CHAPTER 3 - SITE SELECTION

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One great advantage of eucalypts is that because there are so many species to choose from, a species can be found to suit almost any site. The challenge is to match the right species to the right site. This is the key to successful eucalypt plantations.

Fortunately the experience gained from planting the large number of species in New Zealand has resulted in a great deal of information about the site requirements for individual eucalypt species. Climate and site conditions in specific locations cannot be defined precisely and often micro-sites are as important as broad scale information.

Five major factors should be considered when matching species to local sites:

- Air drainage. Frost intolerant species can be grown at lower temperatures if there is adequate air movement.
- Unseasonal frosts. These can be devastating for many eucalypt species, even those able to tolerate cold conditions.
- Seed source. Conditions in the region from which seed was obtained can influence responses to climate and site. Variability related to provenance (seed source) can be as important as species variability.
- Aspect. Planting on warmer, north facing slopes reduces the risk of cold damage, especially if there is good air drainage.
- Age. Young seedlings are more vulnerable to cold events than saplings. Saplings may suffer damage, but this is not necessarily fatal.

For the ten species most commonly grown in New Zealand, broad information about siting requirements can be summarised as follows:

Ash Group (and *E. nitens*)

E. delegatensis

Able to withstand cold and wind better than most other eucalypts, this species can grow in stony soils such as those found on the Canterbury Plains. It does not tolerate mild, warm sites, drought and poor drainage. Best growth has been observed under central North Island and inland South Island conditions where it appears to need 1300-1500 mm of rainfall per year. It tolerates frost and will grow on cold sites. Although North Auckland is generally too warm, it will grow there in cooler valleys away from the coast. It thrives in fertile soils and damp conditions, and grows very well on sandy loams. There have been failures on eroded soils at exposed sites 760 m in inland Hawke's Bay. It should not be planted below 300 m in the central North Island.

E. fastigata

Best growth has been observed on well-drained volcanic soils in sheltered valleys of the Bay of Plenty and Taranaki regions. Trees cannot withstand strong winds but tolerate high rainfall and some snow. *E. fastigata* is more tolerant of cold than *E. regnans*. It grows well in the Waikato and Rotorua/Bay of Plenty regions, but conditions are apparently too warm at lower altitudes north of Auckland. Frost tender when young, it soon becomes hardy, and has survived temperatures of -9C. In the North Island, growth has been successful at altitudes up to 550 m. It prefers light loamy soils, but clays are tolerated. *E. fastigata* is considered to be more wind-firm than radiata pine.

E. fastigata, Poverty Bay

E. obliqua

This species is ideal for clay soils. It also grows in shallow limestone soils and can tolerate exposure and frost after the first year unless the winters are unusually severe. It is also able to withstand the effects of salt winds. *E. obliqua* is best suited to conditions in the Waikato, Taranaki, Canterbury and Marlborough regions. Northland is apparently too warm and Southland too cold. Annual rainfall of at least 1000 mm is required. Growth is best on medium clays with good drainage but satisfactory on most sites other than dry stony areas. It is not successful at altitudes higher than 600 m in the North Island.

E. regnans

This species grows well at medium altitudes in the North Island and in South Island coastal areas. It can tolerate exposure, and has been known to survive temperatures of -9°C. It cannot withstand drought, poor drainage, salt winds or continuous severe frost. It grows well on clay soils of medium fertility and on pumice soils in warmer areas, especially when fertiliser is applied. On pumice soils growth appears to be controlled by pH, aspect and soil depth. *E. regnans* grows well in areas with high rainfall and also in drier regions, provided soil moisture is adequate. Best growth is seen in Otago and Southland. In Canterbury trees perform better when located on a river bank or by a water race. Northland is outside the optimum climate range, but good performance has been noted in cool shady valleys. In the South Island the altitudinal limit for this species is about 300 m. In the North Island, best growth can be expected between 300 and 600 m. Like *E. fastigata*, *E. regnans* is considered to be more resistant to wind damage than radiata pine.

E. nitens

This species is sensitive to sustained drought, low rainfall and hot dry winds, but is able to tolerate snow, frost, heavy (moist) soils and exposure. It is suited to colder regions and areas with climatic variability. Although *E. nitens* can withstand temperatures as low as -15C, trees approximately 20 m in height did not survive temperatures of -17C at Tara Hills (Central Otago). In warmer areas this species becomes susceptible to leaf fungi and can be completely defoliated.

E. nitens, Otago

E. nitens, Bay of Plenty

Stringybarks (and *E. pilularis*)

E. microcorys, **Northland**

E. globoidea

Good growth has been observed in the Northland, Waikato, Bay of Plenty, Taranaki and Banks Peninsula regions. Rainfall preferences are considered to be 1000-1500 mm annually. Frost tenderness precludes planting in cold areas, although trees at Whakarewarewa (Rotorua) have withstood temperatures of -9°C. *E. globoidea* requires some shelter from wind. Growing best in moist, free-draining soils it has succeeded on sands and pumice, but not on dry sites, hard clays, or where drainage is poor. Planting should be restricted to cooler sites below 300 m in the central North Island.

E. globoidea, Bay of Plenty

E. muelleriana, Bay of Plenty

E. muelleriana

Although sensitive to frost, this species is more cold tolerant than *E. pilularis* and can be grown in warmer parts of the South Island. Because good drainage is required, hill sites are preferable, especially if soils contain clay. *E. muelleriana* has grown well in the Northland, Waikato, Taranaki and Hawkes Bay regions. At 300 m near Rotorua it has failed in frost hollows where temperatures of -8°C were recorded, but survived on hill slopes. *E. muelleriana* has done well on costal sand dunes in Rangitikei, there are impressive trees scattered throughout the lower North Island. It seems happy on relatively infertile sites and seems to stand exposure to winds and can tolerate some saline winds. It should not be planted above 300 m in the Bay of Plenty or above 150 m in the Hawkes Bay or Taranaki regions. Although plantings of *E. muelleriana* at Kawerau (Bay of Plenty) and Frankton (Hamilton) were destroyed by frost, some seed lots (provenances) have been found to be more susceptible than others, confirming the need for matching the seed origin with site which will improve the likelihood of successful establishment.

E. pilularis

This species performs best on well drained, moist sites in milder areas. It can withstand occasional mild frosts. Although it tolerates poor clays, growth is better on pumice soils. Plantings in the Auckland, Waikato, Bay of Plenty and Hawkes Bay regions have been successful. In Northland it grows well on gumland clays at Riverhead and also on clay loams and sandy loams. In Taranaki and Hawkes Bay it performs reasonably well on moist clay loams providing drainage is good. It has performed well on coastal sand dunes in Rangitikei, though has proven somewhat

drought sensitive, it tolerates saline winds. The altitude limit is probably about 150 m in the northern part of the North Island. At 300m near Rotorua, it failed due to the effect of frost. There have also been reports of widespread frost damage in Northland.

E. pilularis, Northland

E. saligna, Bay of Plenty

Gums

E. botryoides

This species has a wide tolerance range. It can withstand frosts and salt spray, but not strong winds. It will grow on a range of sites including swamps, dry clay hills and open sand dunes, provided that rainfall is adequate, but requires access to some fertile soil for timber growing growth rates. It has done well on moist, heavy clays. In the North Island it has not performed well at altitudes above 150 m and it is only occasionally successful south of Taranaki and Hawkes Bay. Nevertheless it has withstood temperatures of -10C. *E. botryoides* has proved very attractive to many of the insect pests that have arrived from Australia over the last 20-30 years and this has lead to it being abandoned as a candidate for large scale planting. However, some individual trees seem to show considerable insect resistance or tolerance.

E. saligna

Requiring well-drained soils and sheltered sites, this species cannot withstand strong or salt winds, or drought. On the other hand it grows in clay with low nutrient levels and can survive temperatures of -7C. Wind damage has been observed when stocking density is low, and avoidance of exposure is important. This species has performed well on very poor clays at Riverhead in Northland and on clays and silty soils in areas where annual rainfall exceeds 1000 mm. It has survived at 450 m near Taihape but should not be planted above 300 m in the central North Island.

A trial comparing the performance of 20 eucalypt species and two eucalypt hybrids at a range of sites

E. regnans, E. delegatensis, E. fastigata, E. oreades, E. fraxinoides, E. obliqua, E. sieberi, E. obliqua x *E. regnans, E. regnans x E. fastigata, E. nitens, E. saligna, E. viminalis, E. dalrympleana, E. johstonii, E. gunii, E, dunii, E. cypellocarpa, E. andrewsii, E. campanulata, E. dendromorpha, E. stenostoma* and *E. triflora.*

The trials were assessed at age 9 years. Climate conditions were classed as "mild" at Rotoehu Forest near Te Puke (70 m), "intermediate" at Waiotapu Forest near Reporoa (380 m) and "cold" at Matea Forest near Taupo (920 m).

E. delegatensis and *E. dendromorpha* were considered to perform best at the cold, high altitude site. Trees from a seedlot of *E. delegatensis* obtained from Victoria, Australia, showed the best growth at this site.

E. delegatensis growth was satisfactory at the intermediate site but poor at the mild, low altitude site.

E. fastigata was one of the best-performing species at the mild, low altitude site. Growth was satisfactory at the intermediate site and at the cold site, some seed lots grew well. This was the only species considered to tolerate conditions at all three sites.

E. obliqua was rated as a species tolerant of mild and intermediate conditions, but trees did not have good form.

E. regnans produced best growth at the intermediate site.

E. nitens grew well initially at all three sites but mature foliage was attacked by the tortoise beetle *Paropsis*, which reduced tree vigour. At the warm, low altitude site, leaf spot fungi caused complete loss of juvenile leaves at age 5 years. Despite these problems it was concluded that if, in the future, *Paropsis* could be controlled economically with chemicals or biological agents, *E. nitens* would become one of the most favoured eucalypt species.

E. saligna was ranked highly at the mild, low altitude site, but only 18% survival was recorded at the intermediate site.

Source: Johnson and Wilcox 1989

Matching eucalypt species requirements to local site and climatic conditions was suggested by Simmonds as long ago as 1927, and has been evolving ever since, mainly with regard to temperature and frosting patterns.

Simmonds' observations remain valid after 80 years, and his species groupings are reproduced here as a guide for prospective planters. Species introduced to New Zealand since 1927 have been added to Simmonds' climatic groups, and an additional group (VI), representing the most cold-hardy eucalypts, has been added.

Table 7: Guide to the site tolerance of eucalypt species in New Zealand

GROUP I FROST-FREE .....

Species adapted to sites where frost-free or almost frost free winters are followed by long hot summers.

Estimated range of mean annual temperature for successful growth: 15° to >18°C.

Probable limit of resistance to cold for seedlings and young saplings: -2° to >1°C.

C. calophylla
C. citriodora
C. gummifera
C. maculata
C. tessellaris
E. cornuta
E. gomphocephala
E. marginata
E. patens
E. propinqua

GROUP II SLIGHT FROSTS .....

Species adapted to sites where slight frosts occur in winter, the spring is usually warm, the summer hot and autumn calm and sunny.

Estimated range of mean annual temperature for successful growth: 14° to >16°C.

Probable limit of resistance to cold for seedlings and young saplings: -4° to -1°C.

C. ficifolia
E. acmenoides
E. agglomerata
E. cladocalyx
E. crebra
E. deanii
E. diversicolor
E. grandis
E. microcorys
E. paniculata
E. pilularis
E. punctata
E. resinifera
E. robusta
E. siderophloia

GROUP III MILD TO SHARP FROSTS .....

Species adapted to sites where mild to sharp frosts occur in winter and occasionally in spring, the summer is usually hot and the autumn calm and sunny.

Estimated range of mean annual temperature for successful growth: 12° to 15°C.

Probable limit of resistance to cold for seedlings and young saplings: -7° to -3°C.

E. bosistoana
E. botryoides
E. camaldulensis
E. capitellata
(*E. elata*)
E. eugenoides
E. globoidea
E. haemastoma
E. laevopinea
E. leucoxylon
E. longifolia
E. melliodora
E. microcarpa
E. moluccana
E. muelleriana
E. piperita
E. quadrangulata
E. saligna
E. sideroxylon
E. sieberi
E. tereticornis

GROUP IV LIGHT FALLS OF SNOW .....

Species adapted to sites where there are light falls of snow in some years, hard frosts occur in winter and early spring, and summer and autumn are usually warm, without temperature extremes.

Estimated range of mean annual temperature for successful growth: 11° to 14°C.

Probable limit of resistance to cold for seedlings and young saplings: -9° to -6°C.

E. andrewsii
E. blaxlandii
E. bridgesiana
E. fastigata
E. fraxinoides
E. globulus
E. goniocalyx
E. maidenii
E. obliqua
E. oreades
E. ovata
E. polyanthemos
E. regnans
E. risdonii

GROUP V MODERATE FALLS OF SNOW .....

Species adapted to sites where there are moderate falls of snow in most years, very hard frosts occur at intervals from late autumn to early spring and summers are variable, but usually warm.

Estimated range of mean annual temperature for successful growth: 10° to 13°C.

Probable limit of resistance to cold for seedlings and young saplings: -11° to -8°C.

E. amygdalina
E. coccifera
E. dalrympleana
E. deanii
E. delegatensis
E. macarthurii
E. macrorhyncha
E. nitens
E. pauciflora
E. radiata
E. smithii
E. viminalis
E. youmanii

GROUP VI VERY COLD SITES .....

Species adapted to very cold sites where there are moderate falls of snow in most years and very hard frosts are common.

Estimated range of mean annual temperature for successful growth: 7° to 10°C.

Probable limit of resistance to cold for seedlings and young saplings: -14° to -10°C.

E. aggregata
E. gunnii
E. neglecta
E. pauciflora
E. stellulata
E. urnigera

Farm forestry eucalypt siting study

With support from the Ministry of Agriculture and Forestry and the Sustainable Farming Fund (SFF Project L03/007), the Eucalypt Action Group of the New Zealand Farm Forestry Association conducted a project in which research packs were distributed to farm foresters. Each pack contained 15 trees of a number of eucalypt species suitable for production of durable timber. The focus was primarily on the "stringybark "group of eucalypt species, and a few other non stringybark eucalypts species that have very similar wood properties. Two species, *E. fastigata* (non durable) and *E. maidenii* were included as indicator species due to the large amount of trial data that already exists for them both in New Zealand and world wide. The trees were planted throughout New Zealand, eleven species in 2004 and five in 2005 (Table 8).

Table 8: Eucalypt species used in the Farm Forestry Site Trial

Species	No. of sites planted	Year of planting
E. baxteri	13	2004
E. blaxlandii	9	2005
E. cameronii	4	2005
E. fastigata	46	2004
E. globoidea	41	2004
E. laevopinea	44	2004
E. longifolia	16	2005
E. macrorhyncha	41	2004
C. maculata	21	2004
E. maidenii	44	2004
E. microcorys	35	2004
E. muelleriana	33	2004
E. obliqua	15	2005
E. pilularis	35	2004
E. tereticornis	4	2005
E. youmanii	44	2004

Survival data from these trials in 2006 suggest that these species can be assigned to three distinct groups on the basis of tolerance to low temperatures:

- Group A: Requirement for 275.1-350.0 frost-free days
- Group B: Requirement for 200.1-275.0 frost-free days
- Group C: Requirement for 100.1-200 frost-free days

Group A: Requirement for 275.1-350.0 frost-free days:

C. maculata, E. microcorys, E. pilularis, E. tereticornis.

These were the most frost-tender, surviving only in areas with a warm climate. Results confirmed the view that *C. maculata* and *E. microcorys* are vulnerable to frost and that *E. pilularis* is only slightly more cold tolerant. *E. tereticornis* was planted at four sites only, and its inclusion in this group is therefore provisional.

Group B: Requirement for 200.1-275.0 frost-free days

E. baxteri, E. cameronii, E. globoidea, E. laevopinea, E. longifolia, E. macrorhyncha, E. muelleriana.

This group survived better on a greater range of sites than species in Group A.

Survival rates were higher at low altitudes, although some species performed well above 500 m. Inclusion of *E. muelleriana* in this group was surprising as this species is reputed to be frost tender. Performance may have been influenced by air drainage or by the provenance of the seedlot. *E. cameronii* was planted at four sites only and its inclusion in this group is therefore provisional.

Group C: Requirement for 100.1-200 frost-free days

E. blaxlandii, E. fastigata, E. maidenii, E. obliqua, E. youmanii.

These were the hardiest species tested. Although all survived well at altitudes up to 700 m (some at 900 m on one central North Island site), best performance was observed at the lowest altitudes in mild temperatures. *E. blaxlandii* was planted at four sites only and its inclusion in this group is therefore provisional.

Maps showing areas in New Zealand suited to the temperature requirements of eucalypt species are shown below.

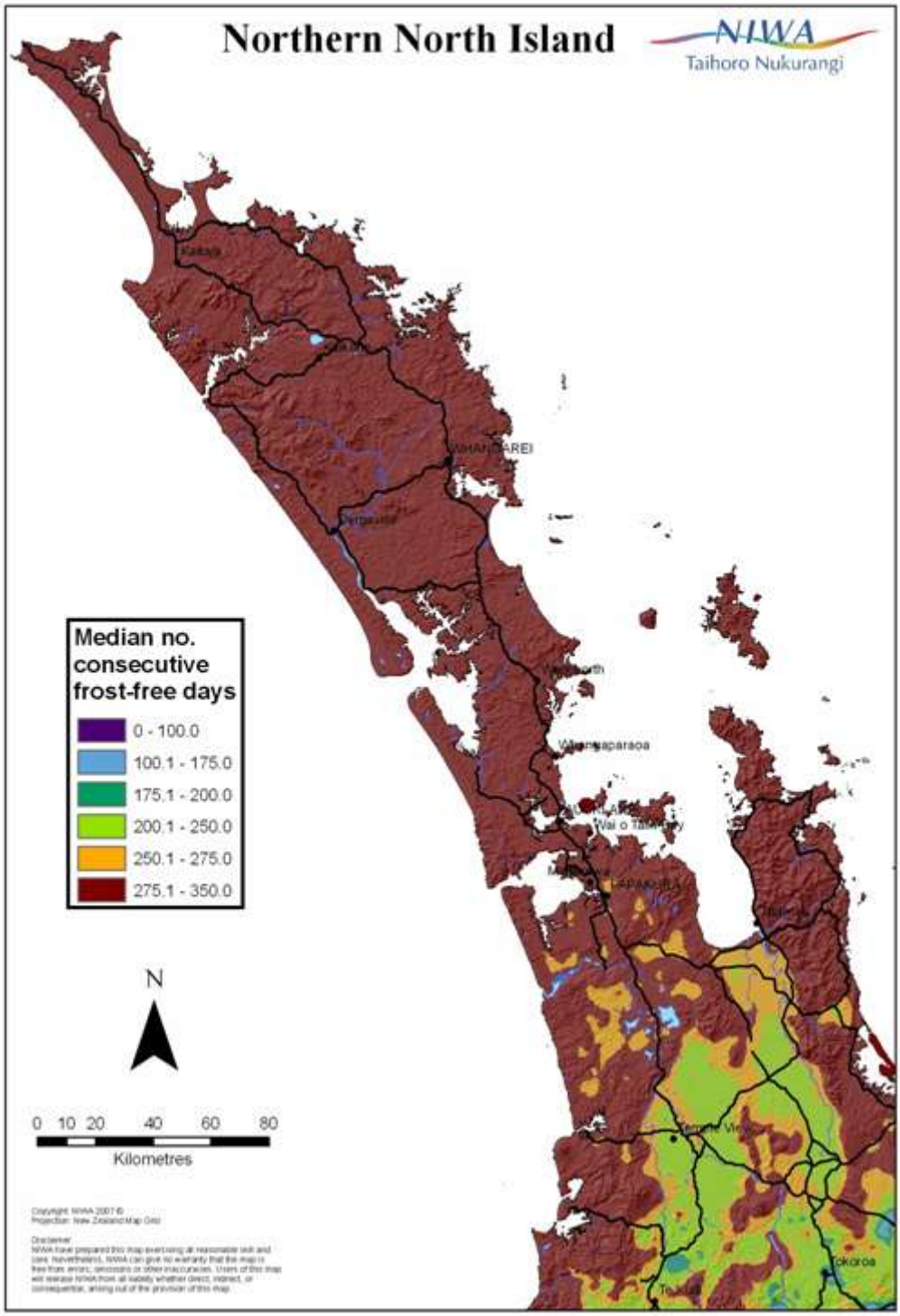
Conclusions drawn from the trial:

- Durable timber eucalypts can be established throughout New Zealand, but species must be matched to climatic conditions.
- Air drainage will improve establishment of trees at sites where frost may be a problem.
- Conditions at some sites are too severe for timber-producing eucalypts.
- Conditions required for growth of the main timber-producing eucalypts in New Zealand are summarised in Table 9.

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]

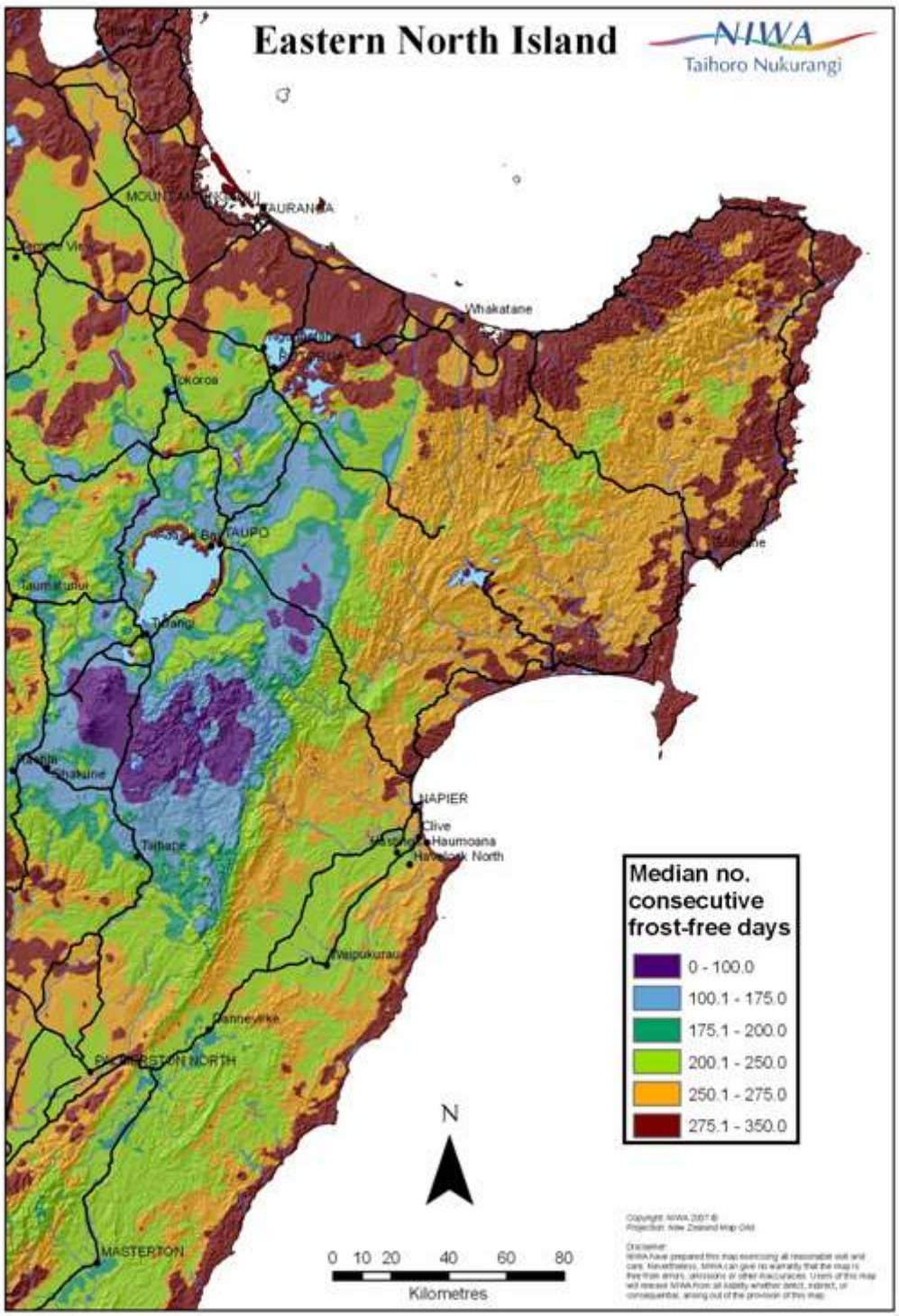


Climate map of Northern North Island to help with eucalypt siting decisions

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]

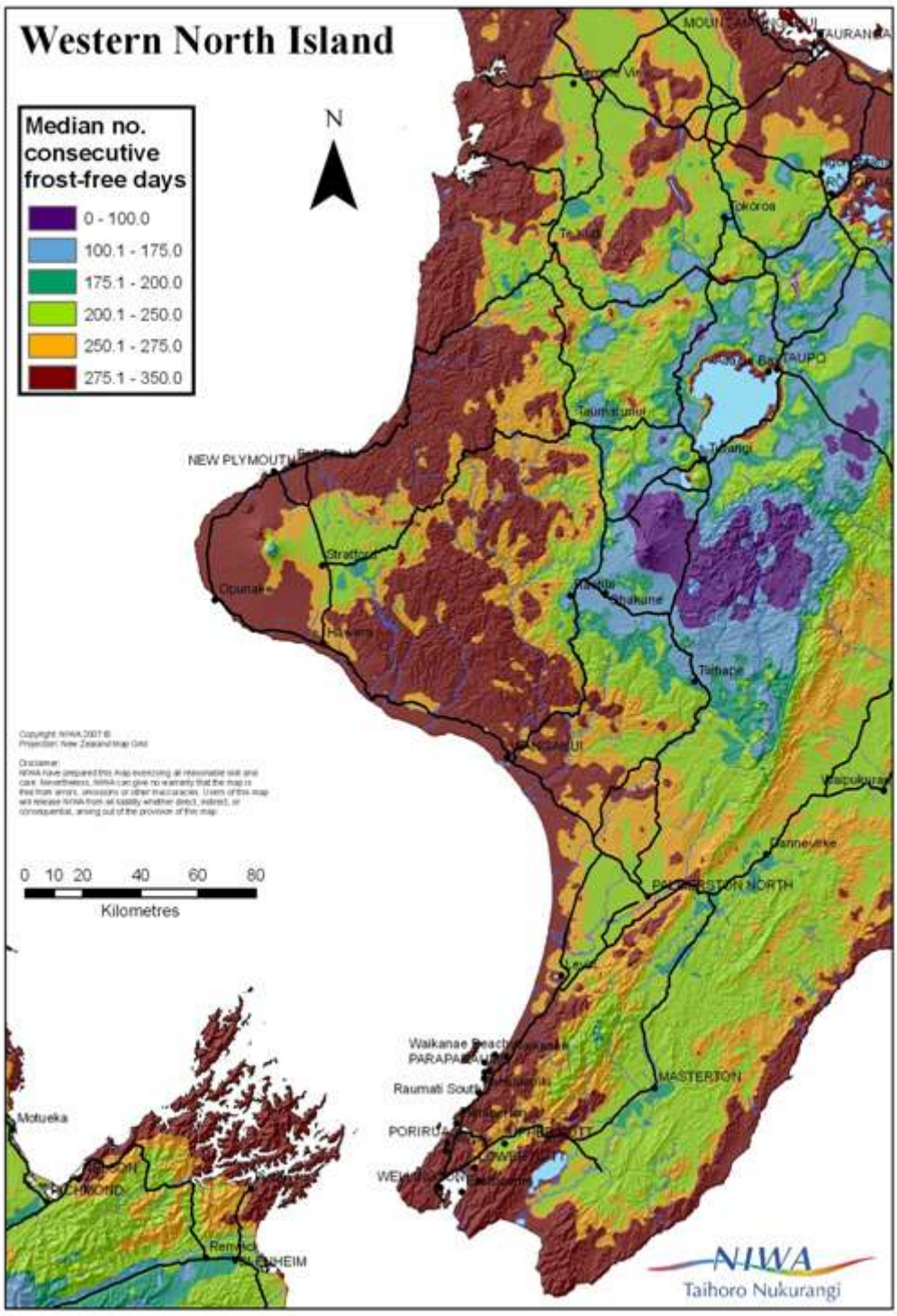


Climate map of Eastern North Island to help with eucalypt siting decisions

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]

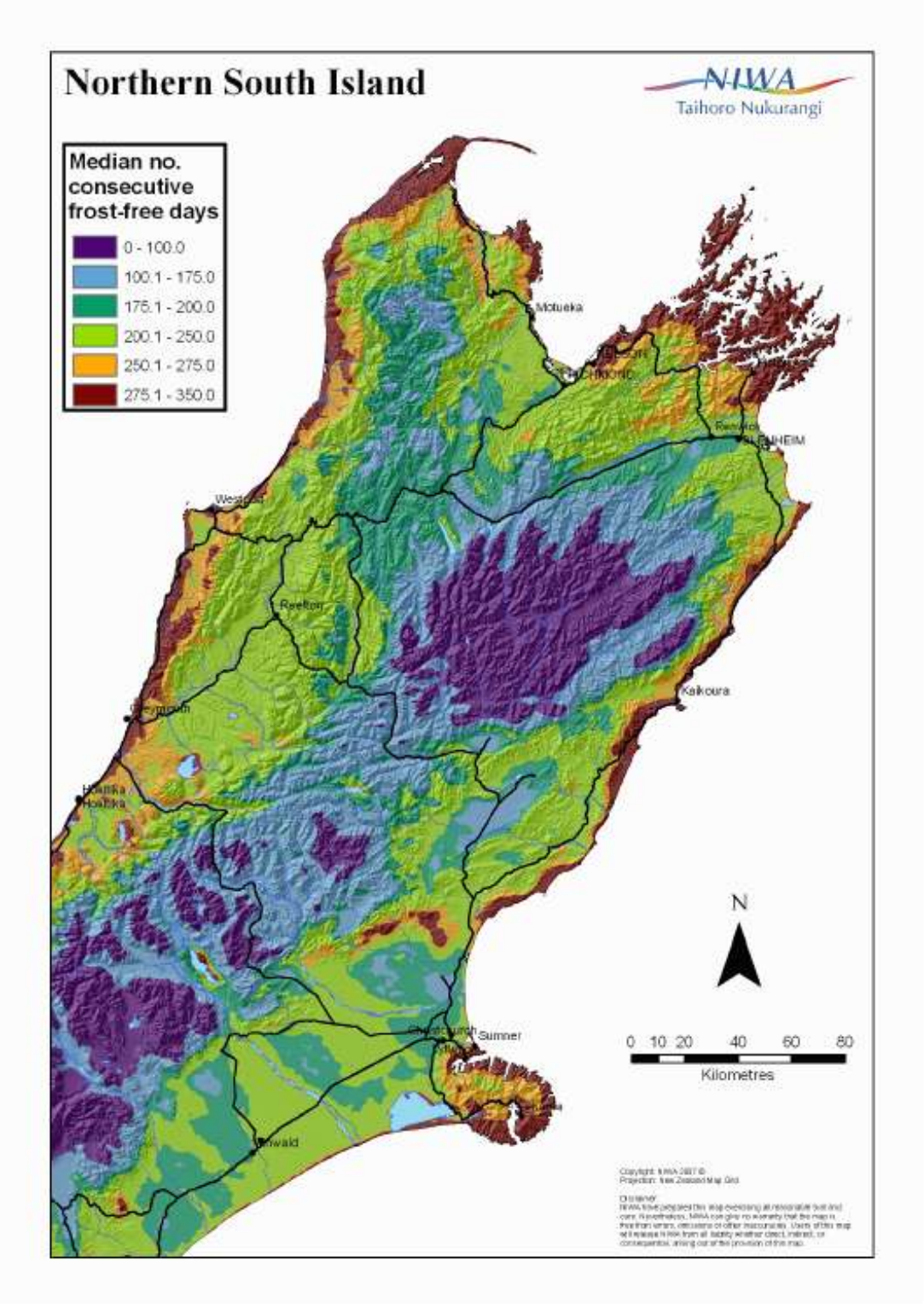


Climate map of Western North Island to help with eucalypt siting decisions

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]

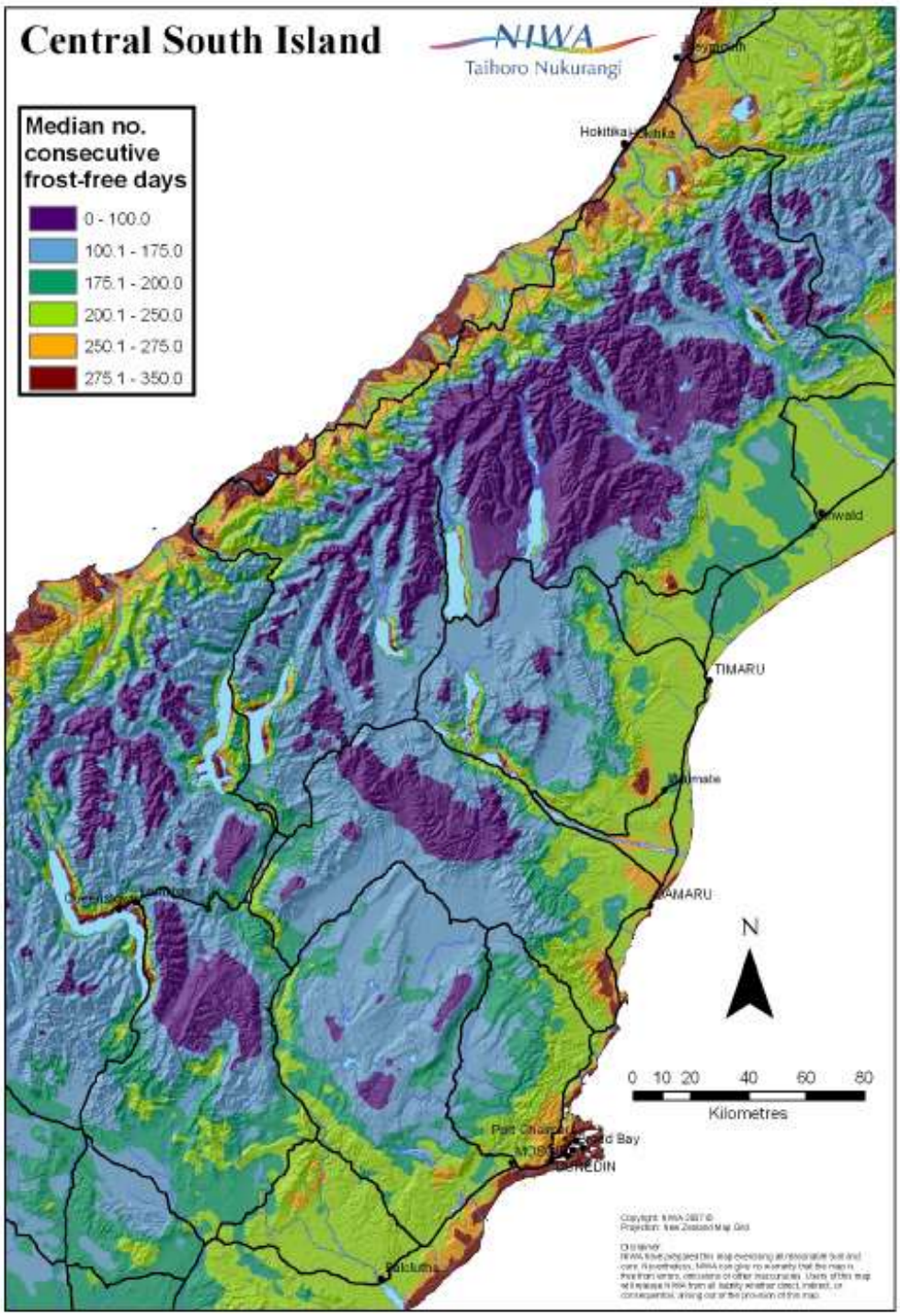


Climate map of Northern South Island to help with eucalypt siting decisions

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]

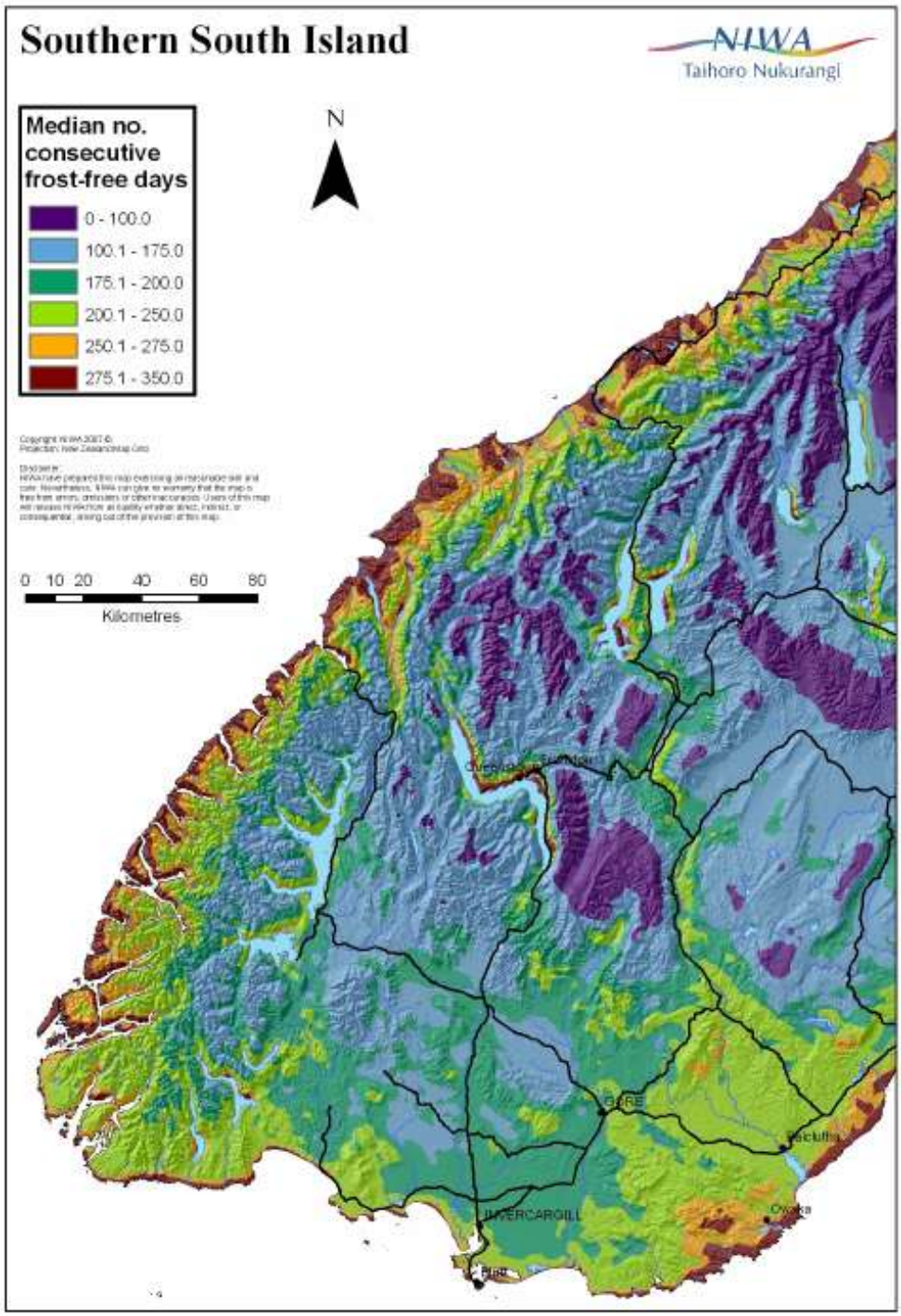


Climate map of Central South Island to help with eucalypt siting decisions

Mild sites: [275.1-350 frost free days

Cool sites: **[200.1-275 frost free days]**

Cold sites: [100.1-200 frost free days]



Climate map of Southern South Island to help with eucalypt siting decisions

Table 9: Summary of site requirements of some eucalypt species suitable for timber production

Species	Soil fertility tolerances and drainage requirements	Sensitivity to exposure	Lowest temperature tolerated	Suitability for hill country	Comments
E. botryoides	Infertile, Moist sites	Intolerant	-8°C	Marginal	Tolerates poor drainage and heavy soils. Susceptible to insect attack (gall producers and lerps).
E. fastigata	Fertile, Free drainage	Tolerant	-10°C	Suitable	Suitable seedlots required.
*E. globoidea**	Infertile	Medium	-6°C	Suitable	Site selection (temperature) critical.
*E. muelleriana**	Infertile, Free drainage	Medium	-5°C	Suitable	Site selection (temperature) critical.
E. nitens	Fertile	Tolerant	-15°C	Suitable	Mild sites should be avoided. Susceptible to leaf eating insects.
E. obliqua	Free drainage	Tolerant	-10°C	Marginal	Seedlots variable, tolerates dry conditions.
*E. pilularis**	Infertile, Free drainage	Intolerant	-4°C	Marginal	Site selection (temperature) critical.
E. regnans	Fertile, Free drainage	Tolerant	-9°C	Suitable	Frost resistant seedlots available.
E. saligna	Fertile, Free drainage	Intolerant	-7°C	Marginal	Susceptible to insect attack (gall producers and lerps).

* Severe drought is not tolerated.

For marginal frost sites a policy of planting container grown stock in mid to late spring, with fertilizer and good weed control, will often ensure that trees are tall enough in their first winter to withstand some frosting. Regardless of theory, the best guide to what species are likely to thrive on a particular site will be what is already thriving in the area, with due regard to micro-environmental effects. Seek advice from the local farm foresters and try to plant the best timber quality species that are performing on similar, local sites.

Key Points

- Individual eucalypt species have specific cold tolerance characteristics.
- Some eucalypts can tolerate cold sites.
- Some eucalypts are very sensitive to frost.
- It is important to match species to site conditions.
- Different eucalypt subgenera and species vary in their requirements for fertility.
- Different eucalypt species vary in their tolerances for wet and very dry sites.
- Micro-environmental influences can be very important in supporting or hindering the growth of eucalypts.

Suggested reading:

Barr 1971, 1996

Carter 1989

Florence 1996

Johnson & Wilcox 1989

Milligan 1989

Mortimer & Mortimer 1984

Nicholas & Calderon 1989

Nicholas 1991

Simmonds 1927

Snowdon 2003

Stockley 1973

Weston 1957

Yeates 1948