 61: 27

Doran JC, Kar AK, Lamour JS and Reid N (2005). Variation in frost tolerance of the 1,8-cineole-rich variants of the peppermint eucalypts, *E. radiata* and *E. dives*. *Australian Forestry* 68: 137–143.

Harris HAK (2002). Selection and Breeding of *Eucalyptus radiata* subsp. *radiata* to Improve the Economics of Essential Oil Production. Master of Resource Science thesis. UNE: Armidale.

Johnstone PC (1984). Chemosystematics and morphometric relationships of populations of some peppermint eucalypts. PhD Thesis, Monash University: Melbourne.

Kar AK (2003). Optimizing Medicinal Oil Yield from *Eucalyptus radiata* Plantations in Northern New South Wales. PhD thesis. UNE: Armidale.

Ladiges, P.Y. (1981). Preserved specimen of *Eucalyptus radiata* subsp. *radiata* | Narrow-leaf Peppermint. Australia's Virtual Herbarium, The University of Melbourne Herbarium. Occurrence record: MELUD105041a.
<https://avh.ala.org.au/occurrences/ac288a5e-df1c-4948-8082-26c9154a2198>.

Penfold AR and Morrison FR (1935, 1937, 1940). The essential oils of *Eucalyptus australiana* (Baker and Smith) and its physiological forms. *Journal and Proceedings of the Royal Society of NSW* Part 1 69: 111–122; Part 11 71: 357–361; Part 111 74: 277–282.

Penfold AR and Morrison FR (1988). *Eucalyptus* oils of lesser importance. Page 505 In

Guenther E. *The Essential Oils, Volume 4 – Individual Essential Oils of the Plant Families Gramineae, Lauraceae, Burseraceae, Myrtaceae, Umbelliferae and Geraniaceae*. Robert Krieger Publishing Co.: Malabar, Florida.

Penfold AR and Willis JL (1961). *The Eucalypts*. World Crop Series Vol. 11. Leonard Hill Ltd: London.

Slee AV, Brooker MIH, Duffey SM and West JG (2020). *EUCLID Eucalypts of Australia*, 4th ed, Identic Pty Ltd: Brisbane, Australia.

Weiss EA (1997). *Essential Oil Crops*. CAB International: Wallingford, UK.

Further reading

Boland DJ, Brophy JJ and House APN (1991). *Eucalyptus Leaf Oils: Use, Chemistry, Distillation and Marketing*. Inkata Press: Melbourne and Sydney, Australia.

Brooker MIH and Kleinig DA (1999). *Field Guide to Eucalypts: South-eastern Australia*. Vol 1 (2nd Edition). Blooming Books: Melbourne, Australia.

Brophy JJ and Southwell IA (2002), *Eucalyptus* chemistry. Pp 102–160 in Coppen JJW (ed.) *Eucalyptus: The Genus Eucalyptus. Medicinal and Aromatic Plants – Industrial Profiles*. Taylor and Francis: London and New York.

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