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PART A: Silvicultural Prescriptions for Wet Forests Managed for Blackwood Production in Tasmania.

PART B: Descriptions of Blackwood Forest within Tasmania.

1. INTRODUCTION

Blackwood (*Acacia melanoxylon* R.Br.) is widespread throughout Tasmania but is most common in the wet forests of the north-west of the State. Stem form is varied, ranging from gnarled and twisted trees in gullies on the east coast to magnificent straight-boled trees in the swamps of the north-west.

Blackwood has a long history of use for shingles, palings, sawn boards, veneers and barrel staves. The swamps of Smithton have been Australia's prime source of high quality blackwood timber for almost a century (Forestry Commission 1989). Much of the original blackwood swamp forest was cleared for agriculture, a practice which effectively ceased in the 1970s.

Blackwood is the basis of an important furniture and veneer industry in Tasmania. An average of 13,100 m^3 per annum of blackwood sawlog was cut over the past five years from State forests. The supply of blackwood is drawn from three main sources:

- the blackwood swamps in Murchison District (north-western Tasmania);
- as a secondary product (arisings) from the harvest of blackwood-rich wet eucalypt forest, and
- a very small supply from additional areas, including riverine rainforests.

The blackwood swamps supply a sustainable sawlog yield assuming that coupes are harvested on a 70-year rotation. Arisings from the harvest of wet eucalypt forest will continue, but at a reduced level, as the proportion of regrowth forest harvesting increases and oldgrowth forest harvesting declines. An additional resource is being created by the fenced-intensive-blackwood program, which established over 1500 ha of fenced eucalypt/blackwood regeneration between 1985 and 2005. Currently up to 200 ha per year of wet eucalypt forests within Murchison District are fenced for blackwood regeneration when suitable areas are available.

Research to evaluate blackwood as a plantation species commenced in 1986 (Neilsen and Brown 1997; Nicholas and Brown 2002; Pinkard and Beadle 2002; Medhurst *et al.* 2003). However, blackwood plantations proved difficult to manage, with issues related to the timing of nurse crop removal and form of plantation blackwood. Blackwood plantations may be more appropriate for intensive farm woodlots rather than for extensive land managers such as Forestry Tasmania. There is currently no active plantation research program on State forest, although work continues on private land.

This technical bulletin contains silvicultural prescriptions for native blackwood forests in Tasmania (Part A) together with more descriptive information (Part B).

2. SILVICULTURAL CONSIDERATIONS

For natural regeneration of blackwood to be successful the following must be present:

1. **Ground-stored seed source.** Blackwood seed, dropped to the ground over previous decades, is the basis of natural regeneration systems for blackwood forests in Tasmania. This seed is available on site, is of the correct provenance, and saves the costly and time-consuming process of collecting and sowing of seed. However, seed distribution may be patchy due to localised seedfall, and blackwood regeneration cannot be expected where there was no blackwood growing in the previous forest.

2. **Disturbance** such as harvesting or fire is required to stimulate blackwood germination by cracking the hard protective seed coat, and to provide a suitable seedbed for seedling establishment.

3. **Sufficient light** for vigorous height growth. Blackwood is not always the dominant tree species within a forest being managed for blackwood production. It is less shade sensitive than eucalypts but over-topping by other crowns will adversely affect the form and vigour of blackwood.

4. **Sufficient side shade for lower branch suppression**. Blackwoods of good stem form are usually found where side-shading, provided by the surrounding vegetation, helps to suppress the lower branches of the blackwood saplings as they grow. This naturally occurs where blackwood is growing in "light-wells" or small gaps in the canopy. In larger gaps or clearfelled areas, a "nurse" species is required. Nurse species can include young eucalypts, teatrees and paperbarks and wet sclerophyll understorey species (particularly *Pomaderris apetala*). At high densities, these species compete with the blackwood seedlings resulting in rapid branch suppression and good stem form. Open grown trees usually show poor bole form.

5. **Protection from browsing**. Blackwood seedlings are highly palatable to native mammals, domestic livestock and rabbits. All blackwood regeneration systems must include effective browsing control. Disturbance usually triggers mass germinations of blackwood seed, and the young seedlings must be protected immediately.

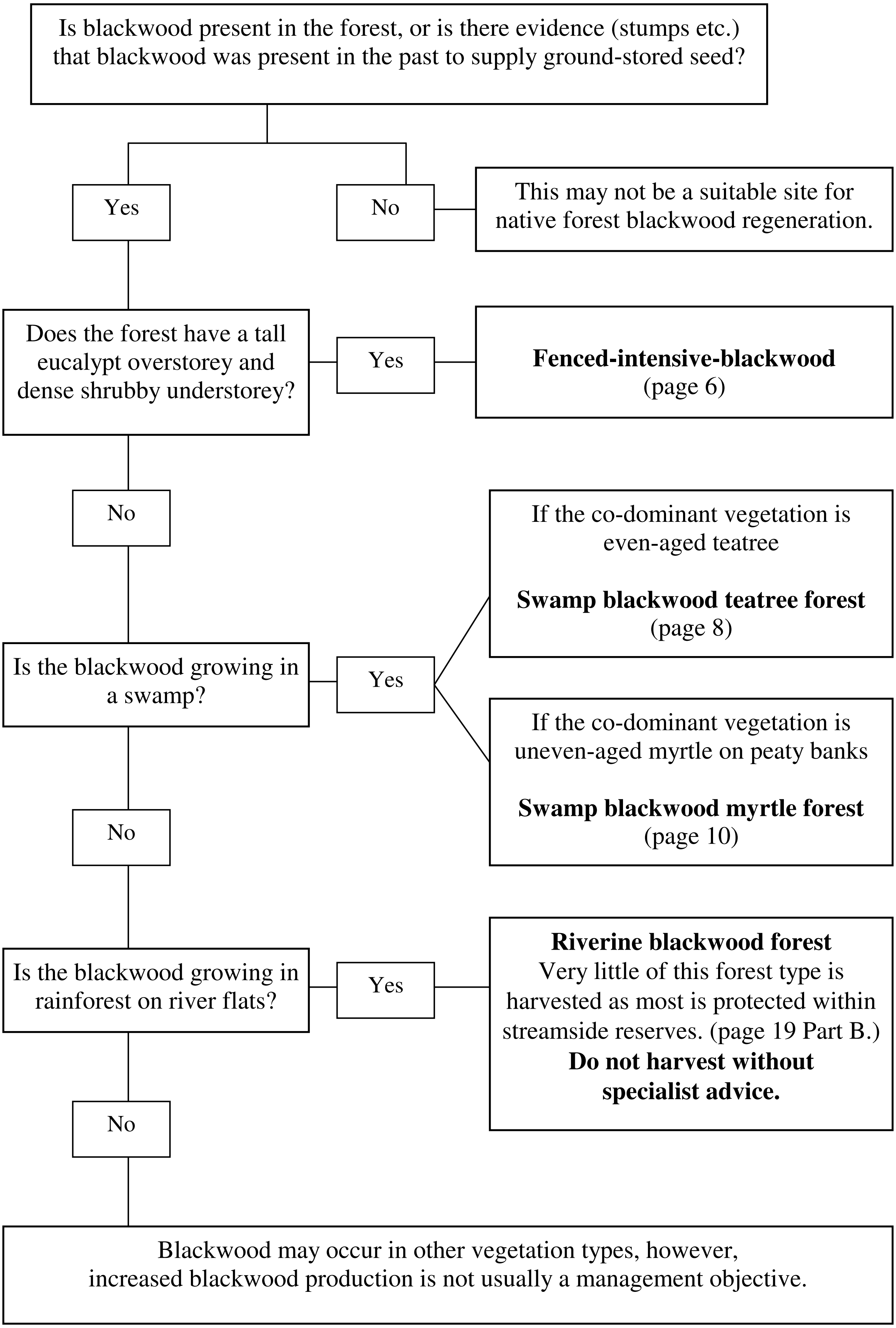
3. SELECTION OF SILVICULTURAL SYSTEMS FOR BLACKWOOD

Blackwood is predominantly a co-dominant or understorey species; therefore its regeneration treatment is often largely determined by the need to provide suitable nurse species.

Figure 1 contains guidelines for selecting an appropriate silvicultural regime for high quality blackwood forest types where blackwood sawlog production is a management priority. These include blackwood-rich wet eucalypt forests, blackwood swamp forests and on rare occasions, riverine blackwood forests.

Blackwood also occurs as a common understorey species in other eucalypt forest communities and regeneration can occur from ground-stored seed following harvesting. Heavy browsing usually reduces the stocking to a level comparable to that of the original forest. Specific silvicultural treatments, such as fencing to increase the proportion of final crop blackwoods, are not economically justified since stocking levels are low and growth rates are slow. Normal silvicultural operations in eucalypt forest should be sufficient to ensure that the blackwood understorey component is maintained on the site.

Figure 1. Selection of silvicultural systems for blackwood forests.



3.1 Fenced-intensive-blackwood

Preconditions:
This regeneration system relies on ground-stored seed, dropped by the understorey blackwoods that are scattered throughout areas of blackwood-rich wet eucalypt forest in Tasmania. The presence of ground-stored seed can be determined by systematic soil sampling or stump counts if necessary, but it is preferable to check the distribution of blackwood in the original forest before harvesting.

Appropriate forest stands:
Blackwood-rich wet eucalypt forests usually dominated by *E. obliqua, E. regnans* or *E. brookeriana.* An understorey comprised of *Pomaderris apetala* is most suitable.

Harvesting method:
Clearfelling of all merchantable timber, including understorey blackwood trees.

Regeneration treatment:

Source of regeneration: Blackwood germination is stimulated by both mechanical disturbance from logging and high intensity burning (Wilkinson and Jennings 1994). Aerial sowing of eucalypt seed at a reduced rate (approximately half of the base rate recommended for moderately favourable sites, Forestry Commission 1991) provides an additional economic crop and maintains the original species mix on-site. Germination of the understorey species required to nurse the blackwood seedlings, will also be stimulated by the high intensity burn.

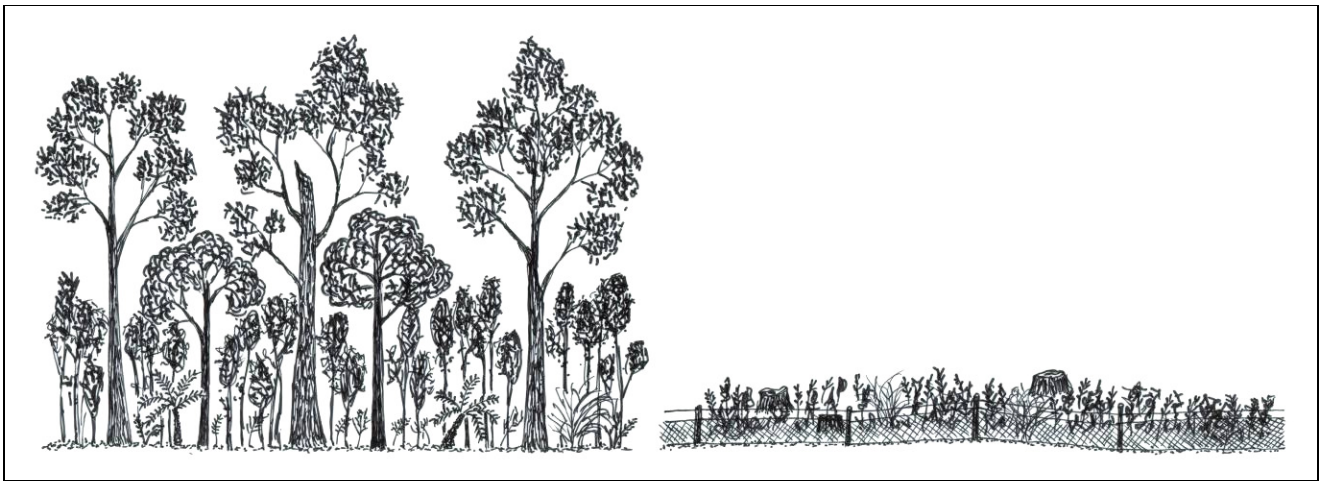
Site preparation: A receptive seedbed should be created by a high intensity broadcast burn, which will also remove browsing mammal habitat.

Browsing Control: Fencing of the whole coupe with wire netting is essential to protect the blackwood seedlings from browsing. The fence should be constructed immediately after the burn to prevent re-invasion of the coupe by browsing mammals. Further information and fence specifications for these areas can be found on page 12 (Part A, 4. Fence specifications). The fence must be rigorously maintained for approximately three years or until the blackwood seedlings are above browsing height (1 - 2 m).

Monitoring and protection: Indicator plots and browsing transects must be established to monitor germination of both eucalypts and blackwood, and browsing damage to blackwood seedlings within the fence. Pegged blackwoods should be monitored until the majority of seedlings are above browsing height.

Regeneration survey: The seedling survey and stocking standards for fenced-intensive-blackwood on wet eucalypt forest sites are described in Forestry Tasmania (2003). The aim is to achieve 65% of 16 m^2 plots stocked for both species. There is no remedial treatment available to increase the blackwood stocking. Remedial treatment of eucalypts should be undertaken if the coupe does not reach 65% of 16 m^2 plots stocked for either species.

PRE-HARVEST POST-HARVEST



3.2 Swamp blackwood teatree forest

Preconditions:
This regeneration system relies on ground-stored seed, dropped by the blackwoods that dominate this forest. There will be no blackwood regeneration where blackwood trees have been absent for many decades. The presence of ground-stored seed can be determined by systematic soil sampling or stump counts if necessary, but it is preferable to check the distribution of blackwood in the original forest before harvesting.

Appropriate forest stands:
Swamp blackwood forests which contain an even-aged mix of blackwood, paperbark/teatree, and occasionally sassafras. These early successional communities occur on sites subject to recent (within 100 years) major disturbance.

Harvesting method:
All merchantable blackwood should be harvested from these early successional forests, which may result in a series of patch-clearfells where blackwood stocking was high. Areas of sassafras which do not contain merchantable blackwood should be retained undamaged.

Timing of harvesting in blackwood swamps is important and it should only occur during dry conditions. Swamp soils are saturated for much of the year. Logging operations are difficult and environmentally damaging if carried out when the soils are wet, as deep ruts and ponding can occur. Natural drainage should be preserved. Blackwood will not grow in areas where stagnant water stands.

Regeneration treatment:

Source of regeneration: Harvesting disturbance will be sufficient to stimulate germination of the ground-stored blackwood seed (Jennings *et al.* 2000).

The paperbark/teatree species, which are important swamp nurse species, develop slowly from seed and root suckers and it may be several years before thick teatree is established throughout the area. Cutting grass and sedges often protect the young blackwood seedlings in the early stages.

Site preparation: Low-intensity burning should be carried out where high fuel loads remain after harvesting. Burning of the slash is not necessary for germination of the blackwood, but thick layers of slash covering the seedbed may prevent successful blackwood establishment.

Scrubrolling of non-commercial species in swamp blackwood teatree forests can be used to maximise the opportunity for blackwood regeneration in understocked patches within or adjacent to areas of commercial blackwood harvesting. It can also be used to "square-up" the boundaries of coupes, reducing the unit costs per hectare for fencing (Jennings and Dawson 2000).

Browsing Control: Fencing of the coupe should be carried out as soon as possible after harvesting and before the first flush of germination has taken place or blackwood seedlings will be browsed. Resident populations of browsing mammals may need to be controlled within the fence, as in the absence of high intensity burning, good animal habitat usually remains.

Where wet conditions make fencing impossible immediately after harvesting, fencing can be delayed until the next summer. The first flush of seedlings caused by the logging disturbance will be lost, but sporadic germination of blackwood seed may continue in spring and autumn for several years. Browsing control will be more difficult, and blackwood stocking lower, on coupes where fencing is delayed.

Further information and fence specifications for these areas can be found on page 12 (Part A, 4. Fence specifications). The fence must be rigorously maintained for approximately three years or until the blackwood seedlings are above browsing height (1 - 2 m).

Monitoring and protection: Browsing transects must be established to monitor any browsing damage to blackwood seedlings within the fence. Blackwood seedlings are highly palatable and any resident browsing population will preferentially browse the blackwood crop. Fifty pegged blackwoods should be monitored until the majority of seedlings are above browsing height, as specified (for eucalypts) in Forestry Tasmania (1999).

Regeneration survey: A regeneration survey should be carried out three years after harvesting to monitor the stocking of both blackwood and nurse species. Regeneration surveys and stocking standards are described in Forestry Tasmania (2003). At least 65% of 16 m^2 plots within harvested areas should contain a blackwood seedling with an effective nurse.

PRE-HARVEST POST-HARVEST

3.3 Swamp blackwood myrtle forest

Preconditions:
This regeneration system relies on ground-stored seed, dropped by the blackwoods that dominate this forest. There will be no blackwood regeneration where blackwood trees have been absent for many decades. Presence of ground-stored seed can be determined by systematic soil sampling or stump counts if necessary, but it is preferable to check the distribution of blackwood in the original forest before harvesting.

Appropriate forest stands:
Swamp blackwood forests with an uneven-aged structure, and a component of older rainforest species that develop on mounds of peaty soil (myrtle peaty banks) in undisturbed forests. The blackwood in these forests tends to be older, bigger and more scattered than in swamp blackwood teatree forests.

Harvesting method:
Merchantable blackwood should be harvested from within the blackwood/teatree associations within these forests without disturbance to the myrtle peaty banks. Retention of the myrtle peaty banks will maintain some structural and species diversity throughout the rotation.

Timing of harvesting in blackwood swamps is important and it should only occur during dry conditions. Swamp soils are saturated for much of the year. Logging operations are difficult and environmentally damaging if carried out when the soils are wet, as deep ruts and ponding occur. Natural drainage should be preserved. Blackwood will not grow in areas where stagnant water stands.

Regeneration treatment:

Source of regeneration: Harvesting disturbance will be sufficient to stimulate germination of the ground stored blackwood seed (Jennings *et al.* 2000).

The paperbark/teatree species, which are important swamp nurse species, develop slowly from seed and root suckers and it may be several years before thick teatree is established throughout the area. Cutting grass and sedges often protect the young blackwood seedlings in the early stages.

Site preparation: These coupes should not be burnt, as the rainforest component is unlikely to survive a fire. Regeneration is only expected where there is harvesting disturbance. Undisturbed myrtle peaty banks are not required to carry blackwood regeneration.

Browsing Control: Fencing of the coupe should be carried out as soon as possible after harvesting and before the first flush of germination has taken place or the blackwood seedlings will be browsed. Resident populations of browsing mammals may need to be controlled within the fence, as in the absence of burning, good animal habitat remains.

Where wet conditions make fencing impossible immediately after harvesting, fencing can be delayed until the next summer. The first flush of seedlings caused by the logging disturbance will be lost, but sporadic germination of blackwood seed may continue in spring and autumn for several years. Browsing control will be more difficult, and blackwood stocking lower on coupes where fencing is delayed.

Further information and fence specifications for these areas can be found on page 12 (Part A, 4. Fence specifications). The fence must be rigorously maintained for approximately three years or until the blackwood seedlings are above browsing height (1 - 2 m).

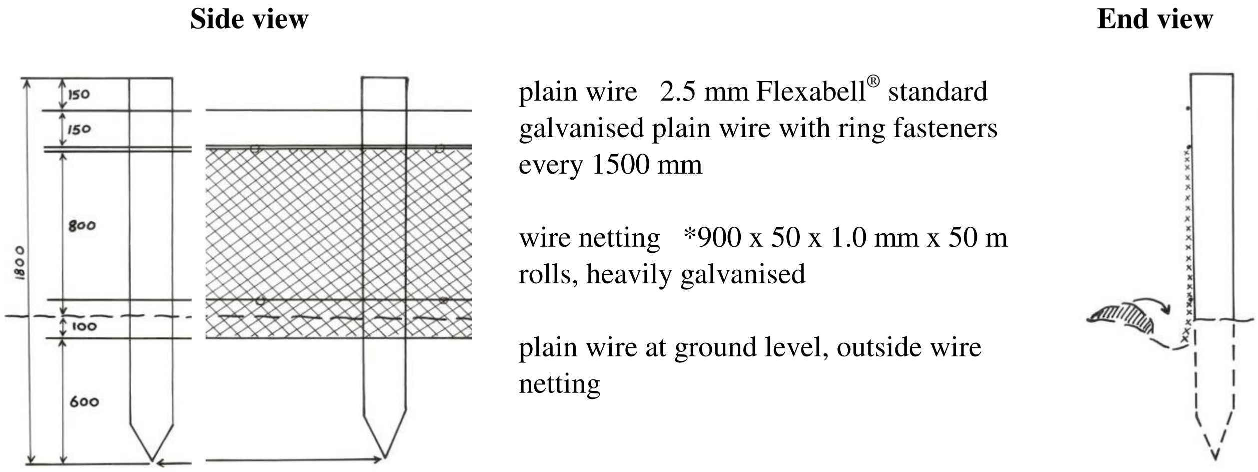
Monitoring and protection: Browsing transects must be established to monitor any browsing damage to blackwood seedlings within the fence. Blackwood seedlings are highly palatable and any resident browsing population will preferentially browse the blackwood crop. Fifty pegged blackwoods should be monitored until the majority of seedlings are above browsing height, as specified (for eucalypts) in Forestry Tasmania (1999).

Regeneration survey: A regeneration survey should be carried out three years after harvesting to monitor the stocking of both blackwood and nurse species. Regeneration surveys and stocking standards are described in Forestry Tasmania (2003). At least 65% of 16 m^2 plots within harvested areas should contain a blackwood seedling with an effective nurse.

PRE-HARVEST POST-HARVEST

4. FENCE SPECIFICATIONS

The fence which has proved most successful in protecting the mass germination of blackwood seedlings in natural regeneration areas, is a combination of wire netting and plain wire. The bottom 10-15 cm of wire netting is buried in the ground to prevent browsers from entering under the fence. This is a critical factor in achieving successful control of browsing caused by the red-bellied pademelon, the main browser of blackwood in closed wet forests. From the top wire to the ground, this fence only stands 950 mm high and therefore is not suitable where protection from Bennetts wallaby is required. Fence specifications are shown in Figure 2.



* A heavier gauge of wire (900 x 40 x 1.4 mm x 100 m rolls, heavily galvanised) is used for swamp coupes as the fences may stand in water.

Figure 2. Recommended blackwood fence specifications.

The aesthetic appearance of these fences is not important. They are a temporary measure to reduce browsing damage of the blackwood seedlings to a level that can be tolerated. Total exclusion of all browsing mammals in a field situation can be difficult.

The fences are most successful if erected immediately after the burn, while the coupe is still smoking and no animal habitat or food source remains. In unburnt coupes (such as some blackwood swamp regeneration) or where unburnt streamside reserves provide good habitat, additional control measures such as the use of shooting or trapping may be necessary to ensure that the coupe is free of browsers before fence construction is complete.

Near agricultural areas, fencing in of resident rabbit populations can be a problem. One-way swing gates are built into the corners of these fences to release trapped wallabies from within fenced areas (Figure 3). The fences must be maintained for three years to ensure the blackwoods grow above browsing height of 1 - 2 m.

Figure 3. Blackwood fencing with "Blakey's one-way wallaby gate".

Although fencing is a very effective method of browsing control it is also expensive. An indicative cost for the type of fence shown in Figure 2 is between $4000 and $5000 per km. Jennings and Dawson (1998) showed that the economics of fencing coupes for blackwood regeneration is very sensitive to the area/perimeter ratio of the coupe. A target of 15 ha protected for each 1 km of fenceline constructed should be met under normal circumstances. Fencing coupes of about 40 ha or larger, with a regular shape and reasonably straight boundaries, achieves this target. It is currently not considered economic to rescue the wire for re-use as it deteriorates where it is buried. The cost of fencing is partially offset by savings in eucalypt seed requirements.

Eucalypt seedlings and other understorey species are also advantaged by the lack of mammal browsing within the fenced coupes. For most fenced-intensive-blackwood coupes (particularly those where a high intensity burn was achieved), satisfactory eucalypt stocking can be achieved by sowing at half the standard eucalypt seed rate for moderately favourable sites.

PART B: Descriptions of Blackwood Forest within Tasmania.

1. ECOLOGY

Blackwood (*Acacia melanoxylon*) is a legume and a member of the Family *Mimosaceae*. It has bipinnate juvenile leaves that are retained for several months to several years and then replaced by deep or dull green phyllodes. Juvenile foliage often reappears after injury (Curtis and Morris 1975; Simmons 1981) or browsing. The phyllodes may be straight or curved, elliptical or lanceolate with 3-5 prominent longitudinal veins. They range in size from 4 to 10 cm long and 10 to 25 mm wide. Blackwood flowers are large pale yellow balls that are usually arranged in short racemes of 2 to 8 flowers. The hard black seeds are contained in a leathery, reddish-brown, elongated pod, which is slightly constricted between seeds. Blackwood bark is hard, rough, furrowed and dark brown when mature (Curtis and Morris 1975; Simmons 1981). Blackwood phyllodes, flowers and seed pods are shown on the front cover of this bulletin.

The natural distribution of blackwood extends from the Atherton Tableland in northern Queensland through the tablelands and escarpments of N.S.W. and Victoria, to the Mount Lofty Ranges in South Australia and to southern Tasmania. It occurs at altitudes from sea level to 1500 m in northern N.S.W. (Boland *et al.* 1984) and 1000 m in central Tasmania. It is most common in cool humid areas of low frost intensity and moderate to high annual rainfall (about 1500 mm). Blackwood is a hardy tree and is considered both moderately drought and frost resistant when planted (Forestry Commission of NSW 1980). A study by Franklin (1987) indicates that frost resistance varies with provenance, with Tasmanian blackwood having better than average frost resistance. Plantings of Tasmanian blackwood in New Zealand withstood severe frosts with few killed outright at -7°C. Many were killed back to ground level and recovered by coppicing. Research plantings in Tasmania, showed growth was severely restricted on frosty sites, with trees suffering frost damage even at heights of 4 - 5 m (Neilsen and Brown 1997).

Blackwood has a wide ecological range and commonly occurs in wet sclerophyll forest, mixed forest, disturbed rainforest and teatree swamps. It occurs occasionally in dry sclerophyll forest. Figure 4 shows occurrences of blackwood within Tasmania as recorded on the GT Spot database (DPIWE 2005).

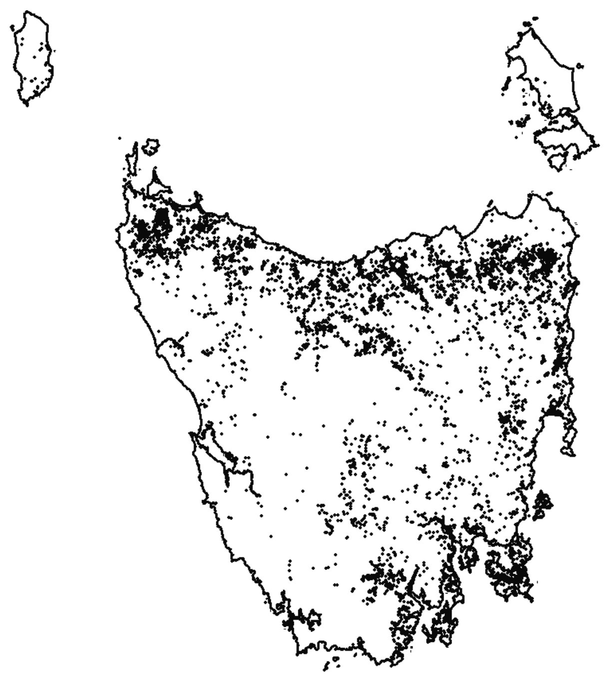


Figure 4. Recorded blackwood distribution in Tasmania

Blackwood has a higher tolerance of saturated soil conditions than most eucalypt or rainforest canopy species and is often a significant component of stands in swampy or seasonally flooded sites. However, the best growth occurs on well-drained soils with blackwood often occupying mounds in swamps and dry banks on swamp margins.

Blackwood usually grows to a height of 10-20 m but has achieved heights up to 35 m and diameters up to 1.5 m in north-western Tasmania and in the Otway Ranges in Victoria (Boland *et al.* 1984). Jennings (unpublished data) measured a height of 40 m for a blackwood on the banks of the Arthur River in north-western Tasmania.

Figure 5. Open grown blackwood.

Blackwoods grown without competition are often characterised by:
- dense healthy crowns
- good diameter growth rates
- persistent low branching
- little or no sawlog production.

1.1 Blackwood-rich wet eucalypt forest

Blackwood commonly occurs as an understorey species in wet eucalypt forests.

Wet eucalypt forests are dominated by eucalypt species, commonly *E. obliqua, E. regnans* or *E. delegatensis* and occasionally *E. nitida* or *E. brookeriana*. Depending upon the structure and composition of the understorey, wet eucalypt forests are further defined as either wet sclerophyll forests or mixed forests.

- Wet sclerophyll forests have a dense shrubby understorey containing species such as *Pomaderris apetala, Nematolepis squamea, Acacia verticillata* and *Olearia argophylla*.

- Mixed forests have a rainforest understorey comprising species such as *Nothofagus cunninghamii, Atherosperma moschatum, Eucryphia lucida* and *Phyllocladus aspleniifolius*.

Wet eucalypt forests usually contain one or two cohorts of even-aged eucalypts originating from previous wildfires. With a typical fire frequency of once or twice every hundred years, these forests maintain their wet sclerophyll understorey. With longer intervals between fires (up to 350 years) the wet sclerophyll species are gradually replaced by rainforest species (Gilbert 1959).

Figure 6. Blackwood in wet eucalypt forest.

Where blackwood is an understorey species in eucalypt forests:
- sawlog form is often good
- other understorey species such as *Pomaderris* help to suppress the blackwood side branches.

Blackwood is one of the longest-lived of the wet sclerophyll understorey species and remains in the forest during the transition from wet sclerophyll to mixed forest. It commonly lives for more than 100 years and the oldest known blackwood harvested in Smithton was 210 years old when cut (Mesibov 1980). Unlike rainforest species, which can reproduce without disturbance or fire, blackwood regeneration under these conditions is very limited, although its seed remains stored in the soil. Blackwoods in mixed forests are therefore usually older, larger and less frequent than in wet sclerophyll forests. If the fire frequency is 200 years or greater, the blackwood component may disappear from the forest, leaving only ground-stored seed awaiting the next major disturbance.

After catastrophic fire, eucalypt seed, released from capsules high in the crowns, germinates at the same time as the ground-stored seed of understorey species such as blackwood and *Pomaderris apetala, Nematolepis squamea* and other *Acacia* species. Browsing of the blackwood seedlings by native mammals usually reduces the blackwood stocking to quite low numbers, but some seedlings survive in clumps of cutting grass, sword grass or protected by “natural cages” of fallen branches or woody debris. The wet sclerophyll understorey species grow up with the blackwood seedlings and form a dense layer beneath the eucalypt crowns. These species provide dense side-shading, resulting in suppression of the lower branches of the blackwoods. The dead branches are shed with prompt and effective occlusion (Jennings *et al.* 2003). The resulting eucalypt forest has a wet sclerophyll understorey, which contains a scattering of well-formed blackwoods.

1.2 Swamp blackwood forest

Blackwood is a dominant tree species in the swamps of north-western Tasmania. This locally distinct vegetation type occurs predominantly in flat, wet, slow draining areas in the catchments of the Welcome, Montagu, Roger, Duck and Arthur Rivers. The composition and structure of much of the swamp vegetation is a result of poor drainage, seasonal inundation, selective harvesting and fire (Duncan *et al.* 1994). *Eucalyptus brookeriana* and *E. nitida*, are common on the drier edges of swamps.

The early successional stages of blackwood swamp forests are typified by a closed canopy of blackwood, paperbark and teatree species (*Melaleuca ericifolia*, *M. squarrosa, Leptospermum lanigerum, L. scoparium*). They are low in species diversity and many of the even-aged stands have arisen as a direct result of massive disturbance (Pannell 1992). The teatree species regenerate vigorously after fire or disturbance and "nurse" the blackwood seedlings by providing protection from browsing and promoting good form by shading out lower branches. These forests are known as swamp blackwood teatree forests.

Figure 7. Blackwood in swamps.

Where blackwood grows in **pure stands** it produces:
- many poorly formed stems
- a branchy habit
- limited light competition between crop trees.

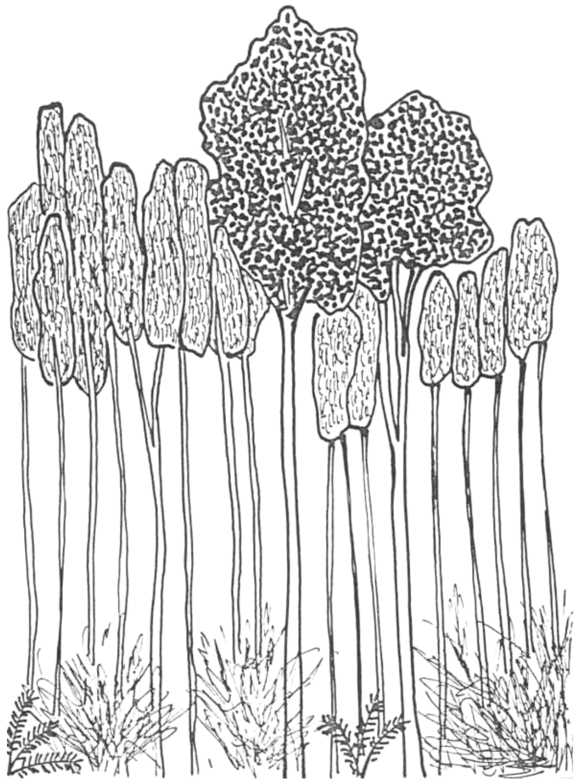


Figure 8. Blackwood in swamps.

Where blackwood grows with a thick teatree nurse:
- it grows up with excellent form
- the dense teatree crowns suppress the lower blackwood branches
- the blackwood develops a crown above the teatree canopy.

The later successional stages of these forests often develop an understorey rich in rainforest species, cutting grass, sedges and a thick fern layer. These rainforest species typically grow on soils with a well-formed peat horizon (Pannell 1992). "Islands" of myrtle and other rainforest species growing on peaty banks (which are host to a high diversity of non-vascular species) can easily be identified in these blackwood swamp forests and should be protected during harvesting. These communities are self-perpetuating and do not require large-scale disturbance for the maintenance of their floristic composition and structure (Pannell 1992). Fire should be excluded from this community, known as swamp blackwood myrtle forest.

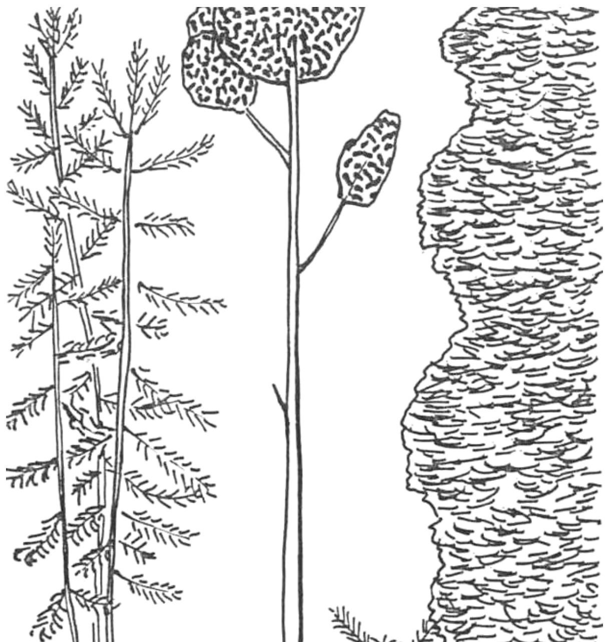
1.3 Riverine blackwood forest

In the cool temperate rainforests of Tasmania, blackwood occurs most frequently along the banks of major rivers. These areas are disturbed by flooding and have relatively high light intensity, ample moisture and a suitable seed-bed of river sand and silt. Originally, seed dispersal may have been via the river but once blackwood becomes established, the main seed source is from ground-stored seed.

These forests are dominated by *Nothofagus cunninghamii* and *Atherosperma moschatum* with scattered understorey species (eg. *Anopterus glandulosus, Aristotelia peduncularis, Coprosma quadrifida*) and a well-developed fern layer. Away from the rivers, blackwood occurs sporadically in rainforest and is generally associated with some form of disturbance which has opened up the forest canopy. Blackwood is not considered a true rainforest species due to its occurrence in sclerophyllous vegetation and other fire prone vegetation and its reliance on disturbance for regeneration (Jarman and Brown 1983).

Figure 9. Blackwood in riverine forest.

Where blackwood is a co-dominant species in riverine rainforests:
- it grows in canopy gaps between the dense myrtle crowns
- the dense rainforest crowns which extend to ground level, together with low light levels, help suppress blackwood branches.



Successful establishment of blackwood with good form requires "light-wells", which are small gaps in the rainforest overstorey resulting from tree mortality, windthrow, flood damage or other disturbance. Light-wells provide sufficient overhead light for growth while providing side shade for branch suppression. The blackwood is usually multi-aged, corresponding to these minor disturbances.

Periodic flooding does not appear to damage the standing forest to any great extent and also provides sufficient stimulation for germination of ground-stored seed.

However, most of these riverine blackwood forests are not available for harvest as they occur within streamside reserves. Where small areas of this forest type are harvested, a low impact system copying the natural gap regeneration system is recommended. Riverine blackwood forests often occupy areas of high visual and environmental priority. The silty riverbank soils are susceptible to erosion during flooding if significant vegetation cover is removed. A selective logging system can be used to perpetuate the multi-aged blackwood forest. Ground-stored blackwood seed is available and snigtracks and gaps in the existing myrtle forest caused by partial logging will provide light-wells suitable for establishment of blackwood of good form. However, myrtle is susceptible to myrtle wilt caused by the fungus *Chalara australis* that enters the tree through wounds often caused by logging or disturbance. Hence, extensive death of the nurse species can result from logging damage. Any fencing erected for browsing protection is at risk from windthrow of retained myrtle stems and periodic flooding.

To minimise these problems, blackwood should be selectively logged down to a 40 cm dbhob limit, with care taken not to damage myrtle trees during logging. All advanced growth should be retained undamaged.

A regeneration survey (Forestry Tasmania 2003) should be carried out three years after logging. This involves the survey of blackwood seedlings which germinated as a result of harvesting disturbance and have survived browsing, blackwood advance growth and surrounding healthy rainforest trees. Planting of at least 100 individually caged blackwood seedlings per hectare in existing canopy gaps would be mandatory for coupes which did not reach 40% (low wood production) stocking. This should be done while the coupe is still easily accessable and before planting spots are colonised by weeds, sedges and ferns.

For enrichment planting of blackwood seedlings to be successful the following must be considered:

- **Seed source**. There is considerable genetic variation between seedlings from different localities - in both growth and form.

- **Timing of planting**. Under-plantings of blackwood in areas of partial canopy can be carried out during most seasons, but the dry soils of summer should be avoided.

- **Suitable light conditions**. Blackwood seedlings will not survive if planted underneath the dense crowns of rainforest species. Planting sites must be carefully chosen, with sufficient overhead light to allow height growth while being surrounded by enough vegetation for lower branch suppression.

- **Protection from browsing**. Details of individual plant protectors can be found on page 24. (Part B, 2.3 Browsing control)

1.4 Dry forest blackwood

Blackwood occurs occasionally throughout the dry eucalypt forests of Tasmania, concentrated mainly in gullies and wet soaks. In these areas of increased moisture, blackwood may reach 15 m and have good form, but elsewhere it appears as a small stunted tree.

It occurs as an understorey species in forests dominated by *E. obliqua, E. amygdalina, E. ovata, E. pulchella, E. globulus* and *E. viminalis* and is generally associated with plants from the wetter end of the dry forest range, although its floristic associations are extremely variable. It is often evident as a small shrub on rocky dolerite slopes in dry forests.

Blackwood is not tolerant of the frequent fires that may sweep through dry eucalypt forests every 5-20 years and is more common in the moist gully areas that have a fire frequency of 20-80 years. These areas are often excluded from logging and set aside as streamside reserves and wildlife habitat strips.

Where blackwood occurs in drier forest it readily germinates after logging disturbance or fire. Heavy browsing probably reduces the stocking to a level comparable with that of the original forest.

2. *BLACKWOOD REGENERATION AND GROWTH*

2.1 Seed production

Blackwood flowers from late August to early October in Tasmania. It closely follows the flowering of silver wattle (*Acacia dealbata*) and flowers at about the same time as *A. mucronata* and *A. verticillata*. Seed is formed over the following months and shed from January to early March with peak seedfall in mid-February. Little seed is retained on branches beyond April.

Some seed is shed every year, although seed crops in some years are heavier than others. Mass flowering occurs occasionally but this does not always go on to produce heavy seed crops. Blackwood may flower from as young as five years old.

Blackwood seed is approximately 5 mm x 3 mm, a flattened oval in shape, and is covered by a hard black coating which protects the seed from insects and other damage. The seed grows in a pod to which it is attached by a salmon-pink seed stalk or funicle that often stays with the seed when it is shed.

Viability is generally very good with up to 99% of freshly collected seed germinating, however this may be reduced in poor seed years and by poor storage conditions. There are approximately 50 viable seeds per gram of cleaned seed.

2.2 Germination

Blackwood seed is ground stored and appears to last in the soil for many decades after seedfall. Blackwood seed continues to germinate along current drainage lines and disturbances in areas such as Brittons Swamp, which was cleared prior to 1935 (Closer Settlement Board 1935).

A large reserve of local seed builds up over time. Surveys in Dismal and Montagu Swamps in 1984 showed nine to 38 million blackwood seeds per hectare in the top 15 cm of soil (Jennings 1998). Wilkinson and Jennings (1994) found more than 20,000 seeds per m² in a soil profile taken from just north of the Arthur River, with seed distributed throughout the profile to a depth of at least 100 cm. Nearly 50% of the seed was located within the top 10 cm of soil. The average viability of the seed was greater than 94% and there was no indication of a decline in viability even at a soil depth of 100 cm (Wilkinson and Jennings 1994). Native forest regeneration methods aim to utilise this resource.

Germination of small numbers of ground-stored seed occurs sporadically, occurring mainly in spring and autumn. A major disturbance is needed to stimulate massive germination. This occurs naturally following wildfire, flooding or windthrow, and can be artificially reproduced using fire or mechanical disturbance. Logging and burning have been used successfully to stimulate germination of ground-stored seed in Murchison District. For example, field germinations of 154,000 seedlings per hectare have been recorded in swamp forests, and 70,000 seedlings per hectare in wet eucalypt forest (Jennings 1998).

Results from experimental treatments indicated that high intensity burning destroyed 67% of the viable seed in the top 7.5 cm of the soil profile and stimulated the germination of more than 95% of the remaining seed (Wilkinson and Jennings 1994). High intensity burning therefore produces a “one-off” flush of regeneration by stimulating germination and depleting the normal reservoir of non-germinated seed stored in the surface soil. This single flush of germination is highly vulnerable to browsing. Where burning is used as a silvicultural tool to promote massive germination of blackwood seed, browsing control must be immediate and very effective. In contrast, soil disturbance resulted in the germination of up to 21% of the seed in the top 7.5 cm, with the remainder being retained for future germination (Wilkinson and Jennings 1994). A secondary or remedial disturbance treatment would therefore be possible following soil disturbance germination.

Standard nursery methods for pre-germination treatment of *Acacia* seed include:

- pouring near-boiling water over the seed and soaking for several hours;
- nicking the seed coat with a sharp blade (Doran and Gunn 1986);
- scarification of the seed with sandpaper (Neilsen and Brown 1997), or
- treating the seed with acid (Simmons 1981).

2.3 Browsing control

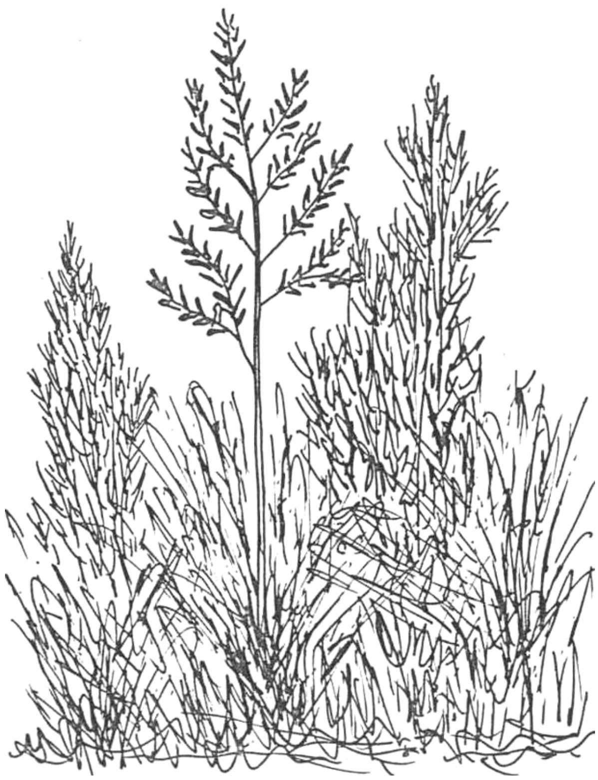
One of the major factors which limits blackwood regeneration is browsing. Blackwood is highly palatable to the red-bellied pademelon (*Thylogale billardierii*), Bennetts wallaby (*Macropus rufogriseus*), other native mammals including the eastern swamp rat (*Rattus lutreolus*) and the long-tailed mouse (*Pseudomys higginsi*) as well as to European rabbits (*Oryctolagus cuniculus*) and domestic livestock (Statham 1983). Young seedlings are killed by browsing. Older seedlings may reshoot and recover but repeated browsing damage affects form and lowers growth rates. Possums do not generally cause significant damage to blackwood seedlings.

Without protection, young seedlings are almost invariably browsed. Natural regeneration is dependent on seedlings growing up within the thick protective cover of cutting grass and teatree, or germinating on logs and amidst debris, out of reach of browsing animals. It may be several years after logging or disturbance before there is sufficient scrub protection for successful blackwood regeneration. The resulting seedling numbers are low and distribution is patchy, dependent on the occurrence of thick patches of protective scrub as shown in Figure 10.

Figure 10. Natural browsing protection.

Blackwood seedlings are readily browsed by native mammals. Natural protection includes:

- dense teatree regeneration
- cutting grass
- fallen branches or debris.



A review of silvicultural and operational swamp logging trials from 1978 to 1992 by Jennings *et al.* (2000) found that provided a harvested area with ground-stored blackwood seed received sufficient light and disturbance, the overwhelming factor determining the success of regeneration was browsing control. Fencing the entire coupe with wire netting has proven to be the most successful form of browsing control for areas currently being regenerated. Fencing resulted in up to 7000 established blackwood saplings per hectare for coupes up to 12 years old. Unfenced coupes at the same age carried less 360 seedlings per hectare and did not reach the Forestry Tasmania stocking standard (Jennings and Dawson 2000; Jennings *et al.* 2000).

Jennings and Dawson (1998) compared five unfenced eucalypt regeneration coupes with seven similar fenced coupes aged from four to eleven years old, and showed an increase in mean blackwood stocking from 70 seedlings per hectare in unfenced areas to 2500 seedlings per hectare in fenced coupes.

Fencing also protects the many wet forest understorey species and colonising plants (fireweed, Macquarie vine etc.) from browsing but both blackwood and eucalypt regeneration are vigorous on good sites and should dominate the site quickly.

Both electric and conventional fencing have been used to protect blackwood seedlings.

Electric fencing can be used successfully on plantation sites where a high degree of site preparation is carried out. It requires a well-prepared fenceline to prevent gaps under the fence or debris shorting out the electric circuit. In swamp areas where fencing is often adjacent to a forest edge it is susceptible to failure due to windthrown trees. Winter flooding also causes electric fences to short circuit. A disadvantage of electric fences is that if they are damaged anywhere, the whole fence loses its effectiveness. Electric fencing is not generally used in native forest situations.

An alternative to fencing, particularly for underplanted areas, is caging of individual seedlings. Blackwood plantings have been established since the 1970s and a number of methods of caging have been trialled. These include plastic sleeves, wire netting, woven plastic mesh and corflute plastic. The cages were supported by wooden stakes.

- UV stabilised plastic sleeves are available in a range of widths and heights. They seem to be effective in areas of low browsing pressure, provided they are high enough (800 - 900 mm tall). Where browsing pressure is high, animal damage to the plastic sleeve generally occurs and seedlings are browsed over the top of the sleeve. Very narrow sleeves have been produced which need only one stake for support. However blackwood seedlings seem to "sweat" inside them and are susceptible to aphids and sooty mould.

- Wire mesh has proven to be effective in most situations but is expensive and very difficult to install on an operational basis in a forest situation.

- Woven plastic tubes and plastic mesh appear to be tougher than plastic sleeves, but if dark coloured can restrict light to the seedlings. Woven plastic materials are quite pliable and have been pulled both up and down by browsers.

Figure 11. Corflute plastic tree guard, which is highly durable and can be re-used.

Figure 12. Corrugated cardboard guard, which is biodegradable for sensitive sites.

- Corflute protectors are very effective. They may come with the top edge folded over to prevent damage to the bark of the seedlings and can be secured with one or two stakes (Figure 11). They are translucent and light coloured and the seedlings grow quickly within their protection. They are expensive, but easy to use and usually last long enough to re-use. Several brands are commercially available, although the standard height of 600 mm high is not considered tall enough. Some companies will make treeguards to specific heights (about 900 mm is required) provided they are ordered by the thousands. Cost at time of printing is about $2.00 for the taller guards.

- Corrugated cardboard protectors are similar to corflute ones (Figure 12). They do not last as long in the field (1 - 2 years) but have the advantage of being biodegradable for use in streamside reserves or other sensitive sites, or where salvage for re-use is not being considered. They cost $0.60 each for 600 mm guards in large quantities, but could be custom produced at 900 mm for about $1.00 each.

Caged plantings have been largely unsuccessful with many cages failing before the seedlings grow above browsing height. The cages cost as much or more than the seedlings, and erecting them more than doubles planting time. However there are some areas, such as selectively logged riverine forests, where individually caged seedlings still seem to be the best alternative.

2.4 Light requirements

Blackwood seedlings grow vigorously under favourable conditions; up to 145 cm per year in height (Jennings 1998) although 40 - 80 cm per year is more usual (Jennings and Dawson 1998). They are sensitive to light availability which affects both growth rate and form. In open situations where both top- and side-light is unlimited, blackwood growth rates are high but lateral branches persist and the tree develops a large bushy crown at a low height. This form of blackwood is common on farms in north-western Tasmania and gives good shade and shelter for livestock.

Blackwood is reasonably tolerant of low light conditions and seedlings may retain their juvenile foliage and persist with little height growth for several years before either responding to increased light availability or dying from lack of light.

Adequate top light combined with side shading enables vigorous blackwood height growth with lower branch suppression. This situation occurs naturally where blackwood grows with a thick co-dominant layer of teatree species or *Pomaderris apetala*. These species, also stimulated by disturbance, grow up with the young blackwood and suppress lateral growth, while not growing fast enough to suppress the blackwood crown. A similar effect is also seen where blackwood grows in natural light-wells in rainforest.

Experiments with light-wells in a 6-year-old fenced-intensive-blackwood coupe in Murchison District showed that the diameter growth of the untreated blackwood saplings (0.8 cm/yr) could be increased to 1.4 cm/yr by removal of the eucalypt canopy, and up to 2.1 cm/yr with the additional removal of the competing *Pomaderris* (Jennings *et al.* 2003). However, removal of the dense sub-canopy produced heavier, broader blackwood crowns, increased branch size and retention, and reduced the length of branch-free bole (Jennings *et al.* 2003).

2.5 Moisture tolerance

Blackwood is tolerant of very moist conditions. It is the dominant species in the swamp forests in north-western Tasmania where the ground is covered with water for several months of the year. It is important that the water is moving, as blackwood will not grow in waterlogged undrained soils. Established blackwood forest will die where roading, logging or clearing block the natural drainage lines causing water to become still or stagnant.

2.6 Thinning and windthrow

Thinning of pure blackwood stands rarely undertaken. It is expensive and growth responses have not been well studied. Blackwood is a shallow rooted species and operations that remove crown cover leave blackwood susceptible to windthrow, particularly in the saturated swamp soils. However, thinning of the eucalypt overstorey in fenced-intensive-blackwood stands appears more promising and is being pursued operationally.

Pure blackwood swamp stands are poor at self thinning. Where many blackwood stems are competing for light or blackwood is being suppressed by other species, the number of stems remains high. The result as the stand ages is a dense even-aged blackwood stand of tall spindly poles with poor form.

Several blackwood thinning trials (Mesibov 1981; Mesibov 1982b) were conducted in blackwood pole stands in north-western Tasmania, and results suggest that:

- in general, blackwood responds to thinning with increased diameter and crown growth,
- in very wet areas thinning may have no effect on diameter growth,
- salvage of thinnings can be very expensive,
- thinned stands are prone to windthrow.

In order to reduce stand disturbance and windthrow, thinning by herbicide application and ringbarking has been tried. The most effective herbicide killed two-thirds of the treated trees. Ringbarking killed crowns but encouraged stem sprouting (Mesibov 1982a).

It is likely that the fenced-intensive-blackwood regeneration areas currently being established will require thinning of the eucalypts to improve blackwood growth rates. Most of these coupes reach the stocking standard for both eucalypt and blackwood and are therefore carrying two crops. These new stands are being managed primarily for blackwood and high quality eucalypt sawlog production. A eucalypt thinning regime for highly stocked fenced-intensive-blackwood coupes is currently being developed based on the results of several stand management trials. The effect of thinning the understorey blackwood is yet to be tested.

A release trial in a 6-year-old fenced-intensive-blackwood coupe showed that both the eucalypt overstorey and the co-dominant *Pomaderris apetala* impacted significantly on the diameter growth of the blackwood saplings (Jennings *et al.* 2003). Removal of the *Pomaderris* improved blackwood diameter growth in the short term, but resulted in greater branch size and retention which reduced the potential sawlog length. The best long-term improvement resulted from removal of the eucalypts.

In an adjacent trial, the standard pre-commercial thinning prescription for highly stocked young eucalypt stands, which involves removal of 50% of the eucalypt basal area (described in Forestry Tasmania 2001), did not significantly improve blackwood diameter growth. However, in a treatment where 75% of the eucalypt basal area was removed, blackwood diameter increment increased by almost 50% over that of the controls (LaSala and Jennings in press).

Two approaches to thinning regimes are being considered for the most heavily stocked fenced-intensive-blackwood stands:

- Pre-commercial removal of 75% of the eucalypt basal area at age 10 - 15 years, followed by a commercial thinning of the eucalypts at age 30, or
- Pre-commercial thinning of the eucalypts down to a notional final crop stocking of 250 stems/ha at age 15 years, with no commercial thinning.

The early “final crop” thinning without a commercial thinning is currently the preferred option as there are concerns regarding both damage to the blackwoods and windthrow following commercial thinning. Rotation lengths for thinned fenced-intensive-blackwood stands are expected to be 60 – 70 years.

2.7 Fire

Fire is a useful tool for stimulating the germination of ground-stored blackwood seed, however established blackwoods are killed by even moderate intensity fire and show no tendency to recover through basal or epicormic shoots.

2.8 Insects and diseases

Blackwood does not suffer from any major insect pests or diseases. Susceptibility to fungal diseases such as *Armillaria* and *Phytophthora* appears to be minimal. Although many insects are present on blackwoods they are not generally an economic problem, but often occur on isolated trees, in localised patches, garden situations or nurseries. Seedlings may be defoliated by moths and grasshoppers, or have their shoots deformed by psyllids. Larger trees may be attacked by wood borers, leaf eaters, psyllids and scale insects. In some years seed crops may be reduced due to the presence of gall insects.

3. BLACKWOOD TIMBER PRODUCTION

3.1 Blackwood growth and stand volumes

Most of the blackwood growth information available was derived from measurement plots established in blackwood swamps. Growth information on blackwood in wet eucalypt forests is currently being gathered from young fenced-intensive-blackwood coupes.

The best available increment data, based on ring counts, indicate that average blackwood diameter growth rates in the swamps range from 0.55 to 0.75 cm per year with growth slowest in densely stocked stands and in trees older than 70 years (Forestry Commission 1982).

The proportion of blackwood within individual forest stands is highly variable, ranging from only a minor presence to stands where blackwood constitutes over 90% of the total merchantable volume. Recovered volumes in areas logged in the Blackwood Working Circle between 1980 and 1990 ranged from 21 m^3 per ha on the riverine flats to 196 m^3 per ha at Plains Creek. The average recovered volume over this period was 57 m^3 per ha.

Information from Forestry Commission research plots (RP529) indicates that the very best 40 to 80-year-old swamp blackwood stands may have sawlog volume mean annual increments (MAI) of 3 to 6 m^3 per ha per annum. However, because blackwood occurs as a variable proportion of total stand volume the average blackwood sawlog MAI would be much lower (Forestry Commission 1982).

3.2 Timber production

Forestry Tasmania expects to supply at least 10,000 m^3 blackwood sawlog annually from State forest to 2015, although this figure is subject to periodic review. At least half of this production should be Category 4 (high quality) sawlog, with the remainder being lower grades of sawlog (Utility and Outspec) and craftwood.

Figure 13 shows the mean annual sawlog produced by each Forest District over the last five years, and the breakdown by sawlog category. Approximately 75% of the blackwood sawlog from State forest is produced by Murchison District, but both Bass and Huon Districts contribute significant quantities of Cat 4 sawlog.

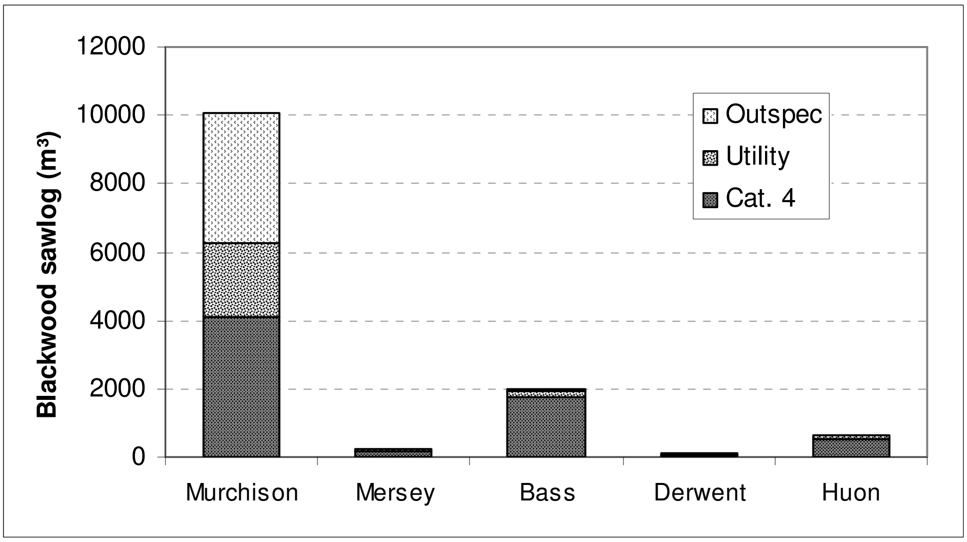


Figure 13. Mean annual sawlog production from each Forest District from 2001 to 2005, shown by sawlog category.

3.3 Timber quality

Blackwood produces one of the world's best furniture timbers (Boland *et al.* 1984) and is prized for the patterns and colours of its heartwood (Searle 2000). Timber colour varies from light brown to dark brown, with occasional red tints and black streaks. The sapwood is white (Boland *et al.* 1984). The timber is a medium-density hardwood that dries easily, has low shrinkage, stains easily and takes a fine even polish (Searle 2000). It glues satisfactorily with most common adhesives and is a very good bending timber. Logs are moderately easy to peel for veneer, although veneers may split and buckle during drying (Searle 2000).

The grain of blackwood timber is usually straight, but sometimes features wavy grain patterns such as fiddleback and birdseye, which are favoured by craftsmen and in veneers (Nicholas and Brown 2002). The variation in timber colour can cause difficulties in matching timber (Nicholas and Brown 2002). The darkest wood is generally preferred, but this preference can be influenced by world timber fashion colours, which vary from dark to blonde woods periodically. The percentage of the dark heartwood is also important because the value of a blackwood tree is largely determined by the heartwood content (Bradbury 2005).

Some Tasmanian sawmills have a problem with staining in the heartwood of harvested logs and milled flitches of blackwood during the drying process (Barry *et al.* 2003). This stain is a major cause of blackwood veneer downgrade. Barry *et al.* (2003) found that this was probably due to an oxidation process, which occurs when cut logs are stored for periods of time, particularly during warmer weather.

A recent study into blackwood timber quality showed that the measurable attributes of basic density, green moisture content, percentage heartwood and heartwood colour were very similar in 14-22 year-old silvicultural regeneration established in both swamp areas and wet eucalypt forests. Plantation blackwoods of about the same age were similar in most respects but had significantly higher green moisture content (Bradbury 2005).

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