Best Practice with Farm Forestry Timber Species

No. 4: BLACKWOOD

Ian Nicholas and Ian Brown

NZFFA Electronic Handbook Series

DEDICATION

This Handbook is dedicated to the memory of the late Norval Gibson Smith, who founded AMIGO. Norval was also founding chariman, inaugural secretary, and treasurer. Without his vision and input, this Handbook would not have been realised

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Best Practice with Farm Forestry Timber Species

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Revised edition of Forest Research Bulletin No. 225 -
BLACKWOOD
A Handbook for Growers and Users

FOREWORD

Following the success of the publication *Blackwood - a handbook for growers and end users*, several New Zealand Farm Forestry Association (NZFFA) action groups expressed an interest in the production of handbooks for other tree species.

This publication is the fourth in a series designed to present up-to-date information about cypresses, eucalypts, redwoods and blackwood (revision of Forest Research Bulletin 225. Support for the project has been received from the MAF Sustainable Farming Fund with additional assistance from NZFFA, Scion (FRST new species CO4X0304), Proseed NZ Ltd, Environment Bay of Plenty, Horizons Regional Council, Rarefind Timbers, the Plantation Management Cooperative and relevant NZFFA action groups.

New material added to Bulletin 225 in this 2008 update is boxed in pale green boxes

Visit the NZ Farm Forestry Association website (www.nzffa.org.nz) for the most up-to-date information available.

AMIGO (Acacia Melanoxylon Interest Group Organisation) is an action group within the New Zealand Farm ForestryAssociation.

Founded by the late Norval Gibson Smith in 1989, it has the objective of bringing together tree growers and forest researchers in an information- sharing network.

- To share research findings (both Scion and private) with blackwood growers.
- To develop improved genetic stock for planting.
- To encourage the adoption of the best silvicultural techniques.
- To cooperate in a marketing strategy.

AMIGO publish regular newsletters, run seminars, and hold field days. Currently it has over 200 members.

AMIGO can be contacted through the national office of the NZ Farm Forestry Association

(see web links in Chapter 15).

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Visit www.nzffa.org.nz for the most up-to-date information available.

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CHAPTER 1 - SPECIES RECOGNITION, HISTORY AND HABITAT

Key Points

Blackwood is well established as a minor species in the New Zealand forestry scene, especially at the farm forestry level.

Blackwood has an extensive natural distribution, and is tolerant of adverse sites. However, blackwood of commercial value has strict site requirements - it needs adequate rainfall, shelter, fertile, free-draining soils and moderate temperatures.

Blackwood tolerates damp soils and periodic flooding, but is intolerant of stagnant or permanently waterlogged soils.

Blackwood regenerates from ground-stored seed after disturbance and its good form in natural stands is the result of intensive competition among competing species.

Blackwood occurs throughout eastern Australia, but most commercial production is in Tasmania and Victoria.

Blackwood is established as an exotic plantation species in South Africa, India, Chile, Hawaii and China.

CHAPTER 2 - TIMBER PROPERTIES, MARKET AND RESOURCE

Key Points

Blackwood is a medium-weight timber that is easy to work, turns and bends well, and dresses to a smooth finish. It has even texture with usually straight, but sometimes wavy, grain.

Blackwood timber is extremely variable in wood density, colour and heartwood percentage.

Growth rate has little bearing on wood quality.

Blackwood is developing a market-following in New Zealand, where current demand is outstripping supply.

The Australian market is cyclical, reflecting the Australian economy and fashion.

Australia exports blackwood to at least five countries.

The resource in New Zealand, estimated at approximately 3,000 ha, is young but will be producing timber from about 2015 when it will be capable of supporting a blackwood industry.

The resource in Australia is based on sustainable production from natural forests and from plantations (when they mature in 2018-2048).

CHAPTER 3 - SITE REQUIREMENTS AND LAND USE

Key Points

Blackwood requires careful siting.

Blackwood grows best and shows best form on sheltered sites.

Blackwood sites should provide adequate moisture for optimum growth.

Frost prone sites should be avoided.

Blackwood can be suitable for a wide range of land uses, for both timber and non-timber values.

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CHAPTER 4 - AGROFORESTRY

Key Points

Blackwood is a useful agroforestry species, provided it is properly sited and careful stock management is undertaken.

As tree-stocking rate and tree green-crown length increase, understorey shade also increases.

Pasture yield decreases with increasing shade, but not as much as with other non nitrogen-fixing tree species, particularly at low shade levels.

Total soil nitrogen and nitrogen availability increases with higher tree-stocking rate. This differs from non nitrogen-fixing tree species, where total soil nitrogen and nitrogen availability decrease as tree-stocking rate increases.

Pasture legume content decreases as tree-stocking rate increases.

Tree litter fall and nitrogen return increases with an increase in tree-stocking rate.

On moist sites, understorey soil moisture is unaffected by tree stocking rate. This indicates that the trees are not competing with understorey pasture species for moisture.

CHAPTER 5 - SEED, GENETICS AND CLONAL PROPOGATION

Key Points

We have reached a stage where we can be reasonably confident about site selection for blackwood in New Zealand and we have silvicultural systems which will allow us to grow straight trees. The opportunity to exploit the wide genetic variability of blackwood will become increasingly important.

Blackwood shows considerable genetic variation, both between and within provenances.

There is a lack of research results to guide the establishment of plantations and breeding programmes. Studies conducted have often been limited in scope, particularly with regard to the number of representative provenances. A recent initiative by Forest Research, NZ Lotteries Commission and Amigo aimed to address some of these issues.

Propagation systems for clonal material are available.

The variation in blackwood growth habit and wood properties lends itself to a clonal propagation system. However, the heritability of important selection traits, and the influence of site are also unknown.

Clonal selections will require assessment of their performance before they can be considered more than experimental.

CHAPTER 6 - PRODUCTION, ESTABLISHMENT AND NUTRITION

Key Points

Siting is very important.

Robust planting stock + good spade cultivation + good weed control = good plantation establishment.

Seed requires treatment to ensure even germination.

Seedling type is not critical to success.

Fertiliser is not always necessary, however P and S should be applied on P deficient soils.

If fertiliser is applied it should be in conjunction with weed control.

Seedlings need protection from stock/wildlife during establishment.

Nutrient deficiency and/or optimum levels are unknown.

Foliage collection is recommended in the month of April.

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CHAPTER 7 - HEALTH

Key Points

Insect damage is present in all blackwood stands.

Due to New Zealand's proximity to Australia, blackwood plantations will always be threatened with the establishment of new insect pests and diseases.

Insects commonly establish without the parasitoids which control their populations in their natural environment, allowing them to become pests.

The most damaging effect of insect pests on blackwood is their contribution to leader dieback, malformation and subsequent multileadering. They are therefore important in the early stages of plantation establishment.

Well-sited, well-established and well-managed blackwood can produce excellent sawlog material, although growth reduction from insect pests during the rotation has not been quantified.

Mature and healthy trees grown on good sites show little obvious insect damage.

CHAPTER 8 - MANAGEMENT OPTIONS

Key Points

Blackwood can be grown in plantations.

Form pruning is an essential component of all blackwood management systems.

The use of a trainer species can result in improved stem form. However the method has pitfalls, and requires attention to detail.

The temptation to retain the trainer species after the blackwood butt log is formed must be resisted.

An attempt to extract commercial timber from the trainer species is unlikely to succeed, and can compromise good blackwood management.

Enrichment planting in indigenous scrub can be very effective, but can raise environmental concerns that it might result in conversion.

CHAPTER 9 - GROWTH HABIT, AND MALFORMATION

Key Points

Growth Habit

Blackwood shows a striking plasticity in its form and growth rate in response to site factors (in particular moisture, shelter, light, and soil type).

The seeds are long-lived in the soil. Once established, blackwood is therefore likely to persist on a site.

Extensive root systems give blackwood a role in soil stabilisation, and in riparian planting.

Blackwood is moderately shade-tolerant when young, but become light demanding as it matures.

Advantage should be taken of the capacity for rapid extension growth and reduced branching which occur during the juvenile growth phase

The coppice response varies between seasons. There is therefore an optimal time to cut when either thinning, or encouraging new growth (autumn and spring respectively).

The recommended period for annual assessments of both diameter and height for blackwood in New Zealand conditions is during June and July.

CHAPTER 9 - cont'd

Malformation

Malformation is inevitable in plantation grown trees.

Stem malformation can be reduced by encouraging vigorous juvenile growth.

Multiple leaders, stem kinks and rogue branches can be controlled by form pruning (see chapter 10).

Crown malformation can be reduced by form pruning and thinning on time.

Crown malformation can be reduced by ensuring even spacing between final crop trees and avoiding a fork at the base of the crown.

CHAPTER 10 - PRUNING AND THINNING

Key Points

Form pruning is essential. This involves selective branch removal to achieve acceptable form.

A combination of leader training and gauge pruning is recommended and should be carried out annually during the formation of the 6 metre stem.

Leave 3 metres of green crown at lift pruning.

Remove or shorten competing leaders at the crown base.

Do not thin heavily too early, but reduce stocking to approximately 200 stems/ha by age 10 years.

Depending on site, thin on time to prevent the adverse effects of crown competition.

Chapter 11 - GROWTH MODEL, YIELDS, SUGGESTED REGIME

Key Points

A growth model for stand prediction has been developed, but is not yet available.

Future model predictions should be reviewed and updated periodically, as more growth data becomes available.

Site indices suggest that a range of MTH from 15-45 m at age 30 could be expected.

Assessment of recoverable yield suggests large butt log diameters should be targeted.

The regime is designed to produce a target tree of 60 cm DBH, pruned to 6 m with a rotation length of 35-40 years.

An initial stocking of 800 stems/ha that receives form pruning, clearwood pruning by age 8 and thinning to 200 stems/ha by age 10 is recommended.

Yields of 300 m^3/ha sawlog material is estimated.

As more data is collected preferred regimes are likely to be updated, therefore seek up to date advice.

CHAPTER 12 - ECONOMIC ANALYSES

Key Points

Economic analyses are difficult because of uncertain data.

Blackwood economic evaluations have returned positive values, usually with IRR of 5-8%.

In New Zealand, blackwood returns appear less than radiata pine.

Silvicultural costs are difficult to determine.

Recoverable yields are relatively unknown.

Log sales have insufficient history to give consistent pricing.

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CHAPTER 13 - UTILISATION

Key Points

New Zealand plantation blackwood has been utilised for many years and has proved very acceptable in the marketplace.

Flat sawing is preferred to quarter sawing.

Sawing studies on untended stands have produced an average conversion close to 50%, and show the importance of large diameter logs.

Heartwood percentage is variable.

Some tension in logs occurs, but is variable.

Blackwood dries and machines well, and has excellent working properties.

Processors should ensure a dust-free work environment.

Processors prefer larger logs (SED 400 mm +).

New Zealand plantation material is being converted to furniture and is selling in the market place.

Chapter 14 CASE STUDIES

Key Points

Blackwood is not a plant and leave crop.

Blackwood working circles require commitment to the full value chain from correct siting through silviculture to the marketing of logs or timber.

Do your homework and commit to timely silviculture.

Identify the best blackwood sites and concentrate on good management for those areas.

Develop a marketing strategy for best use of logs and/or timber.

Chapter 15 SUMMARY

Key Points

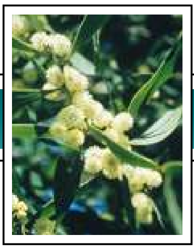
Basic management practices are well understood and successful stands can be grown if the available knowledge is utilised.

Siting and timely silviculture are important to get the best from blackwood plantations.

Blackwood has a developing market niche in New Zealand.

As current plantations mature blackwood has the opportunity to be one of the premier furniture timbers in New Zealand.

CHAPTER 16 - REFERENCES AND WEB LINKS



INTRODUCTION

15 year old blackwood stand near Whangarei

Australian Blackwood (*Acacia melanoxylon*), commonly called Tasmanian blackwood, is a species native to Australia. It is internationally renowned for its timber qualities. Since Blackwood's introduction to New Zealand in the 19th century both its potential and problems have become apparent. Interest from the New Zealand Forest Service (NZFS) in the late 1970s and early 1980s was followed by increased planting by private growers, and new research initiatives by Forest Research. AMIGO (*Acacia melanoxylon* Interest Group Organisation), an action group of the New Zealand Farm Forestry Association, has been the main agent in bringing together growers and researchers.

Blackwood has received mixed press among tree growers, with both successes and failures. We now know that it is highly influenced by site, and responsive to silvicultural treatment that bears no resemblance to radiata pine management. Both research data and the experience of farm foresters over the years have generated considerable knowledge, especially with regard to the silvicultural management of blackwood. A small but steady market for blackwood timber has developed in New Zealand.

The aim of this electronic manual is to revise the Bulletin 225, a joint venture between AMIGO, Forest Research and MAF, is to assemble the latest knowledge on the growing and processing of blackwood. We refer to overseas sources where useful, but in presenting the New Zealand experience the manual has a local flavour.

The text is intended to give practical guidance to growers or potential growers. This is underpinned by a description of the species designed to give an understanding of its growth and behaviour.

Although Blackwood is likely to have no more than a minor role in forestry, we believe there is a strong case for growing this species in New Zealand.

- Its superb timber is likely to remain in strong demand both locally and internationally. It makes an ideal substitute for native timbers, such as rimu, which will become less accessible from native forests, until plantation material is available over time. To international consumers increasingly concerned over rainforest destruction, New Zealand-sourced blackwood can be clearly labelled as plantation grown and sustainably produced.
- If diversity is the first principle in an investment portfolio, blackwood may help to reduce the potential risks associated with reliance on a single tree species.
- The site requirements of blackwood ensure a place in forest and farm plantations. It is ideally suited to gullies and lower valley slopes - sites on farms which are commonly either neglected or unproductive, and where extraction costs will exclude radiata pine. Blackwood grows well in scrub, and could therefore provide resources and work in areas that are economically disadvantaged, isolated or where complete denudation to establish pine may put a planting site at risk of erosion. With its extensive root systems blackwood has a role in soil stabilisation and in riparian planting.

Blackwood trees are aesthetically appealing, and in association with other species can form a visual oasis in what might otherwise be a monocultural desert.

96-year-old plantation blackwood, Whakarewarewa forest, Rotorua.

CHAPTER ONE: SPECIES RECOGNITION, HISTORY and HABITAT

Figure 1 : Blackwood foliage. Left: adult foliage (phyllode).
Centre: two examples of the transition stage showing both juvenile and adult foliage.
Right: juvenile foliage

There are probably over 1000 species of Acacia in Australia – including some that are yet to be identified. They show striking variations in size, structure, and adaptation to site. Blackwood is unusual among the acacias in that it is adapted to moist rather than dry sites. Blackwood and *A. bakeri*, a subtropical species, are the largest of them.

A distinctive characteristic of blackwood foliage is that the juvenile form is of a feathery "wattle" type, but changes quickly to a mature leathery "leaf" (Fig 1). Botanically called a phyllode, this is a flattened petiole. The phyllode is 75-150 mm long and 20-40 mm wide, bluntly pointed but tapering to the base, and has 3-5 main parallel veins running the full length instead of the usual midrib. Flowers (August to November) are in globular heads on short racemes situated in the forks of the phyllode (Fig 2). Seeds are black, oval, flat, and up to 5 mm long, with 6-10 seeds in a brown, flat twisted pod. The seed is encircled by a fleshy, pink to deep red funicle, (Figs 3 and 4). The bark is hard, rough and furrowed.

Figure 2: Blackwood flowers.

Longevity

Among the acacias, blackwood is relatively long-lived. The oldest recorded blackwood in Tasmania was 230 years of age. Blackwood can grow to about 40 metres, with a diameter of over a metre.

BLACKWOOD IN NEW ZEALAND

Acacia species have a long history in New Zealand. Acacia fossil records indicate they were well established in New Zealand, but were wiped out during the Ice Age. *Eucalyptus* and *Casuarina* had a similar history. Blackwood was first planted at Taita in the North Island's Hutt Valley in 1896.

The first major plantation was established in Whakarewarewa Forest in 1906. This stand of 29 ha was untended. (Recent measurements are summarised in Table 1). For many years after these early plantings further blackwood establishment was sporadic, scattered, and stands mostly received no silvicultural attention.

In 1979 a New Zealand Forest Service (NZFS) workshop evaluated the role of "exotic minor species", and identified blackwood as one of several species worth special attention. This led to a considerable increase in planting by the NZFS, and by small (private) forest growers. In addition several research projects were undertaken in the 1980s by Forest Research. These have provided much of the data in this manual.

It is not easy to estimate the size of the blackwood resource in New Zealand. It includes scattered groups of trees in gullies, along stream margins, and on farms. Blackwood can be commonly seen from the roadside throughout the North Island. Limiting factors to its success in the South Island are frosts and moisture. Larger plantings have been made by individual farm foresters, and many of these have been well tended. In addition, substantial areas have been planted in Westland.

There has been concern that blackwood could become a major weed problem in our native ecosystems, but to date there has been little evidence of this. With limited shade tolerance blackwood is unlikely to infiltrate our closed canopy native forests. However, it will colonise disturbed sites. Blackwood is here to stay – it is securely naturalised in New Zealand, and will have a permanent place in the rural landscape.

Figure 3: Blackwood seed pods and seed.

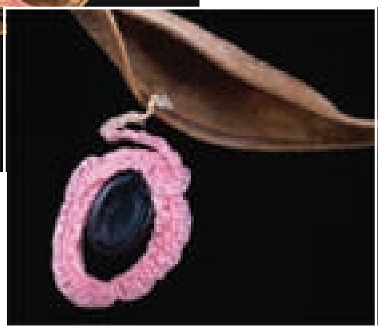


Figure 4: Close up of blackwood seed.

Table 1: Data from the oldest known NZ plantation

Plot (0.1 ha) and tree measurements for 96 year old plantation blackwood, Whakarewarewa Forest, Rotorua.

Variable	
Age (in 2002)	96 years
Stocking	270 stems/ha
Mean DBH	60.4 cm
Mean height	37.8 m
MTD	80.8 cm
MTH	40.3 m
BA	77.3 m²/ha
Volume	1104.0 m³/ha*
Largest tree diameter	107.4 cm
Tallest tree	44.8 m

* Volume data uncertain as tree size is greater than volume equation database.

Blackwood as an environmental weed in New Zealand

Blackwood (*Acacia melanoxylon* R. Br.) has been introduced and planted in New Zealand as a potential timber tree, and this has led to the development of a small market for high-quality furniture. Some plantings were placed in gaps in logged-over native forest as enrichment plantings, to encourage improved form and to provide high cover to support native regeneration. Concern has been expressed about the potential weediness of blackwood, as regeneration is often noted in or adjacent to planted stands. A survey of timber plantations and enrichment plantings established within native forests was done in Central North Island plantings (near Rotorua) in 1984. The same sites were revisited in 2001 to monitor regeneration. Assessments of plantings in Hunua Forest near Auckland and on the West Coast of the South Island were also undertaken in 2001. The Central North Island sites showed a reduction in surviving regeneration between 1984 and 2001, although where seedlings had been noted on disturbed sites, these have now developed into saplings. No invasion of native forest has occurred on any of the sites visited which also included enrichment plantings from 1960. The 2001 study has reinforced the conclusions from the 1984 study which stated; "It was considered that these studies confirmed the ability of blackwood to regenerate well in open, disturbed conditions (after logging), but no significant spread is likely to occur in shaded, undisturbed conditions within indigenous forest".

A survey of Regional and District Councils and The Department of Conservation by Forest Research in 1999 also showed that although other acacia species are considered to have weed status in many regions, blackwood does not. Despite this verdict the weediness score assigned to blackwood in New Zealand is 27, the same as for radiata pine. Field assessments have shown that, although blackwood will regenerate where light and soil conditions are suitable, there is no strong evidence to suggest that it will invade native forest. It has not readily invaded or colonised native vegetation, despite being planted as an enrichment species. However, it is acknowledged that blackwood plantings are likely to remain in blackwood for a significant time because of root suckering and germination of ground-stored seed. If blackwood is not wanted on such sites, it may be considered a weed problem. While blackwood is still considered by many to be a potential high-risk weed species, it would be prudent to continue monitoring of blackwood regeneration at research sites.

Because viability and germination of seed contribute to weed potential, seed health was also briefly assessed in 2001. Preliminary tests show that in the North Island up to 50% of seed can be damaged by an insect (*Storeus albocignatus*). From limited studies undertaken in both 1980 and 2001, South Island seed appears to be free of such seed predation. Dispersal of seed by birds has never been reported in New Zealand. In South Africa, by contrast, the seed is subject to bird dispersal but no reported insect predation.

Source Nicholas 2006

BLACKWOOD IN AUSTRALIA

Distribution

Blackwood has a range of distribution that is remarkable, even among the acacias. This extends throughout Eastern Australia, from Tasmania in the south to the Atherton Tablelands in Queensland. Blackwood is found from sea level to over 1500 metres and occupies a variety of soils. It can tolerate exposure, and low rainfall.

The ability of blackwood to survive across a range of site conditions is related to two attributes: a wide variation in its genetic structure, and a high degree of flexibility in its growth habit. On exposed dry sites blackwood is often slow growing and shrubby, and has no commercial value. On better sites, however, it can grow into magnificent timber trees, reaching up to 40 metres in height, and 1.5 metres in diameter. Blackwood can live up to 230 years.

It is easy to be led astray by the adaptability of blackwood in surviving across a range of sites, and to confuse biological success with commercial value. The ability of blackwood to cope with harsh conditions has often encouraged its planting on marginal sites, which are commonly either exposed, or waterlogged. In these conditions, the trees which survive are unlikely to produce useful timber. It is worth noting that most blackwood of commercial value in Australia is currently confined to limited parts of its natural range. These are areas which combine high rainfall, mild temperatures, humidity, and good soils. Most of Australia's blackwood timber is extracted from Tasmania, mostly from the North West. In areas where it grows best, blackwood is associated with three forest systems: the blackwood swamps, the wet eucalypt, and the rain forests. These three great forest ecosystems are locked in a territorial battle, in which the boundaries between them are determined by fire, and by soil conditions.

Although, like eucalypts, blackwood is primarily a pioneer species, it has adaptations which give it a foothold in all camps. In addition, there are locations where blackwood has it mainly its own way, and forms the dominant species. The most striking of these is in the Blackwood "Swamps" of North West Tasmania.

Figure 5: Swamp blackwood with new drainage ditch.
(Smithton, Tasmania)

The Blackwood Swamps

The Blackwood Swamps occupy an area of low lying territory in North West Tasmania. They are flood plains (Fig 5), associated with several river systems. The swamps were formerly extensive, but after logging and draining, have been largely converted to farms. The swamps which remain have been greatly reduced in area, and apart from reserves of about 6500 hectares are now being managed for sustained blackwood production.

The swamps have a complex structure, and form a mosaic of sites which result from previous disturbances. In pre-European times the main agent of disturbance was fire – more recently it has been logging. Blackwood regenerates from ground-stored seeds, and within each zone it forms an even-aged community. In addition, some recruitment occurs later when seeds germinate in local gaps which result from mortality or windthrow of dominant trees.

Swamp blackwood is notable in that it is the dominant species in the presence of some tough competitors. It also has good stem form. Both features deserve further comment.

Dominance

Blackwood enjoys a competitive advantage over both eucalypt and rainforest species in that it is more tolerant of wet soil conditions. Trees are found in nature where they compete best, rather than where they grow best. Most trees grow well on good mesic (neither wet nor dry) sites, but in natural forests are often forced out by more aggressive competitors. The nature of the "swamps" should be qualified:

- The swamps are not permanently waterlogged, but are seasonally flooded. The surface water is flowing, although slowly, and it is oxygenated. In summer, the ground is dry underfoot.
- Blackwood does not grow in stagnant water. When water flow is blocked, for example by road construction, blackwood in the affected area will commonly die.
- Within the swamps, blackwood grows best on banks and raised areas.

Stem Form

The good stem form commonly seen in swamp blackwood is a product of intense competition for light.

Blackwood seeds are present in the soil in vast numbers (up to 10,000 per cubic metre). Soil changes following fire or the mechanical effects of logging are followed by profuse germination (Fig 6). The emerging seedlings now engage in a struggle for space in competition with shrubby species which also germinate from ground-stored seeds. These include the "tea-tree" species, *Leptospermum* and *Melaleuca*, and also *Pomaderris*. This is *"close-packed" competition*, in which the seedlings jostle for space, and lateral branches are suppressed by mutual shading.

Figure 6: Blackwood and Pomaderris regeneration after fire. (Smithton, Tasmania)

The competing shrub species grow at about the same rate as blackwood, but eventually reach their limit for height. Pomaderris, for example, stops at a height of about ten metres. (Fig 7). The blackwood trees now emerge into the space above them, and expand their crowns.

Blackwood seedlings are highly palatable to marsupials, and their numbers are greatly reduced unless protected by either a thicket of shrubs, or a netting boundary fence.

Successful management of swamp blackwood therefore requires two conditions: (i) a seed bank of both blackwood and competing shrub species, and; (ii) if a full stand is desired, a secure boundary fence.

Blackwood does not self-thin well. This can result in many tall, thin stems. Tasmanian foresters consider that it should be thinned to about 200 stems per hectare to be most productive.

Although the final product, in size and form, can be impressive, the growth rate of swamp blackwood is less so. In these conditions it commonly takes 70 years to produce a 50 cm diameter stem.

Figure 7: Young blackwood emerging through regenerating Pomaderris. (Smithton, Tasmania)

In Tasmania, the regeneration of blackwood after milling in the mixed eucalypt forests is severely hampered by marsupial predation. This has led to the introduction of a FIB "fenced-intensive-blackwood" programme. After clearfelling, the slash is burnt, and the sites are enriched with aerial-sown eucalypt seeds (*E. obliqua*), harvested sites must be returned to original forest type. The boundaries are fenced with wire netting. Blackwood and pomaderris germinate from ground-stored seeds. The dense lateral shading from the pomaderris results in clear blackwood stems of up to 8 metres.

Sowing with *E. obliqua*, however, creates problems. The eucalypts are strongly competitive with both species. Their effect on the blackwood is to reduce diameter growth - the basal area can be reduced by two thirds. They also have an indirect effect; by inhibiting the pomaderris "nurse", they cause a reduction in both the clear-bole height and branch suppression in the blackwood. Under this regime, the blackwood is expected to have a diameter of 50 cm by 60-65 years, when clearfelling would occur.

Wet Eucalypt Forests

These forests are located in areas of moderate to high rainfall, and are dominated by tall eucalypts (in particular *E. regnans*, and *E. obliqua*). The blackwood forests of the Otway ranges in Victoria are a classic example (Fig 8). Blackwood forms part of a mix of species which occupy the understorey. These forests are even-aged, and follow disturbance. The fires which initiate stand replacement are infrequent, but often of high intensity. The blackwood, together with a mix of shrubby species, germinate from ground-stored seeds, and the eucalypts germinate from seeds stored in their capsules.

After germination blackwood competes for space with understorey shrubs, and it is these, rather than the dominant eucalypts, that are responsible for the good form in the blackwood stems.

Within these forests the open eucalypt canopies transmit sufficient light to allow the blackwood trees to form their crowns beneath them. However, in these mixed forests, the eucalypts compete strongly for resources. Growth of the blackwood is therefore slow, and the productivity is well below their potential.

Figure 8: Blackwood and eucalypts - Otway ranges.

Rainforests

Blackwood requires disturbance for seed germination, and sufficient light for seedling growth. Within the rainforests, disturbances are infrequent and often localised, and the rainforest canopies cast a dense shade. Blackwood therefore has a limited place in these systems.

Within the rainforests blackwood is found along river banks, where it germinates on soils exposed by floods (Fig 9). It also appears in light wells, where it occupies gaps created by mortality or windthrow of canopy trees.

Figure 9: Blackwood on riverbanks. (Strahan, Tasmania)

The commercial extraction of blackwood timber from these forests has been limited. Attempts to manage blackwood by planting in light wells in the rainforests have proved to be difficult - the challenge is to create the correct amount of light, not too much, and not too little. Moreover, these are areas of high ecological value.

Plantations

The establishment of blackwood plantations in Australia is a relatively new development. In Tasmania, attempts in the 1970s to manage regeneration in pure stands had major browsing problems. However, substantial research trials were planted in the 1980s to underpin larger scale activities. These have emphasised the use of mixtures to generate commercial income, but the transfer of experimental concepts to operational scale has not yet been achieved. Smaller scale plantings in Victoria and Queensland have also been established.

BLACKWOOD IN OTHER COUNTRIES

Blackwood has been introduced to a number of countries (Italy, France, Spain, Argentina, Palestine, Ethiopia, Congo, Kenya and Japan) where it has been evaluated for timber production with varying success. In particular the following countries have reported on plantation resources:

South Africa

Blackwood was introduced into South Africa around 1856. Originally planted into open spaces in indigenous forests, it was also established in plantations from 1891 onwards, particularly in the Southern Cape area. Blackwood was seen as an important substitute for the native species, Stinkwood (*Ocotea bullata*). However, blackwood is currently considered a threat to native forests and planting for natural forest enrichment is now discouraged. Problems with seed spread have been caused by water dispersion and by birds. In natural forests blackwood has not invaded closed, evergreen forests. Considerable establishment, breeding and silvicultural research, particularly by Hans de Zwaan, was undertaken in the 1970s and 1980s, but much less information has been published since his retirement.

Blackwood logs are sold by auction with the best prices paid for large diameter logs with darker timber.

Blackwood was introduced into South Africa in 1848. Originally planted in open spaces in indigenous forests, it was also established in plantations from 1891 onwards, particularly in the Southern Cape area. Blackwood was favoured as its timber closely resembles that of the prized native species stinkwood (*Ocotea bullata*).

The status of blackwood in the native forests has been controversial. The native forests in South Africa are small, and scattered, and environmental concerns support the elimination of exotic species. Fortunately, blackwood has limited shade tolerance, and does not regenerate in these closed-canopy forests unless large gaps are created. Moreover, it provides over 60% of the harvested timber volume and revenue from these forests. A continued presence is therefore supported by the timber industry.

Outside the closed forests blackwood takes its place in a long list of exotic invader species, which include radiata pine and New Zealand pohutukawa. Blackwood has invaded open disturbed sites, which include river banks, forest margins and shrublands. Seed spread has been caused by birds, and by water dispersal.

Silvicultural management is based on thinning, but no form pruning, with a rotation age of about 45 years.

Blackwood timber is used for high-quality furniture, where darker colours are preferred, and for panelling and timber frames. Blackwood logs are sold at auction, with the best prices paid for large diameter logs with darker timber.

India

In the temperate Nilgiri Hills region of India, blackwood was introduced in 1842. Subsequently some trees reached a height of 34 metres in 40 years. It was naturalised by the year 1900 and is utilised for fuelwood, utility wood and for the foliage collected for cattle fodder. Given its palability to stock and its site requirements, futher planting in India has not continued.

Sri Lanka

Blackwood was introduced into Sri Lanka in the late 1860s and is common at an altitude around 1,400-2,000 metres. Plantations were established in 1918 and it is reported to grow well in sheltered locations. Its main uses have been in general construction, fuelwood and amenity planting. Between 1929-1935 about 1200 ha were planted in mixture with eucalypts and cypress. Deer browsing forced the abandonment of further planting.

Chile

Blackwood was planted in Chile some time ago, but only in the late 1980s was specific attention given to it as a plantation forestry species. Approximately 1,000 ha have been established.

Blackwood was first introduced into Chile in the early 1950s. Chile has many suitable blackwood sites, with good soils, adequate rainfall, and little wind. At present close to 4,000 ha have been established in plantation. In addition, blackwood is present in mixed stands, and alongside rivers.

Trees have been milled since the 1980s, mainly for export, and when available blackwood timber is used domestically for furniture. Currently, the demand exceeds supply. Chilean foresters have based their silvicultural management on close planting, at over 1000 stems/ha, with progressive thinning. This has resulted in tall trees, but slow diameter growth. Since the 1990s, the Forestry Institute ("Instituto Forestal") has engaged in an active research programme, focussed on genetic improvement, and more aggressive silvicultural regimes of pruning and thinning.

There is considerable interest in blackwood in Chile, and increased planting is expected to result in a significant commercial resource.

Excellent form blackwood in Chile, previously mixed with Eucalypts

Poor form blackwood in Chile, grown on a hard site

Sawn blackwood at a parquet factory in Chile

Blackwood boards in Chile processed for conversion to parquet floors kits

Hawaii

Blackwood was tested by the United States Department of Agriculture, Pacific Southwest Forest and Range Experiment Station in Hawaii, along with 90 hardwood and coniferous species from 38 countries in the tropical, subtropical and warm temperate zones of the world. The emphasis was on fast growing species recognised in the world market for their high quality. After approximately 6 years the results were mixed. Blackwood was considered a promising species on some sites, but it failed on others.

China

Although planted in China in the 1950s, blackwood has only recently been given forestry status through the efforts of the Australian Centre for International Agricultural Research (ACIAR). A series of species trials in the 1990s demonstrated that blackwood showed promising growth at altitude in the tropics of south-east China. Successes with the species have seen more than 500 ha established in some areas and large scale provenance trials have recently been established, although a shortage of seed has hindered some efforts to increase planting.

In China, blackwood has been identified as a species of special interest for inclusion in the massive reforestation program. Its dark, richly figured timber has the quality that for centuries has been sought in traditional Chinese furniture. Chinese forest researchers expect it to find a ready market among their increasingly affluent middle classes.

Blackwood was first introduced into China in the 1950s. Since 1986 the Institute of Tropical Forestry at Guangzhou has been associated with ACIAR in a provenance research programme. From 1986 to 1998 a series of provenance trials have been established in the Guangdong province in South East China. The best-performing of these have been from Queensland and New South Wales. The Tasmanian and Victorian provenances, which perform best in New Zealand, have been less successful on these high-rainfall tropical sites.

More than 15,000 ha had been planted by 2005, and as seed becomes available, extensive further plantings will follow.

As a market develops, China should provide good commercial opportunities for New Zealand and Australian blackwood growers, and help establish international recognition. For several years, small quantities of blackwood have been sent to China from Britton's Mill in Tasmania. Much of it has returned as furniture.

Key Points

- Blackwood is well established as a minor species in the New Zealand forestry scene, especially at the farm forestry level.
- Blackwood has an extensive natural distribution, and is tolerant of adverse sites. However, blackwood of commercial value has strict site requirements - it needs adequate rainfall, shelter, fertile, free-draining soils and moderate temperatures.
- Blackwood tolerates damp soils and periodic flooding, but is intolerant of stagnant or permanently waterlogged soils.
- Blackwood regenerates from ground-stored seed after disturbance and its good form in natural stands is the result of intensive competition among competing species.
- Blackwood occurs throughout eastern Australia, but most commercial production is in Tasmania and Victoria.
- Blackwood is established as an exotic plantation species in South Africa, India, Chile, Hawaii and China.

Suggested reading:

Allen 1992.

Brown 2000.

Burdon and Miller 1995.

de Zwaan 1981.

Gleason 1986.

Jennings 1991.

Mortimer and Mortimer 1984.

Nicholas 1988, 1983.

Purey Cust 1979.

NZFS 1981.

Wilcox 1993.

Searle 2000a&b.

Stevens 1980.

CHAPTER 2 - TIMBER PROPERTIES, MARKET and RESOURCE

Timber properties

For well over 100 years blackwood has been accepted internationally as one of the world's great decorative timbers. It can be classed within an elite group of species which include walnut, mahogany and teak. Apart from black walnut, it has qualities which are unlikely to be matched by any other exotic species that can be grown in New Zealand. Blackwood was extremely popular with Victorian and Edwardian cabinet makers. It is highly suitable for furniture, cabinet-making (see photo above), veneers, turnery and knobs. It is also suitable for panelling, carving, flooring, boat-building, and gunstocks.

The timber is medium-weight and is easy to work, has even texture, is usually straight, but sometimes has wavy grain. It turns and bends well and dresses to a smooth finish.

Colour/Figure/Texture

The heart wood is commonly golden-brown in colour, often containing darker bands or reddish streaks. The sapwood is pale, from white to straw. However, there can be considerable variation in heartwood colour, ranging from yellow to reddish-brown, to almost black. This variation causes some problems for furniture makers. Tension wood streaks can result in dark, denser wood, and can add to the character of the timber.

Variation in colour has been attributed to:

- Genetics - this appears to be the dominant influence. Striking variations in colour occur within seedlots, and on the same site. A small-scale New Zealand study (p.26) showed no significant difference between two Tasmanian and two South African seedlots.

- Site – there is much anecdotal, but little scientific evidence to suggest that site strongly influences colour. A South African study suggested that the best colour is found on sites with deep organic soils, well watered in the growing season, and with a definite dormant season.
- Growth rate – two New Zealand studies have shown no relation between colour and growth rate. Many New Zealand users feel there is no significant difference between blackwood sourced in Australia and New Zealand.

Colour variation can cause difficulties in matching timber. To date, this has not influenced prices in the Australian or New Zealand markets, but it has influenced South African sales, where the darkest wood is preferred and fetches a premium.

The Australians recognise several attractive grain patterns which are favored by craftsmen and in veneers. These include fiddleback, and birdseye. These features are believed to be genetically influenced.

Figure 10: Variation in log colour from a Rotorua plantation.

Density

There is remarkable variation in density between blackwood trees in New Zealand. Basic density ranged from 465 - 670 kg/m³ in a group of 70 year-old trees, and another study has shown considerable differences between seedlots. These studies also confirmed that density is not influenced by growth rate.

Basic density varies very little with height, but considerably over the radial profile. Density appears to be largely determined by formative age, since it increases from the centre outwards. New Zealand material is slightly denser than Australian material (Table 2).

Table 2: Comparison of blackwood density for NZ and Australian grown material

	Density kg/m³		
New Zealand	green	air-dry	basic
Mortimer 1984	-	660	-
Haslett 1983, 1986	1040	680	593
Nicholas *et al*. 1994a[1]	972	-	471
Clifton 1990	-	680	-
Miller and Young 1989[2]		-	428
Australia	889		
Bootle 1983	870	640	570

[1] 10 year old trees
[2] Mean age 7 years

Strength

The strength values of New Zealand grown blackwood compare favorably with data from Australian grown material. The strength is directly related to the basic density of wood (Table 3).

Shrinkage

Blackwood has a low shrinkage. Shrinkage from green to 12% moisture content is 3.6% and 1.8% tangentially and radially respectively. Because blackwood is more impermeable than radiata pine, it has better short term stability.

However, radiata pine has superior long term stability probably because of the very low shrinkage intersection point of blackwood (Table 4).

Australian grown blackwood has a reputation for dimensional instability, which can result in glue-line failures. To minimise this problem, timber should be dried to the correct moisture content and correctly glued. Wide cross sections should be avoided. These recommendations apply equally to New Zealand grown blackwood.

Table 3: Comparison of blackwood strength properties for NZ and Australian grown material

	Modulus of rupture (MPa)		Modulus of elasticity (GPa)		Compression parallel to grain (MPa)		Hardness (kN)	
Source	green	air-dry	green	air-dry	green	air-dry	green	air-dry
New Zealand								
Haslett 1986	76.4	129.9	9.95	14.4	29.4	62.5	na	6.60
Australia								
Bolza and Kloot 1963	75.0	115.0	9.27	13.2	29.8	60.3	4.23	4.89
Bootle 1983	70	99	13	13	33	48	4.6	5.9

Table 4: Dimensional stability (in %) of blackwood and radiata pine (from Haslett 1986).

	Blackwood	Radiata pine
Shrinkage Intersection point	25.4	28.7
e.m.c. at 90 % RH	19.2	21.2
e.m.c. at 60% RH	12.0	12.3
Long term movement		
Tangential movement from 60%-90%RH	2.7	2.0
Radial movement from 60%-90%RH	1.3	1.0
Short term movement		
Tangential swelling after 24 h at 95% RH	1.6	2.2
m.c. increase after 24 h at 95% RH	4.6	7.4

Durability

Tests by Forest Research have shown that the heartwood is moderately durable. It is unsuitable for ground contact, and is not reliable in situations where it is fully exposed to the weather. The sapwood is perishable. Blackwood is rated as Class 3 (5-15 years in-ground natural durability).

Heartwood Percentage

A New Zealand study showed wide variation in heartwood percentage (0 – 74% in 10 year-old trees). The heartwood percentage was not related to seedlot, but varied significantly within seedlots. The mean percentage of heartwood matched the figures published by Harrison in South Africa, where it was reported that within regions the highest heartwood percentage was produced on moist, well-drained organic soils.

Some clonal selections for blackwood in New Zealand have included heartwood percentage among selection criteria.

The Market

New Zealand

Blackwood should be readily accepted in the local and international market place. New Zealand grown blackwood can be promoted as both exotic and plantation grown. It should therefore occupy a niche in an international market increasingly aware of the exploitation of tropical rain forests and fragile native ecosystems.

Several authors who have reviewed the role of specialty timber species in New Zealand considered blackwood has a role to play in providing cabinet timbers for both local and export markets. Although the species did not have the ability to attract major corporate support, it can produce high-quality timber and veneer when correctly sited and managed. Others have stated that blackwood can be ranked along with black walnut in the very high value category, but also recognised that it has major form problems. However, unlike many other high value species, it was more tolerant to a wide range of sites.

A New Zealand company specialising in blackwood lumber sales began promoting the timber in the early 1980s. Current demand for this company alone has grown and there is concern that the available resource is unlikely to sustain even the current level of supply until new plantings reach millable size around 2015-2020.

The current price in 2002 for good (clear two faces) air dried blackwood is around $3,000/m³, compared to radiata pine clearwood at approx. $750-800/m³.

At the present time, New Zealand blackwood is receiving stumpages in the order of $150 /m³ to between $200 /m³ for sound trees.

Currently, three New Zealand furniture companies have developed specialist blackwood lines (see web links, Chapter 15). There are many others who utilise the timber for one-off products.

The value of blackwood timber in New Zealand has been rising steadily over the last decade, but a consistent market price requires a regular supply. Oneoff sales have lead to a wide range in prices paid for a variety of quality. With pressure on the existing Rimu timber sources, blackwood is poised to provide a more than suitable substitute, which may command similar prices or higher. With Rimu wholesale prices in 2002 for clear heart grades currently averaging $3,241/m³, prices for blackwood timber appear promising in the long term.

Australia

Prices in 2002, supplied by Hasell Britton Pty Limited, a major blackwood retailer located in Australia, are listed in Table 5. This firm using Tasmanian sourced material is exporting to New Zealand, South East Asia, China, USA, and Japan.

The market for blackwood in Australia is described by Hasell Britton as small but consistent, with only enough business for a few wholesalers in different states. Kitchen door companies make up the majority of their blackwood sales, with most of the 25 mm (75 – 200 mm) pieces going into kitchen door manufacture. The other sizes are utilised in furniture and joinery manufacture.

These end uses mean that blackwood sales are dependent on domestic and commercial building trends, and hence reflect the current Australian market situation.

However, Hasell Britton are developing finger jointed, laminated and flooring products to expand the market in blackwood away from dependency on door manufacture and to utilise sizes that are not used in other applications.

Britton Bros. from Smithton who have specialised in blackwood timber production for over 90 years annually produce about 2,500 m³ of sawn blackwood of all grades.

This represents approximately 30-40% of Tasmanian and Victorian production. They have reported cyclic markets with little timber price increases, and have extended processing capability by installing veneer processing equipment. They consider that an emphasis on quality and more effective marketing in a united manner by the blackwood industry are the requirements for a sustainable and healthy blackwood market in the long term.

Plantation wood property and colour assessment.

Some basic wood properties were assessed by Forest Research on 45 trees of 21 year-old blackwood trees grown in Hunua Forest, Auckland. Basic density averaged 480 kg/m³ with a range between individual trees of 382 to 566 kg/m³. These results were in keeping with the known variability of blackwood density in New Zealand. Green density of 1045 kg/m³ and green moisture content of 118% were also recorded. Heartwood percentage at this relatively young felling age was 61%.

Assessments were made of heartwood colour intensity using both instrumentation and visual estimates. Linear regression analysis suggested that green density was the best predictor of colour but that basic density, heartwood percentage and growth rate all had a contributing influence. Colour assessments carried out while the wood was "green" bore little relation to those assessments carried out after drying, and it is probable that green field assessments of colour will not assist in matching colour intensities in use. The best techniques for assessment are probably visual assessments following drying and surface preparation. Alternatively a "colourometer" could be used to assess the black/white colour variation.

Preliminary analysis of the wood properties of blackwood thinnings from five North Island regime trials in New Zealand

The influence of site and silviculture was assessed on growth and selected wood properties of 18-year-old blackwood. Height, diameter, basic wood density, heartwood colour, and heartwood percentage were measured in thinnings from silvicultural-regime trials at five sites in the North Island of New Zealand. A total of 306 trees, all of one common seedlot from Tasmania, were felled from 22 plots across all sites. Stocking of these plots ranged from 150 to 800 stems/ha. Discs were collected at a height of 1.4 m from all felled trees and used to make visual assessments of colour: quantitative measurements were made with a Minolta Chroma Meter.

Diameter growth of the thinned trees was greatest in regimes with the lowest stocking. Conversely, the tallest trees were in regimes with the highest stocking. Height and diameter were least at Hunua, near Auckland. Heartwood percentage was positively related to stocking and lowest in the lower stockings. Among the sites, Hunua had the lowest heartwood percentage. Darker visually-rated heartwood colour was associated with higher stockings, and heartwood was darkest at Hunua. The L* colour range (black to white) also indicated a trend of darker heartwood with higher stockings. Basic wood density was inversely related to stocking and highest at lower stockings. Trees at the fastest-growing site, Whakarewarewa, had higher density than at the other sites. Density at the slowest-growing site, Hunua, although lowest, was not significantly different from the remaining three sites.

This study has shown that wood properties can be influenced by site and silviculture. Increased growth rate from lower stockings was associated with increased basic wood density and reduced heartwood percentage but had little influence on wood colour. Several of these attributes were also influenced by site. The data suggest that there is no reason to target silviculture for wood characteristics.

Source: Nicholas *et al.* 2006a

DBH Discs from regime trial wood study, by plot

Variation in colour from wood study samples

A comparison of timber quality of blackwood grown in young swamp forest, fenced regeneration, and a plantation in Tasmania

This study compared the timber properties of blackwood grown under three different silvicultural systems: swamp forest regeneration, fenced regeneration mixed with eucalypts, and plantation. The plantation material was sourced from seed taken from a single tree at the same location as the swamp forest regeneration. Trees sampled were from 14 to 22 years old.

Timber attributes, including basic density, green moisture content, percentage heartwood and heartwood colour, were measured, as were tree and bole height. Wood samples from the two native forest treatments (swamp forest regeneration, and fenced regeneration) had similar properties. Wood samples from the plantation were similar in most respects to those from the native forests but had significantly higher green moisture content. Increased diameter increment did not adversely affect basic density or heartwood colour of the timber at the tree ages studied.

Source: Bradbury, 2005

For further discussion of heartwood colour, see chapter 5 - genetics.

Understanding blackwood (*Acacia melanoxylon*) markets; an opportunity for improving blackwood plantation returns

In 2005 Ian Nicholas was awarded a Chavasse Travel Award by the New Zealand Institute of Forestry, to investigate blackwood (*Acacia melanoxylon*) markets in Australia and New Zealand. Nearly 50 blackwood processors and manufacturers using blackwood in Tasmania, Sydney, Victoria and New Zealand were interviewed in late 2005 and early 2006. It is estimated those interviewed trade approximately 80% of the volume of the Australasian blackwood market.

In total, the blackwood market in Australia is approximately 14,000 m^3/yr of logs and 4,000 m^3/yr of sawn timber, while the New Zealand market is only about 85 m^3/yr of sawn timber. The most important blackwood wood characteristic recognised by those interviewed was wood colour, and the most important issue was supply of logs/timber. Most of the trade in blackwood involves select or clear timber, often in short lengths which creates problems for many users.

Both Australia and New Zealand have a similar price for clear grades, lack a consistent use of knotty grade boards, and are exploring export opportunities. Both Australians and New Zealanders see potential in marketing blackwood as a flooring material using knotty and clean grades. The investigation of innovative uses of poorer grades showed that although small clear lengths were used for craft material, this was not recognised as a viable market by processors in either country.

The greatest new opportunity in blackwood marketing in both countries is to develop a range of flooring products. New Zealand has an opportunity to supply quality timber to Australia as New Zealand's resource matures, but the priority should be to establish a stronger market following in New Zealand before exporting is considered.

Blackwood manufacturers in both countries need to raise the profile of blackwood above commodity level into an elite timber market.

As part of this marketing strategy, the recognition that plantation-grown blackwood is a sustainable plantation timber resource should be emphasised.

New Zealand has an estimated 26,000 m^3 annual harvest of sawlogs available when the blackwood resource reaches normality.

Source Nicholas, 2006

Blackwood floors, Marlborough


STAINLESS
STEEL

Table 5: Blackwood prices (2002) select kiln dried. Sawn ex. Sydney.

Board size	Price AUD $/m³	Price NZ$/m³
75 - 125 x 25	2,200	2,651
150/175 x 25	2,790	3,361
200wdr* x 25	2,960	3,566
75 - 125 x 38	2,790	3,361
150/175 x 38	2960	3,566
200wdr* x 38	3150	3,795
75-125 x 50	2860	3,446
150/175 x 50	3050	3,675
200wdr* x 50	3,150	3,795
Random 75mm	3,930	4,735
Random 100mm	4,110	4,952

The Resource

New Zealand

The true size of the resource in New Zealand is difficult to determine because of the many small-scale plantings by individual farmers. Other than some small forest plantings in the 1960s, most of the New Zealand blackwood planting occurred in the 1970s and 1980s by the NZFS. Since the mid-1980s, planting by farm foresters has ensured a small but consistent increment in the national resource.

Approximately half the New Zealand resource was established on the West coast of the South Island in the 1980s. The remainder consists of smaller areas established by the NZFS, now in private ownership, local body plantings (Hunua Ranges) and small farm forestry plantings. It is estimated that New Zealand has approximately 3,000 ha of blackwood.

Silviculture in New Zealand blackwood plantations has been variable, ranging from none at all, to excellent stand management practices.

Total yield of blackwood in New Zealand will depend on siting and silviculture. MAI figures range from 5-10 m³/ha/yr. If a mean productivity value of 7.5 m³/ha/yr and a rotation of 35 years is calculated, an annual cut of 22,500 m³/yr is possible, provided of course plantations continue to be established. Most of this resource will not become available until around 2015, although small amounts from the earlier plantings could be available before 2015. With the increase in supply from 2015, the quality of the logs will also improve, reflecting a better standard of silviculture on many of the stands.

Tasmania

Blackwood sawlogs are sourced from several State forests. Material comes from swamp forest and from arisings (blackwood logs obtained in the course of harvesting or conversion of native eucalypt forest). A future supply will also be available from plantations.

The most important production areas are the blackwood swamps west of Smithton in the far Northwest, which over the last 5-10 years have yielded 60% of the State's blackwood sawlog total.

The total swamp production area is calculated at 5,650 ha. Blackwood plantations are currently 900 ha, with approximately 250 ha established on an annual basis for the next five years, to give a total State plantation estate of 1000 ha. These plantations are expected to contribute to the wood flow from 2018 to 2048.

The volume from arisings is difficult to predict but it is expected that it will make a significant contribution over the next 10 years. Arisings may contribute up to 50% of the annual yield, but are expected to drop to 10% in the long term.

The Tasmanian Forest and Forest Industry Strategy (TFFIS) has set a blackwood sawlog target for public land at 10,000 m³/yr.

A sustainable annual yield of 8500 m³/yr has been calculated for swamp forest and arisings through to 2063. The target of 10,000 m³/yr will not be met until 2025, when sawlogs from existing plantations come onstream. It is estimated that the target will be exceeded for the following 20 years, peaking at 25,000 m^3/yr for a short time before a sharp drop to 8,500 m^3/yr (ie. The sustainable cut from swamps plus arisings).

Victoria

In the Otways, production from private land is estimated to be about 1000 m^3/yr. Under the State Forest Management Plan it was stated in 1996 that up to 1,600 m^3/yr of blackwood sawlogs would be made available to licence holders, with additional logs being sold by tender.

Other States

It is estimated that blackwood sawlogs from states other than Tasmania or Victoria provide less than 5% of the total annual production.

Key Points

- Blackwood is a medium-weight timber that is easy to work, turns and bends well, and dresses to a smooth finish. It has even texture with usually straight, but sometimes wavy, grain.
- Blackwood timber is extremely variable in wood density, colour and heartwood percentage.
- Growth rate has little bearing on wood quality.
- Blackwood is developing a market-following in New Zealand, where current demand is outstripping supply.
- The Australian market is cyclical, reflecting the Australian economy and fashion.
- Australia exports blackwood to at least five countries.
- The resource in New Zealand, estimated at approximately 3,000 ha, is young but will be producing timber from about 2015 when it will be capable of supporting a blackwood industry.
- The resource in Australia is based on sustainable production from natural forests and from plantations (when they mature in 2018-2048).

Suggested reading:

Bolza and Kloot 1963.

Bootle 1983.

Britton 2000.

Burdon and Miller 1995.

Clifton 1990.

Harrison 1975.

Haslett 1983, 1986.

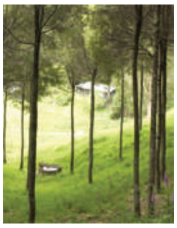
Mesibov 2000.

Miller and Young 1989.

Mortimer and Mortimer 1984.

Nicholas, Young, and Gifford 1994a.

Wilcox 1993.



CHAPTER 3 - SITE REQUIREMENTS and LAND USE

Site requirements

Blackwood is a tough and adaptable species. It will survive across a range of different site and climatic conditions. Unfortunately many blackwood stands in New Zealand have been poorly sited and this has resulted in slow growth and malformed trees. Experience has shown that, for both growth rate and form, it is highly responsive to site factors. When growing blackwood for timber therefore, it should be regarded as highly site selective. The first principle in growing blackwood successfully is careful site selection.

The main site requirements for blackwood are:

Shelter – this is critical. Early research showed that shelter is the main factor associated with good form in blackwood (see box over page). Shelter can be provided by topography (gullies), adjacent vegetation, or shelterbelt planting.

Moisture – adequate moisture throughout the growing season is important for blackwood. Although blackwood is not suited to drier sites, well-established trees can withstand occasional dry seasons and some drought. However, these are not good sites for producing blackwood timber.

Soil Type – Like most trees, blackwood grows best in mesic soils (neither wet nor dry), which have reasonable fertility, and a structure which retains moisture while allowing free drainage.

On dry exposed sites, blackwood is slow growing, bushy, and prone to insect (psyllid) damage. Blackwood will tolerate occasional flooding, but will not grow in stagnant swamps and is prone to root rots when drainage is impaired. However, it can tolerate peaty or clay soils.

Ideal sites for blackwood are sheltered gullies, and lower valley slopes (Fig 11).

Freedom from frost – Areas prone to severe frosts should be avoided (see box over page). In New Zealand blackwood can suffer from severe out-of-season frosts.

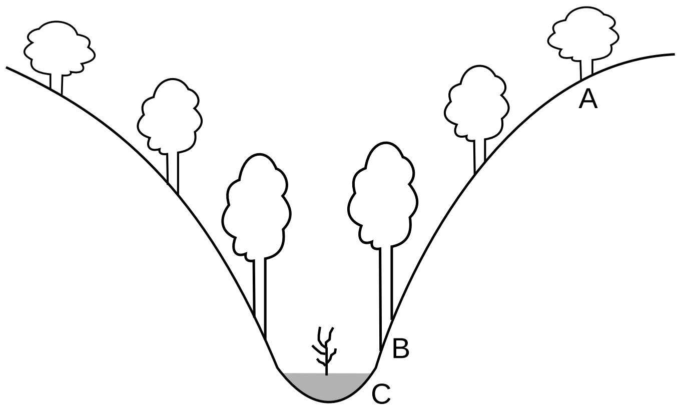


Figure 11: Where to site blackwood.
Growth is best in sheltered gully bottoms (B),
much poorer on exposed ridges (A)
and worst with mortality in poorly drained swamps (C).

Continuous-cover forestry

In response to environmental pressures, CCF is likely to become increasingly common in New Zealand. Blackwood has a number of attributes which make it suitable for inclusion in CCF systems:

- Moderate shade tolerance when young. As the trees mature, optimal growth requires full canopy exposure.
- Active regeneration from ground-stored seeds, coppice, and root suckering.
- Improved bole form when competing for light.
- Nitrogen fixation. This supports the growth of other species. A study has shown that kauri grow well in company with blackwood, much better and with lower mortality than when mixed with kanuka, a natural 'nurse' species for kauri.
- The valuable timber allows individual tree extraction.
- Native species regenerate freely under a blackwood canopy.
- The colour of blackwood foliage blends well with native species.

Ian Barton, a leading expert on CCF, regards blackwood as possibly the most useful exotic species for inclusion in CCF systems in New Zealand.

Land Use

Plantations

Blackwood integrates well with other tree species in forest landscapes. Because of its site requirements for optimal growth they should be carefully located in areas that are moist and sheltered. More exposed sites should be reserved for other species.

Interplanting

Blackwood is well suited to planting in regenerating scrub. This is discussed in Chapter 8.

Riparian Planting

Blackwood grows well in the sheltered damp conditions along stream margins. Its extensive root system helps to stabilise stream banks, and it tolerates occasional flooding. It is important to note that its seeds can move downstream, and may germinate and spread along stream margins. However, there is little evidence of this being a problem in New Zealand to date.

Open grown trees

In Tasmania, open grown blackwood is commonly seen on farms, as single trees (Fig 12) or in small groups. It is visually appealing, and provides good shelter for livestock. In these conditions it has large crowns, but boles are often too short for saw logs. Open-grown trees of this appearance are a lost opportunity – it is a simple matter to manage individual trees, and to extend the stem to a usable 3 to 4 metres by form-pruning at the appropriate time.

Gully planting

Many farms contain unproductive areas, including gullies. Stock is normally excluded from these areas because of steep contours, erosion, and proximity to streams. These sites can provide excellent conditions for growing blackwood.

Shelterbelts

Where soil moisture is adequate and prevailing winds not severe, blackwood can be used in a shelterbelt. Without silvicultural attention, the stems within the shelterbelt will usually become multileadered, and will not provide much usable timber. However, it takes very little effort when creating a shelterbelt to perform selective pruning, which will allow some timber extraction at a later date. This involves an annual visit to remove competing leaders and large branches to a height of 3 or 4 metres. If the site is not too exposed, lift pruning to 6 metres can be carried out with associated planting to provide low shelter.

Shelter

Sixty nine blackwood plantings in the North Island were surveyed in 1978. This study showed that while blackwood was tolerant of a wide range of site conditions, both bole length and tree height were positively affected by shelter. Similar observations of blackwood stands have been made in Westland.

Forest Research Permanent Sample Plots throughout the country have shown a striking range in estimated Site Indices (15 to 45 metres at 30 years).

A series of blackwood trials on five North Island sites showed the best growth in a sheltered valley bottom, and the poorest growth on an exposed ridge with clay soil. At age 14 years, individual plot MTH across the five trials ranged from 7.2 m on the poorest and most exposed site to 19.9 m on the best site.

Frost Resistance

Field studies have shown differences in frost resistance between seedlots from varying locations. These indicated that Tasmanian seedlots were the most frost-tolerant, with a few New Zealand progeny similar to those from Tasmania.

South African and Victorian seedlots were less tolerant. Frost damage was noted in an establishment trial near Rotorua (Tasmanian seedlot). The South Island replication of this trial near Reefton had excellent survival. Provenances from central Tasmania are more frost-tolerant than those from Smithton.

Agroforestry

Blackwood is a nitrogen-fixing (N_2-fixing) tree, which has the potential to enhance understorey pasture yield and increase soil nitrogen (N) levels and availability. Trees in an agroforestry system also have the potential to reduce erosion and provide shelter for stock. See Chapter 4 for more information on agroforestry.

Waste water schemes

Blackwood has been shown to be tolerant of waste water application in several schemes where either meat works effluent, or treated domestic effluent have been applied. However, the growth rate of blackwood is too slow for it to be considered a biomass species for efficient nutrient removal and in most schemes faster growing species are preferred.

Figure 12: Open grown blackwood, a common sight in Tasmania.

Erosion control

The ability of blackwood to root sucker from broken roots (Fig 13) has been used to advantage with plantings on eroding land to stabilise slips. It has also been planted on road batters in New Zealand for this purpose. Blackwood was tested in some species trials on the East Coast of the North Island where it grew well, but it was considered that the erect habit made it unsuitable for unstable sites. However, as many eroding areas are also very exposed, other species may be more suitable.

Figure 13: Root suckers originating from damaged roots.

Key Points

- Blackwood requires careful siting.
- Blackwood grows best and shows best form on sheltered sites.
- Blackwood sites should provide adequate moisture for optimum growth.
- Frost prone sites should be avoided.
- Blackwood can be suitable for a wide range of land uses, for both timber and non-timber values.

Suggested reading:

Barton, Oliver, Nicholas, and Thorn 1991.

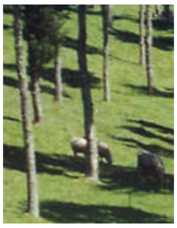
Franklin 1987.

FRI 1978.

FRI 1982.

FRI 1983.

Sheppard and Bulloch 1986.



CHAPTER 4 - AGROFORESTRY

The concept of two-tier forestry, in which trees are combined with livestock, is appealing in theory. It can cause problems in practice, however, and has largely fallen from favour. Blackwood appears to hold considerable promise for agroforestry because its bark is usually resistant to stock damage. As a nitrogen-fixer, it can also benefit pasture growth. On most farms trees and livestock are separated by a fence. However, there are circumstances where blackwood and livestock can be combined.

The case for agroforestry:

- As a nitrogen-fixing tree blackwood has the potential to increase soil nitrogen levels, and therefore enhance understorey pasture yield.
- Erosion control.
- Shelter for stock.
- The bark is relatively resistant to stock damage.

Management

The first principle in blackwood management is site selection. Avoid ridge tops and exposed areas.

- Juvenile foliage is highly palatable to livestock. The phyllodes are often chewed, but with less enthusiasm.
- Stock should be excluded until the crowns are securely out of reach.
- Blackwood bark contains tannins, and is normally unpalatable. Occasional bark stripping occurs and cattle have been known to attack the bark at the stem-root junction in older trees (about 15 years), causing significant damage.
- Cattle can disturb the surface roots, particularly on steep wet slopes, and stimulate shoot formation. The risk of damage to the surface-feeding roots of trees by cattle is always of concern.

- Sheep can normally be introduced among blackwood after about two years, when the leading shoot is comfortably out of reach.
- Cattle can normally be introduced after 4 or 5 years. Bulls and dairy heifers should be kept away from trees at all times.
- When blackwood has been planted in regenerating scrub, access can be difficult for future pruning visits. Periodic stocking with cattle, provided it is carefully supervised, can be useful in maintaining access to the trees.
- Careful stock management is essential to avoid tree damage.

Agroforestry trials

Blackwood has been subjected to extensive agroforestry studies (see box at right). The main effects of blackwood on pasture can be summarised as follows:

N fixation

Blackwood provided an increase in soil nitrogen levels and in pasture yield. This contrasts with other species that have been studied (radiata pine and *E. nitens*), which are not nitrogen-fixing trees.

Shading

Increased shading caused a reduction in understorey pasture yield. This effect is related to planting density and canopy structure.

Pasture reduction is less pronounced under lower levels of shade than under other non nitrogen-fixing tree species that were studied. This may be a result of increased nitrogen production.

Pasture quality was reduced over 9 years, with a reduction in ryegrass and pasture legumes, and an increase in less palatable pasture species.

Moisture

Throughout the year, soil moisture under the trees was greater than in the surrounding pasture, including the summer months. The trials were located on naturally moist sites, so it is possible that a different result might occur on dry sites.

Figure 14: Cows grazing under 12 year old blackwood on Te Kuiti site used for agroforestry analysis.

Agroforestry Trials

The information summarised in this chapter has been obtained from AgResearch Ltd. studies on the interaction of blackwood plantations with pasture production on five separate stands of nine year-old blackwood. Four of the stands assessed are Forest Research regime trials established in 1987 at Te Kuiti (Fig 14), Lake Okareka (near Rotorua), Hunua Ranges, and in Rotorua's Whakarewarewa Forest, (see chapter 10). The latter site has not been grazed but provided material for biomass production. The fifth stand is an agroforestry planting near Whangarei which was established in 1982 and has been pruned to six metres.

Key Points

- Blackwood is a useful agroforestry species, provided it is properly sited and careful stock management is undertaken.
- As tree-stocking rate and tree green-crown length increase, understorey shade also increases.
- Pasture yield decreases with increasing shade, but not as much as with other non nitrogen-fixing tree species, particularly at low shade levels.
- Total soil nitrogen and nitrogen availability increases with higher tree-stocking rate. This differs from non nitrogen-fixing tree species, where total soil nitrogen and nitrogen availability decrease as tree-stocking rate increases.
- Pasture legume content decreases as tree-stocking rate increases.
- Tree litter fall and nitrogen return increases with an increase in tree-stocking rate.
- On moist sites, understorey soil moisture is unaffected by tree stocking rate. This indicates that the trees are not competing with understorey pasture species for moisture.

Suggested reading:

Power, Dodd, and Thorrold 1999.

Power, Dodd, and Thorrold 2001.

Power, Thorrold, Balks, Dodd, and Nicholas 1998.

Thorrold, Knowles, Nicholas, Power, and Carter 1997.

Thorrold, Power, and Dodd 1997.

Power, Thorrold, and Balks 2003.

CHAPTER 5 - SEED, GENETICS and CLONAL PROPAGATION

Seed source

Genetic Variation in blackwood

Blackwood shows a high degree of genetic variation. This is present both within and between provenances.

Variation between Seedlots

In its natural distribution, blackwood is found from latitude 15° in Queensland, to 43° in Tasmania (Fig 15). It occurs in very diverse site conditions. Not surprisingly, differences are seen between provenances which reflect adaptations to climate, soils, exposure and competition. Examples are variations in frost tolerance, and in phyllode structure.

Site selection for blackwood in New Zealand is now well understood, and silvicultural systems allow reasonably straight butt logs to be produced. The possibility of exploiting the wide genetic variability of blackwood will therefore become increasingly important. This will need to be examined at two levels:

Provenance selection

- Provenance trials have been established in Tasmania, Queensland, Victoria, South Africa, China and New Zealand (see box over page). In Tasmania, trials with Tasmanian and mainland seedlots showed that soon after planting the Victorian and NSW seedlots were similar in performance to local seedlots. The Queensland seedlots were inferior in both growth and survival.
- In Victoria, two trial series with approximately 20 seedlots have shown a similar pattern. Some Tasmanian seedlots, and a South Australian seedlot, were ranked higher than Victorian seedlots for both form and diameter. In some of these trials, other Tasmanian, New South Wales and Queensland seedlots varied in performance, but generally Victorian seedlots were better than New South Wales and Queensland seedlots.
- In Queensland, provenance performance has varied, with local sources performing better than Tasmanian or Victorian seedlots, but not consistently so.
- In South Africa, some Tasmanian, Victorian and South African seedlots were consistently better than a New South Wales seedlot and other Tasmanian and Victorian seedlots, but performance varied with site.

Individual tree selection

This is supported by the wide variation between trees within provenances. This shows promise, but there are pitfalls:

- A selected tree will have been strongly influenced by microsite factors, including moisture, shelter, soil, adjacent vegetation, and insects.
- The relative influence of genes and environment can only be assessed by an examination of the progenies of selected trees, or their vegetatively-propagated clones, across a range of sites.

Trials of limited numbers of Australian provenances in New Zealand have indicated that Tasmanian and Victorian provenances perform best in our conditions (See box below).

Variation within Seedlots

Variation between trees in the same seedlot is equally striking, (heartwood colour variation will be obvious to anyone who has thinned a blackwood plantation) suggesting that there is genetic variation. Individual tree selection, establishment of seed orchards and/or clonal forestry are likely to result in genetic improvement.

Forest Research 1984 Genetic Trials

This trial series was established on 10 sites and 29 seedlots were tested: 6 provenances from Tasmania, 2 from Victoria, 1 from New South Wales, as well as seedlots from exotic plantations, 14 from South Africa, 5 from New Zealand, and 1 from Chile.

The results from an evaluation of three North Island sites in 1992 at age 8 years showed that Victorian and Tasmanian (Smithton) provenances and a New Zealand (Waipoua) seedlot had the best growth and form of the seedlots tested. South African seedlots have on average performed poorly with only a few seedlots proving superior.

Recent measurement of one of the trials (Whakarewarewa) in 2002 at age 18 years indicated that a Victorian, a Tasmanian (Smithton) provenance, a New Zealand (Waipoua) and a South African seedlot were the better performers.

Scion 2003 Genetic Trials

In 2003 a provenance trial testing 65 seedlots of blackwood was planted. Funding from the New Zealand Lotteries Grant Board assisted with the project. The seedlots were sourced from Scion Genetics, the Tasmanian Seed Centre and from the CSIRO Tree Seed Centre in Canberra. Additional Victorian seedlots were obtained from NRE at Hamilton, Victoria and Clinton Tepper of Wollybutt, Victoria.

The seedlots were grouped into 13 broad regional sets, with four replications of each group. The objective of this grouping was to place seedlots that may have a similar growth pattern together. This reduces the opportunity for suppression by fast growing seedlots and provides a longer opportunity for slower growing lots to fully express themselves. Fifty two plots were established with 40 seedlings per set comprised of 8 seedlings of five seedlots randomly allocated within the set. Each seedlot was represented by 32 individuals across the 4 replications.

Trials were established in the Waikato and South-Westland, complemented by a step-out planting of 19 seedlots near Auckland. A number of individual seedlots were also planted by Farm Forestry members in the North Island and the top of the South Island.

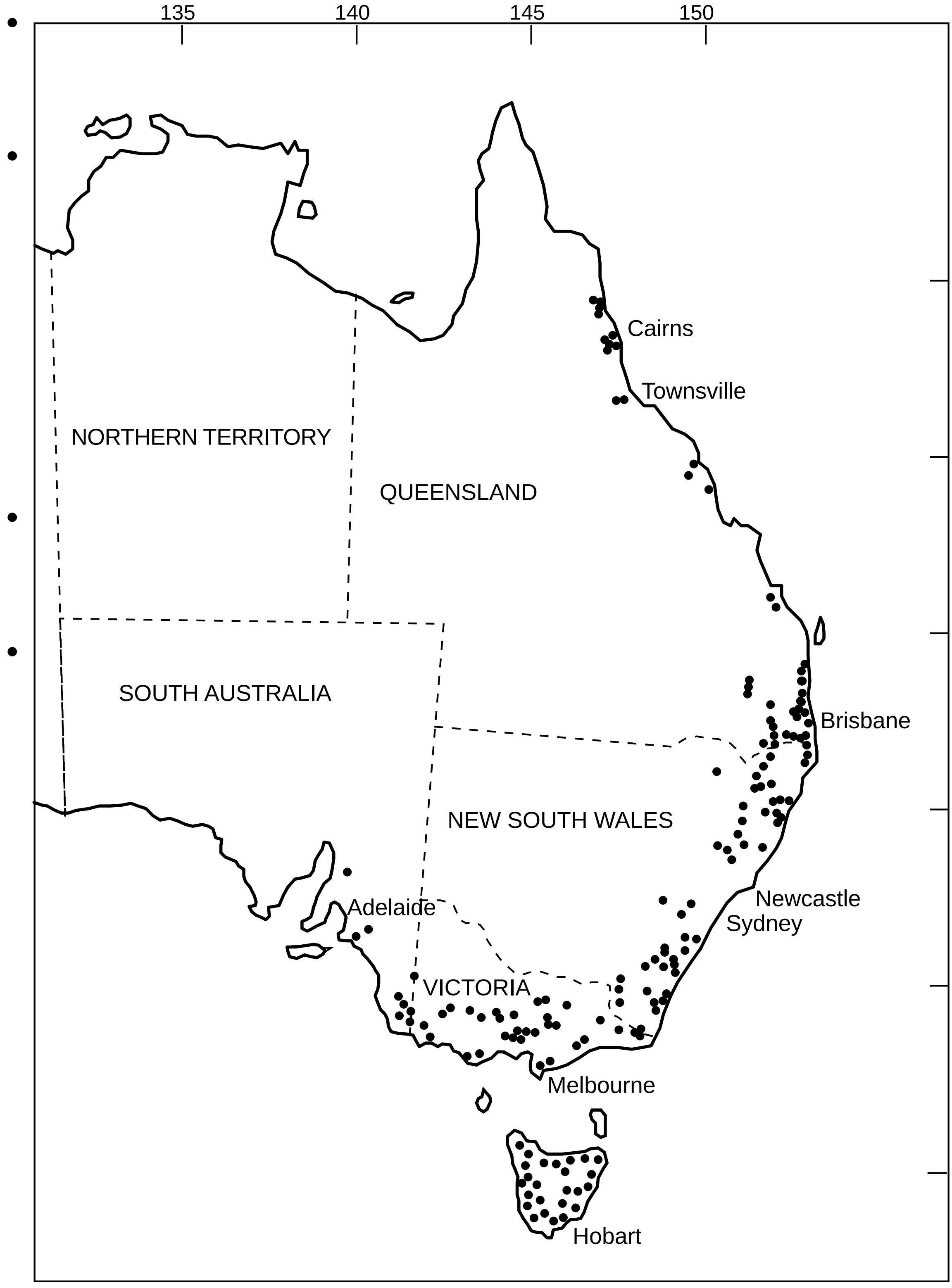


Figure15: Map of natural distribution of blackwood in Australia (Adapted from Stehbens 1992).

Genetic Evaluations

In 1959 Forest Research tested seed from 10 superior trees near Smithton on several New Zealand trial sites. Their form was no better than trees from unselected sources.

In 1988 Forest Research identified 74 good form trees from North Island plantations and collected root cuttings. Of the 35 clones that were successfully rooted 26 were archived on two sites north of Auckland in 1991. Measurements at age 6 years showed considerable variation in stem form amongst individual clones within sites. Although they were selected for form these clones were neither uniform nor of good form.

Heartwood Colour

An evaluation of two Tasmanian and two South African seedlots in a trial by Forest Research in 1983 showed no significant difference in heartwood colour between seedlots. In contrast there was an extreme range of colour within each seedlot. Several Australian reports suggest some association between colour and provenance.

Form

Selections have been made in South Africa for better form types. When assessed in New Zealand these showed no better form than other seedlots and poorer growth than Tasmanian seedlots.

Frost

Studies in Australia and New Zealand have shown genetic variation in frost tolerance. Frost tolerance and growth performance appear to be inversely related. Trees grown from seed collected from central Tasmania are quite frost tolerant, but the parent trees are described as having little timber value.

A South Island study showed wide variation in frost tolerance by individual trees within provenances, as well as between provenances.

Genetics

Genes or Environment?

In all the characteristics of blackwood there is a strong interplay between genetic and environmental factors. They can only be separated by planting progeny or clonal tests. Many studies have addressed the genetic influence in blackwood. They have often been limited in scope, and have often shown conflicting results. At the risk of grossly oversimplifying a complex issue, the likely genetic influence on some of the attributes of blackwood can be summarised:

- heartwood colour - mainly genetic; possible site influence.
- basic density - some genetic control.
- frost tolerance - genetic.
- vigour - both site and genetic, but strongly influenced by site.
- stem form - both site and genetic, but strongly influenced by site and insects.

Forest Research investigations

Cuttings

A series of experiments was conducted at Forest Research from 1987-1992 to develop techniques for vegetative propagation of blackwood. A total of five small studies were undertaken. These showed that:

- For repropagation from nursery stools, exposure of stumps and/or roots to light was necessary for the production of large numbers of shoots (roots were the best method).
- Root cuttings were more successful than stem cuttings.
- There was variation between clones in rooting success.
- Health of root material was very important. All healthy root material survived.
- Semi-hardwood cuttings were better than softwood cuttings.

Issues in root collection are:

- Care is required to ensure the root material collected belongs to the identified tree.
- Root material collected must be healthy.
- Root cuttings of 30-40 cm should be collected, approximately 10-20 mm in diameter. These can then be cut into 2-4 cm lengths and set. (While cuttings have been placed in the same orientation as naturally occurred in ground, the importance of this aspect is unknown).
- Cuttings have been collected in June, July and September with no time period preferred from Forest Research's limited experience.
- From successful rooted cuttings, stool beds can be set up for future propagation; the initial propagation is likely to be the hardest part.

Micropropagation

Plants have been regenerated from dissected embryos using tissue culture techniques. Shoots excised from seedlings grown *in vitro* formed roots in a non-sterile environment following an *in vitro* auxin/cytokinin treatment. The Quorin-Le Poivre medium used for the *in vitro* culture was not optimal; addition of activated charcoal resulted in clones with less foliage abscission, larger shoots, more leaves, and higher leaflet numbers.

Subsequent trial work showed that tissue-cultured planting stock (originating from dissected embryos) had a similar growth rate to seedlings. Although the tissue-cultured plants were not considered to have as good a root-shoot ratio as the seedlings at time of lifting, a preliminary trial showed that three randomly selected clones were not inferior to seedlings in the critical first year following field planting.

Clonal propagation

Clonal material selected for form, heartwood colour and heartwood percentage is available commercially in New Zealand. Although numbers are limited, it will provide a valuable resource for future evaluation.

The variation in blackwood growth habit and wood properties lends itself to a clonal programme, but this requires a successful propagation system. However, the influence of site on inherent properties and consistency of selected attributes are unknown.

Clonal selections will require assessment of their performance before they can be considered more than experimental.

Background research has identified the technology required for micropropagation. However the success of root cuttings has meant that this method is likely to be the preferred method of bulking up selections in the future, largely because it will be a cheaper option. Research in Australia showed that provenance, potting media, hormone and season all influenced the number of viable shoots produced.

In isolating the various contributions of genetic and environmental influences in blackwood performance, a study of clonally-produced replicates of individual trees, planted across different sites, would provide valuable information.

Our knowledge of genetic variation in blackwood has been based on subjective assessment of provenance trials for tree form, height and diameter. There have recently been one or two studies of the genetic structure of blackwood. Allozyme analysis has confirmed the high degree of genetic variation within and between provenances. It has also demonstrated what appears to be a significant genetic disjunction, which is emerging within the natural population of blackwood. This disjunction occurs in the Great Dividing Range at the Hunter River region with northern and southern populations identified.

Key Points

- We have reached a stage where we can be reasonably confident about site selection for blackwood in New Zealand and we have silvicultural systems which will allow us to grow straight trees. The opportunity to exploit the wide genetic variability of blackwood will become increasingly important.
- Blackwood shows considerable genetic variation, both between and within provenances.
- There is a lack of research results to guide the establishment of plantations and breeding programmes. Studies conducted have often been limited in scope, particularly with regard to the number of representative provenances. A recent initiative by Forest Research, NZ Lotteries Commission and Amigo aimed to address some of these issues.
- Propagation systems for clonal material are available.
- The variation in blackwood growth habit and wood properties lends itself to a clonal propagation system. However, the heritability of important selection traits, and the influence of site are also unknown.
- Clonal selections will require assessment of their performance before they can be considered more than experimental.

Suggested reading:

Cornell 1996.

Farrell and Ashton 1978.

Jones 1986.

Jones and Smith 1988.

Jones, Smith, Gifford and Nicholas 1991.

Harrison 1975.

Nicholas, Young, and Gifford 1994.

Playford, Bell and Moran 1993.

Searle 2000.

Stehbens 1992.

CHAPTER 6 - SEEDLING PRODUCTION, ESTABLISHMENT and NUTRITION

Open grown blackwood aged 1 year
(see also p.73)

Seed

Blackwood seed requires treatment to ensure rapid and even germination. Several methods are used:

- Clipped or nicked seed produces maximum germination within 14 days. This is ideal for germination tests, or small valuable research seedlots.
- The hot water method is standard practice (i.e. pouring boiling water over the seed and leaving the seed to steep and swell overnight), but variation in germination percentage, and time to germinate between seed sources has been noted.
- Bulk scarification is considered in Tasmania to be the most practical method for pre-treating seedlots over 20 gm. This gives similar germination times to clipped seed, but higher germination percentage. The recommended scarification is 10 minutes in their machine, with 10 gm lots, using 40 grit sand paper. Seed is then immersed in 90°C hot water for one minute prior to sowing. New Zealand nurserymen are simplifying operations by importing scarified seed, with excellent results.

Bare rooted seedling production

For the production of bare-rooted seedlings at Forest Research, seed is sown using the vacuum drum seed sower at 12.5 cm between lines and 7 cm between seeds. Soil covers the seed to a depth of 3-6 mm. Wind lift and soil splash are countered by 50% shade cloth tunnels over the beds until emergence is complete, if considered necessary.

Standard undercutting and wrenching operations are also carried out.

Planting stock

For 1/0 bare rooted stock in New Zealand, it is recommended that plants should be 60 cm tall with a minimum 7 mm root collar diameter. Topping in New Zealand nurseries is standard procedure.

Characteristics of bare rooted seedlings:

- These are the most robust, cost less, and are easy to transport.
- Planting must be done in winter.
- Planting should be done as soon as possible after receiving the stock.

Planting stock

A New Zealand establishment trial tested the following on two sites: bare rooted one year; one and a half year seedlings; plus the same treatments stumped 15 cm above the root collar before planting; one-year-old seedlings with mostly juvenile foliage; one-year-old seedlings with mostly mature foliage; two container types and direct sowing (on one of the two trial sites) After three years the type of seedling (Fig 16) was not critical to successful establishment. All treatments except direct sowing showed similar diameter and height growth. Direct sowing was not considered a viable establishment option.

Figure 16: Seedling types used in trial

Container

Blackwood can be grown in a wide range of container types: paper pot, jiffy pot, root trainers etc. Provided seedlings are grown correctly and pricked out on time, and not left in the container too long, container type is of little importance to blackwood establishment.

Characteristics of container seedlings:

- The size of container stock is dependent on the size of container used. Seedlings are usually smaller than bare rooted, more expensive, and difficult to carry.
- They allow planting outside the winter months.
- Planting can be delayed.
- To get optimal growth in the first year, the plants should be well established before spring.

In Tasmania it is recommended that container stock should not be used on sites that are prone to:

- Frost.
- Browsing.
- Weeds that are difficult to control.

Establishment

If the first principle in growing blackwood successfully is careful site selection, the second is to give the young trees a kick start in the establishment phase.

The Kick Start

There is a clear advantage in encouraging rapid early growth in blackwood. This can be achieved by providing conditions where growth is rapid and sustained, and malformation less prominent. On difficult sites with slower growth, a branchier habit develops and it is harder to produce an adequate butt log.

Factors which favour a kick start are:

- Site selection (shelter and moisture).
- Robust planting stock.
- Site preparation.
- Good genetic stock (see Chapter 5).

Site Preparation

Weed control

Blackwood seedlings will struggle through long grass and scrub, but grow much faster when competing weeds are controlled.

A useful regime is:

- Pre-plant spray with Roundup (1 metre diameter) - optional.
- Post-plant release with Gardoprim, soon after planting.
- Tree protectors allow sheep to graze the site and also permit sprays to be used safely, if necessary.
- Good spot cultivation at planting.

Fertiliser

A number of studies have shown conflicting responses to fertiliser application in New Zealand.

In summary:

- There is no benefit in applying nitrogen (blackwood is a legume, and therefore fixes nitrogen).

  On most sites there is no need for additional phosphorous. However, if soils are deficient in phosphorous it is advisable to apply it in the form of superphosphate. The recommended dose is 150 gm per tree, soon after planting.
- A New Zealand glasshouse study concluded that superphosphate, with its balanced phosphorus (P) and sulphur (S) content, would be a very suitable low cost fertiliser to use when establishing blackwood in soils low in either P, or P and S. Similar responses are reported from South Africa.

Cultivation

No full cultivation trials have been established in New Zealand, but one trial at Whangamata suggested that fertiliser was more important than weed control or a light cultivation while another trial in the Hunua Ranges indicated that good spade cultivation was beneficial to growth.

Protection

Livestock must be kept away from the young trees by either a boundary fence or tree protectors.

Both rabbits and hares are troublesome in New Zealand. In Australia, wallabies and pademelons are highly destructive.

Rabbits chew young foliage, but cause most damage by digging around the roots.

Hares are more destructive.

- They attack newly planted trees at night.
- They slice through the stem near its base, causing a typical 45° cut.
- They do not eat the foliage.
- They return on successive nights, causing an enlarging zone of destruction.
- They appear territorial, often selecting elevated sites (the tree damage may be a method of defining territory).
- They can be controlled by either:
    - A good rifle (effective and satisfying).
    - Tree protectors (60 cm K.B.C.)
    - Chemical deterrent.

Fertiliser Trials

Early New Zealand research indicated that an important factor in obtaining vigorous early plantation growth was the post planting application of superphosphate. However, just how much fertiliser to apply was not clear. This trial, with stock from the same seedlot, replicated at five North Island locations, was designed to give a definite pointer to the optimum per tree application rate per location. However, although there was considerable variation in growth between locations, statistical analysis of the growth data to age four showed no significant differences between any of the treatments (0, 150, 300 and 450 g/tree) at any of the locations.

These studies concluded that weed control should be applied in conjunction with fertiliser application, in order to gain maximum tree growth.

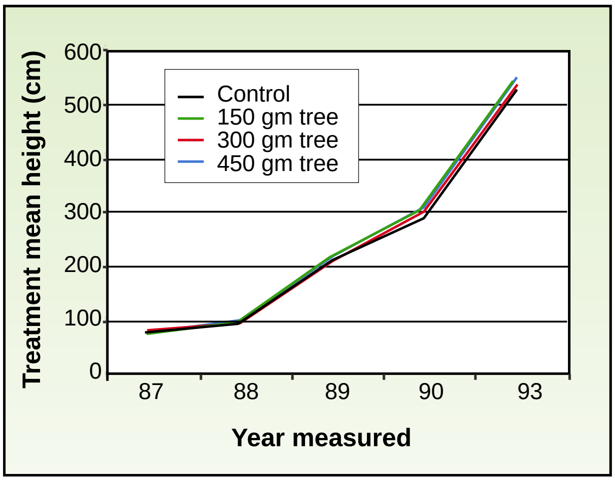


Figure 17: Results of varying fertiliser rates at five sites.

Tree Protectors

These protect the tree from damage by hares and sheep. The greenhouse conditions within the shelters also result in increased growth rate. Tree stability is not a problem with blackwood, although it can be with conifers.

By using shelters, blackwood can be planted in pasture with continued grazing by sheep. Trees should be located in selected areas that are moist and sheltered.

The trees can be planted in groups of three or four, at 7 or 8 metres between each group and silviculturally treated as described in Chapter 10.

Protection against sheep can be achieved using 1.2 metre K.B.C. shelters, and 0.6 metre shelters give protection against hares. Because of stock rubbing, two stakes per shelter are advised, and they need occasional checking. Weeds growing inside the shelters can be withdrawn from beneath the shelter, and sprayed with Roundup. The shelters can be used again after 2-3 years.

Nutrition

Monthly foliage nutrient trends over three years.

Forest Research collected foliage samples over a three year period, in the regime trial at Rotorua. These were taken from the top third of the crown, from 24 dominant trees, every four weeks (tree age 5-8 years). This data showed that the most logical month for foliage sampling blackwood would appear to be April. However, collections in this period may not be sampling for minimum concentrations of K or Ca, which are both lowest in March.

The analysis of approximately 600 nutrient samples is held in the national database at Forest Research. No information is available on the optimum nutrient status for blackwood growth. The database shows the following mean and range of nutrients for New Zealand grown blackwood (Table 6).

Table 6: Mean and range for nutrient samples analysed at Forest Research

Nutrient	Unit	Mean	Range
N	mg/g	3.05	0.22-4.73
P	mg/g	0.17	0.03-0.55
K	mg/g	1.14	0.31-2.24
Ca	mg/g	0.61	0.14-2.03
Mg	mg/g	0.16	0.07-0.41
S	mg/g	0.18	0.09-0.44
Na	mg/g	0.06	0.02-0.22
Mn	µg/g	321.19	26.00-1960.18
Zn	µg/g	21.33	6.20-120.00
Cu	µg/g	5.58	0.38-22.70
Fe	µg/g	63.70	27.66-301.00
B	µg/g	18.13	3.00-39.00

Key Points

- Siting is very important.
- Robust planting stock + good spade cultivation + good weed control = good plantation establishment.
- Seed requires treatment to ensure even germination.
- Seedling type is not critical to success.
- Fertiliser is not always necessary, however P and S should be applied on P deficient soils.
- If fertiliser is applied it should be in conjunction with weed control.
- Seedlings need protection from stock/wildlife during establishment.
- Nutrient deficiency and/or optimum levels are unknown.
- Foliage collection is recommended in the month of April.

Suggested reading:

de Zwann 1982.

Fairweather and McNeil 1997.

Knight 1986.

Hunter, Knight, and Messina 1989.

Messina, and Barton 1985.

Nicholas and Gifford 1989.

Nicholas 1981.

Neilsen (ed) 1990.

Van Dorsser 1981.

Wilkinson and Jennings 1994.

CHAPTER 7 - HEALTH

Considerable research has been undertaken in New Zealand on managing blackwood in plantations. This research has not been accompanied by a similar focus on health issues of the species. There is a wide range of pests and diseases on blackwood in Australia; relatively few of these are found in New Zealand. However, some of the insects present in New Zealand can cause significant growth loss and malformation. Furthermore, with the relative proximity of the two countries, increasing trade and travel, combined with the knowledge that small insects and fungal spores can readily be blown from Australia to New Zealand, it is likely that more blackwood pests and diseases could establish in the future.

Major Insect pests

Psyllids (*Acizzia acaciae*, *A. uncatoides* and *A. albizziae*)

The psyllids originate from Australia, and are one of the most common insects associated with blackwood (Fig 18). Eggs are mostly oviposited on newly developing foliage; however, at high population levels, eggs can be found on all parts of the plant.

Psyllids feed on the phloem of the growing shoots, chiefly sourcing nitrogen, and excreting waste sugars as honeydew. The honeydew is a suitable growth medium for sooty moulds, which enter the plant via puncture wounds made by the insect's feeding mouth parts. The sooty moulds cause localized cell necrosis and shoot die-back, which results in multi-leadering. The combined effect of the psyllids and fungi is to reduce the vigour of the tree, and to bring the seasonal growth to a premature close.

By damaging the shoot tips psyllids *contribute* to malformation and multileadering.

When psyllids were controlled in trials involving the regular application of insecticide, tree height growth was increased by 40 to 50% compared to unprotected trees. However, malformation still occurs in response to shoot tip abortion. Other causes of this shoot tip death, which reduces tree growth, are discussed below. Psyllids are not the sole agent of malformation.

Psyllids are present throughout the year, with population peaks often in late spring, and at the completion of the growing season in autumn.

Figure 18: Psyllid (Acizzia acaciae) adult and nymphs on a blackwood stem.

They are more prevalent on trees on dry exposed sites, and less common in sheltered lightwells, and in areas of high rainfall. Psyllids are easily knocked off the trees by heavy rainfall.

Their natural predators, lacewings and ladybirds, are often found on blackwood, but in numbers too small to provide adequate control. Full control of pysllids by insecticides is possible, although impractical, because a monthly spray application would be required. Not only would this be costly, but most insecticide sprays also remove the natural predators present on the tree that control psyllids and other insect pests.

Seed source

Research efforts on the effect of psyllids on blackwood in New Zealand found no significant difference between six provenances of blackwood tested - neither in growth performance, health nor presence of malformation. However, there was significant tree to tree variation in these attributes.

Acacia leaf miner (*Acrocercops alysidota)*

This small acacia leaf mining moth is native to Australia. It lives in most acacia species present in New Zealand and on blackwood it can develop and burrow within the phyllodes (Fig 19). Larvae can also enter the stems and then can cause shoot dieback, and in doing so contribute to multileadering and malformation. Larvae are present in the field from November to May, and have multiple generations per annum.

Two species of eulophid wasp* , which are probably from Australia, appear to be keeping leaf miner populations under reasonable biological control in most years. Larvae feeding within phyllodes are parasitized by the wasp, but those that tunnel into the stems probably escape parasitism by the wasps.

* (*Diaulomorpha* sp. and *Cirrospilus* sp.)

Figure 19: Leaf miner attack on blackwood phyllodes.

Figure 20: Adult blackwood tortoise beetle

Blackwood tortoise beetle (*Dicranosterna semipunctata*)

This is a native Australian leaf feeding beetle, first discovered in Auckland in 1996. Since then it has spread to the far North, and south to at least Taupo. The current spread of blackwood tortoise beetle is unlikely to be restricted by climate, as it is found in the tablelands from northern New South Wales and south through to Victoria where the climate is similar to New Zealand's. In Australia, both adults and larvae are defoliators of phyllodinous acacias (however feeding trials in New Zealand indicate that adults will not feed on *A. longifolia)*.

The adult beetle is approximately 10 mm in length, with a dark brown shiny body (Fig 20). The slug-like larvae are black when small, turning to pale green when older. Both adult and larva eat scallop-shaped chunks out of edge of the phyllodes. Although it causes some defoliation, its effect on mature and vigorous blackwoods is less severe than was first thought likely. On young blackwoods its preference for phyllodes on the growing shoot tips can leave them bare at the end of the growing season, and might contribute to malformation. In Australia, two wasp parasitoids* have been found attacking the eggs of blackwood tortoise beetle. These are under investigation as potential agents of biological control in New Zealand.
* (*Neopolycystus* sp. and *Enoggera polita)*

Figure 21: Larvae and egg (top) of blackwood tortoise beetle

The Southern ladybird release.

The Southern ladybird (*Cleobora mellyi*) is native to Tasmania and South East Australia. It is commonly found on blackwoods, where it feeds on acacia psyllids.

It was released in several locations in New Zealand in the 1970s in the hope of controlling paropsis beetles in eucalypts. It survived in one location in the Marlborough Sounds, where it migrated into an adjacent valley and colonised a plantation of blackwoods. Since then it has spread through the sounds, to reach Picton.

In 2002, AMIGO received SSF funding for a release program. The work has been carried out by Dean Satchell. Insects were collected from the sounds and bred up. They have been released on 20 North Island sites. If it becomes established, the Southern ladybird could be a useful agent in the biological control of acacia psyllids. It might also help to control the tortoise beetle, by eating its eggs.

Lemon-tree borer (*Oemona hirta)*

The lemon tree borer is a native beetle that has been recorded from a wide range of native and exotic hardwoods, including blackwood. Damage is infrequent but when present this beetle can be a nuisance. Young larvae chew within and kill small twigs while older larvae eat out larger branches and also the main stem. Occasionally branches are girdled just beneath the bark, causing them to break off. If necessary, affected branches should be cut back to the stem.

Cicada (*Amphisalta* spp.)

Stem damage to young blackwood saplings can be caused by cicadas. The female cicadas place their eggs in herringbone scars which they carve by their ovipositors in small branches and stems (Fig 22). The scars do not occlude and the stems can subsequently break off (larval development later occurs in the soil). Damage is usually intermittent, but in certain years can be heavy. If severe, the trees are best treated by coppicing in the following spring.

Figure 22: Cicada damage on twig

Seed pests

The Australian beetle, *Storeus albosignatus* introduced into New Zealand has been recorded in seed from blackwood and several other acacia species. Little is known about the biology of *S. albosignatus*, except that anecdotal information from New Zealand nurseries indicates that occasionally large quantities of seed are infested. Apart from placing bags around pollinated flowers to protect seed set before attack occurs, there is no easy means to prevent infestation.

Seed Damage Assessments

In 1980 Forest Research staff assessed insect damage to blackwood seed. This unpublished report raised as many questions as answers. Seed was obtained from six localities in the North Island and three from the South Island; no damaged seed were found in the South Island material and only two of the North Island sites had damaged seed.

In 2001 an assessment of seven seedlots of New Zealand sourced seed held in the Forest Research seed store showed variable attack, ranging from none in the single South Island seedlot and between 2-49% damaged seed in the six North Island collected seedlots.

Minor insect pests

Pinhole borers (*Platypus* spp)

These tiny native wood-boring beetles have been known to make unsuccessful attacks on the trunks of blackwood, resulting in tiny holes in the trunk. Although the beetles die before boring deep into the trees, the quality of timber may be slightly affected.

Puriri Moth (*Aenetus virescens)*

Present only in the North Island, the native puriri moth can attack blackwood interplanted in indigenous forest. It is also present in exotic plantations but attack is less common in this environment. The larvae produce a 7-shaped tunnel in the trunk, where they remain for several years. Trees with diameter over 16 cm are less affected. Fortunately the damage they cause is minor, as the stem defects are localised and no worse than pruning stubs.

Fullers Rose Weevil (*Asynonychus cervinus*)

This pest is found commonly in the North Island. It attacks a wide range of plants and trees, and blackwood is no exception. Adult weevils feed on the leaves leaving ragged notches in the margins of the phyllodes, and the larvae feed on the roots within the soil. Obviously root damage is more difficult to locate than the adult feeding damage. It is not known whether such damage impacts upon the growth or form of trees.

Leaf rolling and leaf folding moths*

The larvae of a number of small sized moths, some native, and some from Australia, are found on many native and plantation trees throughout the country. They feed on a wide range of species, including blackwood. Generally they are not found in large numbers, but very occasionally may inflict noticeable damage to foliage. Some larvae will graze the phyllode surface, others will fold the phyllode over, some will web many phyllodes together before chewing them. Natural predators or introduced parasitoids tend to prevent populations from getting too high or remaining high for too long.

Generally these moths are not serious pests as they do not cause extensive dieback or subsequent malformation.

* (e.g., *Ctenopseustis obliquana, Epiphyas postvittana, Penthina doxasticana, Anarsia trichodeta, Dasypodia*)

Acacia tip borer (*Holocola sp. nr. triangulana*)

This small moth is from Australia, and may become a more serious pest of blackwood than the leaf rolling and leaf folding moths. This is because not only do the larvae scrape the phyllode surface leaving it brown, but they also burrow down into the growing tips. This can lead to tip dieback and subsequent malformation.

Miscellaneous insects

A number of other insects, native and from overseas, have been recorded on blackwood trees from time to time. Many of these have wide host ranges and will not build up to damaging levels on blackwood, when there is a choice of other tree species. Such insects may include: scales, thrips, crickets, mites, mealy bugs, bag moths, wood-borers and others.

Diseases

Figure 23: Rust damage on blackwood phyllode.

Rust *(Uromycladium robinsonii)*

Uromycladium robinsonii infects blackwood throughout the country, causing tiny foliage galls, sometimes causing death and loss of phyllodes and leaves. This is different from the large galls from other rust species present on some other acacia species. In severe infections, brown-black sunken cankers (up to 4 cm long) can develop on twigs and branches (Fig 23). Generally however, infection by *U. robinsonii* is of minor importance, although in Whakarewarewa Forest in the early 1980s crown loss of up to 80% occurred in a four year old stand. No method of control is known.

Heart rot fungi

Armillaria spp. have been recorded from blackwood in New Zealand. Attack can occur in trees of any age, causing mortality and root and butt log decay. *Armillaria* is thought to be responsible for the *sudden tree death* sometimes seen in blackwood plantations. Attack by these fungi is sporadic and not fully understood. Usually a single tree, previously showing good health, is affected. Sometimes one or more adjacent trees will later die. Anecdotally, trees in areas of poor drainage, often on clay soils, are more likely to be affected.

Armillaria spp. could be important, since they have the potential to cause considerable damage to the heart wood. No method of control is known.

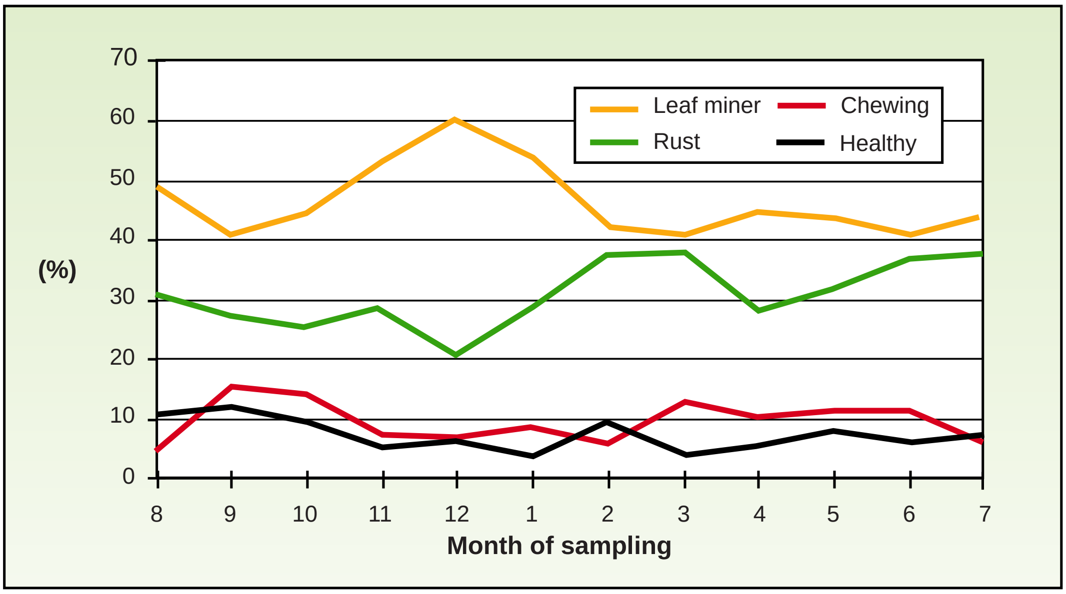
Animal damage

Most animal damage in New Zealand occurs when trees are young, i.e. less than 3 m tall. Anecdotal evidence suggests that possums prefer the juvenile foliage and will climb young trees, damaging the branches in the process as well as eating the foliage. More severe damage has been noted on possum "territorial" trees. Hares will selectively browse newly planted blackwood and animal control or protection is recommended. In Australia animal browsing by marsupials is a major source of plantation failure.

Health monitoring

Two phyllodes were collected from the top third of the crown from 24 dominant trees in the regime trial at Rotorua, every four weeks over a three year period (tree age 5-8 years) to assess changes in phyllode health over time (Fig 24). This monitoring showed that chewing and leaf miner damage were of minor significance in the top one-third of the crown. Never more than 20% of the total phyllodes sampled were affected by these. Rust was present throughout the period sampled, with usually about 30% of the phyllodes damaged, but the least attack appears to be in the driest period over summer.

Psyllids were only collected from two sampling collections: those in September 1992 and April 1994. During these collections, 4% and 12% of phyllodes were damaged by the psyllids respectively. However other psyllid damage was noticed in other areas of the trial. There could be a number of reasons for the lack of psyllid recordings over this particular assessment period and it may not be indicative of other sites.



Key Points

- Insect damage is present in all blackwood stands.
- Due to New Zealand's proximity to Australia, blackwood plantations will always be threatened with the establishment of new insect pests and diseases.
- Insects commonly establish without the parasitoids which control their populations in their natural environment, allowing them to become pests.
- The most damaging effect of insect pests on blackwood is their contribution to leader dieback, malformation and subsequent multileadering. They are therefore important in the early stages of plantation establishment.
- Well-sited, well-established and well-managed blackwood can produce excellent sawlog material, although growth reduction from insect pests during the rotation has not been quantified.
- Mature and healthy trees grown on good sites show little obvious insect damage.

Suggested reading:

Alma 1977.

Appleton 1998.

Appleton and Walsh 1997.

Appleton, Walsh, and Wratten 1997.

Appleton 1999.

Dick 1985.

Hosking 1978.

Kuschel 1990.

Milligan 1979.

Nicholas and Hay 1990.

Noyes 1988.

www.nzffa.org.nz

CHAPTER 8 - MANAGEMENT OPTIONS

If the first principle in growing blackwood successfully is careful site selection, the second is to give the young trees a kick start at the time of establishment. The third is to use a system of management that will ensure the formation of a well formed straight 6 metre stem. This can be achieved either by form pruning or by planting blackwood in a mixture with a trainer or companion species, or by both. The use of companion planting has been widely trialled in New Zealand, and forms the basis of blackwood plantations in Australia. When properly managed it can be very effective, but problems are common. Increasingly the main focus of blackwood plantation silviculture in New Zealand has been to abandon companion planting and rely on form pruning.

Plantation blackwood

Blackwood can be managed effectively as a plantation. To do so requires a program of regular form pruning and an understanding of blackwood pruning. This operation is not difficult, or particularly time consuming. It requires, however, a commitment to visit the trees annually for pruning until the butt log is formed and pruned (4-6 years depending on site).

The nature of malformation in blackwood, and its management by form pruning are described in Chapters 9 and 10 respectively.

Mixed planting (trainer species)

The Trainer's Role

To describe a tree as a trainer, nurse, or even a companion species is misleading. Although supplementary species can provide protection against exposure, the main aim of a mixed planting is to create an environment in which the trees compete for resources of light, water and nutrients. This is a struggle for territory in which the blackwood defends itself – it does so by modifying its growth habit. From a biological perspective the trainer species therefore is not a benefactor but a threat, and should be treated with cautious respect.

The aim in using a trainer is to force the blackwood to produce a straight stem of 6 metres. However, once this has been achieved the trainer is no longer needed. The retention of the trainer will then have an adverse influence on crown development. This can take either of two forms (Fig 25):

- continued lateral shade. This forces the crown to retreat, and causes a small high crown. The effects of this are described in Chapter 9.
- high shade. Under high shade the blackwood crown can expand, but height growth is severely suppressed.

To avoid these effects, the trainer should be regarded as expendable, and it should be removed as soon as it has served its purpose.

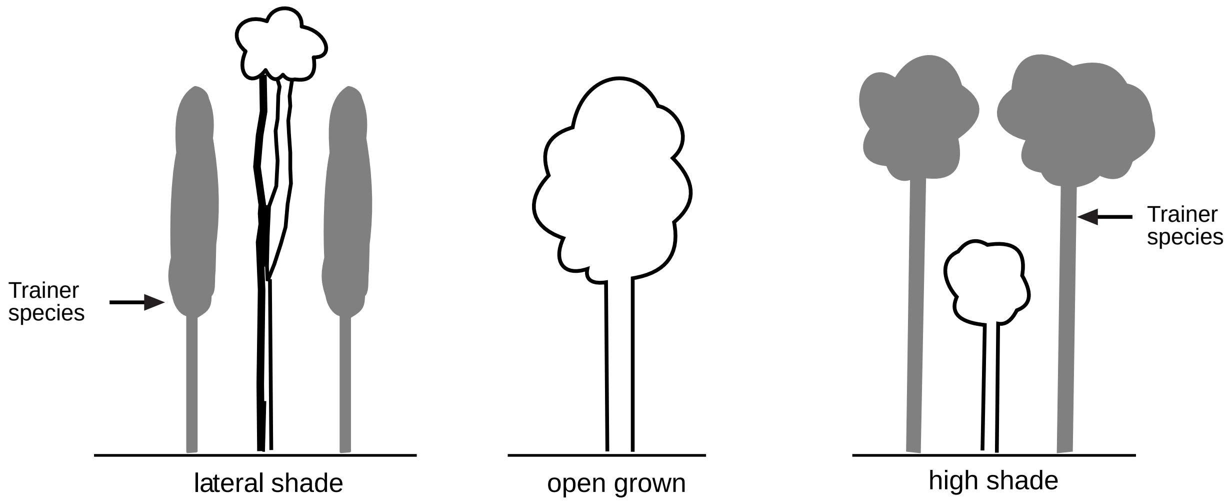


Figure 25: Effects of prolonged crown competition on Blackwood development.

The Ideal Trainer species

The ideal trainer species should:

- grow at the same speed, or slightly faster than blackwood.
- have a narrow crown.
- finish height growth at about 8 metres (or be felled at that height).
- break down rapidly after felling, to allow access.
- not coppice.

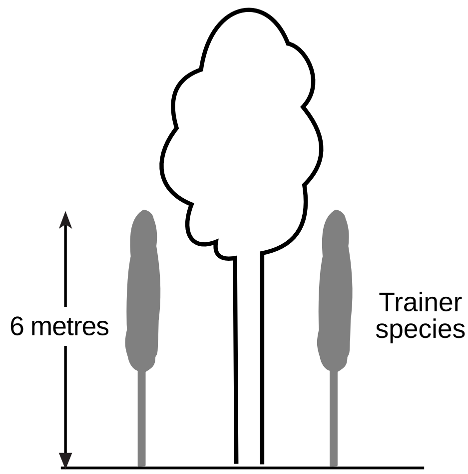


Figure 26: Diagram of ideal trainer concept

The Growth Response

The trainer is likely to encourage a growth response-

- by providing shelter.
- by imposing lateral shading. This causes the lateral branches on the blackwood to become suppressed. The terminal shoot receives more light, and continues to grow.
- by inducing changes in the growth habit of the blackwood.

There is evidence that in the environment created by a trainer species the blackwood responds by delaying its conversion from the juvenile to the adult growth phase (see box below). There may also be a phytochrome response, in which the tree responds to a modified light spectrum transmitted from adjacent foliage (see box below). Insect attack is also reduced in a shady environment.

Growth Response

Delayed phase change. In a study of two year-old blackwood at Pirongia in the Waikato it was shown that blackwood responded to adjacent vegetation by delaying its phase conversion from juvenile to adult. The effect was greatest when vegetation was close at 1 metre distance, and any effect was lost at 3 metres. The retention of juvenile foliage was associated with an increase in height growth at the expense of branching, a sustained growth period, and reduction in multileadering. The stimulus for this response was not clear, and may be multifactorial. Delayed maturation phase change may therefore be one of the mechanisms of the trainer effect. In an associated study, juvenile foliage was found to be photosynthetically more active in low light intensity – this supports the concept of juvenile foliage as equivalent to shade leaves.

Phytochrome response. Trees have a mechanism which allows them to detect and respond to adjacent vegetation. As light passes through or is reflected from foliage the red light within the spectrum is absorbed by chlorophyll. A pigment, Phytochrome B which is present within leaves and stems detects a change in the ratio of red to far-red light, and induces a series of growth responses which favour height growth at the expense of branching.

Trainer Species Management

This requires:

- a well designed planting plan. The spacing and the numbers of blackwood to be planted must not be compromised by the need to accommodate the trainer.
- regular visits (preferably annual). The blackwood will need some form pruning, and branches on the trainer may need cutting back to avoid crowding or damage to the blackwood leader.
- thinning on time. Start thinning the trainer when the blackwood stem has good form to at least 6 metres. Resist any temptation to retain the trainer.

Problems With Trainer Species

1. Planning

It is easy to be distracted by the trainer. This can result in incorrect spacing (rows too far apart), or a low selection ratio (too few blackwood trees planted).

2. Early Management

- If the trainer is a slow starter (radiata pine), it may need to be planted 1 or 2 years in advance. Before planting the blackwood one or two years after establishing the trainer species very good weed control will be required.

- It is unlikely that the two species will have matching growth rates.
- It is difficult to provide the correct amount of lateral shading, not too much and not too little.
- The trainer is competing for light and water.
- Regular pruning visits are needed to remove double leaders and large branches, and to ensure that the blackwood is not over-crowded, by removing overhanging foliage from the trainer species.

3. Trainer Disposal

- At about 6 years the trainer can look very impressive, especially if it is a eucalypt. This raises the temptation to retain both species. The blackwood will then become suppressed, and the trainer species will become the final crop.
- The blackwood can be damaged when the trainer is felled.
- The slash left after trainer disposal can make access difficult for subsequent pruning visits, and limits the opportunity of introducing grazing stock.
- The blackwood has been stress-shielded, and is prone to windthrow in subsequent gales. It becomes windresistant after 1 to 2 years.
- Some exotic trainer species will coppice after felling or regenerate from seed, but this is not usually a problem.

Selection of Trainer Species

Different species will create their own problems. The most widely used species have been:

Radiata Pine

• The growth rates do not match if planted at the same time. Blackwood normally grows faster than the pine for the first 2 to 3 years, and therefore does not benefit from a trainer effect. The pines catch up by about year 4, and by year 6 are clearly dominant, and will need to be removed. The duration of the trainer effect is therefore limited.

- Pines cast a heavy shade, and if retained beyond 6 years the blackwood becomes severely suppressed.
- After felling the pine, slash makes access very difficult, and the blackwood can be unstable.

Eucalypts

Most of the common species grow too rapidly (Fig 27), but with very careful felling (on time) this may be the best option.

- The eucalypts transmit sufficient light, but compete strongly for water.
- At 6 years they often look too good to fell, and the temptation is to retain them.
- Many species will coppice.
- The use of eucalypts as a pulp crop felled at age 10-12 shows some promise.

Deciduous Species-Poplar and Willow

Most of the common species grow too rapidly.

- The deciduous species compete strongly for water and light during the growing season.
- Most will coppice.
- Blackwoods will be exposed to strong winds in spring and autumn when the deciduous trainer species has no leaves.

Figure 27: Eucalypt overtopping blackwood, age 9 years. (Warkworth)

Figure 28: Eucalypts removed, age 10 years. (Warkworth)

Two tier forestry

The theory is appealing: plant two species, blackwood and a trainer (typically radiata pine or a eucalypt). Manage both species, extracting the trainer crop for early cash-flow, and run the blackwood through to maturity. It sounds easy, but attempts to translate the theory into practice have resulted, even in expert hands, in some impressive failures. Some of the problems are as follows:

- An attempt to accommodate the trainer species can lead to incorrect spacing of both species, and a low selection ratio of blackwood (too few trees are planted).
- In practice, some malformation occurs, and the trees will still need form pruning.

Figure 29: Remaining blackwood, age 23 years. (Warkworth)

- In an encounter in which the two species are competing for resources, the blackwood is likely to be the loser. When mixed with radiata pine grown on a 28-year rotation, blackwood becomes grossly suppressed, and the few that survive when the pines are extracted are very unstable. If the pines are planted at wide spacing in order to allow more light, the outcome is low quality pine logs. Blackwood will survive under a eucalypt canopy, but growth is slow.
- The blackwood can show crown distortion if spacing is irregular.
- The effects of felling the trainer species are predictable: some damage to the blackwood, soil compaction/root damage, and instability in the surviving trees.

Planting in regenerating scrub

The simplest and most effective way to achieve a trainer effect is to plant in regenerating native scrub.

Early plantings of blackwood to enrich native forest have been quite successful, but in New Zealand the concept of replacing indigenous forest or scrub with an exotic species has become less acceptable.

Manuka/kanuka is an effective trainer for blackwood, as it is for native species. Broadleaf species are more difficult to manage because their more vigorous growth causes greater shading.

Site selection is important - it must have sufficient soil moisture.

It should be remembered that when blackwood is ready for extraction at about 35 years, depending on spacing, it will be growing in a mixed forest in which a variety of native species will be regenerating. This may raise environmental concerns that will restrict clearfelling, and require other methods of extraction (The original native cover is likely to have been suppressed or, depending on species, to have disappeared through its own natural life span). The potentially high value of blackwood timber is likely to make helicopter logging an option in some cases.

Figure 30: Mamaku enrichment planting, age 22 years

The seed drop of blackwood and root suckering habit of damaged roots means that enrichment planting will ensure a permanent blackwood presence. There is no evidence to suggest blackwood will spread into existing undisturbed native vegetation.

Figure 31: Row planting in lanes. (Wairarapa)

Trial results of enrichment plantings

Mamaku Plateau. An enrichment trial involving several species was established at Mamaku from 1959 to 1961. The forest had been selectively logged in 1904 and 1947, and contained some residual trees of potential future value. Enrichment planting was therefore considered preferable to land clearance. The blackwood trees were planted in lanes, and half were tended. Using this establishment method the blackwood was the most successful species (Fig 30), followed by Cupressus.

On this difficult site, some of the blackwood trees have shown later decline.

East Coast. Enrichment trials have studied lane width and other management practices. In one trial, where blackwood was planted in kanuka 4.5 to 6 m tall, when assessed at age 4-years only 25.4% of the blackwood were multi-leadered. The blackwood trees averaged 4.9 m in height, an excellent result considering no form pruning had been carried out. These trials have shown that lanes as wide as the vegetation height do little for form improvement, but with narrow lanes of 1-3 m, better form is achieved.

Method

- Blackwood can be planted either in lanes cut through scrub (Fig 31), or clustered in a group in lightwells which have been cut in scrub. Row planting has the advantage of allowing easier access for subsequent visits, and the trees are less likely to be lost.
- Seedlings must be planted directly under canopy opening, not necessarily in the middle of lanes or clearings. This is an important consideration on steeper slopes.
- Sufficient blackwood should be planted to give a selection ratio of 4:1.
- The gaps must be planned to transmit sufficient light. It is suggested that the width of the gap should be half the height of the scrub.
- Make regular visits to correct double leaders in the blackwood, and trim back the scrub where it is encroaching on them.

Spacing

Blackwood can be planted either in rows, or in groups.

Row planting:

- 7 m x 2 m approximately 700 - 800 stems/ha (Fig 32)
- this allows easy control of spacing.
- when planting in scrub, the trees can be easily identified.
- trees are less likely to be missed during pruning visits.

Group planting:

- Four tree groups at 7 - 8 m centres approx. 800 stems/ha (Fig 32)
- this gives a better selection ratio (all trees are available for selection).
- it ensures a more even spacing between final crop trees.
- the grower is less likely to retain too many trees.
- it allows no flexibility in adjusting the final crop spacing.

The optimum spacing for blackwood has not yet been determined. Currently a reasonable recommendation for final crop number is approx. 200 trees per hectare, i.e. approx. 7 metres between final crop trees.

A selection ratio of 4:1, provided form pruning is carried out, should give sufficient numbers to allow for genetic variation, i.e. plant approximately 800 trees per hectare, and later thin to 200; see suggested regime in Chapter 12.

Planting larger numbers will improve the selection ratio, but unlike some other species does not result in better tree form, or reduce the need for form pruning.

Agroforestry

Blackwood fits well in agroforestry situations (See Chapter 4).

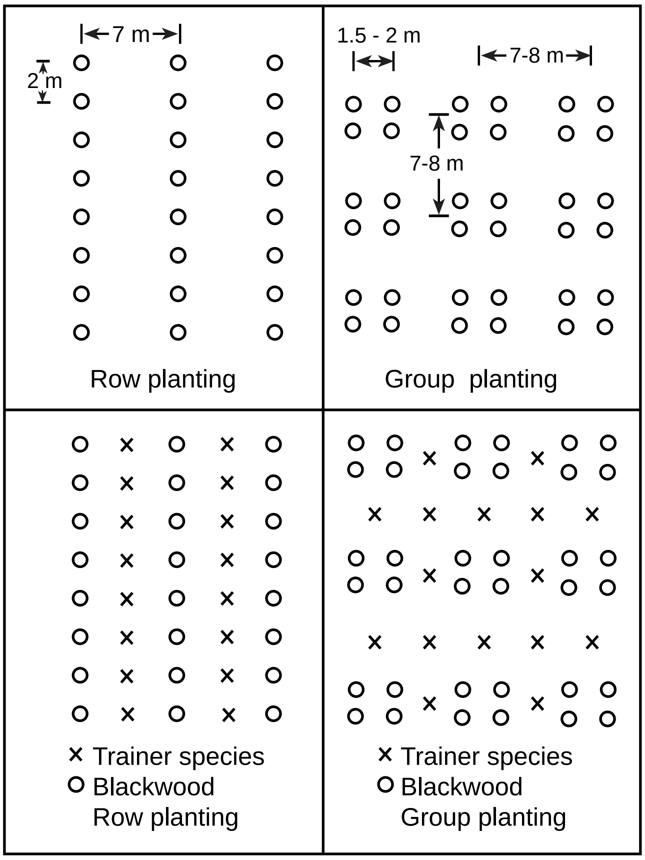


Figure 32: Spacing options for pure or mixed species, planted in rows or groups.

21 year old blackwood agroforestry planting

Well managed 20 year old blackwood trees

Key Points

- Blackwood can be grown in plantations.
- Form pruning is an essential component of all blackwood management systems.
- The use of a trainer species can result in improved stem form. However the method has pitfalls, and requires attention to detail.
- The temptation to retain the trainer species after the blackwood butt log is formed must be resisted.
- An attempt to extract commercial timber from the trainer species is unlikely to succeed, and can compromise good blackwood management.
- Enrichment planting in indigenous scrub can be very effective, but can raise environmental concerns that it might result in conversion.

Suggested reading:

Bathgate and Brown 1996.

FRI 1978.

FRI 1982.

FRI 1983.

Nicholas 1988.

CHAPTER 9 - GROWTH, HABITAT and MALFORMATION

Seed

Seed production commonly starts by year 6 to 8. Blackwood normally flowers in September, and the seed is fully developed by February. Although acacia pollen can be dispersed by wind, it is generally considered to be insect pollinated.

Blackwood invests great care in seed production. Its seed is well packaged (see Fig 3 on page 4). The seed coats are thick and tough, and seed viability is high, usually over 90%.

Blackwood seed is designed for the long haul. Evidence from Tasmania suggests that it can retain viability in the soil for over 250 years (although less than 400 years). As it becomes buried over time in the surface soil, it contributes to a seed bank which contains a high concentration of seeds. These are viable to a depth of over a metre. When established on a site therefore, blackwood is likely to persist.

The seed germinates in response to disturbance, in the form of either fire or mechanical disturbance (see Fig 6 on page 15).

Fire is the primary agent of disturbance in natural conditions. Blackwood seed has evolved in response to lightning induced fire. Over the last 50,000 years, an increased fire frequency caused by Aboriginal “firestick farming“, is likely to have encouraged the spread of blackwood, in common with the eucalypts.

Mechanical damage to the seed coat can result from natural disturbances, including windthrow, floods, or insects. It also follows logging. After mechanical disturbance the rate of germination is less intense than after fire.

Open grown blackwood, aged 7 years.
(Same tree as on page 49)

Foliage

Blackwood is notable for producing two distinct forms of foliage, juvenile leaves and phyllodes.

The time of transition from juvenile to adult foliage is influenced by provenance and growth conditions.

Juvenile Foliage

The fern-like juvenile foliage is illustrated in Figure 1 (page 3, Chap 1). It is believed to represent the foliage that was present on an ancestral form of blackwood.

The juvenile foliage is one of several aspects of juvenile growth which give blackwood the following competitive advantages at this critical time:

- Shade tolerance - the juvenile foliage is photosynthetically active in low light intensity. The foliage is horizontal, and therefore intercepts overhead light.
- Rapid growth – in response to shading there is rapid growth of the terminal shoot, while lateral branching is light.
- Sustained growth - in the juvenile phase shoot growth is sustained rather than periodic. Growth can continue without interruption during the first summer, allowing blackwood on ideal sites to grow more than 3 metres in the first year.

The special features of juvenile growth, in which shoot extension is rapid and sustained, branching is reduced, and there is little malformation, have silvicultural implications. A problem for juvenile foliage is that it is highly palatable to livestock and possums.

Juvenile growth can be encouraged by:

- provenance selection.
- moist sheltered sites.
- competition for light.

The transition from juvenile foliage to phyllodes is delayed in provenances from areas of high rainfall, and in trees growing in shaded conditions. An explanation for this is that on these sites blackwood is confronted by aggressive competitive species. In a race for light between competing species, survival is favoured by rapid growth and shade tolerance.

- Light - transition to phyllodes is delayed in trees which are growing in partial shade, and occurs early in open-grown trees.
- Exposure - transition to phyllodes is early on hot dry sites, and is delayed on sites which are moist and sheltered.

Phyllodes

Phyllodes, which are modified leaf stalks, are shown in Figure 1 (page 3, Chapter 1).

The time of transition from juvenile foliage to phyllodes is influenced by provenance (early in provenances from dry inland areas) and site conditions (early on dry exposed sites).

Phyllodes from inland provenances tend to be small and waxy.

Phyllodes are adapted for survival in strong light, and dry conditions. Their thick waxy coats are designed to restrict water loss.

Phyllodes are photosynthetically active in strong light, but are much less active in low light intensity.

As it matures, therefore, blackwood becomes less shade tolerant (this is true of many tree species).

At this stage of growth, extension of the terminal shoots is periodic, rather than sustained. The periods of growth become shorter over time, and the tree develops a strong and persistent branching habit. As will be discussed later, periodicity is associated with malformation.

Shoot growth

Blackwood shows a striking plasticity in its growth, producing straight stems when forced to compete for light, and expanding its crown when it grows in open space. The mechanism by which this occurs, and its implications for management will be discussed in the section on malformation.

Growth patterns

The seasonal diameter and height growth patterns of 4 year-old blackwood in Whakarewarewa Forest, located at Rotorua, New Zealand, were investigated by the monthly measurement of 50 individual trees over 5 years. Growth rate was divided by the mean annual growth rate to obtain the monthly growth rate as a percentage of total annual growth. Analysis showed that height and diameter growth was at a minimum in June and July. Blackwood diameter growth appears to exhibit a seasonal pattern with two peaks, one in August and a second growth spurt in February. The height growth has only one peak which appears to lag just behind diameter growth, especially in the autumn period, but shows a similar timing for spring growth.

Results from this study clearly indicate that the recommended period for annual assessments of both diameter and height for blackwood in New Zealand conditions is during June and July.

Periodicity

Like most tree species, blackwood has periods of growth, alternating with periods of minimal growth (similar to dormancy).

The duration of each growth period is influenced by insects. Growth periods are often interrupted by acacia psyllids, which damage the shoot tip.

Root systems

Blackwood has a very extensive root system. In the "blackwood swamps" of North West Tasmania, with their high water table, the roots are located near the surface, but they extend more deeply in free-draining soils. Blackwood therefore has a potential role in stabilising soils, and in riparian planting.

The nodules which are attached to the roots contain rhizobial bacteria, which *fix nitrogen*. This can improve soil fertility, and reduce the need for fertiliser application.

When damaged, for example by cattle, new shoots can form from surface roots (see Fig 13 on page 37).

The ability of damaged roots to sucker is considered an advantage in using blackwood for erosion control.

Currently root cuttings are the most reliable way of cloning blackwood.

Root grafting is common in blackwood. This should be considered when contemplating using herbicides for thinning or coppice control.

Coppice

Coppice growth results from the activation of dormant buds. The new shoots therefore show juvenile features. Coppice is probably an adaptive response to predation. Natural regeneration in blackwood occurs mainly from ground-stored seeds. However, blackwood can regenerate by coppice after stem damage or defoliation or felling.

The vigour of coppice in blackwood is influenced by the *season* in which the stem is cut:

- spring - this results in vigorous coppice growth.
- autumn - coppice growth is delayed until the following spring.
  - some mortality occurs during the winter after coppicing.
  - subsequent growth is slow.
  - there is some late mortality during the next few years.

The optimal time for thinning blackwood therefore is in autumn. In contrast, when encouraging new growth the optimal time to cut is in spring.

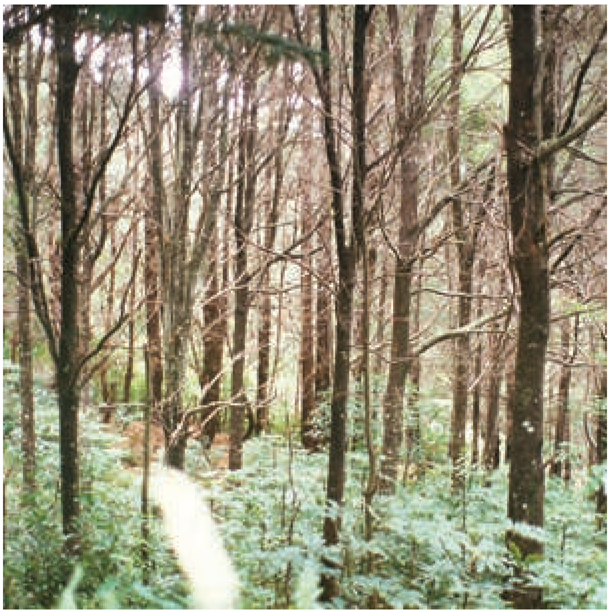


Figure 33: Overstocked stand with retreating crowns.(Hunua)

Malformation

Blackwood has evolved in a challenging environment with periodic fires, recurring drought, and aggressive competing species. Its survival depends on genetic variability, and on the ability of each tree to adjust its growth responses to site factors.

On rich sites it meets the challenge of competing species with rapid extension growth.

Blackwood in the open is at risk from fire and exposure. Here species survival depends on early maturation and seed production. The outcome, where it utilises all available space is the typical open-grown blackwood, with a short bole, and large branching crown (see Fig 12 on page 37).

To a botanist this is a fine-tuned growth response in a highly evolved species, to a physiologist it is a lack of apical dominance. To a forester however it is simply malformation.

Malformation in blackwood can affect both *stem and crown*. Stem malformation is well recognised. Crown malformation is less obvious, but important.

Stem malformation

Stem growth

As described in the previous section, stem extension in blackwood is *periodic*. The processes which start and terminate each period of growth are responsible for stem malformation. The sequence of events in each period of growth is as follows:

Shoot growth

As the leading shoot extends, its branches are controlled by hormones that are produced by the shoot tip. Within each growth segment the branches are uniform, appear in orderly sequence, and come to lie horizontally (Fig 34).

Shoot tip abortion

Each period of shoot extension in blackwood is eventually terminated by abortion of the shoot tip, commonly associated with insect damage. This is a natural process where trees recover from damage. The effect of shoot tip abortion is to remove the source of the hormones which control branch development. This results in an immediate stimulus to branch

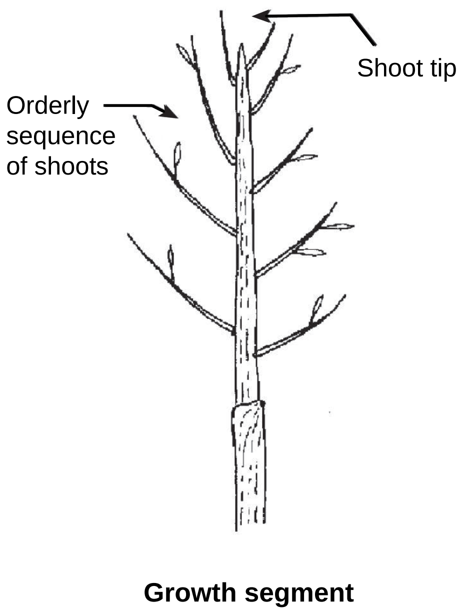


Figure 34: Shoot growth

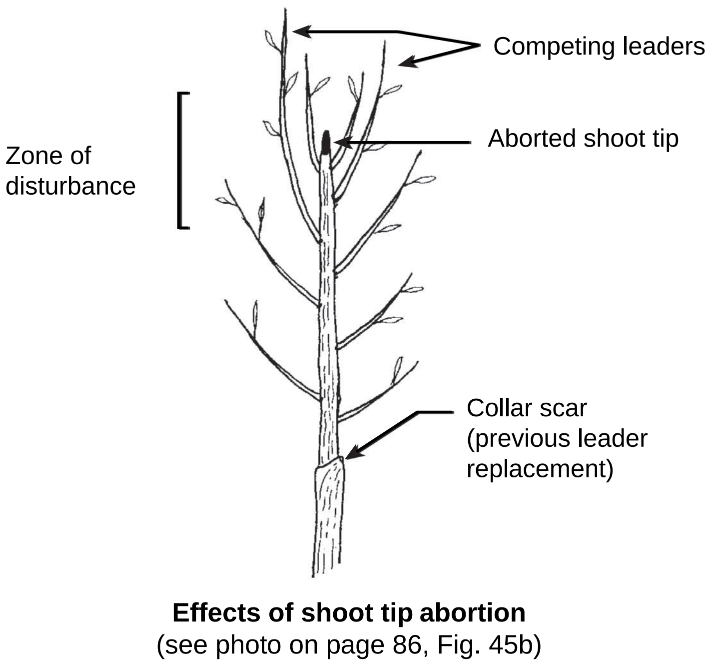


Figure 35: Zone of disturbance

growth - the branches most affected are those nearest to the shoot apex.

The zone of disturbance

The branches located immediately below the aborted shoot tip are now free from hormonal control, and when the next growth period resumes they engage in a contest for leadership (Fig 35*)*. The outcome of the contest depends partly on light conditions. When subjected to lateral shading, one branch often becomes dominant, and the others are suppressed. In open-grown trees, double or multiple leaders are more likely.

The collar scar

The point of origin of a growth segment is easily identified – the lateral shoot, which will replace the former leader, has a branch collar which encircles its point of attachment to the stem. As the shoot enlarges and extends vertically, the branch collar will persist. It gradually comes to lie more horizontally, and it forms a collar scar, which encircles the stem (Fig 36).

Figure 36: Blackwood collar scar

The collar scars remain visible for 2 to 3 years before they are obliterated, and they provide a record of stem growth.

Each collar scar defines a point of disturbance in stem development - it indicates the zone in which the important malformations in stem growth can occur.

Malformation in a blackwood stem can take one of three forms. These are located in the zone of disturbance between growth segments, and result from a change in stem leadership.

- 1. Multiple leaders. The shoots adjacent to the aborted shoot tip develop into competing leaders.
- 2. Stem kinks. These occur at the point of origin of the new leader, and result from the retention of a competing shoot. Stem kinks can be prevented by the early removal of these competing shoots.
- 3. Rogue branches. These develop from lower on the stem and attempt leader dominance.

Segmental growth

Abortion of the leading shoot and its replacement by one of its lateral branches is a process that is repeated several times during the development of a blackwood stem. The stem therefore develops as a series of growth segments, interrupted by zones of disturbance. Each growth segment is formed by a lateral shoot which is located below the aborted shoot tip. This is co-opted by the tree to become a replacement leader which will then form the next segment of stem extension. The new leading shoot develops apical control over its own branches, and after a period of growth will eventually abort its tip when damaged, and will be in turn be replaced (Fig 37).

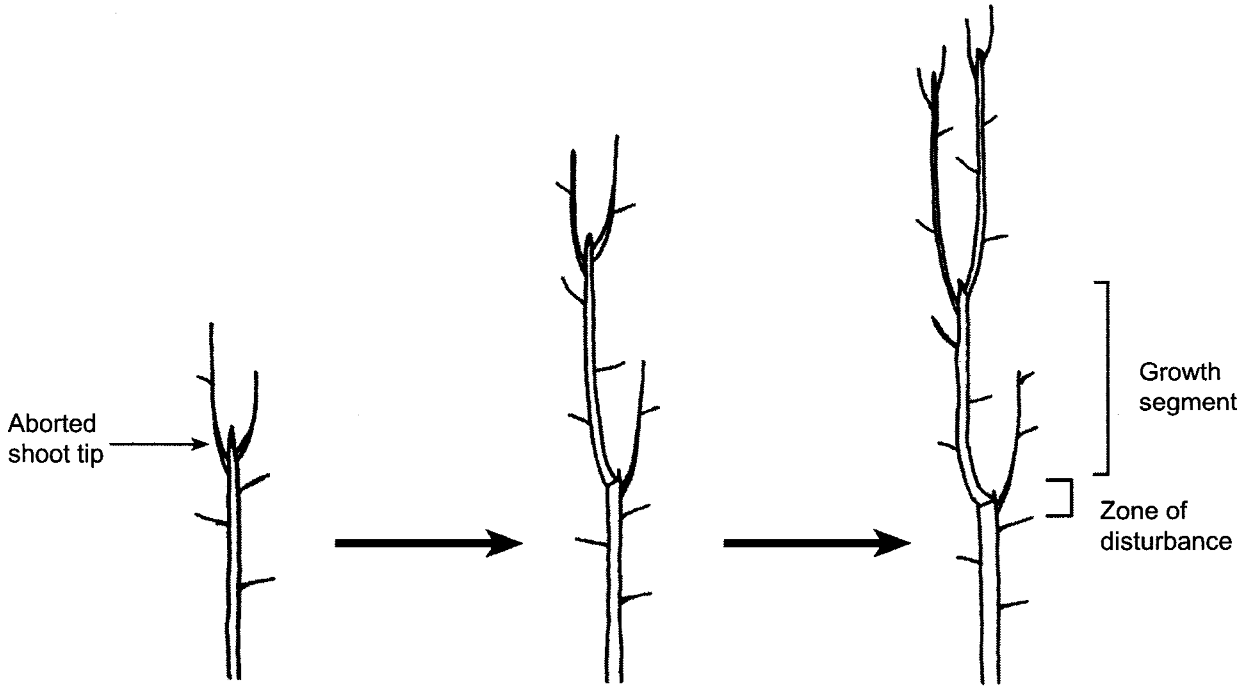


Figure 37: Segmental growth

Crown malformation

The Ideal Crown

Should be vigorous and symmetrical. The live crown should start at the top of the 6 metre stem. It should:

- Be exposed to full light.
- Exhibit good form with a central leader.

Three forms of crown malformation are commonly seen:

1. The Small High Crown

The Cause

Lateral shading is useful during the establishment of a 6 metre stem, but if allowed to continue it has adverse effects on crown development. If the live crown is forced to compete for light it will retreat with disconcerting speed, often over 1 to 2 years. The outcome is a small high crown, perched on long vertical branches that arise from the top of the butt log (Figs 38 and 39).

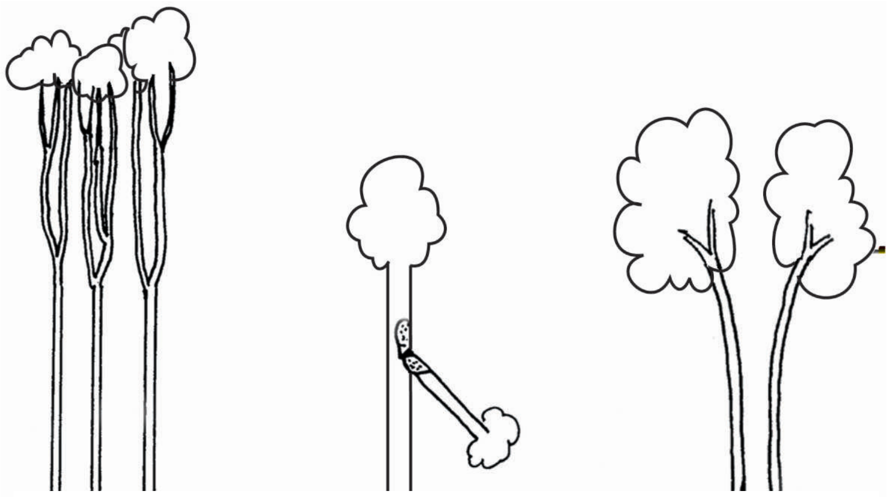


Figure 38: Three types of crown malformation

The Effect

There is an inverse (negative) relationship between the size of the crown and its height. A high crown is condemned to remain small. Its photosynthetic products (sugars, hormones, etc) are used preferentially for essential functions – respiration, shoot and root growth, seed production. Lower priority is given to stem expansion, and for the production of the chemical products used in defense. A small high crown therefore has the following effects:

- reduced diameter growth.
- impaired resistance against disease and predators.
- in addition, the long vertical branches are unstable, and prone to splitting.

Prevention

A high crown can be avoided by timely thinning. The correct time to thin is when the crowns begin to compete – the crowns can then expand without interference. Spacing is also an important consideration (see Chapter 10).

Figure 39: Small high crowns from crown competition.(Hunua)

Figure 40: Crown disintegration from poor structure ofcrown. (Northland)

Figure 41: Asymmetric crowns. (Northland)

2. Unstable Crown

The Cause

A fork, caused by a double leader at the base of the crown, is prone to splitting (Figs 38 and 40). The risk is greater when a delay in thinning results in a high crown, and consequently produces a long lever arm.

The Effect

The crown is prone to major damage or destruction (Fig 40).

Prevention

A double leader arising at the base of the crown can be easily recognised during an inspection at about year 6 to 8. One of the competing leaders can then be pruned off (best option), or simply shortened (preferably in spring), by using a long-handled pruner. Double leaders are best managed before they get too large.

3. Asymmetric Crown

The Cause

Blackwood is crown-shy (not as much as eucalypts, but more than pines). Two trees with crowns in proximity will interact with each other – the result is asymmetry in crown development (Figs 38 and 41). This is often associated with curvature in the stem. Once established, this appearance will persist.

The Effect

The likely outcome will be tension effects in the stem wood during milling and the formation of tension wood.

Prevention

The crowns should be checked periodically, and the trees should be thinned before the crowns interact. The final spacing between trees should be fairly even.

Key Points

Growth Habit

- Blackwood shows a striking plasticity in its form and growth rate in response to site factors (in particular moisture, shelter, light, and soil type).
- The seeds are long-lived in the soil. Once established, blackwood is therefore likely to persist on a site.
- Extensive root systems give blackwood a role in soil stabilisation, and in riparian planting.
- Blackwood is moderately shade-tolerant when young, but become light demanding as it matures.
- Advantage should be taken of the capacity for rapid extension growth and reduced branching which occur during the juvenile growth phase.
- The coppice response varies between seasons. There is therefore an optimal time to cut when either thinning, or encouraging new growth (autumn and spring respectively).
- The recommended period for annual assessments of both diameter and height for blackwood in New Zealand conditions is during June and July.

Malformation

- Malformation is inevitable in plantation grown trees.
- Stem malformation can be reduced by encouraging vigorous juvenile growth.
- Multiple leaders, stem kinks and rogue branches can be controlled by form pruning (see chapter 10).
- Crown malformation can be reduced by form pruning and thinning on time.
- Crown malformation can be reduced by ensuring even spacing between final crop trees and avoiding a fork at the base of the crown.

Suggested reading:

Brown 1995.

Brown 1997.

CHAPTER 10 - PRUNING and THINNING

Pruning

First Principles

When blackwood is grown for timber in plantations the trees must be pruned (see photo on right). The intensity of pruning will vary in different systems. However, even in a well-managed plantation with a trainer species some malformation is common. Increasing the number of blackwood planted will improve the selection ratio, but will not eliminate the need for form pruning.

1. Pruning should start early, and be carried out on a regular basis, preferably annually. There is no point in planting blackwood unless a commitment is made to carry out regular pruning visits. All pruning operations on reasonable growth sites should be completed by age 8 at the latest. Form pruning to 6 m should be completed before this.

Typical unpruned blackwood stand (aged 8 years)

A delay in pruning will have the following effects:

- The need to remove large branches at a later date. This is time-consuming, and the large branch wounds are slow to heal over.
- A reduction in growth during the following season if excessive crown removal occurs.
- The stem kinks, previously described in Chapter 9, are unlikely to realign. The result is malformation in the stem.
- A large defect core.
- A multi-leadered stem, in which it is difficult to identify a central leader.

2. The method involves selective branch removal. It is not difficult or time-consuming. However, it bears no resemblance to radiata pine silviculture. Applying radiata "clearwood pruning" to blackwood will result in something that resembles a deformed cabbage tree.

3. Pruning should concentrate on developing good stem form before clearwood pruning. A study has shown that the retention of a 3 metre green crown will support vigorous growth (see box on regime trials - page 91).

4. The aim in pruning blackwood is to:

- prevent malformation in the stem and crown.
- maximise clearwood production.

Stem pruning therefore involves two distinct stages:

- Form pruning. This can start as early as year 1 or 2.
- Clearwood pruning. This normally starts at about year 4.

The two stages overlap. All pruning is normally completed by year 8, depending on growth rate.

Crown malformation above 6 m is prevented by management of thinning and spacing. Pruning in the crown should be restricted to the correction of an unstable fork in the base of the crown.

Form pruning

Form pruning involves selective branch removal. It is confined to the zones of disturbance which were described in the section on malformation (Chapter 9). The aim is to remove competing leaders and rogue branches and to eliminate stem kinks.

The branches to be removed can be selected in one of two ways:

i. by measurement.

ii. by visual inspection.

Forest Research developed a simple form pruning technique for removing branches once they reach a critical size - 30 mm (Fig 42).

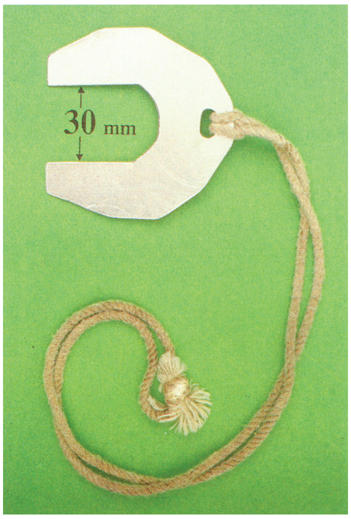


Figure 42: Form pruning branch gauge

Gauge Pruning Method

- Prune annually, preferably in late winter or early spring.
- Start no later than 3 years.
- Use a 30 mm branch gauge, removing all branches that do not fit the gauge.
- Keep pruning cuts close to the branch collar and as vertical as possible.
- Avoid bark tearing down the stem.

Advantages

- The main advantage of gauge pruning is that no experience is required in form pruning
- Minimal time is lost in individual tree assessment.
- Useful research tool for pruning evaluation.
- No large branches remaining at clearwood lifts.

Drawbacks

- Requires using a ladder above 2 m.
- Does not always correct form before kinks initiated.

Advantages

- Up to 3 metres the work is light, easy, and can be done quickly.
- most of the pruning can be done from the ground, without the need to use a ladder.
- stem realignment is rapid.

Drawbacks

- it requires some understanding of the growth habit of the tree.
- above 3 metres the work is more time consuming as long-handled tools are required.
- branches still require removal at clearwood pruning.

Visual Inspection

Form pruning commonly involves the removal of double leaders. It is carried out when the trees are well established. Delayed pruning can cause problems– large branches, slow branch wound occlusion, and stem misalignment.

The outcome of form pruning is strongly influenced by timing. An alternative option is to carry out pre-emptive pruning, in which attention is directed to shoots which are newly formed. This can be described as “leader training”, or “top–down” pruning. It is based on the principle: look after the leader, and the stem will look after itself. The work is repetitive but light, and can be carried out quickly up to 3 m. It is best done in late spring when the new shoots are growing strongly.

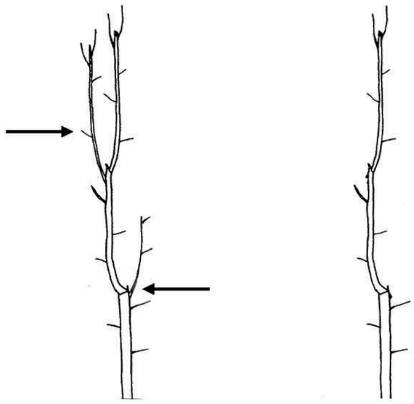


Figure 43: Selective branch removal. (See also Fig 36 on page 73).

Forest Research Form Pruning Trials

Conclusions from gauge pruning trials (1994):

- Form pruning is necessary.
- Remove major defects first.
- Form prune annually using at least 30 mm branch gauge starting no later than age 3 years.
- Prune late winter or early spring.
- Keep pruning cuts close to the branch collar and as vertical as possible

Form pruning treatments met the trial objective in increasing crop tree selection. Following the results from this trial, gauge form pruning on an annual basis was selected as the standard form pruning treatment for all Forest Research silvicultural trials.

> Forest Research Form Pruning Trials
>
> Conclusions from gauge and leader training trials (2000):
>
> - All form pruning treatments compromised growth, especially height and to a lesser degree diameter.
> - The best form improvements resulted when the July biennial 20 mm gauge treatment was applied, although the November annual 30 mm gauge treatment was also successful, although the latter had fewer branches to remove at clearwood pruning.
> - The standard form pruning treatment, July annual 30 mm gauge treatment recommended prior to analysis of this trial yielded similar results to several other treatments, but minor improvements in form may justify a move towards pruning in November.
> - There appeared to be no obvious benefit in reducing gauge size from 30 mm to 20 mm, although diameter growth was reduced less when the 20 mm treatments were applied. No clear differences between biennial compared with annual treatments were revealed within this trial.

Pruning principles

- three steps in leader training

Pruning Method

The method, shown in Figure 44, is as follows:

Leader Training

Identify the zones of disturbance near the top of the tree.

1. Select the new leader - The best shoot is generally obvious – it is usually the most vigorous. When two shoots are similar, select the shoot with the lowest stem attachment. This allows competing branches above it to be removed with a single cut.
2. Remove the former leader - Identify the collar at the base of the new leader, and remove the former leading shoot at that point. The stub will occlude quickly, and is followed by rapid stem straightening.
3. Shorten any remaining vertical shoots - Any large shoots beneath the leader are either shortened to half their length, or removed.

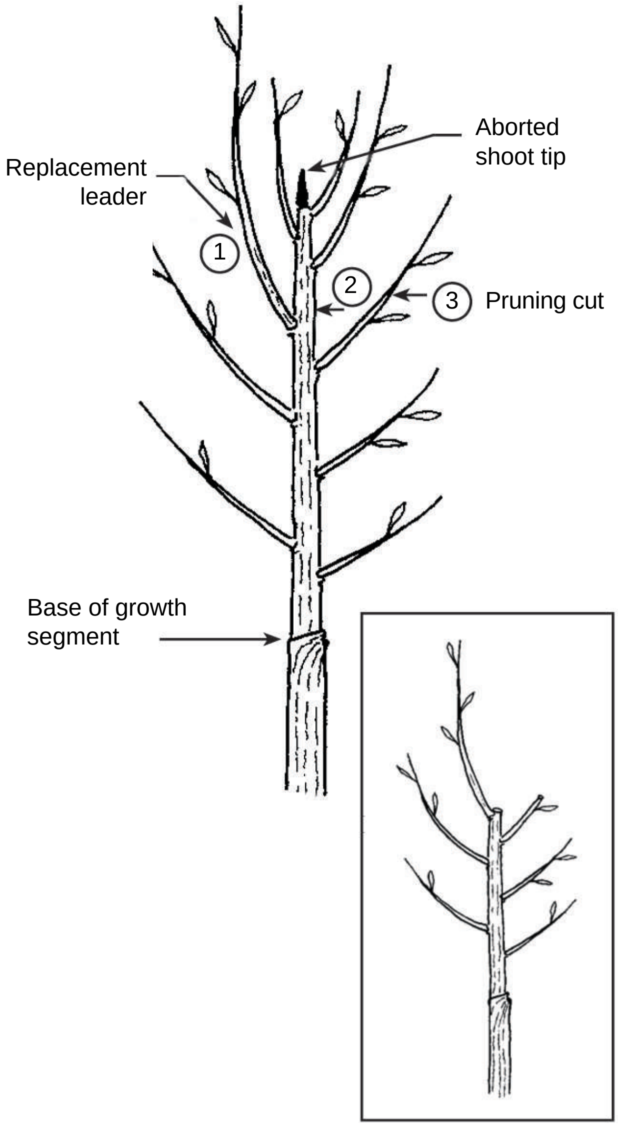


Fig 44: Diagram of pruning principles

Fig 45a: Before pruning.

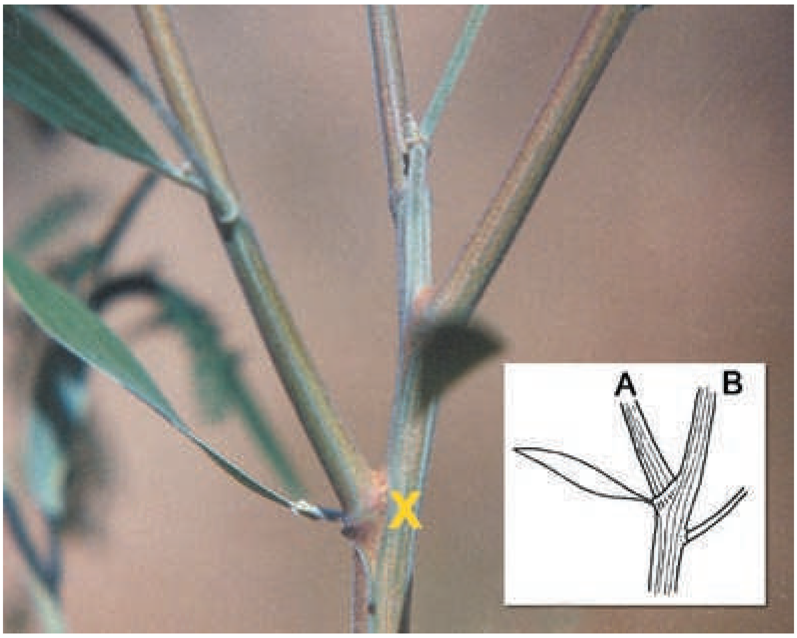


Fig 45b: Before pruning - closeup
(A indicates the replacement leader, B indicates the original leader).

Fig 45c: After pruning.

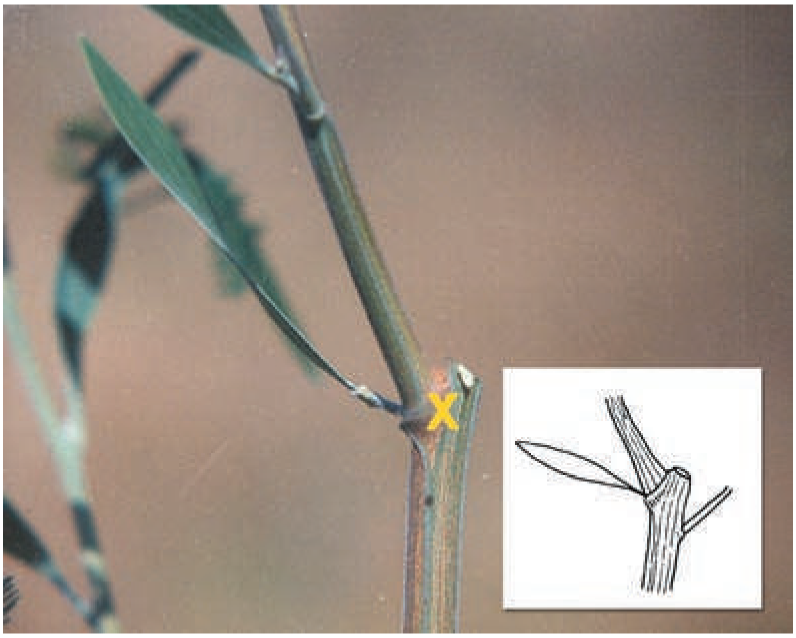


Fig 45d: After pruning - closeup.

Figure 45: Pruning principles in action (Note: common point "X" is the collar scar).

With suitable tools, leader training can be carried out from the ground. With hand secateurs, leader training can be done to 3 metres (the top of the tree can be bent over). By using long-handled secateurs, it can be extended accurately up *to about* 4 metres with patience. Above 4 metres it is difficult to be precise. It is important to avoid leaving a branch stub or "coathanger". When extending the pruning from 4 to 6 metres, therefore, leader training can be replaced by shortening (tip pruning) any competing leaders. ("tip pruning" here means shortening by more than half the branch length). This will inhibit subsequent branch growth, and the branch can be tidied up later during clearwood pruning.

Fig 45e: Shoot pruned, 3 months later.

Fig 45f: Fig 45e, one year later.

Fig 45g: Fig 45e two years later (insert shows collar scar).

Recommended Method

Pruning by either gauge or leader training is effective. The best elements of both methods can be combined as follows:

- start leader training at year 2, concentrating on removing double leaders as soon as possible and repeat annually. Combine with gauge pruning (30 mm) at year 3, and continue annually until the 6 metre butt log is formed.
- start clearwood pruning at year 4, and remove branches progressively up to 6 metres. Leave a green crown of at least 3 metres at each clearwood pruning lift.
- At the final lift to 6 metres, remove any forks in the base of the crown.

Crown Pruning above 6 metres

The value in clearwood pruning above 6 m is unknown, its economic benefit is probably questionable, but there is no doubt as to the need for form pruning above 6 m. This should be restricted to the *prevention of an unstable fork* at the base of the crown.

A double leader at the base of the crown can be easily recognised. One of the leaders can be simply shortened with a long handled pruner. It is preferable to remove it entirely if actioned early.

Branch Shortening

In general it is better to remove branches at their base, rather than shorten them. If a long-handled pruner is available, there are occasions when branch shortening is useful:

- to avoid excessive defoliation during clearwood pruning.
- when shortening a competing leader at the base of the crown.

Branch shortening can cause problems:

- the branch can die back.
- the branch must contain sufficient foliage to be productive. i.e. it must be an exporter of photosynthetic products to the tree, rather than an importer.

The risk of branch die-back can be reduced if:

- some live foliage is retained on the branch.
- branch shortening is done in spring, rather than later in the season.
- the branch is exposed to light.
- shortened branches invariably die off early.

Bark Tearing

Bark tearing is common when pruning large branches. The defects that result are usually very slow to occlude, and stem decay is common over the damaged area. The risk of bark tearing can be reduced by:

- undercutting the bark before pruning – this needs to be a generous cut.
- making a double cut. Shortening the branch before removing it at the base will reduce its weight.
- pruning in late winter or early spring. Bark tearing is more likely when pruning is done from late spring onwards.

The influence of season

For most tree growers, pruning is carried out when time is available from other activities. However, there may be an optimal season for pruning and thinning blackwood.

Pruning early in the growing season (spring) has some advantages:

- it is the best time for leader training.
- branch stub occlusion is rapid.
- bark tearing is less likely than later in the season.
- the tree will respond by producing new foliage.
- branches that are shortened are less likely to die back.

Essential tools*

Hand secateurs - Useful for leader training, up to 3 metres.

Jack saw - The essential tool for larger branches.

Lopper - Prune-off, Kiwi loppers, Hit pruners.

Ladder - Both 2 and 4 metre ladders are very useful. Blackwood bark is thin and is easily damaged. Ladders which grip the stem should be avoided. A well-padded 75 x 50 mm board bolted across the top of the ladder is ideal.

Tools for highpruning from the ground:

Long-handled secateur - e.g. ARS pruner. Useful for leader training.

Long-handled lopper - e.g. Wolff or Sandvik pruner.

Long-handled saw - Slow to operate, and difficult to control bark tearing.

Long-handled chain saw - Stihl HT 75. An excellent tool for trees over 6 years. Good for shortening inaccessible branches. Difficult to cut precisely over 4 metres, so keep well away from the stem. Heavy to operate over sustained periods. Eyes need protection from sawdust.

*Named tools do not indicate brand preference, but are used as examples.

In all cases use the appropriate safety gear when pruning and thinning.

Thinning

A selection ratio of 4:1, provided form pruning is carried out, should give sufficient numbers to allow for genetic variation, i.e. plant 800 trees per hectare, and later thin to 200.

Thinning too early

This has the following effects:

- the beneficial aspects of mutual shelter are lost.
- the trees have little time to interact with each other.
- the trees are still influenced by microsite, and do not have time to express their genetic potential.
- the felled trees can interfere with access.

Thinning too late

This has the following effects:

- distortion in crown development:
  - small high crown.
  - crown asymmetry.
  - unstable crown.
- instability, resulting in windthrow.
- suppression by adjacent unpruned trees.

Timing

The best time to thin blackwood is when the crowns are beginning to form above the 6 metre stem, and are beginning to crowd each other. This is best judged by periodically inspecting the trees. A delay at this time can result in a rapid retreat of the live crown, resulting in a small high crown and a loss of diameter growth.

On good sites, blackwood will commonly need to be thinned at about 7 to 8 years (not before 6, not after 10).

The influence of season

Thinning in autumn will reduce coppice growth from the stumps.

Coppice Growth

Coppice growth is not usually a problem as surrounding trees will soon suppress regrowth which can be cheaply and easily cut if necessary.

Coppice growth from cut stumps can also be controlled by:

- Sheep. Coppice shoots are highly palatable to stock. Sheep are preferred to cattle, which can cause more root damage.
- Thinning in autumn. Coppice growth will be less vigorous.
- Herbicides. There is a need for caution. Painting a newly cut blackwood stump with herbicide is hazardous – in one trial, 30% of adjacent blackwood died as a consequence of root grafting. It is advisable to cautiously trial a few trees before proceeding. It is worth noting that some herbicides are highly selective for acacias.

Group Planting

Trees can be planted in groups of 3 or 4, at 7 or 8 metres between each group. Perform annual form pruning, and thin to one tree per group. In open grown trees a stem of 4 metres is adequate, but a 6 metre bole is achievable with regular form pruning.

Forest Research Regime Trials

Background

In 1987 Forest Research established a series of regime trials to provide a detailed test of blackwood growth response to various pruning and thinning treatments across a range of final crop stockings. The successful trials are located at five sites (Fig 46), two at Hunua, near Auckland; two at Rotorua, at both locations, one on a pasture site and the other a forest cutover; and the fifth is on a pasture site in the King Country. Annual measurements of diameter, height and form were carried out on all five sites from age 3-12 years.

Figure 46: Regime trial on Rotorua pasture site at age 6 years - before clearwood pruning treatments were re-applied.

These trials evaluated:

Pruning

An annual winter form prune with a 30 mm branch gauge was applied from age 3 to 10. Clearwood pruning treatments were applied at ages 4 and 6 (Fig 47), leaving 1.5 m (Figs 48 and 49), 3 (Figs 50 and 51) and 6 m green crown after each pruning lift. A final variable-lift prune to 6 m (where growth was sufficient) was conducted on 4 of the 5 sites at age 10.

Figure 47: Regime trial on Rotorua pasture site at age 6 years - after clearwood pruning and thinning treatments were re-applied.

Final Crop Stocking

Final crop stockings being evaluated are 75, 125, 200, 300 and 425 stems/ha. Not all sites had all final crop treatments. For each plot 6 times the number of final crop trees were established.

Thinning

(i) Early thinning; half of the final crop treatments/plots at each site were thinned to final crop at age 6 years (Fig 47).

(ii) Multiple thinning; the remaining plots were thinned at ages, 6 and 10, with a final thinning scheduled for age 18 years (2005) (Figs 52 and 53).

Regime Trial - main results to date

Green crown removal

These results show that the pruning treatment of leaving 1.5 m green crown at age 4 and 6 years resulted in a significant depression of DBH and height increment when compared with the more conservative 3 m or 6 m green crown treatments. However, this depression in growth was restricted to the year following the pruning treatment. Analysis of the DOS (diameter over stubs) values shows significant differences between treatments. Mean DOS values of 11.0, 13.1 and 14 cm were recorded for 1.5, 3 and 6 m green crown removal respectively.

Although the influence of pruning intensity on regime economics is unknown, it appears reasonable to *recommend leaving 3 m green crown at each clearwood lift* up to age 6 years. This treatment appears to result in a minimal reduction in growth, when compared to the 6 m and 1.5 m green crown treatments and is likely to achieve a reasonable DOS.

Timing of thinning

Stem diameters at age 11 years showed no significant differences between thinning to waste to final crop levels at age 6 years, compared to the multiple thinning treatment. However, the multiple thinning treatment produced a significant increase in height. The multiple thinning treatment has the advantage of carrying more trees to later ages as an insurance against mortality within a plantation.

Stocking

Final crop stocking treatments had no significant effect on diameter at age 11. Stocking had a weak effect on height, with taller trees measured at the higher stockings. This was evidenced by a significant difference between 125 stems/ha and 425 stems/ha.

Site

The regime trials were established on selected sites of varying quality to ensure the data collected reflected a breadth of growth rates. This was certainly achieved, with two sites significantly different from the others for height growth. At age 14 years, the best and worst individual plot MTH ranged from to 19.9 m to 7.2 m.

Diameter growth was also significantly different between sites with only two of the five sites similar in diameter at age 11 years.

Figure 48: Leaving 1.5 m green crown, age 7 years, 1 year after treatment. (Rotorua)

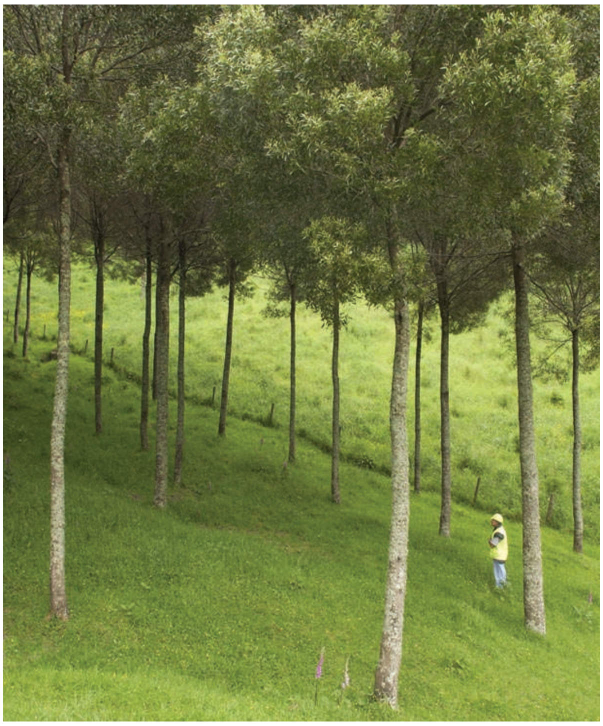


Figure 49: Same plot as Figure 48 at age 14 years. Pruning and thinning 65

Figure 50: Leaving 3.0 m green crown, age 7 years, 1 year after treatment. Variable clearwood pruning lift.

Figure 51: Same plot as Fig 50 at age 14 years. Clearwood pruned to 6 m +.

Figure 52: Regime trial high stocking plot 800 stems/ha at age 14 years. Due for a further thin to 425 stems/ha at age 18 years. Clearwood pruned to 6 m +. (Rotorua)

Figure 53: Regime trial medium stocking plot 250 stems/ha at age 14 years. Due for a further thin to 125 stems/ha at age 18 years. Clearwood pruned to 6 m +. (Rotorua)

Key Points

- Form pruning is essential. This involves selective branch removal to achieve acceptable form.
- A combination of leader training and gauge pruning is recommended and should be carried out annually during the formation of the 6 metre stem.
- Leave 3 metres of green crown at lift pruning.
- Remove or shorten competing leaders at the crown base.
- Do not thin heavily too early, but reduce stocking to approximately 200 stems/ha by age 10 years.
- Depending on site, thin on time to prevent the adverse effects of crown competition.

Suggested reading:

Brown 1997.

Nicholas, Gifford, and Kimberley 1994b.

Nicholas, Gifford, and Kimberley 2000.

Pinkard and Beadle 2001.

CHAPTER 11 - GROWTH MODEL, YIELDS, SUGGESTED REGIMES

Data Collection

Forest Research has been measuring a large number of PSPs throughout New Zealand for many years. Since 1990, the measurement programme has included regime trial plots. To evaluate the blackwood PSP data, appropriate data has been used to develop a preliminary blackwood growth model that can be used to predict managed blackwood growth in New Zealand.

Site Indices

Blackwood will tolerate a wide range of soils, but growth across sites is known to be variable. Interim site indices have been developed, which suggest a height range from 15 to 45 m at a base age of 30 years (Fig 54).

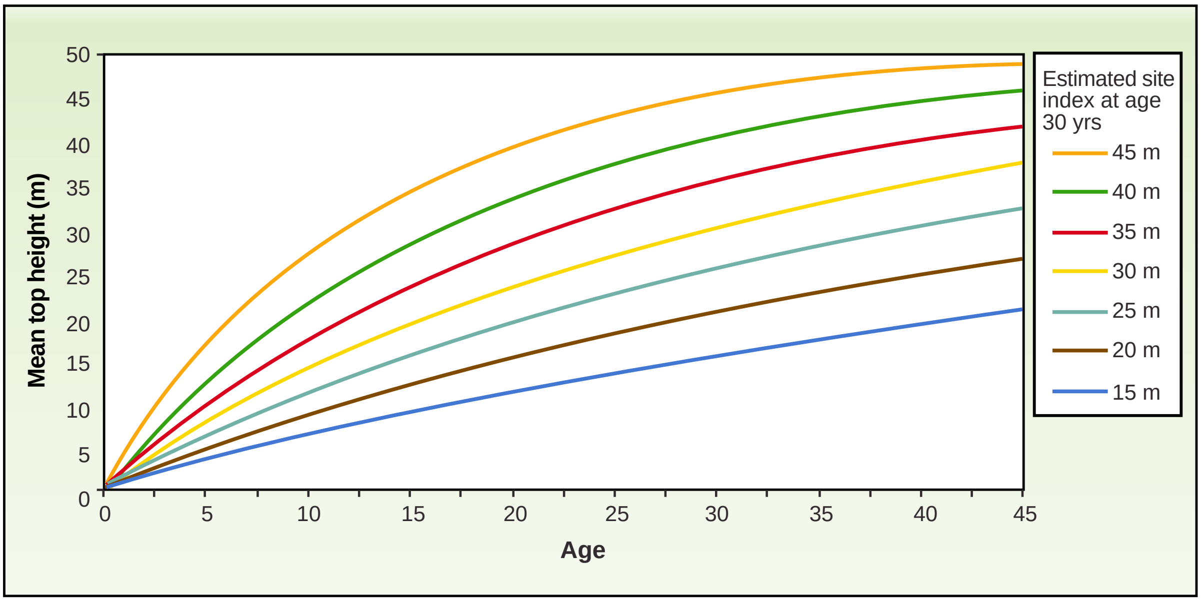


Figure 54: Site index curves

Volume

Volume and taper equations that estimate stem volume have been developed for blackwood. These were based on a sample of 43 trees from a 21 year-old stand from Hunua Forest, and 13 trees from a 12 year-old stand near Rotorua. The taper equations, calculated in 1992, were labelled preliminary until more data was available to cover a wider range of silviculture and sites.

Forest Research Preliminary Growth Model

To test the model, data from one site (the mean of five plots measured from age 5-17 years) was used as a starting point. This site has a mean Site Index of 35.1 m (estimated MTH at 30 yrs). Three scenarios were tested: no thinning from initial plot data (630 stems/ha), current management (thinning down to 160 stems/ha) and the proposed blackwood regime, thinned to 400 and 200 stems/ha (see later in this chapter). Actual data was also included in the graph (Fig 55).

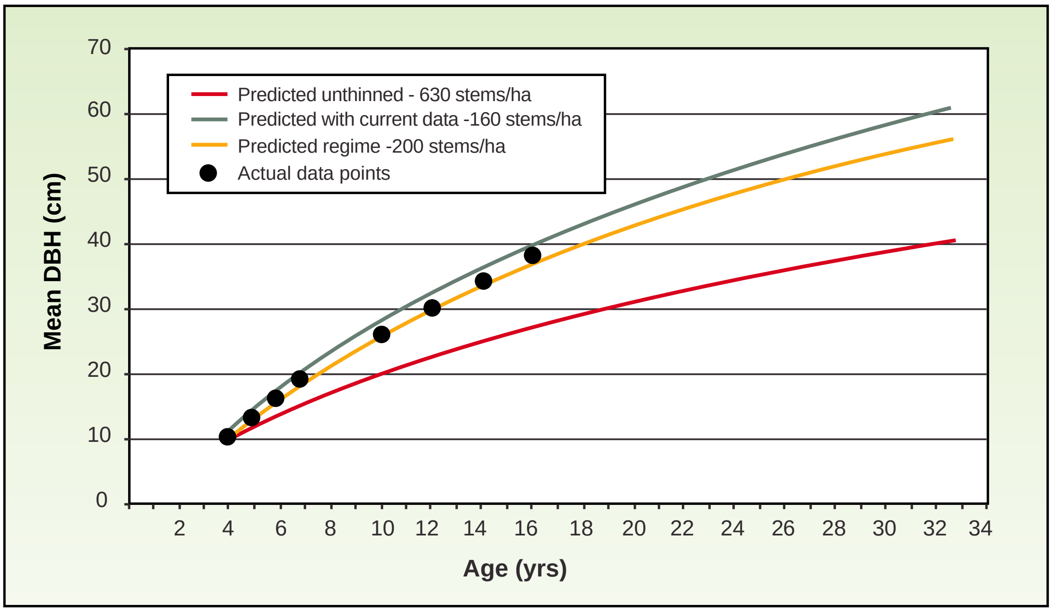


Figure 55: Model predictions of diameter growth at one site testing three regimes

The predictions shown in Figure 55 clearly show reduced diameter growth in an unthinned blackwood stand. This trend is also supported by recent measurements in a 41 year-old stand. The predictions, based on 160 stems/ha using age 5 starting information, suggest a 62 cm diameter at age 34. The model predicts that carrying 200 stems/ha brings mean diameter to 57 cm at age 34. The actual data collected indicates the model is predicting diameter growth reasonably well. The predicted volume difference between 160 and 200 stems/ha is 24 m3/ha in favour of the higher stocking. Although the unthinned has a much higher stand volume, much of the volume would be represented by very small logs. The mortality function in the model also reduced the stockings of 160 and 200 stems/ha down to 128 and 158 stems/ha respectively. It must be stressed that using age 5 data as a starting point may lead to errors in the predictions in an example like this. More model interpretation is required to better understand the silvicultural options. The preliminary model is yet to be released.

Growth Model

Data

The Forest Research blackwood dataset contains a total of 1722 measurements from 229 plots that were considered appropriate for growth modelling (Table 7). Functions that predict mean top height, basal area, mortality, post-thinning basal area, initial basal area and volume have been included in the model.

Table 7: Blackwood growth modelling data summary. Mean annual volume increment (MAI) statistics calculated from maximum MAI for each sample plot.

	Age (years)	**Stocking** (stems/ha)	**Mean top height** (m)	**Basal area** (m^2/ha)	**Volume** (m^3/ha)	**Volume MAI** (m^3/ha/yr)
Mean	9.2	788	9.1	8.6	42.9	5.23
s.d.	5.5	744	5.2	9.3	69.0	4.24
min.	3.0	20	2.1	0.0	0.1	0.136
max.	34.0	6000	31.8	55.4	462.2	21.09

Blackwood managers should establish permanent, or temporary plots, within stands to derive better starting data for model runs.

While much of the data came from pruned stands, the effects of clear bole pruning on growth rate are not modelled explicitly. Therefore, the effect of pruning on growth rate is considered implicitly (by default) in the model.

The model can be employed to derive the appropriate approximate rotation length and final crop stocking for an approximate target piece size or *vice versa*. However this does assume that basal area starting data are appropriate to the site. If starting basal area data are too low, analysis of model predictions may favour an excessively low final crop stocking to achieve a given diameter and rotation length; such a regime may underutilise the available growing space.

The model predicts a mean diameter which will be exceeded by the larger stems, but provides a useful indication of piece size in the absence of a diameter distribution model.

Throughout the development of the model, in particular during basal area and thinning response function development, it became apparent that heavy thinning was often followed by a period of greatly reduced basal area growth, presumably at the expense of crown development to occupy canopy gaps created by thinning. Needless to say, this 'lag phase' is effectively adding to the rotation length, and in theory could be reduced through the adoption of a more conservative, progressive thinning regime. It is not known whether the additional cost of repeated stand entries (to effect more frequent lighter thinnings) would be outweighed by the significant economic advantage of rotation length reduction. The reduction of rotation length is particularly important from the perspective of a discount cashflow analysis over the relatively long rotation lengths predicted for all but the lowest blackwood final crop stockings.

Yields - MARVL

While New Zealand sample plot data and the growth model use taper and volume equations to predict total stem yields, information on actual merchantable yields from plantations is scarce. To estimate recoverable yields some initial research using MARVL (Method of Assessing Recoverable Volume by Log type) has been undertaken.

A number of PSPs have been assessed using the MARVL technique. This system recognises the potential of stands to yield different products, if crosscut using different log selection criteria. A sample of standing trees is assessed and the stem qualities of the trees are recorded. The effect of crosscutting these trees to a set of log product specifications is then analysed by MARVL software, in such a way that the optimal value is recovered from each merchantable stem.

In the stands assessed, trees were described as swept or straight, as well as the following codes:

- Pruned or naturally unbranched stem
- Sawlog with branches <7cm in diameter
- Sawlog with branches >7cm in diameter
- Pulp
- Fork
- Waste (rot, malform, excessively large branch)
- Unmerchantable (including dead standing)

All live trees in the plots were assessed using Forest Research taper and volume functions derived specifically for blackwood.

From the MARVL analysis of two contrasting stands it is apparent that:

- There was wide variation in yield between different silvicultural systems.
- Retention of a high stocking rate will result in a significant proportion of small diameter logs.
- Large diameter is important, especially SED.
- The emphasis should be on butt logs rather than top logs which produce little quality sawlog material.

Figure 56: Overstocked stand used in MARVL inventory, note variable diameters, and high crowns.

Example One

41-year-old overstocked stand, Figure 56

This stand had reduced from 800 stems/ha to 500 through natural mortality. This occurred between age 27 and age 41, when the MARVL inventory was undertaken. A range of minimum SED options was evaluated. In all strategies assessed, the firewood component or non sawlog material was almost half the standing volume, especially when larger minimum SEDs were specified (Fig 57). In all scenarios, cutting waste also provided a large source of residues.

Sawlog SED was also critical to the outturn of the stand. As an example, with the many assumptions in the analysis, an SED of 200 mm compared with one of 300 mm improved nominal stand values from nearly $21,000/ha to nearly $34,000/ha. Increasing the best quality sawlog price, (although firewood values were reduced) increased these values to nearly $25,000/ha and to nearly $40,000/ha. However, the current market in New Zealand will not accept logs with these SEDs. The lowest nominal value scenario was from an SED of 400 mm. This indicates that the current high stocking has significantly reduced the value of acceptable sawlogs (>40 cm SED) (Fig 58).

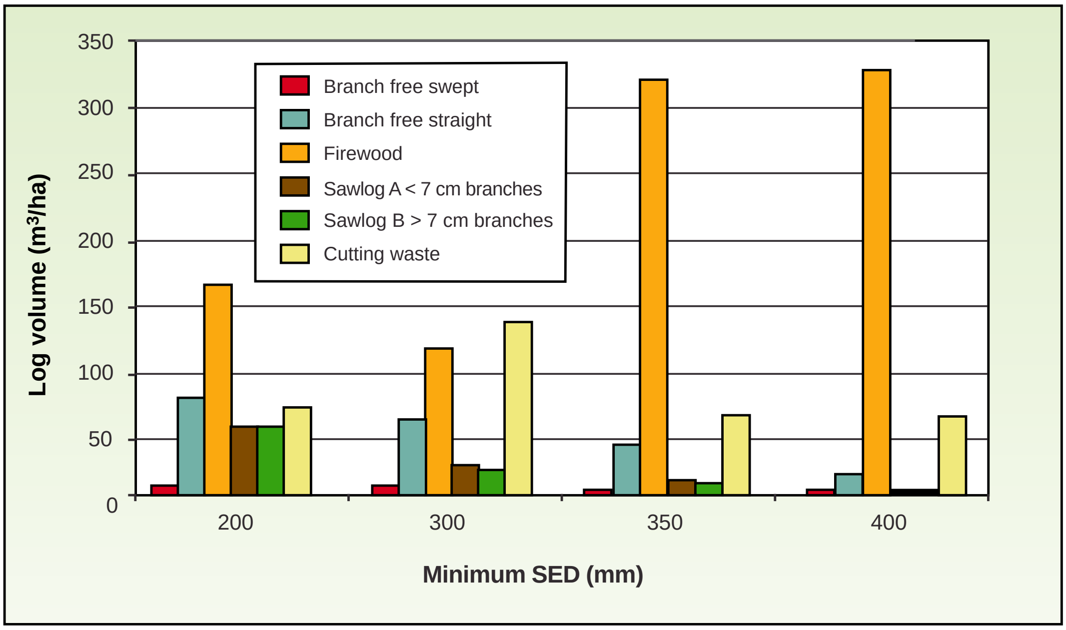


Figure 57: MARVL log volume summary of products by SED group.

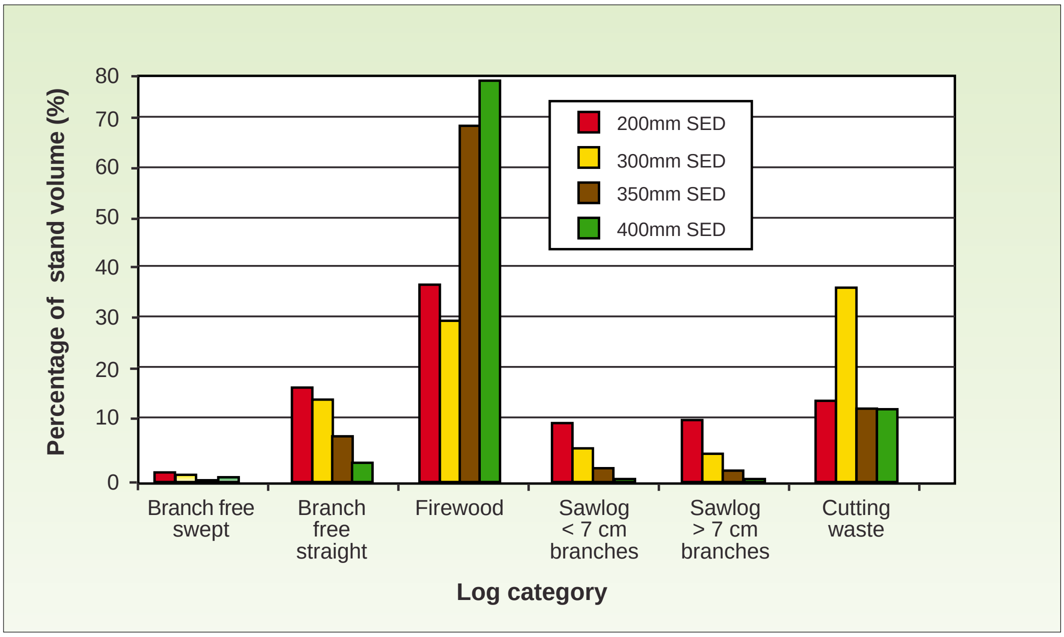


Figure 58: MARVL percentage of stand volume of products by SED

Figure 59: Well managed stand used in MARVL inventory, note photo taken at age 15 years. (Whangarei)

Example Two

17 year old well-managed stand, Figure 59

Five plots were assessed within a 17 year-old stand. This stand was well managed and could be considered typical of well tended blackwood in New Zealand, but well short of rotation length (Figs 60-62).

These MARVL assessments highlight the inherent problem with growing blackwood as a timber tree. Above the pruned butt log there is little sawlog material of any consequence, and most of the top logs, at this very young age, are classified as firewood material.

As can be seen in Figure 62 there is considerable variation between plots, largely as a result of stocking. The best performing plot for pruned log material (Plot 6) is at 150 stems/ha compared with the poorest at 90 stems/ha. It is interesting to note that Plot 2 at 170 stems/ha does not produce the volume of Plot 6, thus stocking alone does not reflect the volume of final log grades. This highlights the need to maintain and improve the current data base before conclusions can be reached on the best blackwood regimes.

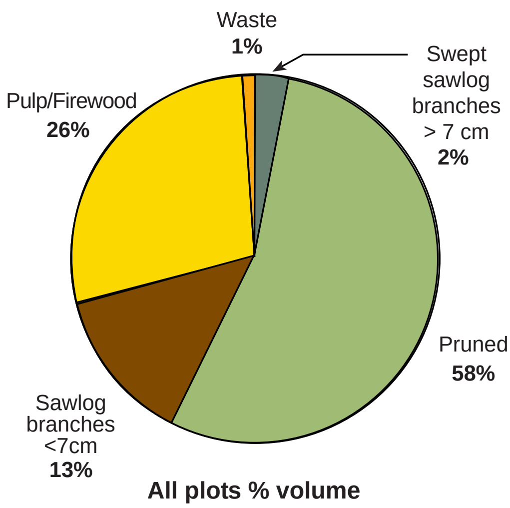


Figure 60: MARVL data, combined plots summary of grade outturn as percentage of volume.

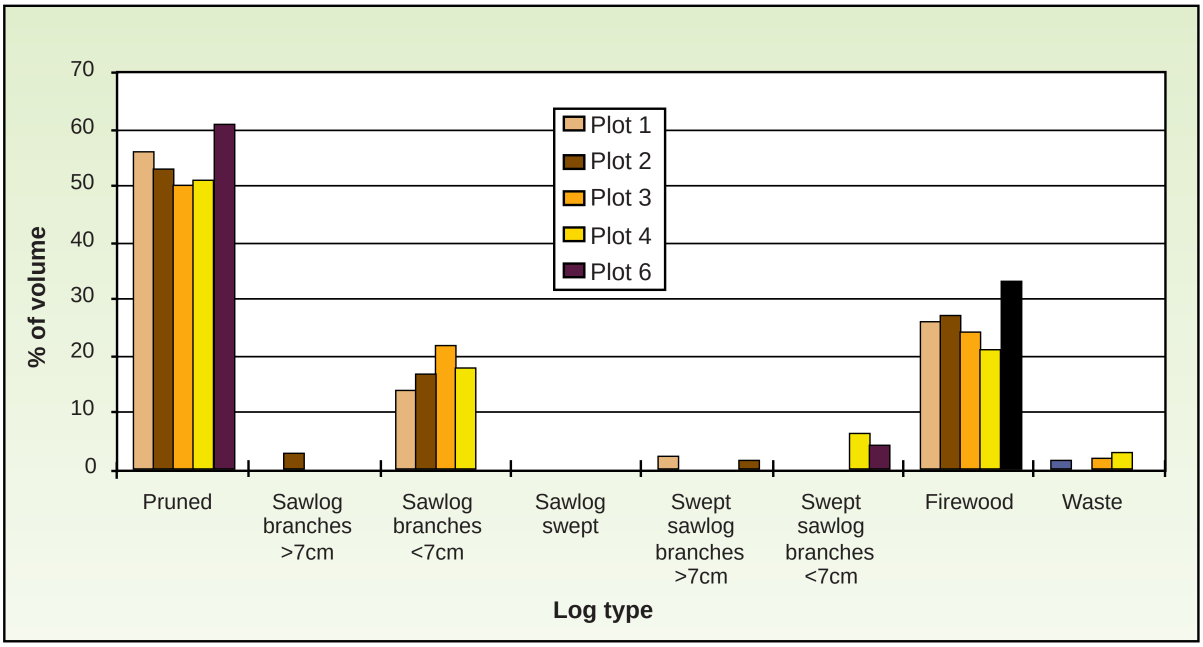


Figure 61: MARVL data as a percentage of volume by log type per plot.

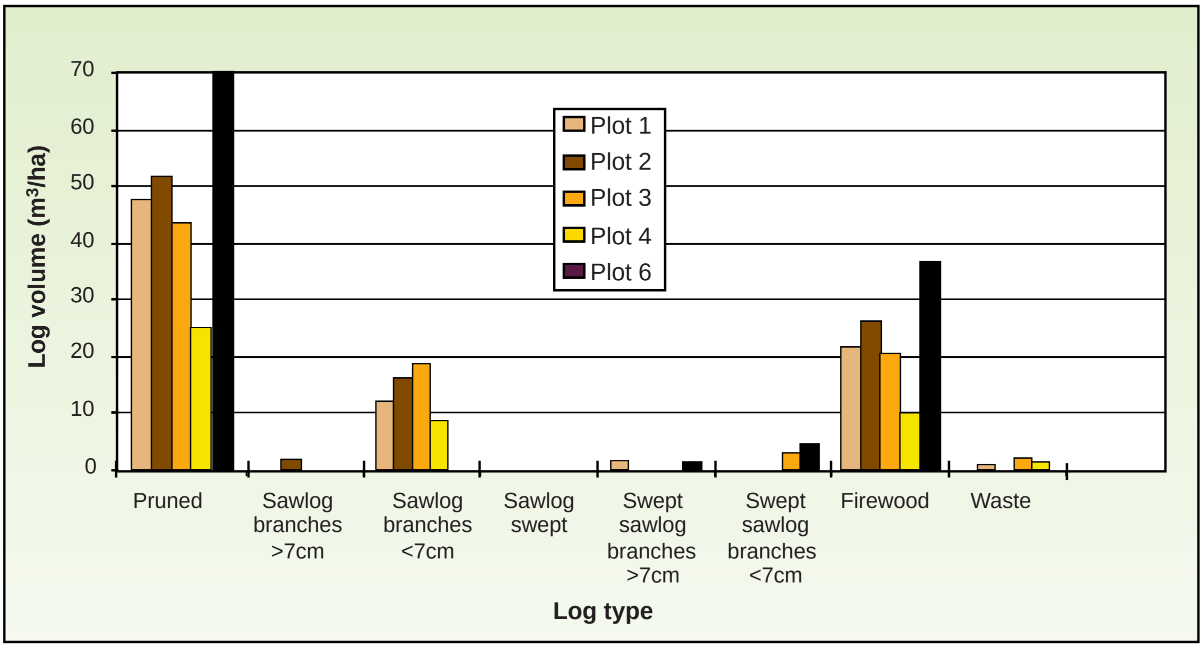


Figure 62: MARVL data of log volume output by plot.

Assessing recoverable yields in blackwood plantations

The potential of plantation blackwood (*Acacia melanoxylon* R. Br.) to produce sawlog material is accepted, but the estimated recoverable yields from plantations is less well documented.

To increase the understanding of recoverable yields, 24 plots of 18-year-old tended blackwood across four sites were evaluated using MARVL (Method of Assessing Recoverable Volume by Log type), and evaluated using computer software (Atlas Cruiser), to assess recoverable yields for a number of scenarios for both the original data and for the stand grown on to tree pieces sizes expected at clearfelling. Results of previous MARVL data from 17-, 25- and 35-year-old stands were compared with the new data collected.

The results show that for the mid-rotation data, stands were carrying nearly three-quarters of the total stand volume as a sawlog component. When the data for the 24 plots were 'grown forward' to simulate expected tree sizes at clearfelling the sawlog component was reduced to two-thirds. This supports published figures which suggests that a mature stand of blackwood will have 55-60%, or approximately 300 m^3/ha, of sawlog material. Comparison with the MARVL results from other stands at 25 and 35 years old suggest this simulated results are conservative, but data from rotation age stands will need collecting to verify this, as will further investigation of the functions used in this analysis to grow the crop forward. The levels of recoverable sawlog material were not very sensitive to log prices of the prime butt logs.

This study has shown that pruned stands produce around 40% of high-quality, pruned butt-log material, as well as 20-30% of branched sawlog material. This refutes the perception that blackwood is a butt-log species only, highlighting the fact that blackwood with a DBH of approximately 60 cm and approximately 38 m tall will produce a range of recoverable sawlog qualities. However, the best-quality material is in the butt log and emphasises the need for quality management and adequate pruning to maximise quality-log outturns

Source: Nicholas *et al*. 2006c

Suggested Blackwood Regime.

The following regime is one based on the authors' experiences and is their "best guess" in 2002. As more information is gathered, aspects of this could change and the regime modified. Therefore, the following regime should be treated as provisional and may be modified in the light of further experience and information.

The target is to produce a tree of 60 cm DBH with a pruned butt log of 6 m, at a final crop stocking of approx. 200 stems/ha. On reasonable blackwood sites, this should be achieved in 35-40 years (Figure 64).

The regime assumes a reasonable site and a commitment to form pruning.

Initial spacing: 800 stems/ha.

Form pruning: (leader training) should start from age 2 years and combine with *gauge pruning* using a 30 mm gauge from age 3 years, continuing on an annual basis until the 6 m butt log is formed (age 4-6 years depending on site conditions).

- Clear wood pruning: can start at age 4 years leaving 3 m green crown at each pruning lift. Two or three lifts may be required to produce a 6 m clear bole. These should be completed by age 7-10 years (depending on site conditions).

- Thinning: should start when crowns compete. First thinning to 400 stems/ha should occur at age 7-8 years, followed by a second thinning by 10 years to a final crop of 200 stems/ha.
- Yields: total stem yield will be approximately 500 m^3/ha, but sawlog recoverable yield may be only three quarters of the material. Therefore, a conservative estimate of 300 m^3/ha sawlog material may be appropriate. More information is required on these aspects.

Figure 63: Well managed stand 200 stems/ha, age 14 years. (Rotorua)

Stand evaluations

The quality of management information has been hindered by a lack of mature well tended stands to evaluate. Two stands established in 1967 were developed as thinning trials, both thinned with different approaches; one receiving a single thinning and the other managed under a multiple thinning strategy. The stands, in Hunua and Riverhead Forests, were assessed by their owners from 1978 and data collection has been continued by Forest Research since 1987. A detailed evaluation was performed in 1993 which included tree quality assessments as well as standard tree growth measurements. Interpretation of the data collected over 16 years has demonstrated that blackwood has responded to thinning, although mean top diameter has been little influenced in the stocking range between 192 to 1392 stems/ha. Growth between the two sites has also varied considerably. Tree quality measured as bole height to major leader defects was not influenced by stocking. A thinning trial from South Africa suggests a final crop stocking of 300 - 400 stems/ha. The New Zealand data from thinning trials and other PSPs lead to an interim recommendation for final crop stockings of at least 200 stems/ha.

Key Points

- A growth model for stand prediction has been developed, but is not yet available.
- Future model predictions should be reviewed and updated periodically, as more growth data becomes available.
- Site indices suggest that a range of MTH from 15-45 m at age 30 could be expected.
- Assessment of recoverable yield suggests large butt log diameters should be targeted.
- The regime is designed to produce a target tree of 60 cm DBH, pruned to 6 m with a rotation length of 35-40 years.
- An initial stocking of 800 stems/ha that receives form pruning, clearwood pruning by age 8 and thinning to 200 stems/ha by age 10 is recommended.
- Yields of 300 m^3/ha sawlog material is estimated.
- As more data is collected preferred regimes are likely to be updated, therefore seek up to date advice.

Suggested reading:

Berrill, Nicholas, and Gifford 2002.

Candy 1989.

Deadman 1990.

Nicholas 1983.

Nicholas 1988.

Pilaar and Dunlop 1990.

de Zwaan 1981.

CHAPTER 12 - ECONOMIC ANALYSES

The lack of information on management costs and consistent stumpage values currently prevents accurate economic analyses of blackwood management in New Zealand.

However several New Zealand studies have been conducted:

- In general these have shown a likely IRR of 5 to 8%.
- In comparison with radiata pine, blackwood incurs higher silvicultural costs, and has lower productivity.

To justify planting on more than a small scale therefore, there will need to be a significant increase in returns from the present value.

- In a hill country study (see box next page) a comparison of probable returns showed that blackwood was:
  - less profitable than radiata pine
  - comparable to *E. fastigata*.
  - more profitable than sheep and beef farming.

Land use evaluations

An assessment was made in 1985 which looked at the economics of growing blackwood based on interplanting. Under the assumptions made for a range of scenarios, blackwood performed better than other specialty timber species (cypresses, eucalypts and black walnut) with a range in IRR from 5.3 - 8.0 %, but was behind radiata pine.

Enrichment: In recent years another paper has also evaluated interplanting. This considered that "on suitable scrubland sites enrichment planting with cypresses (lusitanica/macrocarpa) and blackwood has conservation and potential employment advantages over conventional radiata pine plantation forestry". This determined that based on domestic stumpage sale prices (in 1994) an IRR of 5 - 6% for blackwood compared with 11 - 14% and 11 - 12% for radiata pine and cypresses respectively. However, it was also commented, that if higher timber prices such as those achieved in the Sydney market were used, then blackwood returns were closer to the other species.

Hill Country: In the most recent published economic analysis, tree growth rates, economic returns and the effects of trees on pasture for radiata pine, blackwood and *E. fastigata* were analysed to assess the economic returns of using these tree species within a New Zealand hill country farming operation. Under the assumptions made, all three species options were more profitable in the long run than sheep and beef farming.

Radiata pine produced the greatest return, with large increases in log prices or yields of other tree species being required to give equal profit.

This study commented that compared with radiata pine, blackwood is extremely labour intensive. Each hectare of radiata pine cost $1,805 including plant materials, herbicide, full contract labour and supervision. When the work was completed by on-farm labour 56 hours were required per hectare. This compares with $1,924/ha and 53 hours for *E. fastigata*, and $3,429/ha and 112.4 hours for blackwood.

Problems with Economic Analyses

- Data from Australia may not be relevant to New Zealand. They are subject to marketplace distortions (trees are sourced from state-owned rather than private forests). The trees have different growth rates because of different site conditions and silvicultural management.
- The New Zealand marketplace is distorted by irregular and limited supply.

Future Prospects

Blackwood milled in New Zealand from about 2015 is likely to be:

- of better quality – pruned, thinned, and of larger diameter.
- available in larger volumes. This should produce a regular supply, and introduce economies of scale.
- in increasing demand. Blackwood is suited as a substitute for native species (especially rimu), as well as for rainforest species.

Current prices

- These have shown a significant recent increase.
- There is currently no price differential for colour in the New Zealand market. However, this may occur in the future.
- Log diameter is relatively more important than length.

On many properties where blackwood is grown it has been managed on a small scale as a hobby or sparetime activity. In these circumstances it incurs no or minimal silvicultural costs. However, on these properties later costs may be incurred from the extraction of small numbers of trees from inaccessible sites, and the marketing of small volumes of timber.

Over-stocked blackwood plantation aged 9 years.
(Lardner, Victoria)

Hill country forestry and farming analysis

The results show that all three agroforestry options produce higher long term returns than the current sheep and beef farm. Of the three, radiata pine produced the greatest return with *E. fastigata* giving higher returns than blackwood, on a whole farm basis although the per ha returns were similar (c.$1100/ha/ year). *E. fastigata* had a higher IRR due to the shorter rotation length. *E. fastigata* prices, currently taken to be 10% below radiata pine would need to increase by 43% to give the same return. In contrast, blackwood prices assumed to be three times higher than radiate pine would need to double again to be competitive. Livestock gross margins would need to be $76/su to give the same annual return at normality.

Economic Base Case

The following is presented as a guide to expected costs of blackwood management and is indicative only. Detailed economic analyses using appropriate expertise should be undertaken before substantial investment in blackwood plantations is made.

Table 8: General guide of expected costs and returns of blackwood plantation management for 35 year rotation.

Operation	Age	$/ha#
Seedlings (800)	0	450
Planting (800)	0	150
Fertilising	0	100
Releasing	1	120
Form prune	2	100
Gauge prune	3	125
Low prune (to 2m*-best 400 stems/ha) and gauge prune above lift	4	160
Gauge prune	5	200
Medium prune (to 4m*-best 400 stems/ha) and gauge prune above lift	6	300
Gauge prune	7	200
Thin to waste down to 400 stems/ha	7	150
High prune (to 6m*-best 200 stems/ha)	10	260
Thin to waste down to 200 stems/ha		200
Total silvicultural costs		**2,215**
Plantation overheads @ $80/yr	0 - 35	2,880
Management costs @15% of costs	0 - 35	413
Revenue 300 m^3/ha sawlogs from 550 m^3/ha @$220/$m^3$	35	66,000
IRR, with no management fees and no overheads		10.5%
IRR, with overheads ($80/yr)		9.6%
IRR, with management fees and overheads		7.5%

*Variable lift, leaving 3 m green crown
#Approximate costs and revenues only.

Key Points

- Economic analyses are difficult because of uncertain data.
- Blackwood economic evaluations have returned positive values, usually with IRR of 5-8%.
- In New Zealand, blackwood returns appear less than radiata pine.
- Silvicultural costs are difficult to determine.
- Recoverable yields are relatively unknown.
- Log sales have insufficient history to give consistent pricing.

Suggested reading:

Cavannaand Glass 1985.

Herbert 1994.

MOF 1995.

Nicholas 1991.

Nielsen *et al.* 1990.

Thorrold, Knowles, Nicholas, Power and Carter 1997.

CHAPTER 13 - UTILISATION

The success of growing plantation blackwood will be shown by its successful utilisation and market acceptance.

Sawing of New Zealand plantation-grown blackwood is hampered by a lack of suitable material that has been tended and well managed. Despite this there is some experience with utilising plantation blackwood.

Sawing

Logs can be either flat or quarter sawn, but flat sawing is preferred because it does not require large logs or specialised sawing equipment, and flat sawn boards are more figured. New Zealand blackwood is producing some excellent furniture and joinery (Fig 64).

Profile size

A popular size to saw is 155 x 55 mm as it can be split to 25 mm, or multi-sawn for 50 mm squares for laminating in benches etc. Demand for 25 mm thick lumber is about half that of 55 mm material. Dimensions over 155 x 55 can be milled for confirmed orders, but this is seldom required. In Tasmania, popularity of sizes depends on market conditions, but 150 mm wide by 25, 38 and 50 mm are generally the most popular sizes.

Length

The aim is to have 2.4 m of clean board. Lengths of 1.5 m and less are difficult to market and are of lower price, although they can still be worth holding on pallets unfilleted.

Knots

Knots up to 10 mm are useable in some furniture. They also can give character. Larger knots are undesirable, but sometimes accepted. However, there is a tendency for wood deformation around large knots.

Slabs

These have limited market but are of high value, especially if curved and wide, and can be worth more per m3 than the top lumber price.

Figure 64: High quality niche market use of New Zealand grown blackwood.

Sawing Evaluations

(i) In 1981, 77 sawlogs from 21 trees were extracted from the untended Whakarewarewa stand at age 75 years. Log length ranged from 2.7-5.5 m and SED averaged 396 mm (range 230-660 mm). Log quality was generally poor with 10% logs having included bark pockets. 42% exhibited measurable sweep with an average of 66 mm and 15% of the logs suffered from noticeable spiral grain. Mean branch size was 113 mm with a maximum of 310 mm. Figure 10 shows the logs before sawing. The logs were sawn with a Stenner band headrig and a circular breast bench. A conversion of 46% was achieved. Of the sawn output 73% was in the better grades (clean, dressing and factory i.e. clear cutting).

The timber was very easy to saw, with a smooth to medium saw finish obtained regardless of a range of saw speeds tested. Evaluations made during this study led to a conclusion that a saw pitch of 45-70 mm is recommended.

(ii) An evaluation in 2001 to scope potential outputs from a 40-year-old New Zealand blackwood stand was recently undertaken. As this stand had substantial small logs from being over-stocked, a pilot sawing study of twelve logs was undertaken to evaluate sawing small logs. The logs were sawn on a portable saw of Mahoe design using two right angle circular saws with a kerf of 6mm; this system has no ability to turn logs during sawing. Sawn conversion of three runs with different log sizes was poor with an average of 34% (range 29-40%).

The sawn output from logs of the smallest size sawn (mean SED of 231 mm and LED of 270 mm) was generally of very poor quality because of sap or knots. In one of the runs log tension and sweep caused problems, so much so that the run was abandoned. A small sample of larger diameter logs sawn (400-500 mm SED) showed that logs of this size produce a higher percentage of acceptable timber. Mean heartwood level of the twelve logs was 67%, with a range from 52% to 98%.

(iii) In Westland five 32 year-old trees, a 19 and a 20 year-old tree were helicopter extracted from two forests for evaluation in 1999. The 32 year old trees had a high heartwood content (70-90%) while the younger trees' content was much lower, with 20-30% heartwood. The importance of age, site or genetics on this factor is unknown.

The seven trees with an average SED of 280 mm yielded 12 logs and one veneer log. Tension in logs from two trees caused some sawing problems and a multi-saw edger had some difficulties with the hardness of the wood. One log had significant decay from a dead branch. The sawn volume gave a recovery of 50%. Grade recovery was excellent with 64% dressing, 31% select appearance and 5% standard (Beech grading rules). The main defect reducing dressing grade was large knots and the poorest grade of standard was caused by decayed knots. Veneer was cut from one log length, after the log had been cooked in hot water at 75°C for two days. This appeared insufficient to adequately soften the wood and some difficulty was experienced with knots. However the veneer dried well, was nice and flat and produced attractive veneer.

The timber machined well and was considered very suitable for furniture and joinery applications.

It should be noted that the logs for these sawing studies came from stands which have had minimal or no silvicultural treatment. These studies from a mixed range of ages, quality and sizes have demonstrated that plantation grown material has no major problems. Log size and some stress in logs suggest that well tended logs will be well received in the market place.

The chance to saw some good quality logs from New Zealand plantations is probably a few years away, but these results are encouraging considering well managed stands should produce higher grade recovery percentages.

In New Zealand, experience has shown that processors want logs of reasonable diameter, over 600 mm SED. These logs usually have high yield and low internal stress. As outlined above logs below 300 mm SED have very low recovery of decent boards, frequently display high stress and are milled to minimise crook. They also produce bowed boards. It is reported that even logs of 400 SED can be troublesome.

Fallen trees

These are often worth rescuing from firewood use as they can yield good lumber, even when sapwood is decaying. However, some will have spots of decay, which are obvious when machined. This may have occurred in a standing tree when large branches have broken off.

Drying

Air dry under cover, avoid sun and rain on sides. Use fillets of 20 mm or less for slow drying. When 30% moisture or less, dehumidify to 12-14% for furniture trade. Blackwood can be dried slowly (dehumidifier) from green - low temperature 25-30 °C and maintain 60% moisture content or more until down to 20-25% moisture content. Australian markets generally require timber to be seasoned to between 10-12%.

Grading

This is a key aspect of marketing and quality. End users want timber graded to their specifications and are usually prepared to pay for the right material. The down side of this is that lumber outside the specifications may not have a ready market, resulting in the building up of stocks of low demand material. A practice in the early days of New Zealand timber sales was to sell only cut-of-log, which created problems of wastage and stock build up for the end-user. Current thinking is to be more selective in log buying and grade for specific end uses. While this is better for end-users it creates a problem with lack of markets for all grades. Until this can be achieved, better utilisation and greater value from blackwood stands in New Zealand will be harder to achieve.

Working Properties

Blunting: Moderate, according to density.

Boring: Reasonable; occasional problem with roughness or tear–out.

Nailing: Must be pre-drilled before nailing.

Planing: Straight grained lengths will give an excellent finish with a 30° cutting angle and low to moderate feed speed, although there is a tendency to chip out, especially if cutters are not sharp; tungsten cutters are recommended. Material containing cross-grain incurs severe picking-out and fuzzy grain. For this type of material, the cutting angle should be reduced and lengths individually hand-machined.

Sanding: Sanding occasionally produces a stringy surface. Care must be taken to avoid overheating. Sand paper (i.e. 80 grit) is recommended for initial crosssanding and finishing with a 100/120 grit paper (note dust can cause an allergy, see comment below).

Sawing: Hardness can cause burning so tungstencarbide- tipped saws are an advantage.

Screwing: No problems.

Shaping and routing: Can burn when using high speed machinery.

Chiselling: Good.

Spindle moulding: Good, although burning can occur.

Turning: an excellent turnery timber; turns well at high speed, but with some chipping; cutters must be sharp.

Gluing

Care should be taken to ensure that wood is at the moisture content appropriate for the end-use and that the surfaces to be glued are freshly machined and dust free. It is not advisable to glue boards over 150 mm wide.

A wide variety of glues can be used, but note that casein glues will discolour the wood at the glu line.

Steam bending

Blackwood has an excellent reputation in Australia for steam bending. New Zealand grown material appears to have no problems.

Veneer and plywood

After conditioning at 70°C flitches can be sliced into 0.5 mm thick veneer without difficulty. However, density variation can cause problems. Blackwood slices well along the quarter grain, but the veneer can crinkle-up in the drier if unrestrained. Blackwood is regarded as easy to peel. Care should be taken to minimise iron/tannin staining (which can result from contact between wet veneer and steel). Matching colour with veneer material is considered a constraint in marketing veneer. Blackwood also slices well on the flat grain.

Allergy reactions

Blackwood has been implicated in allergy reactions in Australia, usually associated with processes involving dust. Cases of dermatitis and asthma reactions are reported in the literature. Any processor using blackwood should ensure that adequate dust collection and protection of staff is carried out to avoid blackwood dust allergies.

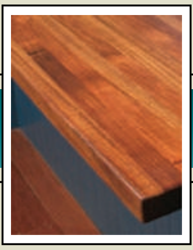
Key Points

- New Zealand plantation blackwood has been utilised for many years and has proved very acceptable in the marketplace.
- Flat sawing is preferred to quarter sawing.
- Sawing studies on untended stands have produced an average conversion close to 50%, and show the importance of large diameter logs.
- Heartwood percentage is variable.
- Some tension in logs occurs, but is variable.
- Blackwood dries and machines well, and has excellent working properties.
- Processors should ensure a dust-free work environment.
- Processors prefer larger logs (SED 400 mm +).
- New Zealand plantation material is being converted to furniture and is selling in the market place.

Suggested reading:

Haslett 1986.

Wood-Baker and Markos 1997.



CHAPTER 14 - CASE STUDIES

HONEYMOON VALLEY, NORTHLAND (Ian Brown)

In 1979 I bought a small abandoned farm property in an inland valley in the Far North. The site is elevated, but protected by a ridge from prevailing winds. The soil is a clay loam derived from ancient basaltic volcanoes, and thanks to a nearby range, the rainfall is high for the district. The original vegetation had been dominated by puriri, a good site indicator.

My brother Richard and I, already heavily engaged in a pine plantation near Wanganui, decided to focus here on alternative species, and to test some unorthodox silviculture.

1980 planting

We fenced a trial area, and planted adjacent blocks of blackwood, Leyland cypress, eucalypts, and redwood. We bought the trees from Joll Hosking's nursery at Whangarei. After weed control, we planted 1000 blackwoods in groups of 4, at 8 metres between the groups, and interplanted the gaps with pines. Ian Nicholas had advised us on spacing.

We visited the site during annual summer holidays in nearby Doubtless Bay. From the first year the trees were showing vigorous growth, accompanied by the unruly behaviour in the leading shoots that is typical of open-grown blackwood. Without a clear plan, but following our instincts, we set upon them with our secateurs, reducing the top to a single leader. Because of competing family obligations, and other distractions such as fishing, we never finished the work, and left some of the trees unpruned. This might be regarded as an undisciplined version of a controlled trial.

After 2 years, two things became apparent:

- There was a striking contrast between the trees that we had pruned, and the rest. The pruned trees had undisturbed vigour, and excellent form.
- The blackwoods were effectively open-grown. They were outpacing the pines, which were too small to have any influence on them. We might have avoided this by planting the pines two years in advance, but this would have required us to plant the blackwoods in long grass, cancelling the benefit of our weed control.

We continued with annual form pruning, confined to the leading shoots, to a height of 6 metres, replacing the secateurs with long-handled pruners. We started clearwood pruning at year 4, and thinned to one tree per group from year 6 to 8. All the work was completed by year 9.

At year 4 the pines had caught up, and for two years provided some lateral shading. However, by year 6 they were dominant, and threatening, so we felled

Good form tree.

them. During the felling, some of the blackwoods were damaged. Others blew over in strong winds, but the remainder became wind-hardened a year later. The pine slash made access difficult and hazardous for further work for several years. It was obvious that any benefit derived from the pines has been limited in time, and outweighed by the problems they created.

Among the blackwood, a group of trees became embedded in regenerating gorse, and remained unthinned. Years later, these have small high crowns, and small diameters, and clearly demonstrate that early thinning is critically important.

On the forest floor there has been considerable regeneration of native species. These include potential canopy species, such as totara.

At 28 years the blackwood are showing respectable growth. In a sample plot the mean top DBH is 52 cm. We expect to start milling at about 35 years. Because of variation in diameter we may do this in two stages.

Pruning a crop tree.

1982 planting

We were encouraged by the response to annual form pruning, and in 1982 adopted a more radical approach. As before, we planted in groups of 4, at 8 metres between the groups, but without a nurse crop. We followed the same regime of annual form pruning and subsequent clearwood pruning, and thinned to one tree per group by year 8. This proved to be simple, quick, and effective, and we found it to be much the best of the systems that we tested. I have used this regime subsequently in more extensive plantings at Pirongia in the Waikato.

In a small number of trees we retained two per group in the hope of extracting one for milling at about 20 years. It was not a good idea. Both trees developed asymmetric crowns, and curvature in the stems.

In an adjacent area there was some regenerating manuka, and here we cut light wells, and planted in the gaps. This proved to be effective, although it still required visits for form pruning, and we spent some time walking in circles locating the trees. Line cutting would have been a better option.

Good form crop trees.

1983 planting

We had not had time to assess the open-planted regime, and in this more extensive area we adopted a more conservative approach, interplanting the groups with eucalypts (*E. saligna*). These grew rapidly, and caused some lateral shading from year 2, but some form pruning was still required. We pruned and thinned the blackwoods as before.

At 6 years we began to thin the eucalypts. Before completing this we were faced with a problem common to growers who have used mixed planting. Quite simply, we were seduced by the nurse. At 6 years the eucalypts were thriving, with tall, straight growth and attractive patterns in their bark. We therefore withdrew apologetically, leaving the remaining eucalypts intact.

The outcome of this act of charity has become apparent over time. Where we thinned, the blackwoods have performed well, with good crowns and diameter growth. In the unthinned area, the blackwoods have been suppressed, with small crowns, greatly reduced diameters, and some mortality. In compensation, we have some fine saligna.

1990 planting

Belatedly, we planted a final group of 1500 blackwood, open-grown, and in groups. In the third summer we had a problem in the form of a massive attack on the trees by cicadas – the entomological equivalent of a mast year – which caused extensive damage to the young trees. After some head-scratching we identified the worst-affected trees, and coppiced them in the following spring. A year later the coppiced trees were thriving. The remainder were struggling.

This led to a later study at Pirongia in which my son and I looked at the influence of season on coppice growth, and which showed that early spring is the best time to coppice blackwood.

The Chief Lessons

These derive largely from trial and error, and from the privilege of making mistakes.

- Site is important. More by luck than choice we have a good blackwood site, combining natural shelter from wind, decent soils, and adequate rainfall.
- Form pruning is essential. It is simple, but requires an annual visit for several years. On sites where growth is rapid, there is no need for companion planting.
- Nurse crops do not eliminate the need for form pruning, but can reduce its intensity. They can create their own set of problems that need to be understood.
- Timely thinning is essential. To take advantage of the growth potential of the tree, their crowns must be allowed to expand without obstruction.

HUNUA FOREST (Richard Harwood and Ian Nicholas)

Hunua Forest (2469 ha) has a prime function as a water catchment for Auckland city. It is located in the Hunua Ranges south-east of Auckland and close to the city. The ranges rise up to about 500 m a.s.l. and have mainly clay or clay-loam soils. A large portion of the ranges is still covered in regenerating logged native forest. From 1880, however, efforts had been made to farm about 6500 ha, but poor access and the Depression of the 1930s saw some farmers walk off the land. These and the other remaining farms were progressively purchased for water-catchment purposes prior to 1960.

In 1961, Ian Barton was appointed by the Auckland Regional Authority (ARA) as forester-in-charge of Hunua Forest. At the time there was a feeling that radiata pine was not the best species for afforestation in water catchments because of its perceived high water use.

Consequently, other species were trialled, including blackwood, the growth of which showed promise. Two small areas (each less than 1 ha) planted in the mid-1960s proved to be the first successfully managed blackwood plantations in New Zealand.

Following these successes, small areas were planted on a regular basis, generally on good, sheltered sites. For the next 30 years, establishment continued with planting from 2-10 ha most years, reaching a peak in the early 1980s when in 1982 and 1984 close to 10 ha was established in each year. There were, of course, some failures mixed in amongst the successes. The total blackwood area in Hunua Forest is about 70 ha.

Ian Barton's tenure from 1961-1986 is notable for the numerous trials he established. These included establishment-, fertiliser-, pruning-, thinning-, stocking- and enrichment trials in cut-over native forest. These trials substantially increased knowledge of the species (Messina and Barton 1985). FRI staff were involved in several of these trials, and following Ian's departure FRI/Forest Researc/Ensis/Scion staff have continued to collect considerable data from the best of his long-term trials.

Silviculture

An area of 3.5 ha of regenerating native forest was underplanted with a number of exotic species including blackwood (0.6 ha) and some native species. The blackwood was the most successful in this experiment. In another trial, about 0.8 ha was underplanted beneath *Eucalyptus saligna*, but the eucalypt failed.

Most if not all stands planted have had some multi-lift pruning to 4 m, while at least two areas had variable-lift pruning to 6 m.

Thinning has also been variable, some being late (age 20 years), but more recently stands have been thinned at age 10 yrs and one even at 6 yrs. Apart from experimental thinning trials, stocking has ranged from 260 stems/ha in the late-thinned stands to between 400 and 500 stems/ in the more recent 1980s plantings. These later plantings were probably intended to receive a further thinning, but because of management changes this has not occurred.

From 1986 to the early 1990s the late Andrew Dakin was forester in charge of ARA, and blackwood management continued along the path planned by his predecessor. Andrew was successful in the marketing of some 22-year-old thinnings by achieving prices of $\$600/m^3$ for sawn timber cut on a portable sawmill in 1992.

In 1987 FRI established a regime trial on a hard site, providing a valuable contrast to stands on better sites treated in the same way.

In 1988 a plus-tree survey was undertaken; 55 trees were selected and root cuttings collected, and about half of the trees were successfully propagated. Rooted cuttings, from these trees, and some others, were established in a potential seed orchard on private property just north of Auckland.

Forest management changes occurred within the Auckland Regional Council; Northern Forests took over the management of the forestry assets in a caretaker role, apparently concentrating on pine silviculture and discontinuing blackwood establishment and silviculture.

In 1998 management and cutting rights were purchased by a private company, Waytemore Forests Ltd, which was most interested in the major resource, pine. Logging and establishment priorities have kept the company fully occupied and little attention has been given to the small blocks of blackwood. In addition, the logging operation is not appropriate for the relatively small areas of blackwood. There has been some interest from a prospective blackwood buyer, but the price offered was not sufficiently high to recover the cost of relocating a logging gang for the one or two day's work required to harvest the small quantity of blackwood logs sought. In this situation these small blocks, often with short, small-diameter logs, may be viewed as a nuisance which complicates management.

Waytemore Forest staff, however, have been impressed with the regeneration from a block of 1 ha that was logged about 10 yrs ago. Here the regeneration (seed and no doubt suckers) has been very dense and the boles of the current pole stand are virtually clean to a minimum height of 8 m, and some thinning is planned.

Apart from a dedicated start to blackwood afforestation, there has been little activity for the last decade. The next major activity will be marketing of logs. This will determine the success of blackwood in Hunua forest.

SOUTH WESTLAND (Ross Jackson and Ian Nicholas)

In central and northern Westland (West Coast of the South Island) small trials of many exotic species including blackwood were planted by the New Zealand Forest Service (NZFS) in the 1960s.

Afforestation in Westland covers very diverse soils, ranging from alluvial terraces to coarse gravels and pakahi soils, many of which have impeded drainage. Most of the variation is a consequence of previous glacial activity. The altitude of forest plantings ranges from 50 to 300 m a.s.l.

The first small trials of blackwood in South Westland, established in 1978 by Ian James (at the time a FRI native ecology scientist), were in a hand-cut lane planting in regenerating scrub in Wanganui Forest and in tractor-cleared lanes in Ianthe Forest in 1979. Both plantings grew well with good form. In 1981, on the strength of these small 2-yr-old trials, blackwood was identified as the species most likely to yield an economic return on such sites. Further development of a NZFS policy on special-purpose species (NZFS 1981) provided some confidence with this approach, and the NZFS started planting up to 5 ha/yr, nearly all of which was in small research blocks, to evaluate fertiliser regimes and establishment techniques.

About the same time the government of the day added two large blocks of virgin native forest in south Westland to the Westland National Park. To compensate for these land transactions, the government initiated a project to establish an estate of up to 10,000 ha with Special Purpose Species which included blackwood, to create employment and future forestry options.

The potential of blackwood for the coast was also recognised by the late Curt Gleason, who favourably reviewed its world performance (Gleason 1986).

With the demise of the NZFS in 1987, the New Zealand Forestry Corporation continued planting blackwood at a rate of 150 ha/yr, with Treasury covering the establishment costs. This arrangement lasted for only about three years, as the New Zealand Forestry Corporation was in turn succeeded by Timberlands West Coast Ltd (a state-owned enterprise created in 1990). In 1990, however, the government provided compensation to Timberlands West Coast Ltd in recognition of its commercial focus. This support consisted of $6 million as a suspensory loan for the continuation of the special-purpose species estate in areas of cut-over forest, particularly in South Westland. Although problems of poor form and defoliation caused by psyllids and leaf miners resulted in a change in emphasis from blackwood to cypresses (mostly *Cupressus lusitanica*), Timberlands did support a comprehensive study of insect attack on blackwood (Appleton 1999).

Blackwood establishment continued under Timberlands West Coast Ltd, but at a much lower rate, 3-5 ha/yr, with much more care being taken to select the best sites for the species. From 1993-1994 to the present there has been increased planting of *C. lusitanica* at the rate of about 150 ha/yr, and blackwood establishment has been on the back burner. However, now that a parasite is reducing the numbers of blackwood leafminers, the situation looks more favourable, and the rate of establishment may increase, perhaps up to 10 ha/yr.

The managers have learnt that site quality governs establishment success and that site variability has a greater influence than silviculture. The key is to confine blackwood to the best sites, so the species will be only a small component of the annual planting program.

Silvicultural treatment has been intermittent and confined to good sites where growth justifies the investment.

There has been some concern that blackwood might invade Westland's native forest adjoining the estate.

Westland blackwood

Lane of westland blackwood.

To investigate the weed potential of blackwood in the Timberland estate, in 2001 a field study was conducted in stands ranging from 17 to 34 years old. There was no evidence that blackwood will invade native vegetation to become a threat to the native ecosystems of Westland. Where blackwood regeneration was occurring in stands, the native vegetation was out-competing the young blackwood regeneration.

A wider review and study of North Island sites recognised that existing planted areas are likely to remain as blackwood areas, especially if soil disturbance occurs during logging, although at this point in the forest-management cycle control- or management options can be undertaken if desired.

To determine the utilisation potential of their plantation blackwood, Timberlands undertook a pilot study of a sample of trees in 1999. Five 32-year-old trees, and a 19- and a 20-yr-old tree, were extracted by helicopter from two forests for evaluation. The heartwood content of the 32-yr-old trees was high (70-90%) but in the younger trees it was much lower (20-30%). The importance of age, site or genetics on this incidence is not well known.

The seven trees, with an average SED of 280 mm, yielded 12 sawlogs and one veneer log. Tension in logs from two trees caused some sawing problems, and a multi-saw edger had some difficulty because of the hardness of the wood. One log had significant decay from a dead branch. The recovery of sawn volume was 50%. Grade recovery was excellent, with 64% being dressing, 31% select appearance and 5% standard (beech grading rules). The main defect reducing dressing grade recovery was large knots, and the main defect type in the poorest grade was decayed knots. Veneer was cut from one log length after the log was soaked in hot water at 75C for two days, but this appeared insufficient to adequately soften the wood, as during slicing some difficulty was experienced with knots. The veneer dried well, however, producing flat and attractive sheets.

The timber machined well and was considered very suitable for furniture and joinery applications.

Westland has the largest single plantation area of blackwood in Australasia, about 1600 ha, but management of the resource has been mixed. The various managing organisations have attempted to juggle social forestry and investment objectives while keeping on top of blackwood's silvicultural requirements. This, and the huge variation in terrain and other characteristics, have resulted in a variable crop. The Westland resource, nevertheless, has the potential to dictate the role of blackwood in New Zealand.

CHAPTER 15 - SUMMARY

Blackwood has an extensive natural distribution in Australia, and is tolerant of adverse sites. However, commercial production is restricted to specific sites. It needs adequate rainfall, shelter, good soils and moderate temperatures. Blackwood occurs throughout eastern Australia, but most commercial production is in Tasmania and Victoria. Blackwood is established as an exotic plantation species in South Africa, India, Chile, Hawaii and China. Blackwood is now well established as a minor exotic species in the New Zealand forestry scene, especially at the farm forestry level.

Timber

Blackwood is a medium weight timber that is easy to work, turns and bends well, and dresses to a smooth finish. It has even texture, with usually straight, but sometimes wavy grain. Blackwood timber is extremely variable in wood density, colour and heartwood percentage. However, growth rate has little bearing on wood quality. It is viewed as an alternative to rimu.

Markets

The Australian market is cyclical and reflects the Australian economy, but blackwood is exported to at least five countries from Australia. Blackwood is developing a market following in New Zealand, where current demand is outstripping supply.

Resource

The resource in Australia is based on sustainable production from natural forests, and from plantations (when they mature between 2018-2048). Tasmania provides most of the resource. The resource in New Zealand, estimated at approximately 3,000 ha, is young but capable of supporting an industry in the future.

Siting

Blackwood requires careful siting. It grows best and produces its best form in sheltered areas. Blackwood sites should provide adequate moisture for optimum growth. Frost prone locations should be avoided.

Land uses

Blackwood can be suitable for a wide range of land uses, such as: plantations, scrub enrichment, riparian planting, open grown trees, shelterbelts, waste water schemes and erosion control, for both timber and nontimber values. Blackwood is a useful agroforestry species, but must be properly sited. Blackwood has less impact on pasture than some other tree species. Total soil nitrogen and nitrogen availability increases with increasing tree stocking rate. Understorey soil moisture is unaffected by tree stocking rate, indicating that trees are not competing with understorey pasture species for moisture.

Genetics

Blackwood shows great genetic variation, both between and within provenances, but there is a lack of research results to guide the establishment of plantations and breeding programmes. Studies conducted have often been limited in scope, particularly with regard to the number of representative provenances. The variation in blackwood growth habit and wood properties lends itself to a clonal propagation system. The heritability of selected attributes and the influence of site on inherent properties are unknown. Clonal selections will require assessment of their performance on a range of sites before they can be considered more than experimental.

Establishment

The most important aspect to plantation success is siting. Seed requires treatment to ensure uniform germination. Seedling type is not critical to success. Nutrient deficiency levels are unknown. Studies suggest that foliage collection for nutrient analysis should be carried out in the month of April.

Fertiliser is not always necessary, although phosphorous and sulphur should be applied on phosphorous deficient soils. If fertiliser is applied it should be in conjunction with weed control. Seedlings need protection from stock/wildlife during establishment. Initial stockings of 800 stems/ha, associated with form pruning, for either row or group planting is recommended.

Health

Insect damage is present in all blackwood stands. The most damaging effect of insect predators (usually psyllids and/or leaf miners) on blackwood is their contribution to leader dieback and multileadering. They are therefore important in the early stages of growth. Due to New Zealand's proximity to Australia blackwood plantations will always be threatened with the establishment of new insect pests. Well sited, well established and well managed blackwood can produce excellent sawlog material, although growth reduction from insect pests during the rotation has not been quantified. Mature and healthy trees on good sites show little damage.

Management options

Blackwood can be grown in plantations, but form pruning is an essential component in all blackwood management options. The use of a trainer species can result in improved stem form. However, the method has pitfalls, and requires attention to detail. The temptation to retain the trainer species after the blackwood butt log is formed must be resisted. An attempt to extract commercial timber from the trainer species is unlikely to succeed, and can compromise good blackwood management.

Enrichment planting in indigenous scrub can be very effective, but can raise environmental concerns.

Growth Habit

Blackwood shows a striking versatility in its form and growth rate in response to site factors (in particular moisture, shelter, light, and soil type). The seeds are long-lived in the soil. Once established, blackwood is therefore likely to persist on a site. The extensive root system gives blackwood a role in soil stabilisation, and in riparian planting.




Blackwood is moderately shade-tolerant when young, but requires light as it matures. Advantage should be taken of the capacity for rapid extension growth and reduced branching, which occur during the juvenile growth phase. The coppice response varies between seasons. There is, therefore, an optimal time to cut when either thinning, or encouraging new growth (autumn and spring respectively). In New Zealand conditions, the recommended period for annual assessments of both diameter and height for blackwood is during June and July.

Malformation

Malformation is inevitable in plantation grown trees, but stem malformation can be reduced by encouraging vigorous juvenile growth. Multiple leaders, stem kinks and rogue branches can be controlled by form pruning. Form pruning through selective branch removal is essential. A combination of leader training and gauge pruning is recommended and should be carried out annually during the formation of the 6 metre stem. It is recommended to leave 3 m of green crown when lift pruning. Competing leaders at the crown base above 6 m should be removed or shortened.

Crown malformation, especially a fork at the base of the crown, can lead to crown disintegration. It can be reduced by pruning and thinning over time, and by ensuring even spacing between final crop trees.

Thinning should not be too heavy, or early. It is important to thin on time, to prevent the adverse effects of crown competition.

Models, yields and regimes

A preliminary growth model for stand prediction has been developed. However, future model predictions should be reviewed and updated periodically as more growth data becomes available. Site indices suggest that, depending on the site, a range of heights from 15-45 m at age 30 could be expected.

Assessment of recoverable yields suggests large butt-log diameter should be targeted.

A target tree of 60 cm DBH, pruned to 6 m, with a rotation length of 35-40 years is suggested.

A regime starting at 800 stems/ha, with form pruning, clearwood pruning, and thinning to 200 stems/ha by age 10, is outlined. As more data is collected, preferred regimes are likely to be updated, so be sure to seek up-to- date advice.

Total yields of approx 500 cubic metres are anticipated with a possible merchantable yield of 300 cubic metres of sawlog material.

Economics

Economic analyses in New Zealand are difficult because of uncertain data, particularly with respect to

silvicultural costs and recoverable yields. Blackwood economic evaluations have returned positive values, usually with IRR of 5-8%. In previous New Zealand studies, blackwood returns appeared less profitable than radiata pine. A current base case evaluation suggests returns of 7-10% are possible.

Utilisation

New Zealand plantation blackwood has been successfully sawn although heartwood percentage is variable. Some tension in logs occurs, and this is also variable. No major problems have been encountered with drying or machining. Processors should ensure a dust free work environment to avoid blackwood allergies.

New Zealand plantation material is being converted to furniture and sold in the market place. Well tended New Zealand plantation blackwood has not been available for evaluation to date.

CHAPTER 16 - REFERENCES and WEB LINKS

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WEBLINKS

Link	Full Name	Comment
www.nzffa.org.nz	New Zealand Farm Forestry Association	Host organisation of AMIGO.
www.rirdc.gov.au	Rural Industries Research & Development	Funding supporter of Corporation (Australia). blackwood workshops.
www.dsd.tas.gov.au	Tasmania Dept of State Development	Links to industry.
www.scionresearch.com	Scion (New Zealand)	NZ blackwood researcher.
www.maf.govt.nz	Ministry of Agriculture and Forestry	Managers of Sustainable farming fund, hand book sponsors.
www.generation-4.co.nz	Kings Fourth Generation Woodworking Company	Joinery manufacturing with special blackwood lines.
www.tablesaside.com.au/special	Corsair Sustainable Timbers	Furniture maker with blackwood lines.
www.enternet.co.nz/users/everwood/	Everwood Custom-made Furniture	Furniture maker with special blackwood lines.
www.scieng.utas.edu.au/arch/research	University of Tasmania, Design and use of School of Architecture	Tasmanian timbers.

GLOSSARY of TERMS

Air-dry density	the average density of the wood at 12% moisture content. It can also vary considerably.
Basic density	the average density of the wood at 0% moisture content. It reflects the amount of actual wood present (i.e. cell wall thickness). It is calculated by dividing oven-dry mass by green volume.
BA	Basal Area.
°C	degrees Celsius.
cm	centimetre.
Compression parallel (//) to the grain:	A measure of the ability of wood to withstand loads applied on the end grain. (Some books refer to maximum crushing strength, which may refer to this property).
DBH	Diameter at Breast Height (1.4 m in New Zealand, 1.3 m in Australia).
e.m.c	equilibrium moisture content. The moisture content at which timber neither gains nor loses moisture when exposed to a constant condition of temperature and humidity.
Funicle	seed attachment.
GCL	Green Crown Length.
gm	gram.
Green density	the density of wood when the tree is freshly felled which can vary considerably depending on site factors, the season etc.
ha	hectare.
Hardness	a measure of wood's resistance to indentation of the side grain. This is important for some furniture and flooring uses.
IRR	Internal Rate of Return.
kg	kilogram.
LED	Large End Diameter - the diameter at the bottom of the log.
km	kilometre.
m.c.	moisture content.
mm	millimetre.
m	metre.
m^2	square metre.
m^3	cubic metre.
m^3/ha.a	cubic metres per hectare per annum.
ml	millilitre.
MARVL	Method of Assessing Recoverable Volume by Log type.
Modulus of elasticity	a measure of stiffness of wood. This is unlikely to be a major constraint in speciality uses.
Modulus of rupture	a measure of the maximum bending strength of wood. This is very important in structural uses, and some speciality uses.
MTD	Mean Top Diameter - the diameter of the 100 largest diameter trees/ha.
MTH	Mean Top Height - the average height of the 100 largest diameter trees/ha.
Phyllode	flattened petiole, colloquially called a mature "leaf".
RH	Relative humidity.
SED	Small End Diameter - the diameter at the top of the log.
Shrinkage	the moisture content at which any further removal of moisture results in shrinkage.
t	tonne.