Forestry Tasmania
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Native Forest Silviculture

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Rainforest Silviculture

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PART A: Silvicultural prescriptions for the management of rainforest

1. INTRODUCTION

Suitable areas of rainforest and mixed forest have been designated Special Timbers Management Units (Forestry Tasmania 1995) in accordance with the Forest and Forest Industry Strategy (FFIC 1990) and the Tasmanian Regional Forest Agreement (Commonwealth of Australia and State of Tasmania 1997).

This bulletin provides silvicultural information for the management of rainforest in Special Timbers Management Units. The information is largely derived from logging and regeneration trials established by Forestry Tasmania during the period 1976 to 1986. Results from these trials indicate that successful regeneration can be obtained with the use of appropriate silvicultural systems in M+ (tall myrtle) and some M- (short myrtle with celery-top pine) rainforests.

Forestry Tasmania has formulated separate policies for the management of Huon pine and King Billy pine (Forestry Commission 1990a) and is developing a general policy for rainforest on Multiple-Use Forest. The Tasmanian Regional Forest Agreement (RFA) designated 405 000 ha, or 68%, of rainforest as being within the Comprehensive, Adequate and Representative (CAR) reserve system on public land.

2. SILVICULTURAL SYSTEMS

Rainforest has evolved to regenerate without catastrophic disturbance such as fire. Its natural method of regeneration is for seedlings to colonise gaps created in the forest by the death or windthrow of older trees. The silvicultural prescriptions are an adaptation of this system and important considerations are:

Seedfall

Adequate seed is provided by retaining seed trees, particularly of myrtle which is the dominant rainforest species. Seedtrees must have healthy crowns. Heavy myrtle seeding (a mast year) occurs every 2 to 4 years. The seed cycle should be monitored before logging takes place. About 10% annual mortality of seedtrees can be expected from myrtle wilt.

Shelter

Survival of rainforest seedlings is greatest in partial shade. Small seedlings are susceptible to summer drought in open conditions. Additional trees of any species should be retained for shelter purposes. Regeneration of other species such as leatherwood will often result from seed shed from these retained trees.

Seedbed

Regeneration is best where a disturbed seedbed is provided. Seedlings do not survive when seeds germinate on a thick litter layer or in thick fern. Ground scarification after logging may be necessary to increase seedbed area.

Sufficient Light

Rainforest seedlings are very tolerant of shady conditions, but in shade their growth rates are extremely slow. Sufficient light for good growth is provided by removing commercial stems.

Protection

Rainforest seedlings and seedtrees are killed by fire. They have limited mechanisms for recovery from fire. Rainforest logging and regeneration areas have an elevated risk from fire for at least 5 - 10 years and must be kept separate from eucalypt silvicultural systems which involve a hot slash burn.

Young rainforest seedlings are susceptible to browsing, predominantly by pademelons. Survival and growth rates of some species can be greatly reduced. Browsing control may be necessary for areas with high browsing pressure.

2.1 Prescription for M+ Rainforest (dominated by tall myrtle on fertile sites)

The silvicultural prescriptions for logging and regeneration of M+ rainforest are summarised in Figures 1 - 3.

These are the most productive of Tasmania's rainforests in terms of commercial timber production. They should be regenerated to rainforest using either an overstorey retention system or selective sawlogging (See Part B, Section 6). Clearfelling is an inappropriate harvesting technique where the management objective is to regenerate rainforest.

The choice of silvicultural system is influenced by forest condition, market factors (especially pulpwood markets), economics, community attitudes and myrtle wilt levels. More vigorous regeneration will be obtained using an overstorey retention system where more of the sawlog and pulpwood trees are removed. This also gives a higher commercial return from the harvest. However, the structure of the forest is significantly altered and the new forest may be more even-aged than the previous one.

Community attitudes or the absence of pulpwood markets may result in selective logging, primarily for sawlogs, being chosen. This system retains the original stand structure and most aesthetic values but forest productivity is low as only the best trees have been removed and regeneration grows slowly under the heavy shade. If sawlog yields are low they may be insufficient to meet roading, harvesting and management costs. Selective sawlogging can increase levels of myrtle wilt which, if prolonged, will significantly reduce stand productivity and aesthetic values. Myrtle wilt levels are considered high if the number of myrtles with brown leaves in the undisturbed stand is greater than three per hectare.

For both overstorey retention or selective sawlogging systems:

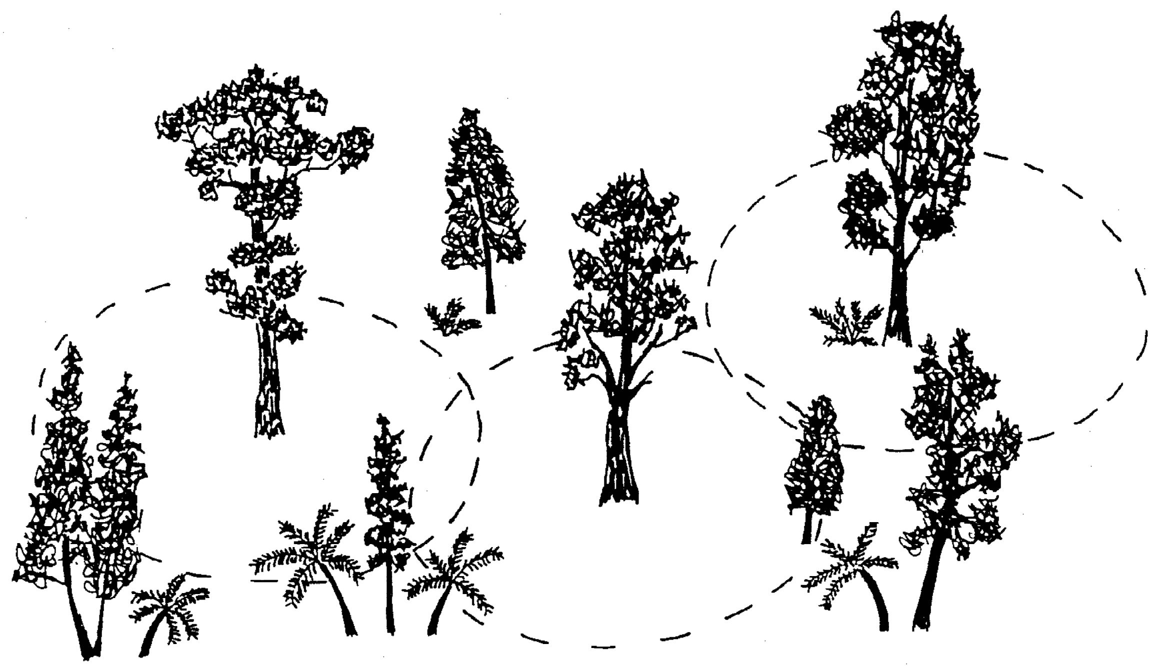
* the myrtle seed cycle should be monitored using the method described in Appendix 1,
* all patches of existing regeneration and advance growth should be retained as they represent many valuable years of seedling establishment and growth,
* good crown health and sound footing is important when selecting seedtrees, as the trees must be able to survive for up to four years to provide seed. Seedtrees do not need to have sawlog form,
* damage to retained trees should be minimised to reduce mortality due to myrtle wilt,
* disturbed seedbed should be created where regeneration is required, and
* fire should be excluded.

OVERSTOREY RETENTION

Where sawlog and pulpwood trees are harvested, retain an overstorey of 30 healthy, evenly spaced trees per ha:

* with at least 50% to be evenly spaced myrtles,
* the remainder to include all tree species such as sassafras and leatherwood,
* avoid damage to retained stems to minimise myrtle wilt, and
* survey 2 - 5 years after logging to monitor establishment of regeneration using the modified standard 'A' regeneration survey shown in Appendix 2.

Figure 1. Overstorey retention
Retain myrtle seedtrees plus shelter trees of any species to give a total of 30 trees per hectare at 15 - 20 m spacing.



Note that some pulpwood will arise from the heads of sawlog trees and from felled trees that have the outer appearance of sawlogs but, when felled, have excessive levels of internal decay.

Post-logging monitoring includes seedbed assessment, browsing severity and seedfall monitoring. This process is detailed in Figure 3.

Selective sawlogging

Where individual tree selection occurs primarily for sawlogs, veneer or craftwood:

* retain all non-sawlog trees to provide seed and shelter for regeneration,
* avoid disturbance to areas containing non-sawlog stems.
* to avoid canopy gaps greater than 30 m in diameter, retain myrtle seedtrees on a 15 - 20 m spacing, and
* Survey 2 - 5 years after logging to monitor establishment of regeneration using the modified standard 'D' regeneration survey shown in Appendix 3.

Figure 2. Selective sawlogging
Retain non-sawlog trees to provide seed and shelter. To avoid canopy gaps greater than 30 m, retain myrtle seedtrees at 15 - 20 m spacing.

Note that some pulpwood will arise from the heads of sawlog trees and from felled trees that have the outer appearance of sawlogs but, when felled, have excessive levels of internal decay.

Post-logging monitoring includes seedbed assessment, browsing severity and seedfall monitoring. This process is detailed in Figure 3.

Figure 3. Seedbed preparation and monitoring for M+ rainforest.

Establish at least two indicator plots on disturbed seedbed.
(Do not hand sow the plots.)

OVERSTOREY RETENTION

SELECTIVE SAWLOGGING

ASSESS SEEDBED

Myrtle regeneration is optimum on areas where a mineral soil seedbed is exposed. Seedlings rarely survive in areas of thick fern or on logs.

Is there at least 50% ground disturbance?

No

Scarification or snigtrack extension is required to increase receptive seedbed.
Retained stems must not be damaged.

Yes

Seedbed adequate.

MONITOR SEEDFALL

Has a mast year occurred since logging?

No

Continue to monitor seedfall, myrtle wilt and windthrow until a mast seed year occurs.

Yes

MONITOR BROWSING DAMAGE

Is browsing severe?

No

Yes

Browsing control should take place over winter.

REGENERATION SURVEY

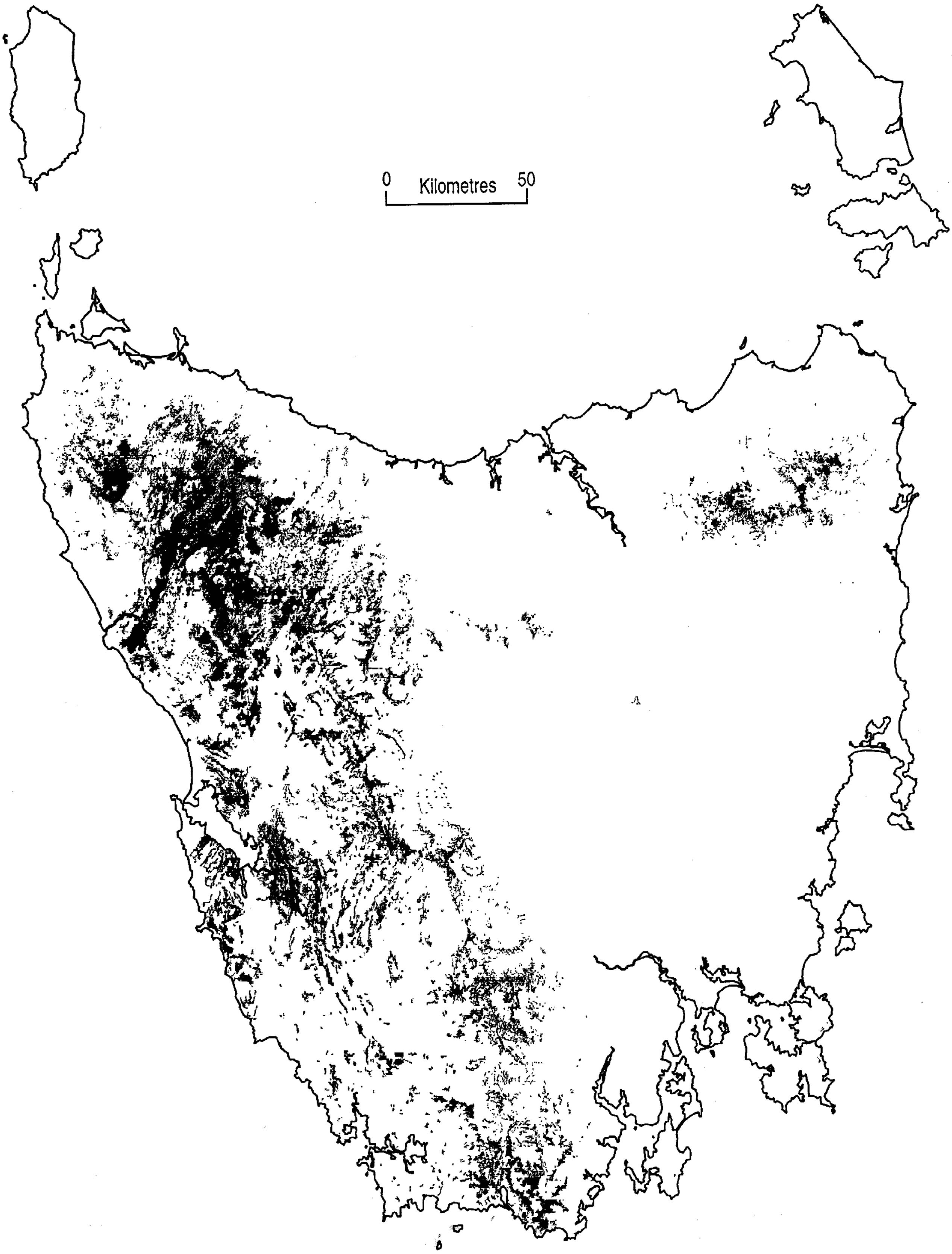
Regeneration surveys should be undertaken as soon as new seedlings are properly established. This may take 2 - 5 years.

For overstorey retention areas where most sawlog and pulpwood trees have been harvested, use the modified stocking standard 'A' regeneration survey as shown in Appendix 2.

For selectively sawlogged areas where utilisation levels are low, use the modified stocking standard 'D' regeneration survey as shown in Appendix 3.

RESULTS FROM REGENERATION SURVEYS MAY ALTER FUTURE PRESCRIPTIONS.

Figure 4. The distribution of rainforest map of Tasmania (from Hickey *et al.* 1993).
The map includes all photo-interpreted forest patches which contain myrtle and which have less than five percent eucalypt crown cover (areas of pencil pine forest are not shown).



2.2 Prescription for M- Rainforest (shrubby, found on infertile sites).

Many M- sites are not suitable for wood production. Soils are poor and often peaty and disturbance can lead to site degradation. Where logging occurs, disturbance to the sub-surface peat should be minimised. The peat layer should not be removed or burnt (see part B, Section 7).

M- rainforest rich in celery-top pine

The objective is to harvest the commercial celery-top pine and minimise damage.

* Remove selected sawlog trees while minimising damage to the peat layer and remaining vegetation.
* Retain myrtle and leatherwood stems for shelter and leatherwood nectar resource.
* Retain all advance growth regeneration.
* Protect from fire.
* Survey 5 years after logging to monitor establishment of regeneration using the modified stocking standard ‘D’ shown in Appendix 3.

Germination of celery-top pine will occur from ground-stored and bird-dispersed seed but growth rates will be extremely slow.

M- rainforest not rich in celery-top pine

* There is a high risk of site degradation on these poor soils (see Part B, Section 7.2).
* Logging in this forest type is not recommended.

M- rainforest dominated by Huon pine

Silvicultural prescriptions will be developed for individual stands. (See prescriptions for Teepookana in Part B, Section 8).

PART B: Ecology and silviculture of rainforest

1. DEFINITION

The temperate rainforests of eastern and southeastern Australia can be divided into warm and cool temperate forests. Cool temperate rainforest is restricted mainly to Tasmania and Victoria, with small patches in New South Wales.

Cool temperate rainforest in Tasmania has been defined by Jarman and Brown (1983) as forest communities with trees greater than 8 m in height dominated by one or more of the following species: myrtle (*Nothofagus cunninghamii),* sassafras (*Atherosperma moschatum*), leatherwood (*Eucryphia lucida),* celery-top pine (*Phyllocladus aspleniifolius*), King Billy pine (*Athrotaxis selaginoides),* pencil pine (*Athrotaxis cupressoides),* Huon pine (*Lagarostrobos franklinii)* or *Diselma archeri*. A list of common and scientific names of rainforest plants is provided in Appendix 4. Rainforest is capable of regenerating in the absence of broadscale disturbances such as wildfire.

Tasmanian cool temperate rainforest is comprised of two alliances, the myrtle beech alliance and the pencil pine alliance (known locally as montane rainforest). The myrtle beech alliance includes most of the rainforest in Tasmania and occurs from the lowlands to the highlands. It can be divided into three groups termed callidendrous, thamnic and implicate rainforest, on the basis of floristics and structure (Jarman *et al*. 1984, 1991, 1994). The pencil pine alliance is a small group confined to high altitudes, mainly in central Tasmania.

Eucalypts are not considered rainforest species as they generally require fire to regenerate. For forest management purposes a stand of rainforest species and eucalypts is considered rainforest if the eucalypt crowns cover less than 5% of the stand (Hickey and Felton 1991).

Traditionally, much of the Tasmanian rainforest was considered to have low commercial value for wood production due to its inaccessibility, high proportion of defective wood, small log sizes and slow growth rates. Past utilisation was confined mainly to selective logging for sawlogs of myrtle and the native conifers (Hickey 1990). However, greater awareness of both the commercial and non-wood values of rainforest has increased the debate on the management and utilisation of Tasmanian rainforests.

2. DISTRIBUTION

Rainforest occurs from sea level to over 1000 m elevation in western Tasmania with some tracts in the northeastern highlands and smaller patches elsewhere. It is most extensive in the north-west where it occurs adjacent to and interspersed with mixed forest. Patches become more fragmented on the west coast and in the south-west where scrub and buttongrass moorlands increase. In drier areas of Tasmania it is found in sheltered wet gullies. The total area of rainforest in Tasmania in 1993 was estimated to be 563 100 ha (Hickey *et al*. 1993); its distribution is shown in Figure 4.

Rainfall is the main environmental factor that determines the distribution of rainforest. Annual rainfall must exceed 1000 mm per year and summer rainfall 25 mm per month (Jackson 1968). As a result of higher fire frequency, rainforest is largely displaced from the 1000 - 1500 mm rainfall zone and achieves its best development in areas receiving over 1500 mm rainfall per year. Soil fertility and altitude largely determine the type of rainforest found in any particular place (Jarman *et al*. 1991).

Thamnic, implicate and montane rainforests are endemic to Tasmania while callidendrous rainforest also occurs in Victoria. These main types can be further subdivided into approximately 40 different plant communities. These are described in detail by Jarman *et al.* (1984, 1991).

The most extensive callidendrous forests are in the north-west with patches in northeastern, southeastern and central Tasmania. It is generally found on more fertile soils, such as those derived from basalt in the north-west.

Thamnic and implicate forests are found mostly in the west and south-west. Thamnic forests tend to occur on soils of medium to low fertility, such as those derived from dolomites and Precambrian sediments. Implicate rainforests are often found on very poor soils derived from quartzites (Jarman *et al.* 1991).

3. DESCRIPTION OF RAINFOREST TYPES

3.1 Callidendrous rainforest

Callidendrous rainforest typifies the popular idea of cool temperate rainforest. The name is derived from the Greek words *kalos* (beautiful) and *dendron* (tree), and refers to the well-formed trees present in many forests (Jarman *et al.* 1984). This rainforest is park-like, with large, widely spaced trees producing a dense canopy above a shaded understorey of manferns, a few inconspicuous shrubs or patches of low ground fern. Myrtle is the dominant species and may reach 40 m in height in some communities. Sassafras is sub-dominant and is often multi-stemmed.

The understorey species may include cheesewood, native currant, heart berry and bushman's bootlace. Manferns and cat-head fern are common, while wet fern may be locally dense in disturbed areas. Figure 5 shows the main species and the occurrence of typical rainforest communities within callidendrous rainforest. Species listed in brackets are those which are only sometimes present.

3.2 Thamnic rainforest

The term thamnic is derived from the Greek word *thamnos* (shrub), and refers to the presence of a well developed shrub layer in these forests (Jarman *et al.* 1984).

Thamnic rainforest is intermediate in structure between the tall callidendrous forests and the low tangled implicate communities. It has trees of a similar height to callidendrous forest but is more shrubby below. Myrtle, leatherwood, celery-top pine and sassafras are the most common tree species.

Shrubs are common and may include native laurel, native plum, horizontal and *Trochocarpa* species. Hard water fern is the main ground fern (see Figure 6).

3.3 Implicate rainforest

Implicate forest is named from the Latin *implicatus* meaning tangled or interwoven. It refers to the dense network of stems in the understorey which makes walking through these forests almost impossible (Jarman *et al.* 1984).

Implicate forests are often less than 20 m tall with broken uneven canopies and a dense shrubby understorey. The trees and shrubs form a continuous tangle of twisted stems and low branches. Species such as deciduous beech, celery-top pine, King Billy pine and leatherwood may be co-dominant with such typical understorey species as white waratah, horizontal and pandani (see Figure 7).

Figure 5. Callidendrous rainforest.

Main Species:
myrtle, sassafras, (blackwood, wallaby wood) manferns, ferns, mosses and liverworts.

Occurrence:
fertile soils, lowland areas.

Main Species:
myrtle, woolly teatree (sassafras, celery top pine) waratah, mountain pepper.

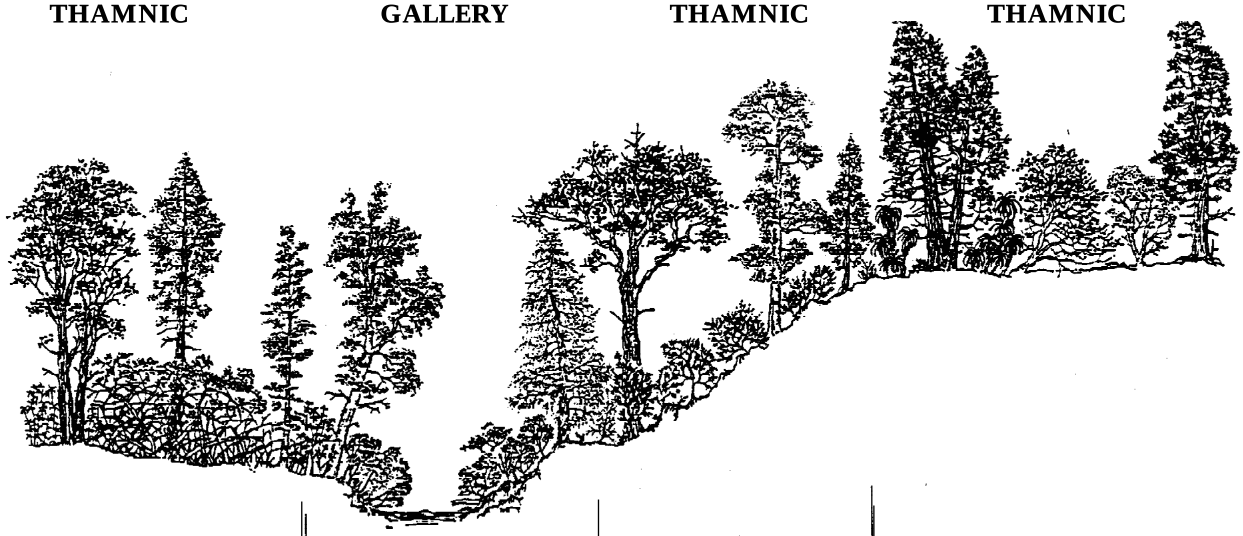
Occurrence:
fertile soils, upland areas.

Main Species:
sassafras, (myrtle, *Eucalyptus regnans*, woolly tea tree) manferns, musk, ferns.

Occurrence:
eastern Tasmania; scattered in gullies and other sites with very high moisture availability.

Figure 6. Thamnic and Gallery rainforest.

THAMNIC **GALLERY** **THAMNIC** **THAMNIC**



Main Species:
myrtle, leatherwood, celery top pine, (sassafras, Huon pine) horizontal, bryophytes, (ferns).

Occurrence:
lowlands of west and southwest, often associated with rivers.

Main Species:
Leptospermum riparium, (*Epacris mucronulata*, leatherwood, Huon pine, myrtle, *Acradenia*) bryophytes, ferns, herbs.

Occurrence:
banks of larger rivers in western Tasmania.

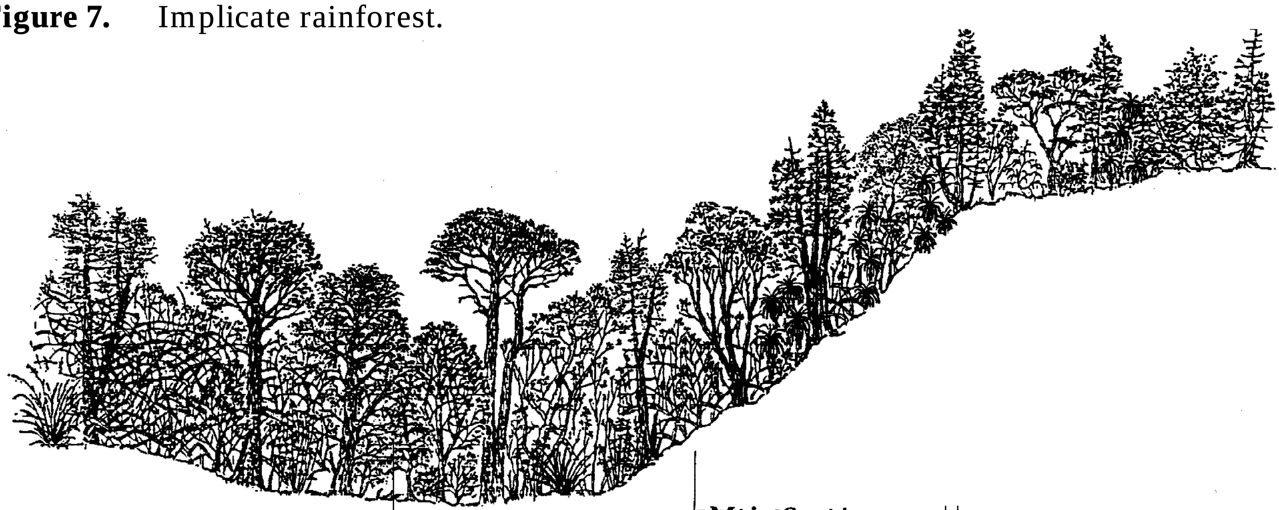
Main Species:
myrtle, leatherwood, celery top pine, (sassafras), *Trochocarpa* spp., *Archeria*, bryophytes, ferns.

Occurrence:
lowlands and uplands.

Main Species:
King Billy pine, (myrtle, leatherwood, celery top pine) pandani, dwarf leatherwood, (horizontal, deciduous beech, *Archeria, Trochocarpa*) bryophytes, (herbs).

Occurrence:
mountain slopes and highlands.

Figure 7. Implicate rainforest.



Main Species: celery top pine, myrtle, leatherwood, (Huon pine, sassafras, paperbark, tea tree) horizontal, native laurel, native plum, white waratah, (*Archeria, Trochocarpa* climbing heath, cutting grass).	**Main Species:** woolly tea tree, celery top pine, myrtle, (sassafras, leatherwood) horizontal, native laurel, native plum, (*Trochocarpa, Archeria*, cutting grass).	**Main Species:** King Billy pine, myrtle, leatherwood, celery top pine, (tea tree) white waratah, pandani, (horizontal, native laurel, native plum, scoparia, climbing heath).	**Main Species:** King Billy pine, celery top pine, deciduous beech, (myrtle, leatherwood) diselma, (pandani, scoparia).
Occurrence: lowland.	**Occurrence:** poorly drained lowland sites.	**Occurrence:** high altitude (above 500 m).	**Occurrence:** high altitude (above 800 m).

Figure 8. Montane rainforest.

Main Species: pencil pine, *Poa* spp., *Danthonia* spp.	**Main Species:** pencil pine, diselma, *Microcachrys, Microstrobos,* scoparia, *Orites, Leptospermum rupestre*.	**Main Species:** pencil pine, deciduous beech, pandani.
Occurrence: highland areas, eg Walls of Jerusalem.	**Occurrence:** boulderfields and rocky sites in highland areas, eg. Mt. Field, Labyrinth.	**Occurrence:** rocky sites in highland areas, eg. widespread on Central Plateau.

3.4 Montane rainforest

Montane rainforests are usually less than 15 m tall and dominated by pencil pine. The canopy is uneven and open with the crowns widely spaced allowing high light penetration to the lower levels of the forest. The understorey is a dense low shrubbery of coniferous species with deciduous beech, scoparia and *Orites* species (see Figure 8). Montane rainforests are restricted to highland situations.

3.5 Gallery rainforest

Gallery rainforest is found along the margins of rivers, creeks and lakes. It occurs in a variety of vegetation types in narrow bands which may be only a few metres wide. It contains a variety of rainforest, riparian and other species, either derived from the surrounding vegetation or spread opportunistically by water-dispersed seed (see Figure 6).

4. *REGENERATION IN UNDISTURBED RAINFOREST.*

Myrtle, leatherwood and sassafras are able to regenerate, more or less continuously, in small canopy gaps in undisturbed rainforest (Read and Hill 1988). Myrtle may show little regeneration under an unbroken canopy, particularly if the seedbed is poor due to excessive litter or fern layers. Leatherwood and sassafras are less affected by adverse conditions for seedling establishment because of their higher frequency of vegetative regeneration. Although sassafras is the most shade tolerant species (Read 1985) and might be expected to eventually dominate the rainforest canopy, it often fails to regenerate from seed, probably due to summer desiccation (Read and Hill 1988) and its high palatability to browsing mammals (Hickey 1982).

The rainforest conifers often show population structures that suggest regeneration has been episodic, presumably following large-scale disturbance which leads to establishment over some decades followed by a reduction in further recruitment as the canopy closes. Such regeneration has been described by Barker and Kirpatrick (1994) for celery-top pine; Gibson and Brown (1991) and Shapcott (1991) for Huon pine; and Cullen (1987) for King Billy pine. Celery-top pine regeneration is favoured by catastrophic disturbances including fire but it is also able to regenerate, to some degree, with minimal disturbance where it shows a preference for elevated sites including logs, buttresses and old stump mounds (Barker and Kirkpatrick 1994).

5. DEVELOPMENT OF SILVICULTURAL TREATMENTS

In the past, myrtle sawlogs were selectively harvested from the rainforest. Little care was taken not to damage retained stems and many subsequently died from myrtle wilt. This produced some large areas of open degraded rainforest. In other areas, regeneration has been quite successful on disturbed areas and snig tracks, with non-commercial stems acting as seed and shelter trees. Early observations from these areas indicated that rainforest was quite resilient and could be regenerated after logging if conditions were favourable.

From 1982 - 1991 a moratorium generally precluded wood production operations in rainforest on public land. Special Timbers Management Units (STMUs), containing areas of rainforest and mixed forest, have since been designated as the main ongoing source for special timbers. In two or three decades the supply of rainforest timbers from areas outside STMUs will be highly variable but generally low, because the planned rotation length of 80 - 100 years for regenerated mixed forest is too short for the development of rainforest species to sawlog size (Hickey and Savva 1992). Careful selection of small areas of rainforest for timber production presents the opportunity for future utilisation of rainforest species on a much longer rotation.

Research into regeneration systems for rainforest commenced in north-western Tasmania in 1976. Fourteen rainforest logging and regeneration trials were established over the next 10 years. These have shown that dense myrtle regeneration occurs after logging on fertile sites if seedbed is exposed and trees are retained for seed and shelter. The development of silvicultural techniques for rainforest also drew on New Zealand experience (eg. Wardle 1984) in similar forests, particularly those dominated by silver and red beech.

Rainforests on the better-quality sites are suitable for wood production for three main reasons:

* these forests are floristically simple and their major species have reliable regeneration pathways,

* on good sites, growth rates are reasonable and there are few site degradation problems, and

* wood quality and form are relatively good.

Prescriptions for logging and regeneration of these forests have been developed and are detailed in Part A, section 2.

Rainforests on the poorer-quality sites may not be suitable for wood production because:

* regeneration is more complex due to greater species diversity than in rainforests on better sites,

* sites are susceptible to soil degradation and growth rates are extremely slow, and

* logging of these forests is often not commercially viable.

6. SILVICULTURE OF TALL MYRTLE (M+) FORESTS

Callidendrous and the taller thamnic forests are identified on forest type maps as M+ rainforest. They usually have higher gross bole and sawlog volumes than M- forests. M+ forests are dominated by myrtle but may also contain small quantities of other commercial species such as sassafras and leatherwood. If all merchantable products are harvested they may yield up to 50 m^3 of myrtle sawlog and 300 m^3 of myrtle pulpwood per hectare (Hickey and Felton 1991).

The regeneration system used after logging depends on the level of utilisation, as determined by management objectives. This may vary from selective logging of sawlogs to an overstorey retention system where there is utilisation of both sawlogs and pulpwood, but at least 20% of the original canopy is retained for seed and shelter from summer desiccation.

Selective sawlogging is a lower impact system which more closely approximates natural gap regeneration of the rainforest but also increases the incidence of myrtle wilt above the natural background level. This may result in large open gaps which are unregenerated in the short term. Regeneration relies on the non-commercial stems providing both seed and shelter but will only occur where a seedbed is exposed. Regeneration establishment generally occurs within one to five years and the result may be patchy, depending on seedfall, seedbed and light availability. Partial canopy retention helps to maintain some of the aesthetic and structural components of the rainforest unless a localised wilt epidemic occurs. Dead myrtle trees and those dying from wilt reduce these values and constitute a high fire risk.

The overstorey retention system requires a market for pulpwood and is a higher impact system than selective sawlogging. Regeneration establishment takes place over a shorter period, seedling growth is faster because of greater light availability, and a more even-aged forest results. To maximise growth of the regeneration it would be ideal to remove the overstorey about 5 - 10 years after harvesting. This silvicultural system would then be described as a shelterwood system. However the depletion of the retained trees by myrtle wilt, windthrow and exposure combined with their often low commercial value usually results in an overstorey removal harvest being unnecessary or impractical. Healthy surviving seedtrees also have value as oldgrowth structures which have biodiversity and aesthetic values.

Small coupe sizes are preferred so that some seeding and sheltering from the surrounding unlogged forest occurs.

Each of the major rainforest tree species has its own regeneration strategy. Some rely on sporadic heavy seedfall, some on frequent light seeding, while other species favour vegetative reproduction. Common to all rainforest species is the ability to regenerate without broadscale disturbance such as fire.

Successful regeneration of tall myrtle rainforest depends on five major factors:

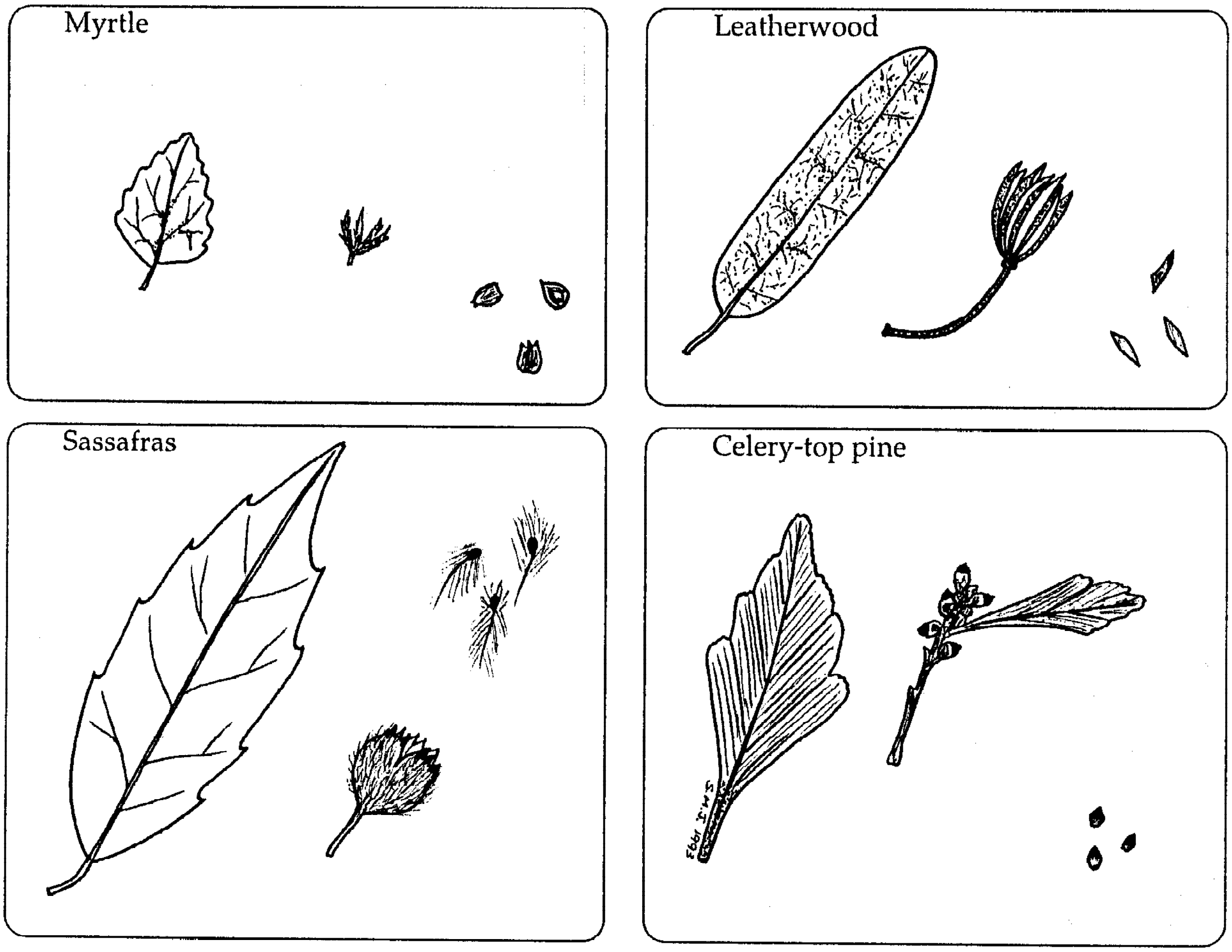
* good seedfall,
* adequate shelter,
* suitable seedbed,
* sufficient light, and
* protection from fire and browsing.

SEEDFALL AND GERMINATION

Myrtle: regenerates readily from recently shed seed. Flowering occurs in October/ November and the main seedfall period is from January to May, peaking in February/March (Hickey *et al*. 1982). Myrtle seedfall is periodic, with a heavy seedfall (mast seed year) occurring approximately every three years with a usual range of two to four years. Rainforest seedfall can be measured using a 1 m^2 funnel trap to collect all litter and seed that falls during the seedfall period. The seed collected is then sorted into species and weighed. Myrtle seedfall may vary from approximately 0 - 2 g per m^2 during a poor seed year to 6 - 80 g per m^2 during a mast seed year, with moderate seedfalls in between. Seed viability is also greatest in a mast seed year (Hickey *et al*. 1982). Myrtle seed appears to be short-lived and does not store well. In the field, seed is unlikely to survive and germinate in the following season (Howard 1973). A simplified method of seedfall assessment for field use is described in Appendix 1.

Sassafras: produces seed consistently each year but also relies heavily on vegetative reproduction. Flowering occurs in August and September and seed is shed from late December to March, peaking in January/February. The seed is light and fluffy and can be windborne over long distances, although most falls immediately under the seed source (Hickey *et al*. 1982). Germinative capacity of sassafras seed is generally low (Hickey *et al*. 1982). Sassafras tends to replace itself by coppicing in undisturbed forest, and coppice regeneration has also been observed following logging (Hickey *et al*. 1982).

Figure 9. Leaves, seedbearing material and seed of the major rainforest species.
(Magnification x1)



Leatherwood: produces seed annually and seedfall is more consistent than myrtle. Flowering occurs from December to March but the fruit does not develop until about the following November. Seed is shed from January to May, peaking in February/March, approximately one year after flowering (Hickey *et al.* 1982). Leatherwood does not have a mechanism like sassafras for long distance seed dispersal but the small winged seed is better wind dispersed than myrtle seed and may travel a couple of hundred metres. Leatherwood seed stores poorly (Hickey *et al.* 1982) and is not ground-stored (Neyland and Hickey 1990).

At low to moderate altitudes, myrtle, sassafras and leatherwood germinate in autumn, within one or two months of seed release (Read 1989). At high altitudes (over 900 m), myrtle germination does not occur until spring (Howard 1973, Read 1989). The germinative capacity of myrtle appears to decrease with increasing altitude. Hickey *et al.* (1982) showed 15% lower peak germinative capacity for myrtle at Pipeline (480 m) than at Sumac (200 m) during two mast seed years. This is consistent with a decrease in seed viability with increasing altitude in Victoria reported by Howard (1973), and a similar trend in New Zealand for *Nothofagus menziesii* observed by Manson (1974).

Good myrtle seedfall is best provided by the retention of myrtle seedtrees. Seedtrees should not be overmature or damaged. They should have healthy crowns with no obvious signs of crown dieback. They do not need to have sawlog form. The current appearance of mature rainforest trees is probably a poor indication of their genetic potential. Old trees that are now culls may once have had excellent sawlog form. Poor form may be a result of growing in sub-optimal crown conditions (e.g. under a heavy canopy) or of being damaged by falling trees or branches.

The majority of myrtle seed falls within 20 m of the seed source and therefore seedtrees should not be more than 40 m apart (Hickey *et al.* 1982). A seedtree retention rate of 10 -12 live healthy trees per ha at time of seedfall (approximately 30 m x 30 m metre spacing) adequately covers the area and makes some allowance for variation in spacing, availability of suitable trees etc. In general 15 trees per ha should be retained as a **seed source** to allow for losses due to windthrow, myrtle wilt and poor seed crops. Additional trees should also be retained to provide **adequate shelter** for young regeneration.

Retained seed trees may need to survive for up to four years after logging before a mast seed year occurs. Seedfall should be monitored so that the occurrence of mast seed years can be roughly predicted. Logging trials have shown that initial seedtree mortality of 10% per annum from wilt and windthrow is likely, and numbers of retained seedtrees should be sufficient to allow for this mortality. Logging supervision must ensure that contractors are properly trained in seedtree selection and retention.

SHELTER

Rainforest species germinants are susceptible to summer droughting. They rarely survive their first or second summer in clearfell areas if they germinate on logs or a thick litter layer or in open gaps with no shade. The good-quality rainforest sites tend to have free-draining soils and the poorer quality sites are often on gravels and peats. Most sites dry out very quickly once the vegetation layer is removed. Shelter trees need to be retained after logging to prevent droughting of the regeneration.

In addition to trees retained as a myrtle seed source, a minimum of 15 additional trees per ha of any species should be retained. These shade trees also provide a seed source for species other than myrtle. In areas where leatherwood is present, Ziegler (1992) recommends that leatherwood trees be amongst those retained for seed and shelter to provide a continued flowering presence and successful regeneration for ongoing leatherwood honey production.

Adequate shelter will generally be provided by the remaining stems where selective sawlogging occurs. Additional disturbance or removal of non-commercial species to create seedbed should not be required. Where rainforest logging occurs at higher altitudes, more shelter is required to protect the young germinants from frost.

SEEDBED

Research trials have shown that myrtle and leatherwood seedlings establish more successfully on a mineral soil seedbed than on seedbeds with a layer of litter or vegetation. Successful seedling regeneration is prevented by layers of ferns such as cat-head fern or hard-water fern which are common under rainforests, and dense patches of wet fern which colonise rainforest gaps. In undisturbed rainforest, seedling regeneration is common on root balls and mounds of soil resulting from windthrow of mature trees. In logged areas, most myrtle and leatherwood regeneration is found on snig tracks or other places where mechanical disturbance has occurred.

Adequate seedbed may be provided by disturbance during the logging operation. However, if an area which has been logged is judged to have insufficient disturbance, then additional scarification or "snig track extension" is necessary. A machine is used to disturb the humus, litter and ground vegetation. This can be done during or immediately after logging and may take one to two hours of bulldozer work per hectare. It is important that the soil is not compacted or scalped by the scarification.

In selectively logged areas where the aim is to minimise damage and disturbance, seedbed will be provided by snig tracks only. Use of more minor snig tracks rather than a few major ones would increase the area covered, but the risk of increasing wilt in the remaining myrtle stems is very high if additional machine disturbance occurs. Selective sawlogging will result in patches of regeneration where canopy gaps, ground disturbance and seedfall coincide.

Where logging to full commercial utilisation has occurred, approximately 65% ground disturbance is recommended (Kelly 1989) to enable adequate stocking of regeneration to cover the area. It is extremely important not to damage seed trees and shelter trees during this operation. All advance growth regeneration should be retained.

Rainforest soils which have been undisturbed for long periods of time contain few ground-stored seeds of competing species. The seedbed remains receptive for several years unless colonised by wet fern. Colonisation of the mineral soil seedbed by stinkwood, dogwood, eucalypts, dollybush, cutting grass, thistles, foxgloves etc. could prevent successful establishment of rainforest regeneration. Rainforests that have been previously cut-over or disturbed, or are adjacent to other forest types or rural land, are more likely to support competing vegetation.

LIGHT

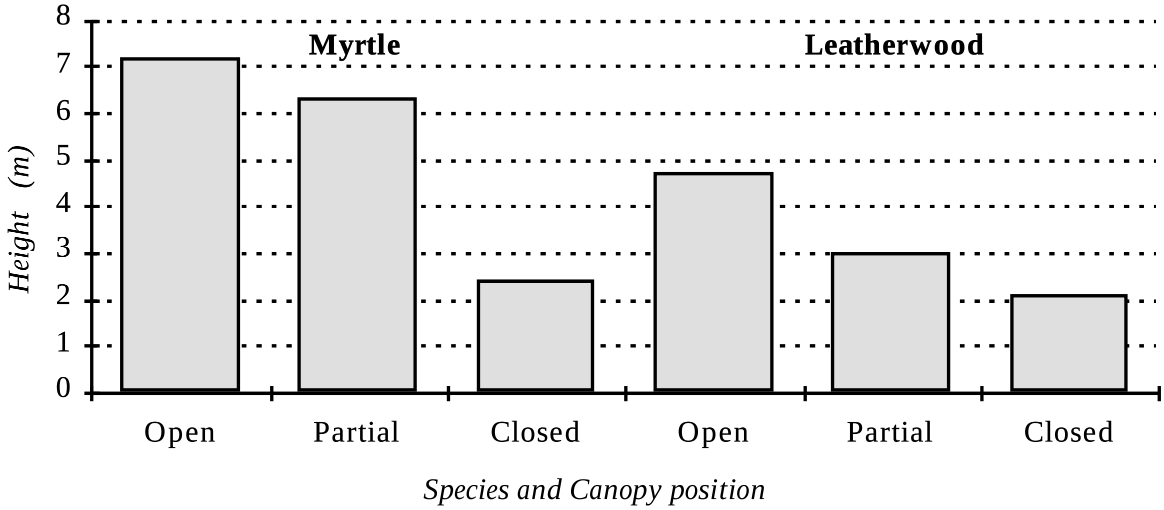
Initial survival of rainforest germinants is best in partial shade, but the growth of established seedlings is greatest in full light. There is considerable variation between the rainforest tree species in their ability to tolerate shade. Read (1985) measured light compensation points of seedlings (i.e. the light intensity at which photosynthesis just balances respiration) and found that the most shade tolerant tree species was celery-top pine followed by sassafras. Myrtle and leatherwood were less shade tolerant with similar light requirements.

Research trials have shown that the maximum height growth of myrtle seedlings after logging is about 40 cm per year over the first two decades. The growth rate of regeneration in selectively logged areas is proportional to the level of shading. Growth rates are very slow for seedlings under complete canopies.

Where a selective sawlogging system is used and the emphasis is on minimal damage and disturbance, slow growth rates must be accepted. These differences are shown in Figure 10 (Forestry Tasmania 1996).

In areas where the rainforest timber is fully utilised, there should be little problem with light availability for seedling regeneration after logging. However, where faster growth rates are important and retained stems are suppressing the regeneration, removal of seed and shelter trees after establishment of regeneration is an option. The trees can either be removed commercially, cull felled or killed and left standing. Damage to regeneration must be minimal. While seed and shelter trees remain, there is continued seedfall, some of which results in successful regeneration. If remaining trees are removed, there will be no further regeneration from seed.

Figure 10. Height at age 18 years for regeneration of myrtle and leatherwood originating under open, partial and closed canopies.



PROTECTION

Fire

Most rainforest tree species are killed by fire. They have limited mechanisms for recovery, although myrtle, leatherwood and sassafras have been observed resprouting after fire (Barker 1991). Seedling regeneration will appear on burnt areas if a seed source is available. Post-fire regeneration tends to be more flammable than mature rainforest (Barker 1991).

Trials have shown that the seedtree method of regeneration results in an elevated fire risk for at least five years (Julius Dolomite Trial: logged 1981, burnt 1986; Sumac 28 Trial: logged 1983, burnt 1988; Sumac 7 Trial: logged 1984, burnt 1988). These fires were escapes from regeneration burns of nearby clearfelled eucalypt forests. Careful planning is necessary to ensure that areas logged using this method are protected from fire. Logging and regeneration of rainforest must be kept separate from areas where slash burning systems are used for eucalypt regeneration.

Myrtle wilt

Myrtle wilt is a disease caused by the fungus *Chalara australis* and is the main cause of myrtle death in undisturbed stands (Kile and Walker 1987). Surveys of undisturbed forest throughout Tasmania showed that on average about 24% of standing myrtle were dead or dying from the disease (Elliott *et al.* 1987, Packham 1991).

Damage or wounding of trees provides a direct infection site for *Chalara*, therefore mechanical disturbance such as logging or thinning increases myrtle wilt incidence and mortality due to wilt. Epidemics can kill up to 70% of the mature myrtles and can often be avoided by minimising disturbance (J. Packham pers. comm.). The disease may spread below ground from tree to tree. Retained seedtrees, particularly if damaged, have a very high risk of dying from myrtle wilt.

However, some sites are more at risk from myrtle wilt than others. Packham (1991) has listed the predisposing factors which identify higher risk areas of forest:

* low altitude forests are more at risk than high altitude forest,
* callidendrous forests are more at risk than thamnic and implicate forests,
* stands of high myrtle density (130 - 250 stems per ha) are more likely to suffer severe attack than those with less myrtle,
* mixed forest may be more at risk than pure rainforest of a comparable myrtle density,
* trees with a large diameter are more susceptible than trees with a smaller diameter and trees of less than 12 cm diameter at breast height (DBH) are not usually attacked,
* any stand adjoining or near an area of myrtle forest which has high levels of wilt or is disturbed, has itself an increased probability of severe attack.

It is likely that most areas of rainforest suitable for wood production will be:

* at low to moderate altitude,
* callidendrous or better quality thamnic forest,
* moderate to high myrtle density, and
* contain medium to large diameter trees.

This puts them in the high risk category for myrtle wilt.

Mortality is likely to be higher where background levels of active myrtle wilt are high or where there has been recent disturbance within or surrounding the coupe. Myrtle trees with brown leaves are a good indicator of trees currently dying from wilt. Elliott *et al.* (1987) found that the average number of myrtle trees dying from myrtle wilt across 20 rainforest sites in Tasmania was 2.4 stems per ha. Myrtle trees take from one to three years to die from wilt (Kile *et al*. 1989) and are infective for most of that time (J. Packham pers. comm.). Packham (1991) found that in some logged or thinned areas, the elevated mortality due to wilt eventually dropped to a more normal level over a period of 4 to 13.5 years.

Although thamnic and implicate rainforests generally have a lower incidence of myrtle wilt than callidendrous forests (Elliott *et al.* 1987), logging trials have shown that mortality of retained trees is high if they are damaged.

Browsing

Some rainforest species are highly palatable to native mammals. In areas of high browsing pressure, successful regeneration of these species may be rare. Research trials have shown that all species have better survival and growth rates inside fenced plots. Although conditions are otherwise suitable, sassafras is often absent outside fenced areas, or is found only under logs or growing high on manferns out of reach of browsing animals.

Damage is caused predominantly by pademelon (*Thylogale billardierii*) and to a lesser extent Bennetts wallaby (*Macropus rufogriseus*), which prefers drier and more open habitat.

Different plant species have different levels of palatability and can be used as an indicator of browsing (Hickey 1982). Only the most palatable species (sassafras, blackwood, native currant, bushman's bootlace and heartberry) will be eaten when browsing pressure is low. As the number of browsers increases or the food supply diminishes, leatherwood, cheesewood and myrtle are eaten. Browsing pressure is very high when celery-top pine, stinkwood, cheeseberry, pinkberry, native pepper or horizontal are browsed. Where moderate levels of browsing are experienced, regeneration may still be successful but recruitment of seedlings will occur over a longer period of time. Regeneration establishment will fail if high levels of browsing are allowed to go unchecked.

Browsing control may take the form of fencing, shooting or poisoning. Timing of browsing control is important because successful regeneration depends on survival of seedtrees, a mast seedfall and receptive seedbed occurring at the same time.

If browsing control is done too early, before germination is expected, weed species usually controlled by browsing may colonise the seedbed before a mast seed year occurs. If browsing control occurs too late, the flush of germination which results from a mast seed year will be lost and a similar mass germination would not be expected for several years. By this time the seedbed may not be receptive and most of the seedtrees may have died.

The seed cycle and browsing pressure should be monitored so that if the browsing level is high, browsing control can take place at or immediately after germination. Browsing control may be required for two winters following a mast seedfall.

MONITORING

Regeneration surveys should be undertaken when new seedlings are properly established. Regeneration surveys should be carried out five years after logging so that the site has received at least one heavy myrtle seedfall. A modified stocking standard ‘A’ regeneration survey (see Appendix 2) should be used for coupes where most of the trees have been harvested or retained trees have died. Stocking of each rainforest tree species and the tallest height for each species should be noted.

Regeneration standards are preliminary and will be reviewed as more coupes are harvested and surveyed. Hickey (1983) suggested that 10 000 established, well distributed myrtle seedlings per ha at age 5 is a desirable minimum stocking for coupes where the seedtrees and sheltertrees have been removed or died. Research trials showed that this equates to 50% 4 m^2 stocking. The stocking of non-myrtle trees should be recorded but no minimum standards are set as the component of sassafras, leatherwood and celery-top pine in unlogged forest is highly variable.

For selectively sawlogged areas a modified stocking standard ‘D’ (see Appendix 3) is recommended. The main modification is that the stocked retention rate of 12 m^2 of basal area can include non-merchantable trees if they have healthy crowns. Plots which have a basal area of less than 12 m^2 should be searched for seedling regeneration.

Informal monitoring on an annual basis for browsing, windthrow, myrtle wilt, seedfall, seedling growth and seedbed receptivity will assist with the understanding of rainforest silviculture. Prescriptions for future logging areas may be modified.

Remedial treatment of any area is not economically justified, and in most cases slow recruitment will continue for many years if a partial canopy has been retained.

GROWTH RATES AND THINNING

Early results from measurement plots located in dense even-aged stands of myrtle resulting from spot fires and early logging, suggest that at least 200 years are needed to produce myrtle trees of 60 cm dbh. Thinning may reduce rotation lengths to around 100 years (Hickey and Felton 1991) but the cost is likely to be prohibitive. If thinning is prescribed, it should be done while the trees are young and vigorous (up to 40 years of age) or excessive mortality due to windthrow and myrtle wilt may result.

Trial results in vigorous 15-year-old myrtle regeneration in the Sumac rainforest have shown diameter increments of 0.3 - 0.4 cm per year for unthinned plots (50 000 - 100 000 stems per ha) increasing to 0.8 - 1.3 cm per year for thinned plots (1900 - 3000 stems per ha) for the first five years after thinning. However, non-commercial thinning will not produce a future economic return and operational thinning of young stands is therefore not currently recommended.

Thinning of a patch of approximately 70-year-old myrtle forest from 1200 to 460 stems per ha resulted in massive mortality from myrtle wilt and windthrow. Only one third of the retained myrtle stems were alive five years after thinning.

7. SILVICULTURE OF LOW SHRUBBY MYRTLE (M-) FORESTS

Implicate and most thamnic forests are labelled as M- rainforests on forest type maps. They occur predominantly on fibrous peat soils over infertile parent material. Unfortunately the rainforest types are not readily interpreted from aerial photographs (Hickey *et al.* 1993). In some cases, other rainforest types such as previously cut-over M+ or short myrtle forest on fertile sites may also be mapped as M- because of the structure and height of the forest. Recommendations in this section refer only to the scrubbier rainforests on poor soils. These forests are not recommended for logging because of low yields, site degradation problems, regeneration difficulties and slow growth rates. However, where celery-top pine is abundant, logging can be viable particularly if there are nearby stands of eucalypts or M+ rainforest which justify the roading cost (Hickey and Felton 1991).

Another important value of M- rainforest is leatherwood nectar production for honey. The highest yielding leatherwood apiary sites have very substantial levels of M- rainforest within a presumed 3 km foraging radius. Ziegler (1993) suggests that M- rainforest may be the most important forest class for leatherwood honey production, and this importance will rise as mature mixed forest types, available for wood production, are regenerated and managed on rotations of 80 - 100 years for eucalypt sawlogs.

7.1 M- rainforest rich in celery-top pine

Although myrtle is usually the most abundant tree, it generally contains too much defective wood on these less fertile sites, to yield significant sawlog. Celery-top pine is the major sawlog species from most M- rainforests, although its occurrence is sporadic. Average yields from logging and regeneration trials in M- forests containing merchantable quantities of celery-top pine are 20 m^3 celery-top pine sawlog and 70 m^3 myrtle pulpwood per ha (Hickey and Felton 1991). If harvesting of these forests proceeds, then it should be confined to selective logging for sawlogs only.

Selective logging of M- rainforest for sawlogs should have a negligible effect on the leatherwood nectar resource (K. Ziegler pers. comm.) The resulting ground disturbance would provide favourable conditions for the regeneration of celery-top pine, leatherwood and myrtle seedlings as long as the peat layer is not removed.

SEEDFALL AND GERMINATION

Celery-top pine seed production fluctuates from year to year although some seed is produced each year. Seasons of good seedfall often correlate with mast seed years of other rainforest species (Read 1989). Most seedfall occurs from January to June. Barker (1992) found that the timing of seedfall varied between years, and that small amounts of seed continued to fall until September during 1989 (a rainforest mast seed year). It appears that the retention of celery-top pine seedtrees is not necessary for regeneration purposes as celery-top pine seed is both ground-stored and bird-dispersed. The small hard black seeds are partially enclosed within a fleshy receptacle. Birds eat the receptacles and can disperse the seed over long distances.

Celery-top pine germinates sporadically from ground-stored seed. Seedlings establish well if the peat is lightly disturbed but germination is intermittent and may continue for several years. The pattern of seed dormancy of celery-top pine may be similar to that of native pepper, a species which often invades disturbed forest and also has seeds that are commonly bird dispersed (Read and Hill 1983). It is likely that some dormancy mechanism is necessary to survive bird dispersal (Read 1989). The conditions which trigger germination are not understood, but some germination has been obtained from watered soil samples kept in a shadehouse for periods of one to two years. All advance growth seedlings and regeneration should be retained to maintain an uneven-aged structure and to provide a future seed source. It is important that retained trees sustain minimal damage during logging.

SHELTER

Celery-top pine seedlings are shade tolerant and require some shelter for early survival. Their growth rates are very slow and the seedlings remain susceptible to drought for several years. Because M- forests contain a high proportion of poorly formed and defective stems there are usually ample trees retained for shelter even if some pulpwood logging occurs (Hickey and Felton 1991). However, disturbance or removal of the peat layer overlying these infertile soils during logging has the potential to produce serious degradation and erosion of these sites. These impacts are reduced if low intensity logging (e.g. sawlogging only) is carried out.

PROTECTION

Browsing

Celery-top pine seedlings are not palatable to wildlife and browsing is not usually a problem. However, in areas of high browsing pressure, planted seedlings have been browsed completely within a few days.

Phytophthora cinnamomi

Root rot is a disease which results from infection by the soil-borne fungus *Phytophthora cinnamomi*. It infects a wide range of plants causing rot of the fine feeder roots, larger roots, root collars and lower stems (Wardlaw 1990). In many species it results in death of the plant.

Generally, soil temperatures are too low under a closed rainforest canopy for the fungus to be active but it can be destructive if the canopy is removed by events such as fire (Podger and Brown 1989). Implicate and thamnic rainforests contain more susceptible species than callidendrous rainforest.

Phytophthora is widespread in Tasmania. In rainforest it appears to be confined to areas of disturbance. The fungus was first isolated from dying seedlings of rainforest regeneration on road verges in south-western Tasmania in 1983 (Podger and Brown 1989). Podger and Brown did not recover it from any site in undisturbed rainforest. They found the most common occurrences and severest effects were on burned or disturbed sites in implicate rainforests over infertile peaty soils.

More open communities are likely to have soil temperatures capable of sustaining infection by *Phytophthora*. Species in the families Epacridaceae (e.g. pandani, pinkberry, cheeseberry), Proteaceae (e.g. banksia, waratah, white waratah) and Eucryphiaceae (e.g. leatherwood) are highly susceptible (Podger and Brown 1989). Celery-top pine is also susceptible.

MONITORING

A survey of natural regeneration should be carried out five years after logging (see Appendix 3). Remedial treatment cannot be justified. Monitoring should assess the progress of regeneration and be used to amend the prescriptions if the results are not satisfactory.

GROWTH RATES

Growth rates of celery-top pine are very slow. Seedlings measured in logging trials under partial canopies have height increments of about 7 cm per year for the first eight years. Ring counts indicate that at least 400 years are needed to grow trees of 60 cm diameter (Hickey and Felton 1991).

7.2 M- rainforest not rich in celery-top pine

These forests do not contain significant amounts of sawlog of any species. The poor quality myrtle and leatherwood may constitute an economic pulpwood resource. However, harvesting of this wood using a high intensity logging system may result in unacceptable disturbance to the site.

8. SILVICULTURE OF RAINFOREST DOMINATED BY HUON PINE

Huon pine occurs in western and south-western Tasmania (Peterson 1990), mainly along the banks of rivers, in several thamnic and implicate communities. About 86% of Huon pine forest is reserved. The Huon pine policy (Forestry Commission 1990a) prescribes a small annual sawlog cut - 500 m^3 per year - from sources such as areas flooded for hydro-electric purposes as well previously cut-over areas outside reserves. The main supply area is the Teepookana State forest, south of the King River.

Huon pine is known to regenerate vegetatively from fallen stems by layering and possibly from broken branchlets striking roots (Hickey and Felton 1991). Seedling regeneration also occurs but is presumed to be less important. Shapcott (1991) found that the germination success after a mast seed year at Riveaux Creek was very low.

A logging and regeneration strategy for areas of Teepookana State Forest has been developed using both seedling and vegetative regeneration. The strategy presribes the following actions:

Pre-Logging

* watch carefully for a mast seed year during early planning stages,
* identify and mark sex of any prolifically coning trees,
* collect cutting material during winter from as many widely spaced trees as possible, to produce a minimum of 100 plants for each ha to be logged,
* note any areas of heavy *Phytophthora* infestation, and
* mark for retention 10 healthy, well-crowned female trees per ha.

Logging

* harvest available commercial Huon pine both standing and on the ground,
* retain advance growth seedlings, taking great care to avoid damage, and
* minimise disturbance to all vegetation layers and to underlying soils.

Post-Logging

* survey surviving natural regeneration to identify understocked areas,
* plant disturbed areas that are understocked with rooted cuttings in winter at a spacing of approximately 5 m x 10 m,
* protect from fire, and
* monitor health of seedtrees, survival of planted stock and establishment of natural regeneration for several years after logging. Results can be used to modify the prescription for future logging.

The aim is to remove merchantable living and dead Huon pine from a designated area with minimum damage to the associated vegetation, leaving enough Huon pine to maintain the local genotypes on site and allow for continued regeneration in the future. By maximising harvest, the area needed to produce the required volume is minimised.

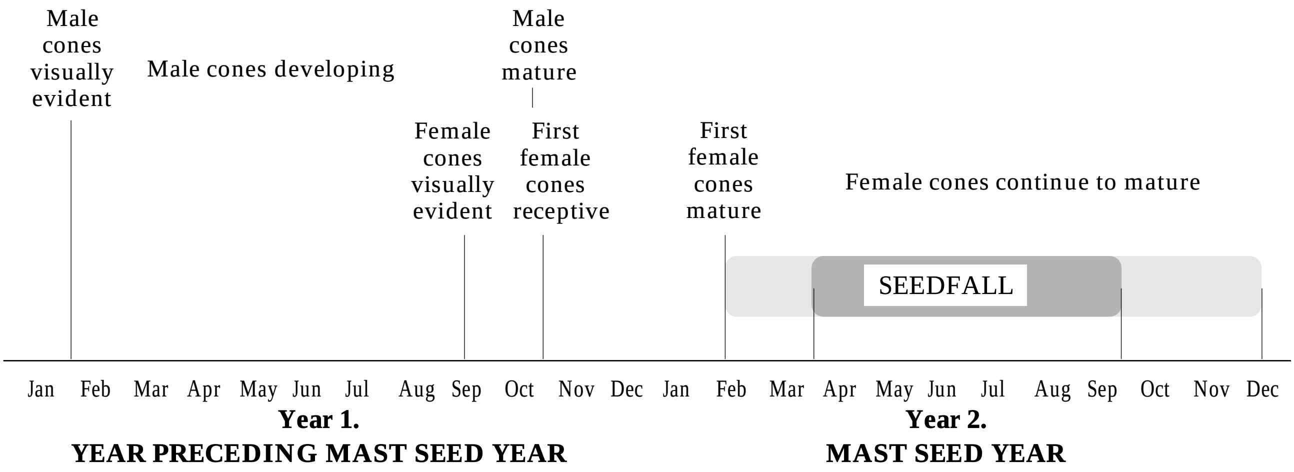
Intensive harvesting allows areas to be left to regenerate without disturbance from repeated harvesting as Huon pine becomes scarcer and more valuable. Huon pine stands vary from site to site. They occur from lowland riverbanks to altitudes of 700 m. Over thousands of years they have formed genetically distinct populations with different age and size structures and sex ratios (Shapcott 1991).

a) Seedling Regeneration

Huon pine is mostly dioecious (having male and female cones on separate plants) and is thought to have years of high seed production (mast years) occurring approximately every 5 to 7 years (Shapcott 1991). The timing of cone development is shown in Figure 11. Foliage and cones are shown in Figure 12. Seedfall started in February at Riveaux Creek during 1989. The peak period of seedfall occurred about 8 weeks later, after which seed continued to fall at a reduced rate. The last of the seed was still dropping in December (Shapcott 1991). Huon pine seed does not appear to persist in the soil beyond a few months after falling (Shapcott 1991).

Continued regeneration should be achieved by retaining a minimum of 10 healthy well spaced Huon pine seedtrees per ha (where they occur). Shapcott (1991) found that the ratio of male:female:bisexual Huon pine trees varies from stand to stand and that the sex of trees is difficult to determine except in mast years. If seedtrees are retained on a given spacing (i.e. approximately 30 m x 30 m), they should be retained at roughly the same ratio as the original stand. However, a greater percentage of female seedtrees is preferred for maximum seeding capacity. When a mast seed year occurs, female seedtrees should be marked in all areas likely to be logged within the following seven years. The older trees generally contribute most to the regeneration potential of a stand (Shapcott 1991) but at the Teepookana site many of these are in very poor health with only remnant crowns. In this case it is better to retain younger healthy trees with larger crowns. Ten seedtrees per ha will only cover about half of the area with seed but will maintain a presence of reproductively active trees on the site. Huon pine pollen can be windborne over long distances so little loss of genetic diversity is expected from this system. Shapcott (1991) recommends that prolifically coning trees of both sexes be identified and retained as genetic stock for regeneration.

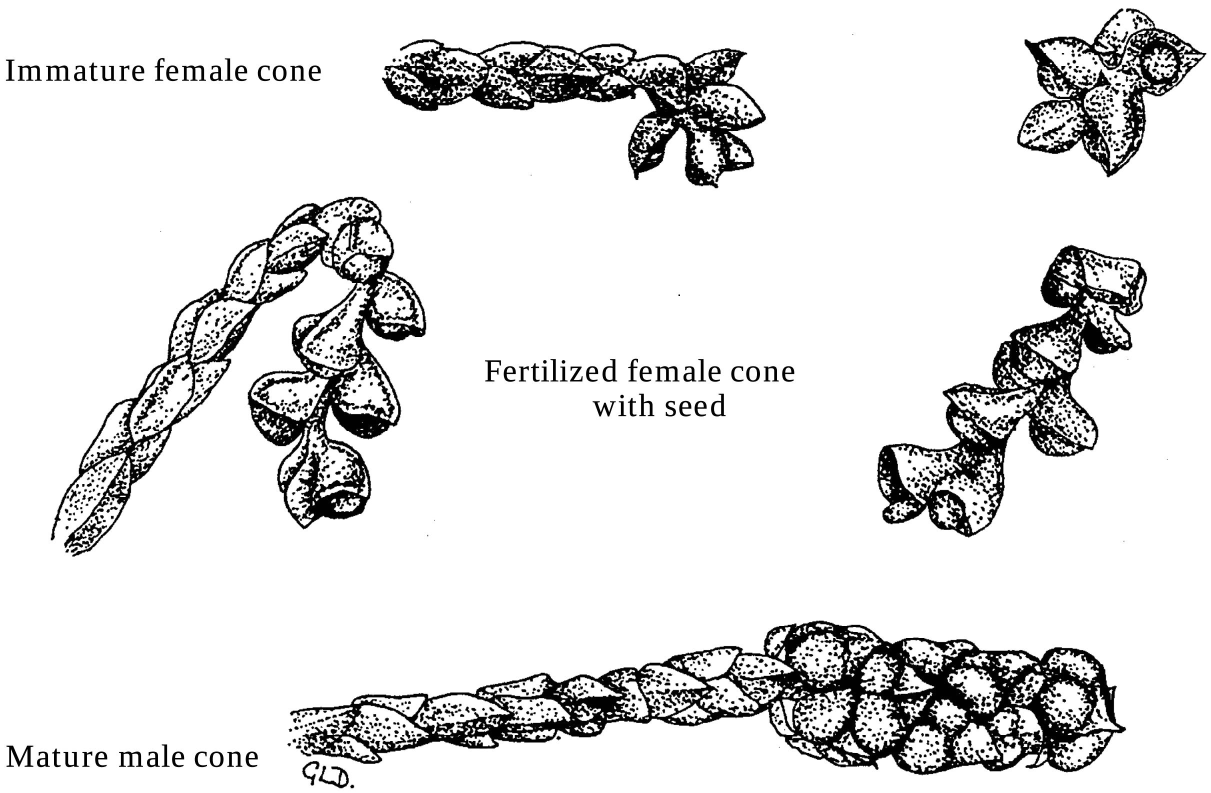
Figure 11. Timing of Huon pine cone development and seedfall. (A. Shapcott pers. comm.)



However, regeneration should not rely solely on seedtrees for the following reasons:

* some previously cut-over areas may not have 10 seedtrees per ha remaining,
* retained seedtrees may not reach their maximum reproductive potential for many years,
* mast seed years are infrequent (5 to 7 years),
* germination success is low, and
* Huon pine is extremely slow growing and seedlings remain vulnerable to drought for many years.

Figure 12. Huon pine cones. (10x magnification) (Drawings by Georgina Davis)



b) Advance growth regeneration

Many areas carry established Huon pine regeneration as a result of previous logging disturbance. Unfortunately much of this is on tracks which may be used again for harvesting, and regeneration will therefore be damaged or destroyed. Wherever possible this resource should be protected. This regeneration is of the local genotype and is established, sometimes having up to 100 years growth advantage over new regeneration.

The harvesting contractor must be aware of the importance of retaining even single advance growth seedlings.

c) Propagation of cuttings

At the completion of logging, the area should be surveyed for surviving advance growth regeneration. Areas which are not stocked should be supplemented with plants grown from cuttings. Nursery-grown cutting stock planted at Travellers Creek in 1987 has shown good survival and growth rates. The rooted cuttings averaged 14 cm in height at planting and 40 cm four years later with the tallest plants over 90 cm high. Survival was approximately 70%. Cutting material should be taken from the coupe during the winter before logging and grown on at the nursery.

It is recommended that cutting material be collected from within the proposed harvesting area at a rate to supply a minimum of 100 plants for each ha to be logged. If cuttings are taken from as many trees as possible, i.e. 10 cuttings from each of 50 trees rather than 50 cuttings from each of 10 trees, then the likelihood of maintaining genetic diversity and a mix of both male and female trees is increased. Planting should take place during the winter following logging.

d) Stand Structure

It is important to protect both the structural and species diversity of Huon pine forest, particularly as it is so slow growing. It is important to retain older seedtrees, young regeneration and advance growth regeneration in all size classes. Minimum damage should be done to other species on site. Existing snig tracks should be used for harvesting, unless they contain valuable advance growth. Areas not containing merchantable timber should be left undisturbed. The primary aim should be to remove the necessary timber while causing the least possible disturbance to the existing forest. This would also ensure the best possible conditions for regeneration survival.

e) Headwater Catchments

Shapcott (1991) suggests that since the most effective dispersal of Huon pine seed and regeneration appears to be down water channels, stands at the headwaters of catchments represent stocks from which downstream regeneration may be possible. Shapcott suggests that they represent key stands to be conserved. Huon pine seed dispersal is very limited, less than one tree height at Teepookana. Priority should be given to the retention of trees within 10 m either side of the headwaters of creeks to maximise the opportunities for natural seed dispersal.

f) Phytophthora cinnamomi

Outbreaks of *Phytophthora* are commonly associated with activities which result in soil disturbance such as roading, mineral exploration and logging Severe infections occur most commonly in poorly drained or water collecting sites supporting heathland, sedgeland, moorland or dry sclerophyll communities (Wardlaw 1990).

The Teepookana forest communities with their high proportion of Proteaceous and Epacridaceous shrubs are very susceptible to *Phytophthora* infection. The risk is increased where the forest is disturbed. As the canopy is opened up, the soil temperature increases and the fungus spreads more rapidly.

Where heavily infested patches are identified, care should be taken not to spread *Phytophthora* from access roads etc. into uncontaminated areas. Even in areas of low infection, numbers of susceptible species will be reduced and their regeneration limited to closed canopy situations where soil temperatures are lower.

The presence of *Phytophthora* at Teepookana underlines the need to minimise the impact on the forest to avoid unnecessary spread of the disease (Forestry Commission 1990b). Spread of *Phytophthora* should be regularly monitored, in particular the health of *Phytophthora* indicator species such as celery-top pine, leatherwood, goldey wood, pandani and white waratah. The Forest Pathologist should be consulted if there is substantial death of understorey species.

g) Fire

Huon pine is susceptible to fire and generally dies after burning, therefore fire must be excluded from Huon pine stands. Maintaining as much as possible of the original forest in an undisturbed state reduces the likelihood of damage by fire.

9. REFERENCES

Barker, M.J. (1991). *The Effect of Fire on West Coast Lowland Rainforest.* Tasmanian NRCP Technical Report No. 7. Forestry Commission, Tasmania, and Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra.

Barker, P.C.J. (1992). *Autecology of* Phyllocladus *and* Anodopetalum *in Tasmania.* Tasmanian NRCP Technical Report No. 10. Forestry Commission, Tasmania, and the Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra.

Barker, P.C.J. and Kirkpatrick (1994). *Phyllocladus aspleniifolius*: Variability in the population structure, the regeneration niche and dispersion patterns in Tasmanian forests. *Aust. J. Bot.,* **42:** 163-190.

Commonwealth of Australia and State of Tasmania (1997), *Tasmanian Regional Forest Agreement between the Commonwealth of Australia & The State of Tasmania*. Commonwealth of Australia.

Cullen, P.J. (1987). Regeneration patterns in populations of *Athrotaxis selaginoides* D. Don. from Tasmania. *J. Biogeography* **14**, 39-51.

Elliott, H.J., Kile, G.A., Candy, S.G., and Ratkowsky, D.A. (1987). The incidence and spatial pattern of *Nothofagus cunninghamii* (Hook.) Oerst. attacked by *Platypus subgranosus* Schedl in Tasmania's cool temperate rainforest. *Aust. J. Ecol.* **12**, 125-138.

Forestry Commission (1990a). *Special Timbers Draft Management Plan and Issue Paper,* Forestry Commission, Hobart.

Forestry Commission (1990b). *Teepookana State Forest Draft Management Plan.* Forestry Commission, Hobart.

Forestry Commission (1991). *Regeneration surveys and stocking standards.* Native Forest Silviculture Technical Bulletin No. 5, Forestry Commission, Hobart.

Forestry Tasmania (1995). Management and Sale of Special Species Timbers. Forestry Tasmania, Hobart. 4pp.

Forestry Tasmania (1996). Comparison of silvicultural systems for tall lowland rainforest, Division of Silvicultural Research and Development Annual Report, 1995-96.

Forests And Forest Industry Council (FFIC) (1990). *Secure Futures for Forests and People*, Government Printer, Tasmania.

Gibson, N. and Brown, M. J. (1991). The ecology of *Lagarostrobos franklinii* (Hook.f) Quinn (Podocarpaceae) in Tasmania. 2. Population and spatial pattern. *Aust. J. Ecol.* **16**, 223-229.

Hickey, J.E. (1982). Natural and artificial regeneration of some rainforest trees. *Tasmanian Rainforests Recent Research Results.* Paper presented at a symposium, November 1983. Forest Ecology Research Fund. Hobart, Tasmania.

Hickey, J.E. (1983). Sumac Trial Progress Report. Forestry Commission, Tasmania. Unpublished report.

Hickey, J.E. (1990). Change in rainforest vegetation in Tasmania. *Tasforests* **2**,143-150.

Hickey, J.E., Blakesley, A.J. and Turner, B. (1982). Seedfall and germination of *Nothofagus cunninghamii* (Hook) Oerst. *Eucryphia lucida* (Labill.) Baill and *Atherosperma moschatum* Labill. Implications for regeneration practice. *Australian Forest Research* **13**, 21-28.

Hickey, J.E. and Felton, K.C. (1991). Management of Tasmania's cool temperate rainforest In: *Forest Management in Australia.* (eds. F.H. McKinnell, E.R. Hopkin and J.E.D. Fox) Surrey Beatty and Sons, Sydney. pp 257-270.

Hickey, J.E. and Savva, M.H. (1992). *The extent, regeneration and growth of Tasmanian Lowland Mixed Forest.* Forestry Commission, Tasmania.

Hickey, J.E., Davis, S.R., Wardman, R. and Harris, J. (1993). How much rainforest is there in Tasmania? A better answer to a difficult question. *Tasforests* **5**, 13-24.

Howard, T.M. (1973). Studies in the ecology of *Nothofagus cunninghamii* Oerst. II. Phenology. *Aust. J. Bot.* **21**, 79-92.

Jackson, W.D. (1968). Fire, air, water and earth - an elemental ecology of Tasmania. *Proc. Ecol. Soc. Aust.* **3**, 9-16.

Jarman, S.J. and Brown, M.J. (1983). A definition of cool temperate rainforest in Tasmania. *Search* **14**, 81-87.

Jarman, S.J., Brown, M.J. and Kantvilas, G. (1984). *Rainforest in Tasmania.* National Parks and Wildlife Service, Tasmania.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1991). *Floristic and Ecological Studies in Tasmanian Rainforest.* Tasmanian NRCP Report No. 3. Forestry Commission, Tasmania, and Department of the Arts, Sport, the Environment, Tourism and Territories, Canberra.

Jarman, S.J., Kantvilas, G. and Brown, M.J. (1994). Phytosociological studies in Tasmanian cool temperate rainforest. *Phytocoenologia* **22**, 391-428.

Kelly, J.W. (1989). The Sumac Rainforest Logging and Regeneration Trial - 1989 Progress Report. Forestry Commission, Tasmania. Unpublished Report.

Kile, G.A., and Walker, J. (1987). *Chalara australis* sp. nov. (Hyphomyces), a vascular pathogen of *Nothofagus cunninghamii* (Fagaceae) in Australia and its relationship to other Chalara species. *Aust. J. Bot.* **35**, 1-32.

Kile, G.A., Packham, J.M., and Elliott, H.J. (1989). Myrtle wilt and its possible management in association with human disturbance of rainforest in Tasmania. *N.Z.J.For.Sci.* **19**, 256-264.

Kirkpatrick, J.B. and Backhouse, S. (1981). *Native Trees of Tasmania.* Pandani Press, Hobart.

Manson, B.R. (1974). The life history of silver beech (*Nothofagus menziesii*). *Proc.N.Z. Ecol. Soc.* **21**, 27-31.

Neyland, M.G., and Hickey, J.E. (1990). Leatherwood Silviculture - Implications for Apiculture. *Tasforests* **2**, 63-72.

Packham, J.M. (1991). *Myrtle Wilt.* Tasmanian NRCP Technical Report No. 2. Forestry Commission, Tasmania, and Department of the Arts, Sports, the Environment, Tourism and Territories, Canberra.

Peterson, M.J. (1990). *Distribution and conservation of Huon pine.* Forestry Commission, Tasmania.

Podger, F.D. and Brown, M.J. (1989). Vegetation damage caused by *Phytophthora cinnamomi* on disturbed sites in temperate rainforest in western Tasmania. *Aust. J. Bot.* **37**, 443-480.

Read, J. (1985). Photosynthetic and growth responses to different light regimes of the major canopy species of Tasmanian cool temperate rainforest. *Aust. J. Ecol.* **10**, 327-334.

Read, J. (1989). Phenology and germination in some rainforest canopy species at Mt. Field National Park, Tasmania. *Pap. Proc. Roy. Soc. Tasm.* **123**, 211-221.

Read, J. and Hill, R.S. (1983). Rainforest invasion onto Tasmanian old-fields. *Aust. J. Ecol.* **8**, 149-161.

Read, J. and Hill, R. S. (1988). The dynamics of some rainforest associations in Tasmania. *J. Ecol.* **76**, 558-584.

Shapcott, A. (1991). *Studies in the population biology and genetic variation of Huon pine* (Lagarostrobos franklinii). NRCP Technical Report No. 4. National Rainforest Conservation Program and Department of Parks, Wildlife and Heritage Hobart, and Department of the Arts, Sport, the Environment and Territories, Canberra.

Wardlaw, T.J. (1990). *Pests and Diseases Management Plan for State Forests in Tasmania.* Forestry Commission, Hobart.

Wardle, J.A. (1984). *The New Zealand Beeches: Ecology, Utilisation and Management.* New Zealand Forest Service.

Working Group For Rainforest Conservation (1987). *The Rainforest of Tasmania.* Government of Tasmania, Hobart.

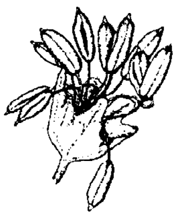
Ziegler, K. I. (1993). *Leatherwood Nectar Resource Management Report.* Forests and Forest Industry Council, Tasmania.

APPENDIX 1. Monitoring the development of a myrtle seed crop

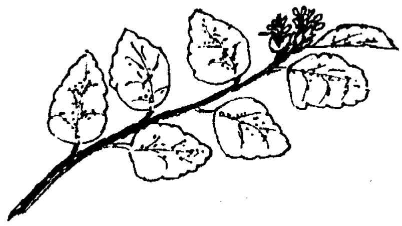
This procedure should be carried out at two sites per District where STMUs are being harvested. Undisturbed, representative stands should be selected which can be re-visited annually, such as rainforest reserves.

1. Select about 10 trees per site over 60 cm dbh with large, healthy crowns. These trees should be grouped around a central point or on a loose transect for ease of re-location.

2. To monitor flowering, visit the site on about 1 November each year. Carefully search the crowns for myrtle flowers with binoculars. Flowering material is inconspicuous. If flowering is obvious it may signal a good seed year.

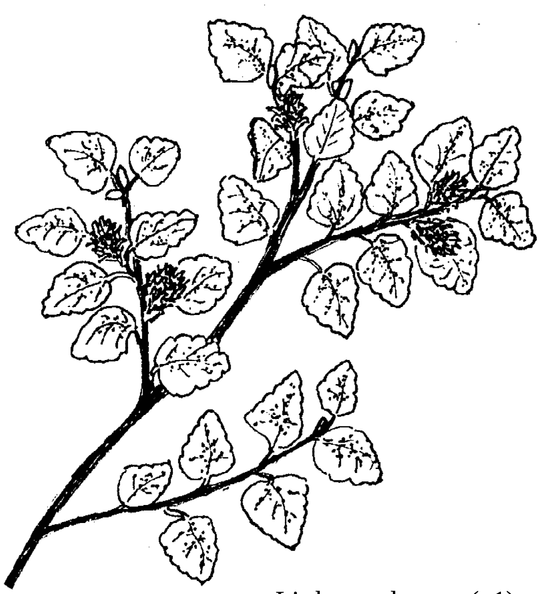


Male myrtle flower (x 4)



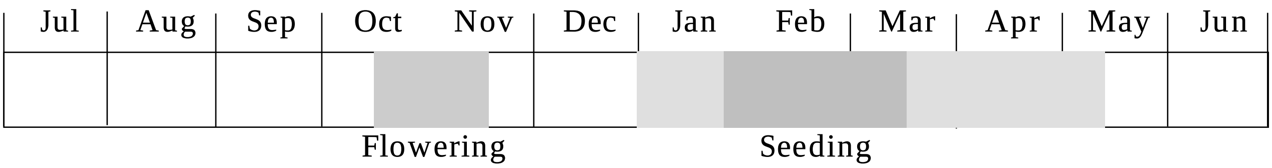
Myrtle flowers on a twig (x1)

3. To monitor seed quantity, visit the site on about 1 February. Carefully search the crowns for well developed seed bearing parts to confirm the original prediction. Search the ground for myrtle twigs to check seed maturity and help categorise the abundance of seed.



Light seed year (x1)

Heavy seed year (x1)



4. The conclusions should be reported to Sue Jennings, Circular Head or Native Forests Branch, DFRD, Hobart and will be summarised on the S:\ drive in the folder called Myrtle Seedfall Monitoring. This will be moved to the Forestry Tasmania Intranet when this becomes available.

APPENDIX 2. Modified standard 'A' regeneration survey for rainforest regeneration

Appropriate harvesting system

This stocking standard is appropriate to monitor the stocking and height of myrtle, leatherwood, sassafras and celery-top pine seedlings where an overstorey retention harvesting system is used and most sawlog and pulpwood trees are harvested.

Field work

Standard regeneration survey procedure is followed (see Technical Bulletin 6) with $4m^2$ and $16m^2$ plots located at 20 m intervals along parallel striplines 100 m apart throughout the coupe. The distance between striplines may be reduced to 50 m where the areas being surveyed are small or the stocking variation is large.

Myrtle, leatherwood, sassafras and celery-top pine seedlings are noted on the $4m^2$ plot and the height of the tallest seedling of each species estimated. If seedlings are not present on the $4m^2$ plot, the search is extended to the $16m^2$ plot.

Other species present on the plot are listed by name or initials and browsing of **any** species is noted. The seedbed is classed as disturbed or undisturbed.

This procedure allows mapping of the stocked and unstocked areas in the usual way and calculation of the following:

- percentage of seedbed disturbance,
- percentage of plots stocked with each species,
- mean height of the tallest seedlings of each species, and
- level of browsing.

Stocking Standard

- At least 50% of $4m^2$ plots should be stocked with myrtle seedlings.
- Leatherwood, sassafras and celery-top pine seedlings should be present where these species occurred in the unlogged forest.
- Browsing control in regenerating rainforest is generally not warranted. However, if browsing rates are significantly affecting stocking and growth, some control measures will be necessary.

APPENDIX 2. (cont) **Example of field data - Modified standard "A" regeneration survey.**

Field book

80 m	4m² 16m²	4(35)	- -	- -	- -	Advanced growth
		C/U/D pime (B), copr (B), poly				
60 m	4m² 16m²	- -	- -	1(4)B	- -	Sassy underlog
		P/U/D pime (B), cyat, poly				
40 m	4m² 16m²	12(17)	8(13)	- -	1(5)	
		P / D - mainly bare cyat, tasm, hist				
20 m	4m² 16m²	23(21)	6(16)	3(9)	- -	nearmain snig track
		O/D cass, zier, hist & hypo				
Strip 1 235ºC	4/2/96	**Myrtle** No(Ht)	**Leatherwood** No(Ht)	**Sassafras** No(Ht)	**Celery-top** No(Ht)	**Comments**

Pipeline Coupe 3
SMJ & LGE
TOP = 50m from southern corner at pipline dirt road.

(B) = browsed
D = Disturbed
U/D=Undisturbed
C = Closed canopy
O=Opencanopy
P = Partial cover canopy

pime = Pimelea drupacea
copr = Coprosma quadrifida
poly = Polystichum proliferum
cyat = Cyathodes spp
tasm = Tasmannia lanceolata
hist = Histiopteris incisa
cass = Cassinia aculeata
zier = Zieria arborescens
hypo=Hypolepisrugosula

Office calculations

Percentage of disturbed seedbed: 50%

	Myrtle	Leatherwood	Sassafras	Celery-top pine
$4m^2$ plots stocked	75%	50%	50%	25%
Average # of seedlings per ha	24 375	8 750	2 500	625
Mean ht of tallest seedlings	24.3 cm	14.5 cm	6.5 cm	5 cm
Level of browsing	0%	0%	50%	0%

APPENDIX 3. Modified standard 'D' regeneration survey for rainforest regeneration

Appropriate harvesting system

This stocking standard is appropriate for multi-aged forests that have been partially logged (more than 20 trees retained per ha), with patchy distribution and requiring some regeneration to fill gaps. It is suitable for rainforests where a selective sawlogging system is used.

It is designed to find whether the stand has been left in a productive or potentially productive condition. The initial survey should be done 5 years after logging.

Field work (see Technical Bulletin 6.)

1. Mark the plot point. Points are at 20 m intervals along lines 100 m apart.

2. If there is no recent stump or fallen crown within 10 m of the sample point, record it as "unlogged" or "landing/clearing" and move on to the next point.

3. If there is logging disturbance, do a wedge sweep of live trees using a 2 or 4 m^2/ha optical wedge. Include trees of any size, regardless of whether they have been counted in a previous sweep. Count only one stem of any multi-stemmed trees or coppice and only the number of rainforest tree species with healthy crowns.

4. If there is at least 12 m^2/ha of local basal area (healthy trees), move to the next plot.

   If there isn't 12 m^2/ha of basal area, continue to 5.

5. Commence a search for seedlings as for stocking standard "A".
   Record the type of seedbed present on the 4 m^2 plot.

6. Move to next plot.

Stocking Standard

The coupe is stocked if more than 80% of the area is mapped as stocked, either by retained trees or new regeneration, according to the mapping rules in Technical Bulletin 6.

APPENDIX 4. List of common and scientific names of plants referred to in the text

banksia	*Banksia marginata* Cav.
blackwood	*Acacia melanoxylon* R.Br.
bushman's bootlace	*Pimelea drupacea* Labill.
button grass	*Gymnoschoenus sphaerocephalus (R. Br.)* Hook.f.
cat-head fern	*Polystichum proliferum* (R.Br.) Presl
celery-top pine	*Phyllocladus aspleniifolius* (Labill.) Hook.f.
cheeseberry	*Cyathodes glauca* Labill.
cheesewood	*Pittosporum bicolor* Hook.
cutting grass	*Gahnia grandis* (Labill.) S.T.Blake
deciduous beech	*Nothofagus gunnii* (Hook.f.) Oerst.
diselma	*Diselma archeri* Hook.f.
dogwood	*Pomaderris apetala* Labill.
dollybush	*Cassinia aculeata* R.Br.
foxglove	*Digitalis purpurea* L.
goldey wood	*Monotoca glauca* (Labill.) Druce
hard water fern	*Blechnum wattsii* Tindale
heartberry	*Aristotelia peduncularis* (Labill.) Hook.f.
horizontal	*Anodopetalum biglandulosum* A.Cunn. ex Hook.f.
Huon pine	*Lagarostobos franklinii* (Hook.f.) Quinn
King Billy pine	*Athrotaxis selaginoides* D. Don
leatherwood	*Eucryphia lucida* (Labill.) Baill.
manfern	*Dicksonia antarctica* Labill.
myrtle	*Nothofagus cunninghamii* (Hook.) Oerst.
native currant	*Coprosma quadrifida* (Labill.) Robinson
native laurel	*Anopterus glandulosus* Labill.
native pepper	*Tasmannia lanceolata* (Poiret) A.C.Smith
native plum	*Cenarrhenes nitida* Labill.
yellow bush	*Orites acicularis* R.Br.
	Orites revoluta R.Br.
pandani	*Richea pandanifolia* Hook.f.
pencil pine	*Athrotaxis cupressoides* D.Don
pinkberry	*Cyathodes juniperina* (Forst.) Druce
sassafras	*Atherosperma moschatum* Labill.
scoparia	*Richea scoparia* Hook.f.
silver beech	*Nothofagus menziesii* (Hook.f.) Oerst.
stinkwood	*Zieria arborescens* Sims.
thistles	*Cirsium vulgare* (Savi.) Ten
	Carduus tenuiflorus Curt.
trochocarpa	*Trochocarpa cunninghamii* (DC.) W.M. Curtis
	Trochocarpa gunnii (Hook.f.) Benth.
wallaby wood	*Pittosporum bicolor* Hook.
waratah	*Telopea truncata* (Labill.) R.Br.
wet fern	*Histiopteris incisa* (Thunb.) J.Sm.
	Hypolepis rugosula (Labill.) J.Sm.
white waratah	*Agastachys odorata* R.Br.
whitey wood	*Acradenia franklinii* Milligan ex Kippist

APPENDIX 5. Extracts from Timber Harvesting Plan - overstorey retention

PLANNING SECTION:

Parent rock	Basalt	**Forest**:	Wet
Soil Erodibility Class:	Low	**Majority Slope:**	< 20%
		Altitude:	150 m
Type of Forest:	Rainforest (M+)		
Dominant Species:	**Forest**:	Myrtle	
Dominant Species:	**Understorey**:	Sassafras, manferns, cat-head fern	

Planned future land use:	Native forest
Level of utilisation:	High
Harvesting prescription:	Overstorey retention

HARVESTING SECTION: **Felling prescriptions:** All commercial trees should be felled other than those required to provide seed and shelter. A minimum of thirty trees per hectare should be retained, at a spacing of 15-20 m. Retained trees should have good crowns, sound footing and be evenly distributed over the harvested area. Trees selected for retention should not be damaged during harvesting. Patches of advance growth and all non-commercial trees should be retained, with disturbance minimised.

REFORESTATION SECTION:

a) **Site preparation including burning**: Seedbed will be created by logging disturbance and/or snig track extension. Disturbance in unlogged patches should be minimised.

b) **Regeneration source:**

[ ]	Sowing	[ ]	Planting
[x]	Natural regeneration	[x]	Retained growing stock

c) **Stocking Standards:** A modified standard “A” regeneration survey should be carried out 2-5 years after logging, when regeneration has established.

d) **Monitoring and browsing control:** Seed crops should be monitored for quantity and maturity before and during harvesting. Browsing levels are expected to be acceptable but will be monitored and controlled if heavy.

e) **Chemical Application:** None required.

APPENDIX 6. Extracts from Timber Harvesting Plan - selective sawlogging

PLANNING SECTION:

Parent rock	Mudstone	**Forest**:	Wet
Soil Erodibility Class:	Moderate	**Majority Slope:**	< 20%
		Altitude:	200 m
Type of Forest:	Rainforest (M+)		
Dominant Species:	**Forest**:	Myrtle	
Dominant Species:	**Understorey**:	Leatherwood, sassafras, native plum, hard water fern	
Planned future land use:	Native forest		
Level of utilisation:	Low		
Harvesting prescription:	Selective sawlogging		

HARVESTING SECTION: **Felling prescriptions:** Minimise any disturbance within the forest. Sawlog trees are to be felled, leaving the surrounding trees undamaged. Patches of advance growth are to be maintained intact. Myrtle seedtrees should be retained on a 15 - 20 m spacing to avoid making canopy gaps greater than 30 metres.

REFORESTATION SECTION:

a) **Site preparation including burning:** Sufficient seedbed will be created by logging disturbance, which will generally only be the snig tracks. Minimise all other impact.

b) **Regeneration source:**

[ ]	Sowing	[ ]	Planting
[x]	Natural regeneration	[x]	Retained growing stock

c) **Stocking Standards:** A modified standard "D" regeneration survey should be carried out 5 years after logging.

d) **Monitoring and browsing control:** Seed crops should be monitored for quantity and maturity before and during harvesting. Browsing levels are expected to be acceptable.

e) **Chemical Application:** None required.

Plate 1. *Seed trap studies indicate that myrtle seedfall is periodic, with heavy seedfall occurring about every three years. Leatherwood and sassafras set seed annually.*

Plate 2. *Myrtle may show little regeneration under an unbroken canopy, particularly if the seedbed is poor due to excessive litter or fern layers.*

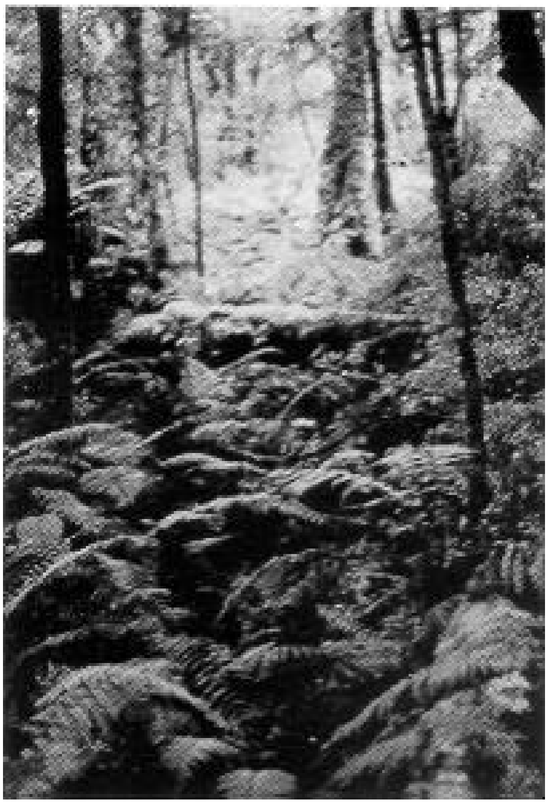


Plate 3. *Canopy remaining after harvesting to an Overstorey Retention prescription.*

Plate 4. *Myrtle regeneration four years after logging.*