



An Australian Government Initiative



Acacia Utilisation and Management – Adding value

*Proceedings of a Blackwood Industry Group (BIG) Workshop,
Victoria, 26-29 April 2006*

Edited by C.L. Beadle and A.G. Brown

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Cover photograph:

Natural regeneration of blackwood on farmland in the Otways, Victoria. Such regeneration is a potentially significant, but undeveloped resource in a number of areas in south-eastern Australia. (Photo by Oliver Strewe for the Australian Tree Seed Centre.)

Foreword

There are around 1000 species of *Acacia* indigenous to the Australian continent. Although not often large trees, the timbers of *Acacia* species are widely recognised for their inherent durability, colour, stability and natural figure, making them of immense value in joinery, furniture, turning and art. Australian blackwood (*Acacia melanoxylon*) is the most important commercial timber of the *Acacia* genus in Australia.

A number of indigenous *Acacia* species are being grown commercially for timber in multi-purpose agroforestry systems in high, medium and medium-to-low rainfall areas. These include *A. melanoxylon*, *A. mearnsii* (black wattle), *A. dealbata* (silver wattle), *A. implexa* (lightwood) and a range of medium-to-low rainfall species with promising timber characteristics. More arid-land *Acacia* species like mulga (*A. aneura*) are being investigated for their timber value, and coojong (*A. saligna*) has a long history of use in landscape rehabilitation, and more recently is being investigated as a fast-growing source of biomass for energy, wood composites and charcoal.

The Blackwood Industry Group has been the focus of three earlier Blackwood Workshops. The first, at Lorne in 1996, considered all aspects of blackwood as a species, while the second at Smithton in 2000 considered blackwood in its natural environment and as a potential plantation species. The third workshop, in New Zealand in 2002 (in cooperation with the AMIGO — *Acacia Melanoxylon* Interest Group Organisation), was the first truly international meeting, with speakers from China and South Africa, and a Chilean paper. That workshop considered the silvicultural management of blackwood in plantations.

This proceedings is the record of the fourth workshop, held in Victoria 26–29 April 2006. Using Australian blackwood as the key species, this workshop covered four areas: utilisation and wood quality; marketing and investment; advances in silviculture; and *Acacia* species and resource management. The meeting attracted 55 registrants and papers from Hawaii, Chile, New Zealand and Australia. It gave an opportunity for growers, processors and researchers to learn of current research, and to discuss growing and marketing of blackwood and allied acacias.

Key conclusions were that supplies of blackwood logs in Australia are at a very low level following the transfer of production forest to reserves. There is an opportunity, currently neglected, to better manage and use natural regeneration in corporately-managed forests and farmland in Tasmania and Victoria to sustain supply. Silviculture of regrowth stands is now well-enough understood to establish demonstration plots to encourage landholder management of regrowth for blackwood harvest. In New Zealand, blackwoods are successfully managed in plantations. Internationally, *Acacia* species are sold for low and high value products, and the greatest opportunity for Australia is to target an expanded share of the high value market.

All these workshops have been supported by funds from the Joint Venture Agroforestry Program (JVAP). JVAP is supported by three R&D Corporations — Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia (LWA), and Forest and Wood Products Research and Development Corporation (FWPRDC). The R&D Corporations are funded principally by the Australian Government.

This report is an addition to RIRDC's diverse range of over 1700 research publications. It forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems. The JVAP, under this program, is managed by RIRDC.

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Peter O'Brien

Managing Director

Rural Industries Research and Development Corporation

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Executive Summary

What this report is about

This proceedings contains the research and review papers presented at a workshop on acacia utilisation and management, held in Victoria 26–29 April 2006. Using Australian blackwood as the key species, the workshop covered four areas: utilisation and wood quality; marketing and investment; advances in silviculture; and *Acacia* species and resource management.

This workshop is the fourth in a series that commenced in 1996. These proceedings, together with those of the second and third workshops (also published by RIRDC), provide a comprehensive view of the blackwood industry in Australia and New Zealand.

Who is the report targeted at?

This proceedings will benefit land managers, researchers and industry investors through providing a comprehensive collation of current knowledge on growing and marketing blackwood and allied acacias. Use of the information will improve efficiency of resource use and promote continued access to a valuable material, which in due course will benefit processors, craftspeople, retailers and the public.

Background

Australian blackwood (*Acacia melanoxylon*) is the most important commercial timber of the *Acacia* genus in Australia. A number of other indigenous *Acacia* species are also being grown commercially for timber in multi-purpose agroforestry systems in high, medium and medium-to-low rainfall areas. These include *A. mearnsii* (black wattle), *A. dealbata* (silver wattle), *A. implexa* (lightwood) and a range of medium-to-low rainfall species with promising timber characteristics. More arid-land *Acacia* species like mulga (*A. aneura*) are being investigated for their timber value, and coojong (*A. saligna*) has a long history of use in coastal sand dune stabilisation, and mine site and landscape rehabilitation, and more recently is being investigated as a fast-growing source of biomass for energy, wood composites and charcoal.

Research on the genus has been small in scale and fragmented. Until 1996, there was little communication between research workers, growers, processors and retailers, or between these people in south-eastern Australia, Western Australia or New Zealand. This workshop held in 2006, together with its predecessors in 1996, 2000 and 2002, provided an important opportunity to maximise the value of research by collating and disseminating existing information, as well as to focus new work in areas of high priority. It was also an opportunity for the acacia growers and processors to meet and consider their sector as a whole.

The Blackwood Industry Group was also the focus of the three earlier Blackwood Workshops. The first, at Lorne in 1996, considered all aspects of blackwood as a species, while the second at Smithton in 2000 considered blackwood in its natural environment and as a potential plantation species. The third workshop, in New Zealand in 2002 (in cooperation with the AMIGO — *Acacia Melanoxylon* Interest Group Organisation), was the first truly international meeting, with speakers from China and South Africa, and a Chilean paper. That workshop considered the silvicultural management of blackwood in plantations.

All these workshops have been supported by funds from the Joint Venture Agroforestry Program (JVAP).

Workshop aims

The aims of the workshop were to:

- Review the market potential of timbers from Australian *Acacia*
- Review the genetic diversity and natural distribution of promising timber producing species, including those with potential for commercial planting in medium to low rainfall zones in Australia and New Zealand
- Update the knowledge base on techniques used for propagation, clonal reproduction and silvicultural management
- Explore new opportunities for processing and value adding, particularly for small-diameter timber
- Investigate market options and strategies for the promotion of *Acacia* timber locally, nationally and internationally.

Results

The meeting attracted 55 registrants and papers from the Hawaii, Chile, New Zealand and Australia. It gave an opportunity for growers, processors and researchers to learn of current research, and to discuss the growing and marketing of blackwood and allied acacias. Key points from the presented papers are given below.

The industry, utilisation and wood quality

In Australia, some blackwood is grown in mixed plantations with a nurse or shelter species. If mixed-species systems are to succeed, there is little room for error in the timing of blackwood pruning or in nurse-crop management — the focus must be on the blackwood, not the nurse crop. It was demonstrated that attributes such as basic density, percentage heartwood and heartwood colour from plantation-grown samples are similar in most respects to native forest samples from trees at a similar stage of growth. Also, increased diameter increment did not adversely affect timber basic density or heartwood colour at the tree ages (15–20 y) studied. More detailed study of growth, basic density, heartwood colour and heartwood percentage in trees of similar age in New Zealand concluded that wood properties can be influenced by site and silviculture. The conclusion was that there is no reason to manipulate silviculture in search of specific wood characteristics.

Marketing and investment

Blackwood is a well known and respected species in Australia, and worldwide is one of the best cabinet timbers. Its market turnover is about 14 000 m³ y⁻¹ of logs and 4000 m³ y⁻¹ of sawn timber. Although Victoria has a history of blackwood production, the declaration of the Otway National Park means that most Australian blackwood now originates from Tasmania. In New Zealand, the market consists of about 85 m³ y⁻¹ of sawn timber.

The market considers colour as the most important wood characteristic, and the supply of logs and timber the most important current issue. In Australia, blackwood has a greater acceptance in the domestic market than in New Zealand, but as the supply comes from native forests, timber supply has political ramifications. Australian blackwood also sells into an immature timber market that does not recognise the true value of premium timber or the quality of products that are made from it, its low value hindering further investment in growing blackwood. As domestic demand has declined, Australia has responded to, and developed, offshore markets, especially in China. In New Zealand, logs from plantations are fetching higher prices than logs from native forest in Tasmania, leading to a greater interest in and a better understanding of plantation management in New Zealand. Both countries have a similar price for clear grades and lack any consistent use of knotty-grade boards.

The greatest new opportunity is to develop a range of flooring products. A broader base is therefore required to secure the future of the industry, but this must be at the right price in niche markets that leads to increased returns for the grower, processor, manufacturer and retailer. Promotion of the attributes of blackwood in these markets and the production of first quality, clear-grade wood of good colour have to be part of this strategy. Entirely new markets could be created through sawn timber or by value-adding.

Competitive stumpage tendering rather than the traditional graded-log sale is one option for increasing returns to the grower, as it shifts risks from the forest owner to the buyer. The stand used by way of illustration was successfully sold, but as the bidder was unfamiliar with competitive stumpage tendering and the qualities of the wood were unknown, the process followed did not provide a perfect solution for establishing a fair market price for blackwood. Competitive stumpage tendering should provide an option for the future when better-managed stands come onto the market.

Tropical ‘Australian’ acacias now form part of a rapidly expanding plantation estate, particularly in Southeast Asia, some of which is being managed for solid-wood products. The timber is competitively priced and is being converted into ‘acacia’ furniture that is sold in western as well as domestic markets. The intense price competition that countries like Indonesia and Vietnam can mount in lower-cost segments of western markets confirms that blackwood growers and processors should target their products towards high-value niche markets.

An example of a strong, high-value local market is that for highly figured material used for guitar making. Blackwood is now taken seriously as a tonewood in guitar making.

Private forestry (non industrial private forestry, generally on farmers’ lands) has never been mainstream in Australia, basically because of the dominance of the public sector, the lack of market transparency and the fragmented nature of the private forest resource. Four main problems for private growers are:

- lack of unity that makes it hard for industry to secure supply from private forests in the same cost-efficient manner as from the public sector
- marketing difficulty because of the lack of transparency in log markets and prices
- the inadequacy of good management information that is critically important to allow industry or a grower group to harmonise the supply with the market demand
- the poor image of the forestry industry within some parts of the community.

It is a responsibility for all members of the industry to improve coordination of marketing and supply, and to ensure the environmental benefits of forests are understood and accepted by the community.

The keys to successful long-term forestry investments are:

- low establishment costs
- low risk of failure
- low management costs
- high returns
- stable markets
- a viable resource
- strong R&D support.

In Australia, blackwood currently rates poorly against all these criteria, except stable markets. The conundrum remains how to grow straight tall specimens in planted systems in its native country! In an economic comparison with shining gum, blackwood had 24% higher establishment costs and 18% higher management costs. Blackwood logs would need to achieve a stumpage of \$580 m⁻³ at current prices to compete with shining gum on the same site.

Advances in silviculture

Blackwood is an exotic crop in New Zealand. In Australia it is currently harvested only from native forest, although it has been established in plantations. The silvicultural objective for growing blackwood in plantations must be to produce a high-quality log that will sustain a blackwood industry. The directions taken have differed. Australia is still considering growing blackwood in mixtures, whereas New Zealand concentrates on pure plantations with intensive silviculture, especially form pruning and thinning-to-waste, that has led to a large number of small-scale, well-managed stands being established. In Australia, the focus on commercial nurse crops has resulted in very few examples of well-managed pure-species stands. A series of regime trials and active permanent-sample-plot measurements in New Zealand are providing a strong data base.

Native blackwood-eucalypt forests in north-western Tasmania are managed for blackwood. These are based on silvicultural systems that use ground-stored blackwood seed, large-scale disturbances to stimulate germination of this seed, and whole-coupe fencing to protect the seedlings. Good blackwood stem form is encouraged by very high densities of naturally-occurring understorey species such as *Pomaderris apetala*. These regrowth forests also carry a young *Eucalyptus obliqua* overstorey. Understanding and managing the light competition between the eucalypt overstorey, the blackwood understorey and the dense co-dominant *Pomaderris* vegetation through thinning is the key for producing both blackwood and eucalypt sawlogs from these forests. An analysis showed that effective self-pruning in the lower bole of blackwood is achieved only through a marked reduction in direct and diffuse sunlight incident on the lower crown, a result that has implications for the improved design of mixed-species plantation nurse systems using functionally-similar species.

Australian blackwood is arguably one of the most challenging tree species to grow for high-quality sawlogs. Inherent genetic variability in stem form and its susceptibility to exposure suggests that growers should consider high initial stocking rates from which to select trees of good form and vigour for pruning. Once established the species does not self-thin well; without intervention stands can become overstocked, resulting in very little diameter increment. Reineke-style stand density diagrams are proposed as an aid to designing appropriate management regimes that reflect growers' particular interests. The ratio of tree diameter to stand basal area provides a simple, practical, yet effective tool for guiding the thinning of blackwood plantations.

Understanding the competition for light and other resources remains critical for successfully managing blackwood in nurse-crop systems. The growth of many nurse-crop species used to date often outstrips that of the blackwood, leading to suppressed blackwood growth because of excessive shade and competition for water. Black wattle (*Acacia mearnsii*) displays rapid early growth but quickly reaches its maximum height and therefore has potential as an alternative nurse crop for blackwood. In a mixed planting of black wattle and blackwood, there was a trend towards decreasing blackwood volume with increasing nurse-crop density.

Recoverable yields from blackwood plantations are not well documented. MARVL (Method of Assessing Recoverable Volume by Log type) and Atlas Cruiser were used to assess recoverable yields from 24 plots of 18-y-old tended blackwood across four sites. When the data were 'grown forward' to simulate expected tree sizes at clearfelling, the sawlog component was reduced to two-thirds. This supports published figures that suggest a mature stand of blackwood will have 55–60%, or about 300 m³ ha⁻¹, of sawlog material. The study showed that pruned stands produce around 40% of high-quality pruned butt log, as well as 20–30% of branched sawlog. This refutes the perception that blackwood is a butt log species only. Blackwood with a dbh of about 60 cm and 38 m tall will produce recoverable sawlog having a range of qualities.

Acacia species and resource management

In the AcaciaSearch project, almost 500 native species of *Acacia* which occur in the southern Australian agricultural zone (250–650 mm rainfall zone) were assessed for their suitability as new woody crops for large-scale planting, primarily as a means of salinity control in recharge areas. Emphasis was given to fast-growing species with potential for producing large amounts of wood biomass that may find uses in solid and reconstituted wood products, and for bioenergy, and which may yield commercially attractive by-products. Thirty-five species were identified as having some potential, and all were ranked as to how well they met selection criteria that indicated their ability to deliver anticipated end products. Species ranked most highly included *A. decurrens*, *A. lasiocalyx*, *A. leucoxyla* subsp. *leucoxyla*, *A. linearifolia*, *A. mearnsii*, *A. microbotrya*, *A. pycnantha*, *A. retinodes*, *A. salicina* and *A. saligna*. Together with the partners in the FloraSearch project, the Western Australian Department of Conservation and Land Management is evaluating *A. saligna* for domestication and biomass production on farmland affected by dryland salinity.

Koa (*Acacia koa*) provides a highly figured wood and is endemic to the Hawaiian Islands, and in Hawaii is the most ecologically and economically important forest tree. The wood colour varies greatly, ranging from pale blonde to dark chocolate. Koa timber is of medium density, easy to work and is the preferred species in the Hawaiian specialty hardwood market. It is used for producing fine furniture, veneers, musical instruments and crafts. The current annual harvest is about 250 000 bd ft or 600 m³. Standing koa timber is now priced at \$1000–1300 US m⁻³. Koa lumber ranges from \$4.50 to over \$65.00 US per bd ft at retail, depending on colour and figure. The forest industry in Hawaii was valued at \$30.7 million US in 2001 and derived at least 90% of its value from koa. Providing an adequate supply is a major concern, and there is extensive interest from land owners and land managers to re-establish koa on many under-utilised lands.

There has been insufficient analysis of genetic improvement of blackwood. Over 60 progeny trials have been established since the mid-1970s in both Australia and overseas, but there are few published reports of results from these trials, although it is clear that blackwood is a species with large within-provenance and family variation as well as significant provenance variation for many characteristics. In Chile, research has been undertaken to provide a basis for exploiting the adaptability of blackwood to local environments and to explore its potential as an alternative forest species for wood production. Although blackwood has been sawn in Chile since the 1980s, and is deemed suitable for particle board and veneer as well as solid wood, the lack of a reliable wood supply and a formal market have meant that its contribution to industrial wood production remains very small.

Concern has been expressed about the potential weediness of blackwood in New Zealand, as regeneration is often noted in or adjacent to planted stands. A study of weediness found no invasion of native forest had occurred on any of the sites visited. The study reinforced an earlier view that blackwood can regenerate well in open, disturbed conditions, but no significant spread is likely to occur in shaded, undisturbed conditions within indigenous forest. Preliminary tests showed that in the North Island up to 50% of seed can be damaged by the insect *Storeus albocignatus*. Seed predation appears relatively absent in the South Island. There is no confirmed evidence of bird dispersal, but there are seed predators. The weediness score for blackwood in New Zealand is 27, the same as for radiata pine. Blackwood plantings can root sucker and germinate from ground-stored seed. If no longer wanted on such sites, it may be considered a weed problem. It remains prudent to continue monitoring regeneration.

Conclusions and implications for stakeholders

Conclusions from the discussions are that, in Victoria, supplies of blackwood logs are at a very low level following the transfer of production forest to reserves. The expectation that reduced log supplies from native forests in Tasmania might be offset by blackwood from mixed-species plantations is unlikely to be realised. There is, however, an opportunity, currently largely neglected, to better manage and utilise natural regeneration in corporately-managed forests and on farmland in Tasmania and Victoria to sustain supply. Silvicultural techniques are available to improve the returns from natural regeneration.

In New Zealand, there is a lot of enthusiasm among farmers for blackwood, and the plantation area already established probably has a potential yield exceeding the present harvest in Australia. Blackwood logs in New Zealand have attracted prices higher than those in Australia, and interest among potential processors is strong. The essential feature of the market for blackwood is that logs must be of high quality.

Among other acacias, *A. saligna* is of particular interest because of its potential role in combating salinity over very large areas of agricultural land in southern Australia; the genetic variation in this species is a significant asset.

Understanding of silviculture has improved as a result of research in Australia and New Zealand, and this knowledge needs to be disseminated to current and potential growers. Lack of improved genetic material for future plantations remains a constraint to productivity.

In 1989, the Acacia Melanoxylon Interest Group Organisation (AMIGO) was formed under the umbrella of the New Zealand Farm Forestry Association (NZFFA). The equivalent group in Australia is the Blackwood Industry Group (BIG). Participants felt that this had been a very successful workshop, but it remains a concern that BIG is no way near AMIGO in its capacity to effectively coordinate the interest of blackwood growers in Australia ten years after its inception.

Recommendations

There is an established market for blackwood and other acacias, but with a shortage of supply in Australia and competition from Asian sources, it is important to develop the high value end of the market, and to increase supply from sustainably-managed regrowth stands in Tasmania and Victoria and plantations there and elsewhere.

Future priorities are:

- In Australia, coordinated demonstrations of ‘best practice’ management in blackwood re-growth stands should be established to improve landholder understanding of this task, and encourage expansion of the area of this species that is in effective production.
- To help develop a better profile for well-managed blackwood stands, an international series of best-practice trials should be initiated.
- A lot of provenance trials of this species have been established—we need more effort to measure, analyse and write up the results for public use, and to apply the results to improve the genetic quality of seed used for planting.
- The task of domesticating *Acacia saligna* has barely begun; such initiatives require persistence for decades.
- Effective and valued communication between industry participants can be efficiently maintained by means of periodic workshops.



Session 1: The Industry, Utilisation and Wood Quality Paper 1

Ten Years of BIG Workshops: A Brief Sketch of How We Got Here

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Abstract

This article explores the ten-year history of the Blackwood Industry Group (BIG) since its inception at the first workshop dedicated to blackwood that was held in 1996. Lack of resources has meant that many of the tasks envisaged for BIG then have never been part of its portfolio. It has been good at organising workshops, though, and the four to date have all received considerable support through registrations and consistent finance from the Joint Venture Agroforestry Program. These workshops have acted as a forum for interested parties to exchange information, to keep abreast of new developments and to get an accurate appreciation of the issues of the moment. There has been progress but there have also been disappointments. The value of blackwood and the vagaries of the market continue to hinder the kind of progress that is deserving of the enthusiasm of those who work throughout the broader framework of the blackwood industry.

Introduction

‘Declining availability of cabinet timbers from native forests has increased interest in their cultivation and in the management of native forests from which they may be obtained. Blackwood is a species of special interest — it is amenable to cultivation and management, it has an extensive natural range in eastern and southern Australia encompassing rural communities seeking to diversify land use and economic activity, is well suited to high-value-added products and has established a favourable reputation as a furniture timber.

Relevant interest groups are widely dispersed in Australia and New Zealand, and there has been no focal point for strategic interaction or exchange of information.

The workshop that is the subject of this report was intended to bring these interests together and to develop a basis for ongoing interaction and mutual assistance. A framework for this has emerged, and the long-term outcome is now in the hands of participants.’

This was the text of the Foreword by Peter Core, the then Managing Director of our loyal sponsors the Joint Venture Agroforestry Program (JVAP), to a report on the first of the series of ‘Blackwood Workshops’ that was held in Lorne in 1996. Unfortunately a report was never published, but this statement clearly places the onus on the participants at that workshop to come together and use their combined skills to make something work for the blackwood industry. Ten years later we are gathered together for the fourth workshop in this series. The combined skills have changed remarkably: only seven out of the 48 participants at that first workshop are at this workshop, though it is encouraging that we again have about the same numbers of participants for this second meeting in Victoria. The interest in blackwood appears to remain as strong as ever.

The workshops

How did we get here: we had four workshops in ten years; the last is in progress here:

- *Growing Australian Blackwood for Timber: A Strategic Workshop*. Lorne and the Otways, 20–22 November 1996
- *Silvicultural Management of Blackwood: A Blackwood Industry Group Workshop*. Smithton and north-west Tasmania, 30 November–1 December 2000
- *Blackwood Management: Learning from New Zealand: An AMIGO and Blackwood Industry Group Workshop*. Rotorua and North Island, 20–23 November 2002
- *Acacia Utilisation and Management: Adding Value*. Melbourne and north-eastern Victoria, April 2006.

The outcomes of the first three workshops are first presented below in the form of summaries. The account borrows heavily from existing material from these workshops.

Lorne

The first workshop was billed as a strategic workshop. Eleven papers were presented and there were visits to see harvesting at Lavers Hill in the Otways, the Otways Hardwoods Sawmill and Bambra Agroforestry Farm. The proceedings were not published though Searle (2000) published her own and other information that had been presented at the workshop in *Australian Forestry*. In the report submitted to JVAP, Alan Brown and Rowan Reid summarised the outcomes of this workshop as follows:

- Blackwood (*Acacia melanoxylon*) is one of a very few species which have potential to produce high-quality cabinet wood in south-eastern Australia. It occurs from Tasmania to Cape York, mainly on the coastal escarpment and tablelands but extending to coastal lowlands in the south. The wood is highly valued for furniture and veneer. Future supplies are expected to come from both native forests and planted trees. The quality of the wood, as determined by density, colour and figure, varies greatly.
- Processing and marketing in Australia has been fragmented. The number of manufacturers of blackwood furniture in Tasmania has declined sharply in the last decade (>12 to 3), and attempts by a Melbourne furniture retailer to develop a vigorous cooperative approach to marketing and retailing have had only limited success.
- The species has been cultivated in several overseas countries, but particularly in New Zealand and South Africa. Accounts of experience in those countries are available. A 'Special Purpose Species' research group, the interests of which include blackwood, exists in the Forest Research Institute at Rotorua, and has an associated national network, 'AMIGO'.
- Research in Australia has been limited. An attempt was made around 1950 to select and propagate trees with fiddleback grain, a highly prized feature, but the effort was too small to yield useful results. The species has been included in the ACIAR Forestry Program from the 1980s. Provenance trials have been established in Tasmania, Victoria (24 provenances), ACT, Queensland and China. Forestry Tasmania is undertaking silvicultural studies.
- Blackwood cultivation does experience significant problems. No genetically-improved stock is available at present, and indeed even the basis for any improvement is not well established. Browsing by marsupials is a real problem. Stand management is more complex than for species such as radiata pine. As the crop is a long-term

one aimed at a high-value product, there is particular merit in getting the genetics and silviculture right.

- The strategic interests of growers, processors and researchers scattered in Australia and New Zealand could undoubtedly be furthered by an active and representative contact group. There has been no clearly-recognisable vehicle for this contact.

This representative contact group was established as a 'Blackwood Industry Group' (BIG). The initial 11 members for the Group were representative of major geographic areas, industry sectors and government agencies. The idea was that it should address issues such as incorporation, secretariat arrangements, a network database and modus operandi. This was the strategy that emerged from what had been a useful forum but it was never put in place and this has still not happened. BIG continues to exist. Back in 1996 it never had the resources to convene meetings to operate at the level proposed. In the brave new world ten years later, there are still no resources and the remaining contact group has even less time than was available then to undertake what it can attempt to achieve. What it has been good at, though, is organising workshops.

Smithton

The focus of the second workshop was silviculture (Beadle and Warner 2001). The area around Smithton is where blackwood truly expresses itself as a valuable native-forest timber tree. There were thirteen presentations and visits to learn about managing blackwood in native forests and plantations, and to Britton Timbers Pty Ltd Sawmill. The following was reported:

- Blackwood sawmilling commenced in the 1830s and expanded significantly in the 1880s with the introduction of steam-driven sawmills. However, the history of the blackwood market is one of market declines. At present Brittons annually cut 8000 m³ and produce 2500 m³ sawn timber of all grades, around 30%–40% of the blackwood produced in Tasmania and Victoria combined. The market is static at present, partly because of limited promotion and the cyclical effects of fashion. One option for revitalising sales is to actively seek niche markets for small volume, high quality furniture production overseas.
- A review by Forestry Tasmania calculates a sustainable yield from State forest of 8500 m³ per annum over the 65 y from 1998. Additional volume from plantations established since 1990 is anticipated to be available from 2018.
- Most blackwood in native forest is associated with areas of a particular fire history. As there is little resource older than 250 y, this may place an age limit on the viability of soil-stored seed. There is little relationship between the growth of

blackwood and rainfall, but there are critical lower temperatures for blackwood presence and minimum temperatures for the commencement of active growth.

- Wet sclerophyll forest dominated by *Eucalyptus obliqua* but with a large quantity of ground-stored blackwood seed has considerable potential to increase the quality of the blackwood resource. Over 500 ha of this type of forest has been fenced within one month of burning to prevent browsing by large animals, and this has resulted in a high stocking of blackwood seedlings with a thick nurse crop of understorey species. The blackwood has shown excellent form.
- As blackwood has little natural apical dominance, a crucial factor leading to good form as well as good growth is the correct light environment. It should be possible to manipulate competition (from the eucalypts and understorey) in managed native forest to improve the crown dynamics of the blackwood while at the same time achieving a predictable branch-free bole.
- Blackwood was first planted in the Nilgiri Hills in India around 1842. Plantations were first established in South Africa (1891) and in New Zealand (1896). They have also been established in environments at lower latitudes, albeit at higher altitudes, but for utility rather than cabinet timber. Abstracts in Tree-CD for *A. melanoxylon* over the period 1939–2000 demonstrate a continuing interest in the species although *Acacia mearnsii* still receives more attention.
- In Tasmania, industrial plantations have been planted with nurse crops (*Eucalyptus globulus*, *E. nitens* or *Pinus radiata*) as a means of imposing good form through the encouragement of apical dominance. These nurse crops were selected for a commercial outcome but their rapid growth has led to suppression of the blackwood. There is also very little nursing early in the rotation and some form pruning is still essential. Alternative systems with the above nurse crops and with closely-spaced shrubby species (*Pomaderris apetala* and *Melaleuca ericifolia*) with early growth rates similar to the blackwood are being tested.
- As long as there is shelter, blackwood tolerates a wide range of sites. In New Zealand it has been successfully planted into existing native vegetation, mixed with exotics but with variable results, and in pure stands and agroforestry plantings. In general form pruning is always required to ensure good form.
- Twenty-five seedlots of blackwood were tested with and without *E. globulus* as a nurse crop to assess the expression of form and growth rate by provenance across the species. Form varied between the seedlots in a consistent way across two sites, though form pruning of even the best provenance would be required to achieve a satisfactory stocking of crop trees.

- Since 1982 Ian Brown, a New Zealand farm forester, has been planting small groups of blackwood without nurse crops in lower valley slopes and sheltered gullies. With various forms of intensive silviculture, including a comprehensive program of form pruning, he is able to produce a 6 m stem by age 8 y that requires no further maintenance until harvest.
- Mature trees can be vegetatively propagated successfully to produce morphologically juvenile plants that are suitable for plantations. Provenance, potting media, the presence of hormone and season significantly vary the number of viable shoots produced. The propagation technique can be used to ‘juvenilise’ the genetic material and allow stem-cutting techniques to be employed.
- Blackwood responds well to clearwood pruning. Stub cutting 15–20 cm from the stem avoids bark tearing and branch splitting. Branches should be removed before they exceed 30 mm in diameter. Given a clean cut, occluded bark should be contained within the defect core and not have an impact on recoverable clearwood volume.
- Tasmanian blackwood is considered to be harder than ash-type eucalypts. Portable mills cost about \$40–45 h⁻¹. Stumpage for Category 4 logs is currently \$60–70 m⁻³. For boards and flitches the following values apply: green select, \$900–1100; green feature, \$300–450; green veneer, \$1200+ per cubic metre. New opportunities for blackwood may be enhanced by recognising ‘internationally accredited standards’ for growing and harvesting, ‘pruned standard certification’ processes and on-line e-marketing. These aims can be assisted through the promotion of the Farm Forestry Toolbox.

At the time, it was probably difficult to pick out the main messages emerging from this meeting. Sustainability of supply was certainly one, although it was not discussed explicitly as a perceived difficulty. Another was the concern being expressed about the suppression of blackwood in plantations under nurse crops in Tasmania, particularly as there was an expectation that this resource would supplement that from native forest as early as 2018. On the positive side in Tasmania, what is now referred to as Fenced Intensive Blackwood was looking in good shape and so was the Farm Forestry Toolbox. The Kiwis were there in small numbers but they were exuding confidence when it came to the silviculture of blackwood in plantations. They reckoned it was about time we learnt.

Learning from New Zealand

Eighteen Australians swallowed their pride and decided that while the Kiwis were unlikely to able to teach us anything about rugby and cricket, there might just be something we could learn about growing blackwood in planted systems. This meeting also attracted participants from South Africa and China and

at least a paper from Chile. It was just about as international as you can get for blackwood. And there were 70 participants, a testament to how keen the locals are about growing exotics well (Brown 2004). The outcomes were as follows:

- A total of about 3000 ha of blackwood plantings had been established in New Zealand, mainly in the 1980s. Experience and research had developed an awareness of the silviculture required to produce acceptable sawlogs. A blackwood growers group (AMIGO) and Forest Research had produced a grower's handbook to summarise current information.
- About one-half of New Zealand's blackwood resource was owned by Timberlands West Coast Ltd. Utilisation studies had shown that this resource would match planting objectives by providing a high-quality timber product. Its successful marketing would be vital to the blackwood industry.
- A blackwood growth model suggested that final-crop stockings of 200 stems ha^{-1} should result in a mean tree diameter of 60 cm in 35 y. Lower stockings provide faster diameter growth but less total volume.
- Blackwood had been tested as an enrichment species in indigenous vegetation in New Zealand and had been identified as the best performing of the range of exotic species used. Blackwood planted in narrow lanes (<2 m wide) cut in young developing scrub had significantly longer clear bole without pruning than those planted in lanes >4 m wide. Gap size or lane width should be about half the height of the existing vegetation.
- Fencing is the most effective method of browsing control in regeneration systems (Fenced Intensive Blackwood) in Tasmania, but was expensive, ranging from \$350 to \$800 ha^{-1} . Economic analysis of fencing showed that, at its best, it can only achieve a 5% return. Trials had shown that if the eucalypt competition is removed, blackwood diameter growth is increased, but this can be at the expense of good form.
- Growth rates in blackwood plantations in Tasmania on good sites were about 1 cm y^{-1} . This suggested that 40-y rotations are optimistic. Nurse-crop systems can improve stem form and apical dominance, but form pruning is still required: inevitably their management will be a compromise between improving stem form and maximising blackwood growth. The slower growth of blackwood during winter suggested that compensatory growth responses will be maximised and the period of crown recovery minimised if pruning is undertaken in spring to coincide with an acceleration in the rate of growth.
- Tasmanian blackwood sawlogs have been harvested, sold and processed since the 1830s. The supply from state forest and base royalty rates have been consistent recently. However, growers needed to aim for sawlogs that increase the rate of recovery. Small growers needed to look for alternative marketing methods such as tendering.
- A SWOT analysis of the blackwood industry in Tasmania concluded that scope existed for 20–30% of timber production to be exported to three or four niche markets. Exports should help even-out variations in domestic demands for sawn wood. Native forest production levels needed to be maintained to ensure that consistent volumes of timber are available.
- In a survey of ten users in Victoria, it was considered that blackwood's unique appearance and traditional name have helped maintain its longstanding use. Demand is highest amongst those organisations that produce only high-value feature products. All users predicted that future demand would remain stable or increase.
- Some species of the genus *Acacia* that have been grown in Chile (including *A. melanoxylon*) are well adapted to local edaphic and climatic conditions, thus establishing quickly and exhibiting rapid growth, characteristics that potentially make acacias economically attractive to the Chilean forest industry.
- In South Africa, *A. melanoxylon* was first planted extensively in 1909. It has become well established in forests and invaded open areas outside forest. However, it is also a useful and valuable timber that contributes 50% of both the timber volume and revenue obtained from indigenous forests. In the larger gaps (1200–1500 m^2) of the Blackwood Group System, diameter growth averaged 1.6–1.9 cm y^{-1} and the largest tree of 58 cm averaged 2.6 cm y^{-1} over 22 y.
- The major challenge for growers, harvesters, processors and manufacturers was to make the cake larger for everyone: this would involve the consumer willingly paying a premium price for quality blackwood products.

The meeting in New Zealand was more than just the papers. A two-day tour took us to some excellent stands; one day was spent looking at trials and plantings around Rotorua. The message for the visitors was that careful tending of blackwood in pure stands can produce butt logs of good form. This is clearly very time-consuming until this log is formed, and perhaps this may be some of the reason that this approach has not been adopted in Australia! The message coming from researchers was that nurse-crop systems were not viable without some form pruning as well. Balancing the requirements for acceptable rates of growth but good form was also an issue in managed Tasmanian native forest. As an enrichment species in other types of indigenous forest, the messages were generally positive. Value and the vagaries of the market, both demand and supply, were becoming the issues of the moment and now of the next workshop.

Adding value: the 4th Blackwood Workshop

What are the tasks of this workshop?

- Review the market potential of timbers from Australian *Acacia*
- Review the genetic diversity and natural distribution of promising timber producing species, including those with potential for commercial planting in medium- to low-rainfall zones in Australia and New Zealand
- Update the knowledge base on techniques used for propagation, clonal reproduction and silvicultural management
- Explore new opportunities for processing and value adding, particularly for small-diameter timber
- Investigate market options and strategies for the promotion of *Acacia* timber locally, nationally and internationally.

As with all workshops, it is difficult to anticipate the interest (the demand) or the supply of papers. This is not the place to synthesise the outcomes from this

workshop: that is the eventual role of the Workshop Summary. However the program in front of us suggests that we should be up to the above tasks.

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Session 1: The Industry, Utilisation and Wood Quality Paper 2

Blackwood Plantation Options: Picking Winners Based on Value

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‘I’m a bloke who likes to follow the horses, but somehow the horses I like to follow ... like to follow other horses.’
The Loser’s Lament

ANDY WARNER has been active for the last 25 y in private forest management and planning — and he says he is still learning! He has forestry training qualifications from universities in Australia and the USA and has been active in the development of measurement procedures for private forests. In 2001, Andy was awarded a Churchill Fellowship to inspect farm forestry extension services in south-eastern USA. He is a past president and committee member of Australian Forest Growers Tasmanian Branch and a senior member of Private Forests Tasmania, the government agency promoting farm forestry in that state. Andy has a particular interest in the empowerment of private tree growers through the effective dissemination of technical information, which has resulted in him initiating and co-ordinating the development of the Farm Forestry Toolbox.

Abstract

Private Forests Tasmania’s experience with trials in north-western Tasmania indicates that successfully growing high-value blackwood timber from plantations will require a different approach to that used for the main plantation species to date. In particular, there is little room for error in the timing of pruning of the blackwood or in nurse-crop management. In work on a winning blackwood clearwood system, pruning and thinning have been shown to be critical. Determining the ‘winner’ in terms of the best blackwood regime will also depend on how the winner is defined.

Background

Interest in growing blackwood in plantations has increased in the past decade. The reduced supply of high-quality native rainforest timbers in Australia, the enthusiasm of New Zealand farm foresters for blackwood, and sponsorship of workshops via the Blackwood Industry Group have all contributed to this increase.



Figure 1. Plantation blackwood at the Abbotsham trial in NW Tasmania. Dbhob was 45 cm at age 23 y.

Experience in growing mainstream eucalypts and radiata pine in plantations has been very influential in the approach adopted in some of the larger-scale blackwood plantations established in Tasmania. Site establishment practices that result in a healthy, actively-growing crop are well proven. However, financial imperatives with plantations to date have required ‘successful’ regimes to focus on either short rotations or interim returns through commercial thinning. Examples of clear winners from this approach are *Pinus radiata* grown for 20–30 y for sawlog and *Eucalyptus globulus* or *E. nitens* grown for 10–15 y for pulpwood.

The financial disclaimer that ‘past performance is no guarantee of future returns’ rings very true in any application of established mainstream plantation regimes to plantation blackwood, where the aim is to grow high-value clearwood.

Private Forests Tasmania (PFT) experience with ongoing nurse-crop field trials in north-western Tasmania indicates that successfully growing high-value blackwood products from plantations will require a different approach to that used for the main plantation species. In particular, there is little room for error in the timing of pruning the blackwood or in nurse-crop management.

So if we cannot simply apply our mainstream silvicultural practices to achieve successful blackwood outcomes, what should we do? How do we pick a winning regime?

Tasmanian farm forestry blackwood trials — lessons learnt

Tasmanian attempts at using *E. nitens* as a nurse crop for blackwood in the 1980s were generally unsuccessful because the rapid growth of the nurse crop suppressed the development of the slower-growing blackwood, most of which died. The impressive growth of the nurse crop on the high-quality soils was also a distraction from the aim of growing blackwood sawlogs — some growers became reluctant to non-commercially thin the nurse crop, instead focusing on growing the nurse crop to a size sufficient for commercial thinning at about age 10 y or older. By this age, however, the surviving blackwood was too suppressed to respond to increased light and space, and many stems when released developed severe sweep or bending and suffered significant windthrow. Figure 2 shows how extreme the impact on the blackwood can be where the nurse crop is unmanaged.

Private Forests Tasmania is now managing two trial sites on privately-owned blocks in north-western Tasmania to evaluate management options for smaller-scale farm forestry blackwood plantations using nurse crops. In both trials the management for high-value clearwood blackwood has been opportunistic, with history requiring some compromise on any strict adherence to the desired regime. This is discussed in more detail below.

The Abbotsham trial involves a stand that was established in 1982 using a nurse crop of *P. radiata* on a high-fertility site. When PFT inspected the site in 1995, the pruned blackwood was being severely suppressed by the nurse crop. Immediate thinning was required: the nurse crop was poisoned to allow the blackwood to progressively increase their stability and to reduce the chance of sweep or windthrow after release. The blackwood stocking was later reduced from 660 stems ha⁻¹ to 233 stems ha⁻¹. The delay in

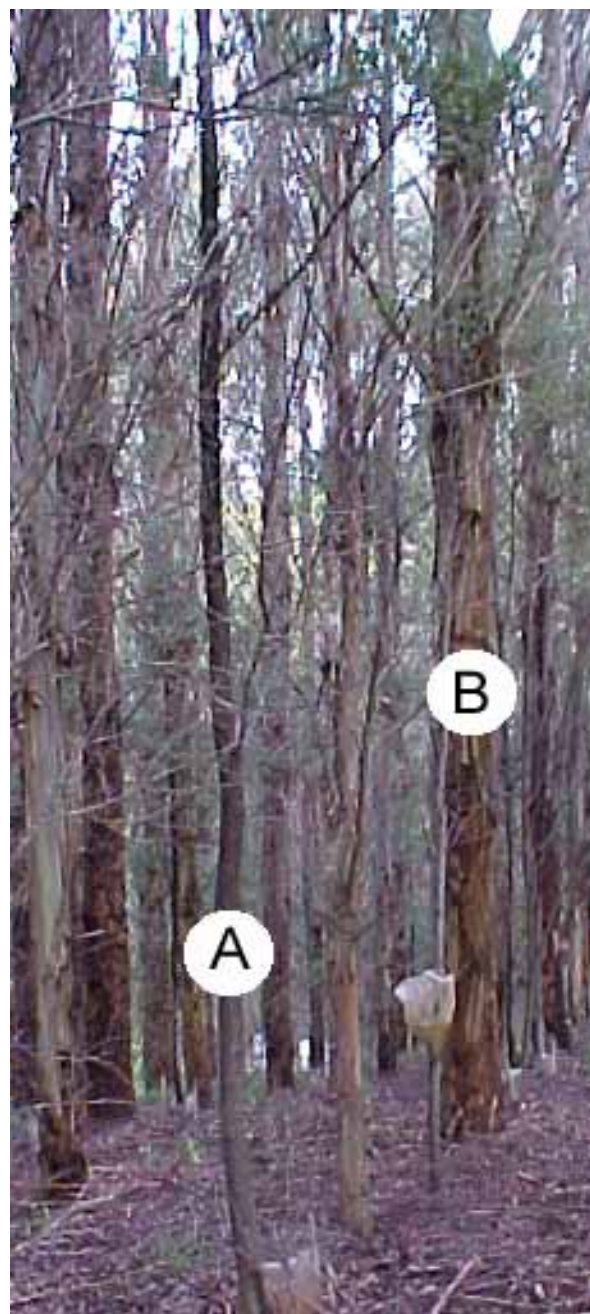


Figure 2. Unmanaged failed blackwood plantation with eucalypt nurse crop. A = blackwood, age = 20 y, dbhob = 7 cm, form = very poor; B = *Eucalyptus nitens* nurse crop

thinning reduced the choice of final-crop stems, so the trial does not represent best practice. Figure 3 summarises the mean annual increment of the blackwood (see also Fig. 1).

The Claude Road trial (Fig. 4) was originally established by PFT in 1997 to evaluate a range of species and their response to a range of establishment methods on a site of poor to average fertility. The standard of cultivation, weed management and browsing control was very high, and tree survival was over 95%. The establishment and species trial was completed in 2002, with a subset of 24 plots involving blackwood then managed to assess regimes to produce

high-quality sawlogs. Both *E. nitens* and *P. radiata* nurse crops were available from the earlier trial. The trial involves form pruning, corrective leader pruning and clearwood pruning, with the careful management of the release of the blackwood through a combination

of manual felling and progressive stem injection of the nurse crops. The blackwood will soon be thinned from the original 600 stems ha^{-1} down to about 160 stems ha^{-1} . Some high pruning above 6 m is also scheduled.

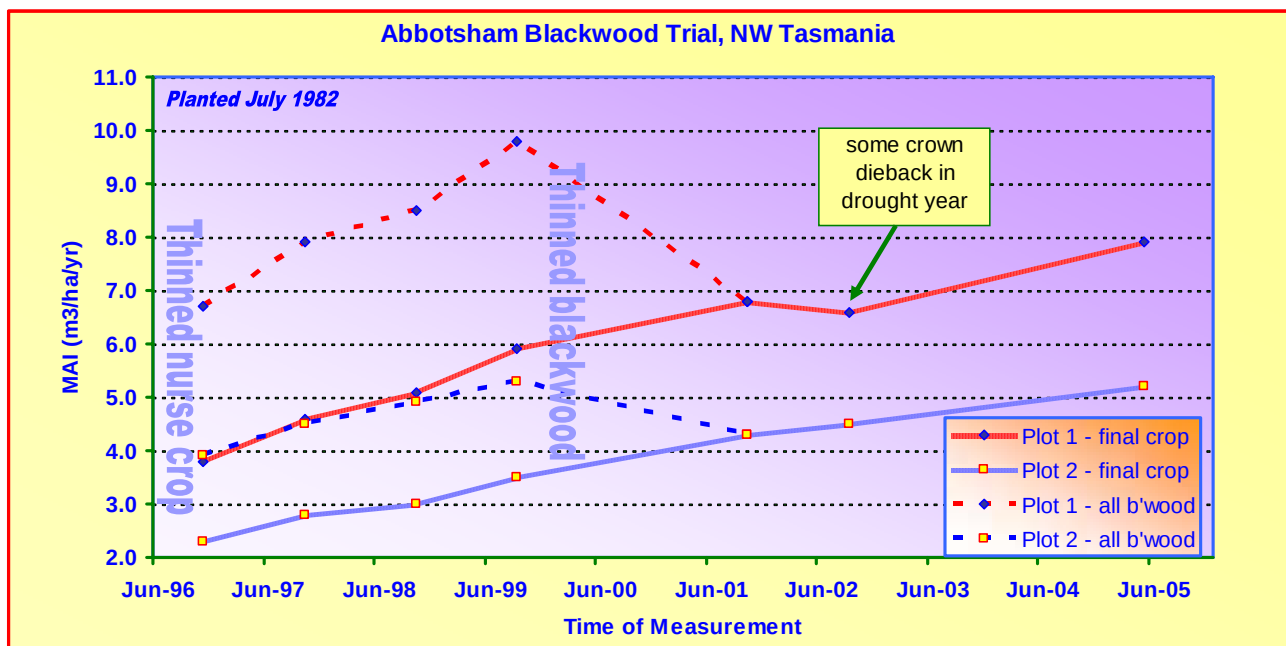


Figure 3. Abbotsham trial, planted July 1982 — mean annual increment of volume of blackwood

Observations on pickings winners

Results from the PFT blackwood plantation trials at two sites in NW Tasmania are encouraging, but the stands are still in the early stages of their rotation. Achieving clearwood logs as quickly as possible is an essential part of any winning strategy. This will involve managing the form of the final crop blackwood:

- Just as in a horse race, the final winner may not be the one that leads at the end of the first straight. Maintaining flexibility in the regime for as long as possible is important. The race analogous to growing blackwood is more akin to a marathon than a sprint.
- At the Claude Road trial, early and regular corrective form pruning (in spring and autumn) was important to produce well-formed lower stems as the basis for clearwood logs.
- At the Claude Road trial some blackwood trees, that initially had poor form, had by age 8 y — and following some development under the crowns of the nurse crop — improved their form to become candidate trees for the final crop.
- Any radiata nurse crop needs to be carefully managed. Once the form of the blackwood has been assured by the 'light-well' effect of the pines (the blackwood reaching sufficient height to

provide the desired clearwood bole), the nurse crop should be removed. Any delay will increase the cost of removal, reduce the increment and increase the chances of windthrow and logging damage to the final-crop trees.

- To avoid damaging the final-crop (blackwood) trees, the nurse crop is best removed by poisoning. It may be tempting to generate revenue by removing the nurse crop in a commercial thinning, but this may entail delaying thinning to ensure that the yield is commercially attractive. This option needs careful appraisal. It is important to ensure that the financial gain of a small intermediate cash flow from such a thinning exceeds any later reduction in revenue due to a loss of growth on the blackwood final-crop trees.
- Financial evaluation needs to be refined to help minimise costs. For example, some growers want to mix a clearwood blackwood regime with clearwood production on selected nurse-crop trees, having a 'bet both ways' in case parts of the blackwood stand do not grow well enough to achieve the final clearwood stocking required. Issues associated with poisoning by stem injection versus felling therefore need to be evaluated more closely.
- The value of blackwood products obtained from plantation-grown logs will be dependent not only on growing logs of acceptable size, but also on



Figure 4. Claude Road trial — *E. nitens* nurse crop (A) killed over two years by stem injection to release blackwood crowns

growing clearwood that has acceptable colour and drying qualities to supplement native forest blackwood.

- An increase in the current stumpages is essential to encourage expansion of blackwood plantations in Tasmania beyond special-interest trials. This has been discussed in previous workshops.

What is a winner?

Determining the ‘winner’ in terms of the best blackwood regime will also depend on how a winner is defined:

- The **grower** is seeking to maximise the return from the crop. Note that for a farm forester the return may not simply be dollars earned from log products, but will increasingly include a consideration and eventual quantification of environmental values associated with the plantation including:
 - increasing agricultural productivity through sheltering adjacent crops or livestock
 - improving or maintaining water quality by limiting deleterious land management practices on steeper slopes leading into streams and previously under agriculture
 - reducing soil erosion by converting steeper marginal agricultural land into long-rotation plantations.

A successful outcome for farm foresters from endeavours to grow high-value blackwood plantation may not require picking an absolute winner in terms of the greatest cash flow at harvest, but rather selecting from a range of options that provide a **satisfactory** return to the grower compared to alternative uses for agricultural land and that allow some diversification into crops with a longer cycle than the normal annual rotation.

- The **processor** is seeking to minimise the purchase price of his raw material.

These apparently different goals are not necessarily mutually exclusive, but traditionally there has been competition over at least part of the total revenue from the plantation harvest between the grower and the processor. In the end there must be an acceptable return to both parties for a sustained relationship.

Without both parties, there will be no blackwood industry.

The major and enduring challenge for all of us involved with blackwood is not to claim a part of someone else’s piece of the blackwood value cake, but rather to continue to make the cake larger for everyone — grower, harvester, processor and manufacturer. This will involve the consumer willingly paying a premium price for high-quality blackwood clearwood products. This in turn will require an increased and sustained commitment by the blackwood industry to marketing.



Session 1: The Industry, Utilisation and Wood Quality Paper 3

How is Wood Quality Affected by Growth Rate and Silviculture?

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GORDON BRADBURY has been a forester with Forestry Tasmania (FT) since 1988, working primarily on strategic wood-resource planning issues. In 2003 he moved to FT's Division of Research and Development and undertook research into blackwood timber quality, comparing young regrowth from fenced intensive blackwood, swamp and plantation-grown blackwood. In late 2005, he commenced a PhD at the University of Tasmania looking at the effects of environment and genetics on blackwood wood quality.

Abstract

This study compared the timber properties of blackwood (*Acacia melanoxylon* R.Br.) grown under three different silvicultural systems in north-western Tasmania. These were: 1) 16–22-y-old swamp forest regeneration, 2) 14–19-y-old fenced regeneration mixed with eucalypts, and 3) 15-y-old plantations. The plantation material was grown from seed from a single tree from the same location as the swamp regeneration.

Tree and bole height were measured, as were timber attributes such as basic density, green moisture content, percentage heartwood and heartwood colour. The wood samples from the two native forest silvicultural systems had similar properties. The samples from the plantation system were similar in most respects to the native forest samples but had significantly higher green moisture content. Increased diameter increment did not adversely affect timber basic density or heartwood colour at the tree ages studied.

Introduction

The main source of blackwood timber in Australia is from the native forests of Tasmania, where sawlog production has averaged $13\,000\text{ m}^3\text{ y}^{-1}$ over the last 5 y (Forestry Tasmania unpublished data). This volume comes from blackwood arising from harvest operations in eucalypt-dominated forests, and from harvest operations in blackwood swamp forests (Forestry Tasmania 1999).

In 1989, in order to increase the future supply of blackwood, Forestry Tasmania began establishing a new blackwood resource known as fenced-intensive-

blackwood (FIB) (Jennings and Dawson 1998). Most of the FIB development has been in north-western Tasmania. The intention is to manage the FIB in order to maximise the production of blackwood. Silvicultural trials to determine appropriate thinning regimes have commenced only recently (Jennings *et al.* 2003 and pp. 60–63 this volume).

An important part of the development of FIB is to assess the timber quality compared to blackwood of similar ages from other sources, and the impact of intensive management on timber quality. This project compared the wood properties of blackwood from FIB, swamp and plantation blackwood stands. Samples from the silvicultural systems were selected to be of equivalent ages (14–22 y old), which is considerably younger than the normal age at commercial maturity. Commercial maturity is expected to be reached at 30, 50 and 80 y of age for blackwood plantations, FIB and swamp blackwood, respectively.

Methods

The three oldest FIB coupes (harvest units) were selected for sampling, along with three coupes of similar-aged blackwood swamp regeneration in the location known as Plains Creek. The Plains Creek blackwood provenance was selected for sampling at the Meunna Blackwood Provenance Trial (Allen 1992) as an example of blackwood plantation. Seed for this provenance had been collected from a single tree of superior phenotype from the same location as the swamp silvicultural system in this study. All sample sites are located in north-western Tasmania.

For each of the FIB and swamp coupes, and the plantation, 30 trees were randomly selected for measurement and sampling. Trees had to be >10 cm diameter at breast height over bark (dbhob) to be sampled. Field measurements were done between January and March 2004.

For each selected tree the dbhob, total height and green crown height (height to lowest green branch) were measured. The number of green branches in the lower 6 m of the stem, with a diameter at their base >2 cm,

was counted. A single stem core was taken from each tree at breast height (1.3 m) in a north-south direction through the central pith. Back in the laboratory, core green volume and mass were measured. Cores were then oven-dried and again measured for volume and mass. Volume was measured using the buoyancy force method. Average width of sapwood and heartwood was measured on the oven-dry cores. Percentage heartwood based on cross-sectional area was calculated from these measurements. Mean annual diameter increment was derived for each core, using the core length and the regeneration age of the sample. Any evidence of figure in the grain of the timber was noted.

A variation of the technique described by Janin and Mazet (1987) was used to assess heartwood colour. The oven-dry cores were set within dressed boards of radiata pine using PVA glue. The pine boards were then put through a planer-thicknesser, so that half of each core remained in the block and presented a dressed radial surface suitable for colour measurement (Fig. 1).

Heartwood colour was measured with a spectrophotometer using a 9-mm aperture and the CIELAB colour space that allows the specification of colour perceptions in terms of a three-dimensional space (CIE 1986). Colour measurements were done two days after the pine boards were dressed to minimise possible colour change resulting from exposure to air and sunlight.

To provide context for the colour measurements from the sample cores, four colour measurements were taken from a selection of blackwood veneer samples. These measurements represented examples of blackwood colour selected by eye at the light (one sample), medium (two) and dark (one) range of the blackwood colour spectrum.

Statistical analysis included analysis of variance (ANOVA) with Tukey's HSD (Honest Significant Difference) multiple comparison test, as well as calculating correlation coefficients across the total sample of 210 trees.

Results and discussion

The project failed to identify any significant differences in the timber properties studied between the new FIB resource and the traditional swamp blackwood, at least at the young ages sampled. This provides encouragement for the continuing development of this important new blackwood resource.

Green moisture content (GMC) was the only timber attribute that differed significantly between the three silvicultural systems, with the plantation having significantly higher GMC (Table 1). The reasons for this difference remain unknown. Green moisture content in blackwood has not been recorded in the literature as a being a significant issue, possibly due to the ease of drying blackwood timber.

Published basic density values for blackwood range between 300 and 680 kg m⁻³, putting the values observed in this study in the low-to-moderate range. This is possibly explained by the generally higher percentage of low-density juvenile wood in these young trees. Percentage heartwood values recorded in this study appear to be rather low (25–40%) but within the range of the limited published data available. Percentage heartwood was not strongly correlated with dbhob, sapwood width or mean diameter increment (Table 2). There is still the opportunity to gain an understanding of the factors that control heartwood development in blackwood.



Figure 1. a) oven-dry blackwood cores, b) drilled pine boards ready for cores, and c) dressed boards with blackwood cores ready for colour measurement

Table 1. Some tree and timber attributes for FIB, swamp and plantation. Values in the row followed by the same letter do not differ significantly ($P < 0.05$).

Trait	Coupe	FIB			Swamp			Plantation RP266/1/2
		TG007a	TG021a	TG021b	CH044a	CH044b	CH044c	
Dbhob (cm)	Mean	13.8 ^a	15.2 ^a	13.8 ^a	21.4 ^a	16.3 ^a	17.0 ^a	20.1 ^a
	SE	0.6	0.6	0.6	1.1	0.7	0.7	0.8
Tree height (m)	Mean	11.5 ^a	13.5 ^a	11.6 ^a	16.1 ^b	12.3 ^a	12.0 ^a	10.7 ^a
	SE	0.4	0.3	0.3	0.5	0.2	0.2	0.2
Height of lowest green branch (m)	Mean	5.4 ^a	6.0 ^a	5.6 ^a	6.9 ^a	6.0 ^a	5.1 ^a	2.3 ^b
	SE	0.3	0.3	0.3	0.5	0.3	0.3	0.2
Heartwood (% area)	Mean	41 ^a	29 ^b	25 ^b	40 ^a	26 ^b	28 ^b	29 ^b
	SE	1.9	2.1	1.7	2.1	2.7	2.1	1.7
Basic density (kg m ⁻³)	Mean	480 ^a	423 ^a	443 ^a	434 ^a	447 ^a	466 ^a	411 ^a
	SE	10	8	9	9	7	7	8
Green moisture content (%)	Mean	109 ^a	97 ^a	98 ^a	114 ^a	99 ^a	113 ^a	148 ^b
	SE	3.4	3.1	2.8	3.6	3.7	3.4	3.8
Mean annual diameter increment (cm)	Mean	0.73 ^a	1.01 ^b	0.99 ^b	0.97 ^b	0.96 ^b	1.06 ^b	1.26 ^c
	SE	0.03	0.04	0.04	0.05	0.04	0.05	0.05

Table 2. Correlation coefficients between variables across all trees. Only significant correlations ($P < 0.01$) are shown. Moderate to strong correlations are shown in bold.

	Dbhob	Sapwood width	Heartwood (%)	Diameter increment	Green density	Oven-dry density	Basic density	Green moisture content	CIELAB L*	CIELAB a*	CIELAB b*
Dbhob											
Sapwood width	0.50										
Heartwood (%)	0.46	-0.47									
Diameter increment	0.87	0.56	0.29								
Green density	0.20	-0.19	0.43								
Oven-dry density		-0.25	0.27		0.61						
Basic density		-0.31	0.29		0.60	0.96					
Green moisture	0.24		0.21	0.21	0.60	-0.22	-0.26				
CIELAB L*		0.24	-0.18		-0.50	-0.46	-0.51				
CIELAB a*					0.25	0.26	0.27	-0.23			
CIELAB b*	0.23	0.24		0.26		-0.25	-0.32		0.72		

Correlation analysis also showed that increasing growth rate does not adversely affect key timber attributes such as basic density, heartwood colour and percentage heartwood (Table 2). There does appear to be a moderate relationship between heartwood colour (CIELAB L*) and basic density (darker wood = higher density) that is worthy of further investigation, as both heartwood colour and basic density are key quality attributes in blackwood. The heartwood colours sampled in this project did not cover the full spectrum of blackwood colours. A larger sample covering the full blackwood colour range may provide a more conclusive result in this possible correlation.

although differences in sampling and measurement techniques make a direct comparison of results problematic. This highlights two important issues in blackwood research. The first is the currently-unrealised opportunity of measuring and reporting provenance variation in wood properties for many of the existing blackwood provenance trials both in Australia and overseas. The second is the need for greater standardisation of methods to allow closer comparison of results from future studies. The world of blackwood research is very small and can only benefit from the use of standardised research practices wherever possible.

This study provides a useful comparison with that of Nicholas *et al.* (1994) who examined variation between four provenances growing in New Zealand at age 10 y,

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Session 1: The Industry, Utilisation and Wood Quality
Paper 4

Preliminary Analysis of the Wood Properties of *Acacia melanoxylon* Thinnings from Five North Island Regime Trials in New Zealand^a

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HAM GIFFORD joined the New Zealand FRI at Rotorua in 1959 after working for 5 y with the Forestry Commission in Britain. He first worked with the Genetics and Tree Improvement group in a new project on radiata pine. He then joined the Soils group, working on catchment studies and a site national productivity study, specialising in lysimeter research. After a period in the Tree Physiology group, he moved to the Special Purpose Species group in 1985, working with Ian Nicholas, in eucalypt, cypress, black walnut and blackwood research. He managed the national blackwood regime series, as well as collecting growth data from the national Permanent Sample Plots for blackwood and other exotic special-purpose species. He officially 'retired' in 1999 but gets hauled back to help Ian with blackwood research. In 2005, Ham was awarded life membership of AMIGO in recognition of his contribution to blackwood knowledge.

Abstract

We assessed the influence of site and silviculture on growth and selected wood properties of 18-y-old blackwood (*Acacia melanoxylon* R.Br.). 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 one common seedlot from Tasmania, were felled from 22 plots across all sites. Stocking of these plots was 150–800 stems ha⁻¹. Discs were collected from all felled trees at a height of 1.4 m 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, the slowest-growing site. Heartwood percentage was positively related to stocking, and lowest in the lower stockings. The trees at 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. 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 other 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. However, further analysis is required to investigate the influence of pruning treatment and green crown length on wood characteristics.

Background

Blackwood (*Acacia melanoxylon*) has been planted in New Zealand since the 1800s (Nicholas 2004). Plantings have been sporadic, and since a 29-ha plantation was established in Whakarewarewa Forest in 1906, most new plantings have been small woodlots on farms (Gifford *et al.* 2004).

^aHam Gifford presented this paper to the workshop.

While silvicultural research has identified some of the better management options, questions have remained on marketing and wood quality of the plantation resource. Nicholas *et al.* (1994) evaluated some wood quality properties of four 9-y-old blackwood seedlots. Although there was considerable within-seedlot variation, they found statistically-significant differences between seedlots for growth rate, basic density and moisture content. They recommended further work on the influence of the environment on wood characteristics. Wilkins and Papassotiriou (1989) found a relationship between latitude and crystals amongst other fibre characteristics, but did not assess colour. It has been suggested that site may influence wood colour in South Africa (Harrison 1975a,b). Issues relating to wood quality were highlighted as being of importance for investigation at a strategic meeting of BIG and AMIGO (New Zealand Acacia Farm Forestry Group) in the 2002 Rotorua Workshop (Beadle *et al.* 2004).

Blackwood silvicultural trials established in 1987 became due for thinning in 2005 (Nicholas *et al.* 2001; Nicholas and Gifford 2002). There was therefore an opportunity for destructive sampling to understand the influence of silviculture and site on some key wood properties. This study used trees from the systematic thinning of five blackwood silvicultural regime trials to examine the effect of site and silviculture on growth, basic wood density, heartwood colour and heartwood percentage.

Methods

Silvicultural trial design

The blackwood silvicultural trial series was established in 1987 across six sites in the North Island (Table 1). The trials were all divided into plots of five final-crop stockings $\times$ two thinning treatments, with two replicates of each final-crop stocking at most sites, and four replicates at Whakarewarewa. The trial at Whakarewarewa, consisting of 23 plots, was the main trial, with smaller satellite trials at other sites, consisting of six plots each (Nicholas *et al.* 2001). Plots varied in size depending on final-crop stocking. All plots had the same selection ratio applied across all sites (1:6) and about 30 trees remained in each treated plot before thinning.

The sites were selected to test the growth of blackwood on exposed forest and sheltered fertile farm sites. The trial established in Westland was later abandoned because of serious mortality and growth variation by age 3 y. The trials had been form-

pruned annually in winter using a 30 mm branch gauge between ages 3 and 10 y. Three clearwood-pruning treatments were randomly allocated within each plot, leaving 1.5, 3 or 6 m green crown at ages 4 and 6 y (Nicholas *et al.* 2001). Thinning occurred across these sub-plots.

Half of the replications underwent an early thinning to final-crop stocking at age 6 y. The remaining plots underwent three thinnings, at ages 6, 10 and finally 18 y. For this assessment, only the blocks due for thinning were available. There were two replicates of five stockings at Whakarewarewa and one replicate per site of three stockings for the other four sites. All plot trees were of a Tasmanian seedlot (9/0/81/075) from Arthur River, Smithton.

Field measurements

In most plots some 10–15 trees were due for thinning. These were selected on diameter, form and spacing. A total of 306 trees were felled and discs collected at breast height (1.4 m).

Assessments conducted in the field were:

- Diameter overbark at breast height (dbhob, 1.4 m)
- Tree height (H)
- Colour of heartwood (scale 1–5; light–dark), consistency of colour
- Length of butt log (a disc was also collected at the top of the butt log for visual assessment only).

Twenty-two plots were thinned: ten at Whakarewarewa and three at each of the other sites (Table 2).

Laboratory measurements

The following measurements were made on the breast-height disc in the laboratory:

- Diameter overbark
- Diameter underbark
- Heartwood diameter (two measurements at right angles, averaged)
- Green density (Rotorua sites only)
- Basic density
- Heartwood colour of oven-dried discs with the Minolta Chroma Meter machine (model CR-400), using three colour spectra:

Table 1. *Acacia melanoxylon* regime trial sites

Region	Site name	Soil type	Altitude (m)
Rotorua	Whakarewarewa (forest site)	Yellow brown loam	500
Rotorua	Okareka (farm site)	Sandy loam	360
Auckland	Hunua Forest (forest site)	Marua clay loam	420
Auckland	Hunua Farm (farm site)	Silty clay loam	140
King Country	Cumberland (farm site)	Yellow-brown loam	200
Westland (abandoned)	NA		

Table 2. Regimes, stocking and number of plots thinned by site

Regime	Nominal 2005 stocking (stems ha ⁻¹)	Whaka- rewarewa	Hunua forest	Hunua farm	Okareka	Cumber- land
2	150	2	-	-	-	-
4	250	2	1	1	1	1
6	400	2	1	1	1	1
8	600	2	-	-	-	-
10	800	2	1	1	1	1
Total	na	10	3	3	3	3

Table 3. Overall statistics across all sites. All measurements were at breast height or from a breast-height disc except for tree height and the length of the butt log. The variables L*, a* and b* are machine-measured aspects of colour.

Variable	Mean	Std dev	CV	Maximum	Minimum	n
Dbhob (mm)	241	62	26	404	90	306
Dbhub (mm)	227	59	26	383	85	306
Dbh-field (mm)	242	62	26	403	90	306
Heartwood (%)	54	12	22	87	20	306
Basic density (kg m ⁻³)	447	57	13	633	0	304
Visual colour	4.11	0.55	13.32	5.00	2.00	304
L*	58.7	3.5	6.0	67.4	46.9	303
a*	9.1	1.5	16.2	14	6	303
b*	18.8	1.4	6.6	22.5	15.3	303
Height (m)	15.8	3.5	22.5	26.7	6.3	302
Butt log (m)	5.58	1.27	22.67	8.50	1.70	306

- o L*; black to white range, where white = 100 and black = 0
- o a*; green to red range, where a negative value = greenness and a positive value = redness
- o b*; blue to yellow range, where a negative value = blue and a positive value = yellow

Analysis

Overall means, coefficients of variation and ranges were estimated using the MEANS procedure (SAS Institute 1990). Data were then analysed using Proc GLM in SAS (SAS Institute 1989). Least-squares means were estimated, using LSMEANS under the following scenarios:

Whakarewarewa was the only site where two plots of all regime treatments were thinned. An individual-site analysis was therefore undertaken for all field and laboratory traits with fixed treatment (stocking) effects:

$$y_{ij} = \text{regime}_i \quad (1)$$

where y_{ij} represented individual observations on trees within the i^{th} silvicultural regime.

Only three regime treatments were consistently represented across sites. These were compared using a model with sites and treatment (stocking) as fixed effects:

$$y_{ij} = \text{site}_i + \text{regime}_{ij} \quad (2)$$

where y_{ij} represented individual observations on trees within the i^{th} site and the j^{th} silvicultural regime within the i^{th} site.

Differences between least-squares means, in all cases, were tested using PDIF (SAS Institute 1989). Pearson's correlation coefficients were estimated using Proc CORR in SAS (SAS Institute 1989).

Results

Overall statistics

Dbhob and dbh-field measured over bark were similar (241.3 and 241.6 mm respectively) (Table

3). All diameter measurements had a high coefficient of variation (CV), around 60%. Overall mean basic density across sites was 447.4 kg m⁻³, and at Whakarewarewa green density was 1042 kg m⁻³. Visual colour using a subjective scale was moderately dark (4.1). Machine colour readings show heartwood colour was relatively light (L* = 58.7), the wood red (a* = 9.1), and quite yellow (b* = 18.8). There were relatively low CVs for all colour traits, although the subjective field score gave a high CV, as might be expected. At age 18 y, the average height across all sites was 15.8 m, and the average length of the butt log was 5.6 m (Table 3).

The different stocking regimes at Whakarewarewa showed significant effects on all traits except wood density, heartwood visual colour, and the a* colour range (Table 4). The effects of site were significant for all traits except the L* colour range. The effects of the three regimes represented across sites were significant for diameter, height, heartwood %, butt log disc height and the L* colour range.

Comparison of stocking treatment means and significance of differences for dbhob, height, disc height, heartwood % and basic density for sites and stockings are presented in the following three sections; firstly for the Whakarewarewa site (five stockings with two replications of each stocking type); secondly, across all sites testing site effects (three stockings); and thirdly testing stocking effects (across five sites).

Table 4. Matrix of significant effects (indicated by ticks) from the ANOVA model, and from the PDIFF comparisons between regimes and sites

Variables	Regimes at Whaka	ANOVA Whaka [#]	Site	Regimes across sites	ANOVA Site [*]	ANOVA Regime [*]
Diameter (ub+ob)	✓	***	✓	✓	***	***
Height	✓	***	✓	✓	***	***
Heartwood (%)	✓	*	✓	✓	***	**
Butt log disc height	✓	***	✓	✓	***	***
Basic wood density	✓	0.08	✓	✓	*	0.09
Visual colour	✓	0.22	✓	-	**	0.19
L*	✓	0.05	✓	✓	0.13	*
a*	✓	0.19	✓	-	*	0.20
b*	✓	**	✓	-	*	0.39

[#]ANOVA probabilities for regimes at Whakarewarewa only

^{*}ANOVA probabilities for site effects in across-site model where only 3 regimes were tested for site or stocking regime

Probabilities are given as $P < 0.05$ *, $0.01 > P > 0.001$ **, $P < 0.001$ ***. Probabilities are given for those effects that were not significant.

Table 5. Effects of stocking on growth, heartwood extent and basic density of wood at Whakarewarewa

Regime (stems ha ⁻¹)	Dbhob (mm)	Height (H) (m)	Disc H (m)	Heartwood (%)	Basic density (kg m ⁻³)
150	303a	16.6c	5.69c	51.0b	473a
250	286ab	16.1c	5.92bc	50.6b	462ab
400	270b	18.0b	6.33a	58.4a	471a
600	242c	17.8b	6.15ab	55.4ab	477a
800	230c	19.5a	6.41a	58.1a	443b

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

Comparison of regimes, Whakarewarewa Forest only

The highest stockings of 600 and 800 stems ha⁻¹ had significantly smaller diameters than the three lower stockings (Table 5). The lowest-stocked regime (150 stems ha⁻¹) was also significantly larger in dbhob than the 400, 600 and 800 stems ha⁻¹ plots. Thus dbhob was negatively related to stocking. In contrast, height showed a positive relationship with stocking with the lowest stockings (150 and 250 stems ha⁻¹) significantly shorter than the medium to high stockings (400 and 600 stems ha⁻¹) which were in turn, significantly lower than at the highest stocking (800 stems ha⁻¹).

The height from which the second disc was taken also reflects the length of the pruned butt log. The effects of stocking on pruned butt log length were similar to the effect on height growth, although not as distinct. The lowest stocking had significantly shorter butt logs than the three highest stockings.

The fraction of heartwood increased significantly from about 50% at the lowest stocking to 58% at medium and higher stockings. Percentage heartwood was not significantly correlated with dbhob at this site ($r = 0.05$, $P = 0.59$). Wood basic density was significantly

lower (443 kg m⁻³) at the highest stocking of 800 stems ha⁻¹ than at all other stockings except for 250 stems ha⁻¹. Wood density also appeared to be related to growth, reflected in the correlation between dbhob and basic wood density ($r = 0.22$, $P = 0.009$). Visually-rated heartwood colour was darkest (= 4.21) in the trees from the 600 stems ha⁻¹ stocking and significantly different from that (= 3.88) at the lowest stocking (Table 6). There were no apparent trends in colour variation with stocking. The highest value in the L* colour range, i.e. the lightest, was from the 250 stems ha⁻¹ stocking. This was significantly different from that at 800 and 600 stems ha⁻¹ but not the other stockings. The highest value in the a* colour range, i.e. the reddest, was from the 600 stems ha⁻¹ stocking but this was significantly

different only from the 250 stems ha⁻¹ stocking. The highest value in the b* colour range, i.e. the yellowest, was from the 150 stems ha⁻¹ stocking. This was significantly different from all other treatments except the 400 stems ha⁻¹ stocking. Overall, the non-subjective colour determinations showed no clear trends in colour with stocking, although the lower stockings appeared to be slightly yellower and slightly lighter. The visual grading also indicated darker wood at the higher stockings.

Table 6. Heartwood colour at Whakarewarewa Forest. Visual colour is a visual grade taken from a disc at breast height. L*, a* and b* represent black to white, green to red, and blue to yellow colour ranges, respectively, obtained from the Minolta Chroma Meter.

Regime	Visual colour	Machine colour		
		L*	a*	b*
150	3.88b	58.7abc	9.18ab	19.4a
250	4.00ab	59.4a	8.62b	18.1c
400	4.04ab	59.2ab	9.20ab	19.1ab
600	4.21a	57.6bc	9.54a	18.4bc
800	4.04ab	57.1c	8.92ab	18.4bc

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

Comparison of site effects (for three common regimes)

The mean dbhob at breast height of the thinned trees for the three regimes that were common across all sites (250, 400 and 800 stems ha⁻¹) was significantly greater at Whakarewarewa than at Hunua Forest (but not Hunua Farm) and Okareka sites (Table 7). Hunua Forest had a significantly smaller dbhob than all other sites. Hunua Farm, Whakarewarewa and Cumberland were not significantly different in diameter growth. These results are substantially different from rankings obtained from the full-site analysis at age 11 y (Nicholas *et al.* 2001), when Hunua Farm had the largest diameters.

The Hunua Forest mean height was also lowest, and significantly different from all sites which were not significantly different from each other (Table 7).

Disc height, equal to the length of the butt log, showed the same trend seen with mean tree height. The butt log from Hunua Forest was significantly shorter (= 3.42 m) than those at all the other sites (Cumberland = 4.87 m and 6.2–6.3 m for Whakarewarewa, Okareka and Hunua Farm).

Hunua Forest had a significantly smaller percentage of heartwood than all other sites (44% v. 56–59%). There were no significant differences between the other sites (Table 7).

The highest mean basic wood density was from Whakarewarewa, which was significantly higher than all other sites. There were no significant differences between any of the other sites.

For all three regimes across sites, wood density was significantly correlated with dbhob ($r = 0.19$, $P = 0.002$). Heartwood percentage and dbhob were also correlated ($r = 0.16$, $P = 0.011$).

Visually-graded heartwood colour score was darkest (4.4) from Hunua Forest, which was significantly different from all other sites (4.0–4.1) (Table 8). The lowest and darkest value in the L* colour range was from Hunua Forest which was significantly lower than from Hunua Farm. The highest and reddest value in the a* colour range was also from Hunua Forest. The yellowest value in the b* colour range was from Okareka: this was significantly higher than for Whakarewarewa, Hunua and Cumberland.

Comparison of effects of regimes across all sites

The diameter of the thinned trees from the three common regimes across sites (250, 400 and 800 stems ha⁻¹) was significantly greater for the lower stockings than for the 800 stems ha⁻¹ stocking (Table 9). In contrast, mean height was least at 250 stems ha⁻¹ and greatest at 800 stems ha⁻¹. The length of butt log (disc height) also reflected changes in mean height: the three regimes were significantly different from each other.

Heartwood percentage was significantly lower at 250 stems ha⁻¹ than at 400 and 800 stems ha⁻¹ which were not significantly different from each other (Table 9).

The highest basic wood density values were from the lower stockings which were significantly higher than at 800 stems ha⁻¹ (Table 9).

Visual heartwood colour assessment was not significantly different between treatments based on fresh discs taken at breast height (Table 10). The greatest and least values in the L* colour range were from the 250 and 400 stems ha⁻¹ stockings. These were significantly different from the 800 stems ha⁻¹ stocking, but not from each other (Table 10). There were no significant differences between stockings for the a* and b* colour ranges (Table 10).

Discussion

Across all sites, the diameter growth rate of the thinned trees from the different regimes was found to be greatest with the lowest stocking. Height growth was the opposite: the highest stocking produced the tallest trees. A strong site effect on growth was evident from the Hunua Forest site, which was significantly smaller

Table 7. Site means, for three common regimes only (250, 400 and 800 stems ha⁻¹)

Site	Dbhob (mm)	Height (H) (m)	Disc H (m)	Heartwood (%)	Basic density (kg m ⁻³)
Whakarewarewa	262a	17.9b	6.21a	55.7a	459a
Hunua forest	169c	9.2a	3.42c	44.1b	425b
Hunua farm	250ab	15.9b	6.33a	58.5a	439b
Okareka	231b	17.3b	6.25a	58.9a	438b
Cumberland	245ab	15.3b	4.87b	55.7a	430b

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

Table 8. Site means for heartwood colour

Site	Visual colour	Machine colour		
		L*	a*	b*
Whakarewarewa	4.03b	58.6ab	8.92b	18.5b
Hunua forest	4.40a	57.8b	9.61a	18.6b
Hunua farm	4.13b	59.9a	8.75b	18.9ab
Okareka	4.02b	58.7ab	9.54a	19.1a
Cumberland	4.07b	59.2ab	8.66b	18.8ab

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

Table 9. Regime means across all sites

Regime (stems ha ⁻¹)	Dbhob (mm)	Height (H) (m)	Disc H (m)	Basic density (kg m ⁻³)	Heartwood (%)
250	251.2a	13.8c	4.98c	443.2a	51.2b
400	242.8a	15.1b	5.41b	444.3a	55.1a
800	199.9b	16.4a	5.86a	426.9b	57.4a

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

Table 10. Mean heartwood colour across all sites

Regime	Visual colour	Machine colour		
		L*	a*	b*
250	4.14a	59.3a	8.87a	18.8a
400	4.05a	59.2a	9.11a	18.9a
800	4.19a	58.0b	9.29a	18.7a

Values for each factor followed by the same letter do not differ significantly ($P = 0.05$).

in diameter and shorter than all other sites. The height at which discs were collected from the top of the pruned butt log also reflected height growth in the trials. However, these analyses are preliminary as they do not investigate the pruning history and crown length of sample trees. A future analysis will take a closer look at these relationships.

A relationship between green crown length and heartwood percentage has been shown for other species (P. Berrill, Ensley, *pers. comm.* 2004) and needs to be examined further for blackwood: the relative importance of the variance components of site and silvicultural regimes will also be considered.

Heartwood percentage was influenced by stocking and was generally lower at the lower stockings. However, the slowest-growing site, Hunua Forest, had the lowest heartwood percentage.

Basic wood density across all trees from this seedlot averaged 449 kg m⁻³. There was considerable variation in individual tree values, 291–633 kg m⁻³. Treatment means were 477–425 kg m⁻³, which is relatively low for blackwood. When this seedlot was compared with three other seedlots at age 9 y, its basic density was 424 kg m⁻³. This was significantly lower than that of the other seedlots, the highest of which was 498 kg m⁻³ (Nicholas *et al.* 1994). Basic wood density was influenced by stocking: the highest density was found at lower stockings and the lowest at higher stockings. Site influenced basic density. Trees at the fastest-growing site, Whakarewarewa, had higher density than those at the other sites. Although trees at the slowest-growing site had the lowest density, this was not significantly different from that of trees at the other three sites.

The visual colour assessment of fresh discs taken from breast height indicated darker heartwood at higher stockings. The slowest-growing site, Hunua Forest, was also darker than other sites. However, stocking

across all sites showed no trends: in fact the effect of stocking was not significant (Table 4, $P = 0.19$). The L* colour range indicated a trend of darker heartwood with higher stockings. The slowest-growing site, Hunua Forest, was different from only one site, the Farm site in the same region. L* was the only measure of wood colour to show a significant difference across regimes (Table 4). The a* colour range indicated a weak trend of redder heartwood with higher stocking at the

Whakarewarewa site only. The slower-growing site, Hunua Forest, was redder than three of the other four sites. The b* colour range indicated a trend of yellowest heartwood with lower stockings at Whaka. The yellowest site was Okareka, while the slowest-growing site, Hunua Forest, was not different from the fastest-growing site, Whakarewarewa.

Further detailed assessment of colour and environment is required to determine the factors that affect wood colour. However, the contention that the best environment for colour of blackwood is 'well watered during the growing season, but which has a definite dormant season enforced by low rainfall and low temperatures, preferably a frost period' (Harrison 1975a), is not supported by this study. The Whakarewarewa site is quite close to the Okareka site and would have a comparable climate, but had significantly different values for a* and b* colour measurements.

Conclusion

This study has shown that wood properties can be influenced by site and silviculture. The implications for blackwood management are that increased growth rate is significantly correlated with an increase in basic wood density and reduced heartwood percentage, but has little influence on wood colour. Several of these attributes are also influenced by site. The data suggest that there is no reason to target management options to meet wood property requirements. Blackwood management should continue to produce prime butt logs in the most efficient and economic way possible. A more detailed wood study should be conducted on this trial series at final harvest (around 2022).

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Session 2: Marketing and Investment Paper 5

Marketing Blackwood in Australia and New Zealand: Differences and Similarities

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Abstract

The author was awarded a Chavasse Travel Award by the New Zealand Institute of Forestry in 2005 to investigate blackwood markets in Australia and New Zealand. Nearly fifty blackwood processors and manufacturers using blackwood in Tasmania, Victoria, Sydney and New Zealand were interviewed in late 2005 and early 2006. It is estimated that those interviewed trade about 80% of the volume of the Australasian blackwood market.

In total the blackwood market in Australia turns over about $14\,000\text{ m}^3\text{ y}^{-1}$ of logs and $4000\text{ m}^3\text{ y}^{-1}$ of sawn timber; the New Zealand market consists of about $85\text{ m}^3\text{ y}^{-1}$ of sawn timber. The most important blackwood wood characteristic recognised by those interviewed was colour, and the most important issue was supply of logs and timber. Most of the trade in blackwood is for select or clear timber, often in short lengths, which creates problems for many users.

The major differences between New Zealand and Australia are that blackwood supply from native forests in Australia is very political and blackwood has a greater acceptance in the Australian domestic market. Because demand is not as strong as it was, Australia has developed offshore markets, especially in China. New Zealand plantation logs are fetching higher prices than logs from native forest in Tasmania, leading to a greater interest and a better understanding of plantation

management in New Zealand. The market in Australia has an interest in sapwood as a feature, and there is a strong local market for highly figured material used for guitar making.

Similarities between Australia and New Zealand in marketing blackwood are that both 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 clear 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 Australia or New Zealand.

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 from commodity level to a well-designed elite timber market.

Background

Blackwood (*Acacia melanoxylon* R.Br.) is one of Australia's premier timbers, and has been traded nationally and internationally since white settlement in Australia. Blackwood occurs naturally from Tasmania to Queensland and South Australia. Timber from the north-west of Tasmania has dominated the market for many years (Britton 1996, 2001, 2004). In Victoria a small steady market supply used to come from the Otway Ranges, but this ceased when the Great Otway National Park was created. Lambert (2004) evaluated blackwood processing and manufacturing in Victoria: his conclusion was that blackwood had a solid market niche there. Internationally, New Zealand and South Africa (Geldenhuys 2004) have established plantations (blackwood is not native to either country), and more

recently Chile and now China are evaluating the species for exotic plantations. New Zealand has over 3000 ha established in blackwood and it is suggested that an annual cut of 26 000 m³ is possible once this resource matures (Nicholas 2004). Blackwood timber imported into New Zealand is priced at \$3300 m⁻³: it is one of the most expensive hardwoods being imported. Domestic prices are about \$3600 m⁻³ (clear two faces), but little effort is being made to identify a wide range of markets to optimise use of the material being processed.

Blackwood is developing a niche market in New Zealand, with some processors and furniture makers specialising in blackwood products (Nicholas and Brown 2002). The New Zealand market is still young and small, but it could get stronger if more, higher-value end-uses could be identified and developed. To help achieve this the author was awarded a Chavasse Travel award by the New Zealand Institute of Forestry to assess the Australian blackwood market and to identify how New Zealand could develop better utilisation of logs and maximise value from its limited resource.

Objectives, outline and questionnaire

The objective of the study tour was to evaluate blackwood markets in Australia and New Zealand, and if possible identify innovative uses of all grades of blackwood.

Blackwood markets were assessed in Tasmania, Victoria and Sydney. Individual processors and manufacturers were interviewed to help determine quality, resource supply, pricing and marketing issues and what markets they saw for non-clear blackwood. A total of 47 formal interviews were conducted: 15, 21, 2 and 9 interviews in Tasmania, Victoria, NSW and New Zealand respectively. Several informal interviews and discussions were also held with those involved in the industry.

To facilitate discussion respondents were asked to complete a questionnaire which requested the following information:

- Most important wood characteristic for business?
- Current supplies from?
- Current blackwood issues?
- Future blackwood issues?
- Supply/resource issues?
- Expected business changes?
- Preferred options for long-term contracts?

- Grades that should be considered?
- Current grading system?
- Current moisture content targets?
- Method of drying timber?
- Who does your marketing?
- What innovative uses do you use non-clear blackwood for?
- Other comments?
- Contacts in your region?

Tasmania

The fifteen interviews conducted covered more than 80% of the Tasmanian market and about 60–70% of the estimated Australasian market. Forestry Tasmania is responsible for the tender of about 12 000 m³ y⁻¹, although the actual annual cut is determined by the amount of blackwood in the felling coupes to be harvested in any year. Most logs are sold as Cat 4, Utility, Out-Spec and Craft (Table 1). In 2004 Forestry Tasmania harvested volumes of these log grades were 6741 m³, 1886 m³, 3186 m³ and 40 m³, respectively. Base royalty prices for Cat 4, Utility and Out-Spec are \$70 m⁻³, \$35 m⁻³ and \$17 m⁻³, respectively. Under the Forestry Tasmania tender process they can receive tenders up to double these values at times.

The four largest tenderers received 39%, 18%, 10% and 9% of the resource respectively: the other 24% was spread over 21 operators. Interviews with processors covered about 10 000 m³ or about 80% of the state resource.

The largest processor in the state is Britton Timbers of Smithton, who process 6000–9000 m³ y⁻¹. Of this, 90% comes from crown and 10% from private forests. Of the total sawn, with a conversion rate of 27%, 80% is in select grade at a price of AU\$1200–\$2800 m⁻³, air dry at mill. 10% is in standard/feature grade at \$500–\$800 m⁻³ with 3% Craft and 7% veneer. Select grade is defect free, whereas feature grade is boards with sound knots/defects.

The main issue highlighted by Brittons was the reduction in solid furniture/door manufacturing in Australia. Future issues identified were the politics of native forest harvesting and the need to maintain awareness of blackwood in Australia as a quality timber. Brittons are exporting their feature-grade timber to China where cheaper labour enables finger-jointing to be carried out to make clear boards. The second-largest processor in Tasmania is Corinna Timbers, who source material from across the state.

Table 1. Forestry Tasmania log specifications

Forestry Tasmania Special Species Timber Sawlog Category 4 (Cat 4) and Utility Log Specifications, June 2000		
Specifications for blackwood*		
Specification	CAT 4	UTILITY
Minimum length	3.1 m	2.5 m
Minimum small end diameter	30 cm	25 cm
Limbs and bumps	3 of 4 faces clear (in 3.1 m lengths)	2 of 4 faces clear (in 2.5 m lengths)
Spiral	1 in 8	1 in 8
Sweep	1 in 7	1 in 7
Scars	¼ face — 3.1 m in 3.1 m	½ face — 2.5 m in 2.5 m
Borers	Nil evident	No significant evidence
End defect	End-diameter 30–40 cm ub minimum of 10 cm radial ring clear of heart and sap End-diameter > 40 cm ub as per Sawlog End Defect Limits Table	End-diameter < 30 cm ub - Nil. End-diameter 30–40 cm ub minimum of 10 cm radial ring clear of heart and sap. End-diameter > 40 cm ub as per Sawlog End Defect Limits Table
OUT-SPEC Special Species Timbers Logs Minimum length of 2.1 m Special Species Timber logs, which cannot meet the specification tables, may be classified as OUT-SPEC. Craft: not meeting any of the above		

*Also for silver wattle, sassafras, celery top pine, leatherwood, tea-tree and other special species timbers

There is some debate amongst Tasmanian processors as to the merit of a craft market. While Island Specialty Timbers in the south of Tasmania operate in this area, blackwood is not a major portion of their output. As there are no big players in the craft market industry, there is no negotiating power and no profile for them as a group.

The greatest issues in Tasmania were wood colour and quality; a current issue was supply and management, and a future issue was supply and quality.

New South Wales

Britton Timbers in Sydney are the major blackwood trader for the state. The company handles 300–500 m³ y⁻¹ of sawn timber, all select grades at \$2000–\$3000 m⁻³ and all imported from Tasmania: this accounts for about 10% of the estimated Australasian sawn timber market. The major issues were availability and supply. Shorts are also an issue because packets of timber have a high proportion of short clear boards resulting from docking-out defects. The issue of shorts was also highlighted by Brittons in Victoria, who provided data on a typical packet of timber, highlighting the consequence of docking for grade (Fig. 1).

Whilst Brittons identified flooring as a potential market, and have demonstration floor material, a visit

to a flooring show room in Sydney found they had no information on blackwood or any samples on their floor. Blackwood seemed to have a high status in parts of Sydney. One retail shop in the tourist area had furniture at prices of \$42 000 for a dining room suite and \$22 000 for an executive desk.

Victoria

Those parties interviewed processed about 1708 m³ of timber and 1000 m³ of log material, about 43% and 7% of the estimated Australasian market, respectively. The volume of log material being processed has declined sharply: one processor in Victoria alone had cut up to 3000 m³ annually but now handles only 400 m³ of logs. The largest processor in Victoria was Matthews who handle 1500 m³ y⁻¹ of timber sourced from Forestry Tasmania through their own mill at Smithton, Tasmania. Of this, 73% is select, 10% natural feature and 17% sapwood grade.

Very little blackwood is produced from crown land in Victoria. Licences were issued for about 1000 m³ y⁻¹ but very little was actually sold and no current contracts exist. Currently about 100 m³ y⁻¹ of logs are produced in East Gippsland and sold by Expression of Interest (G. Featherston, Forest Strategy Pty Ltd, Victoria, *pers. comm.*, 2005).

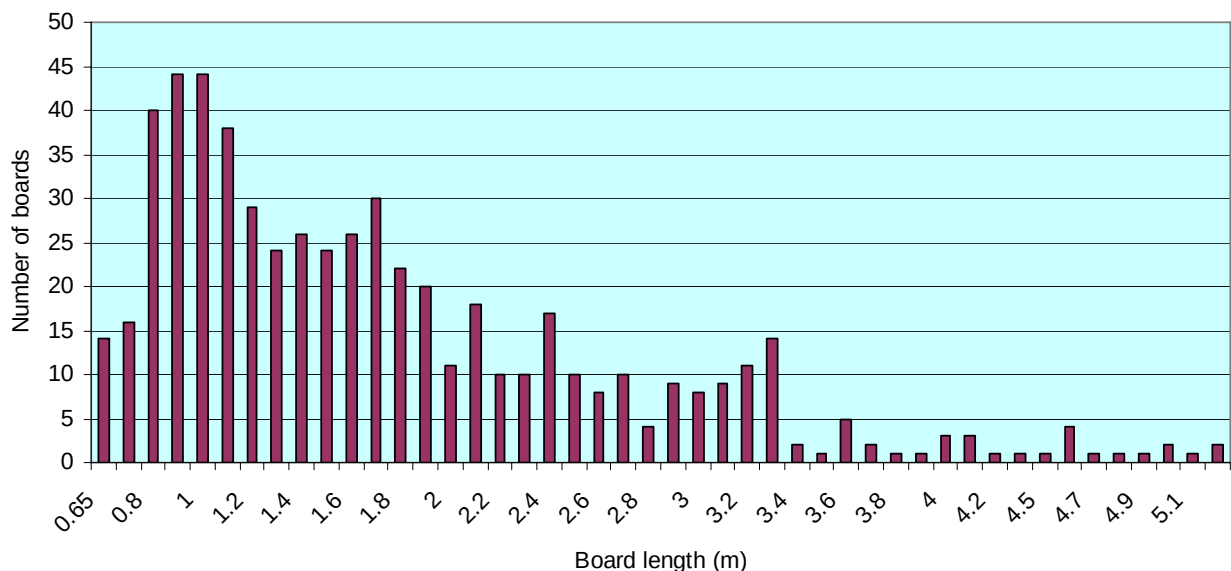


Figure 1. Example of length of boards in a packet of timber (from Brittons, Victoria)

Victorians are also concerned about access to better-quality logs. Their processors differed from those in Tasmania in that more emphasis was placed on grain and figure. The issue of supply was stronger than for Tasmania: there were also concerns with high timber prices.

The Victorians are also involved in links with China, especially Davis who have branded furniture in Harvey Norman stores — particularly chairs as part of dining suites. The bottoms of the chairs have statements saying they are blackwood chairs made in China on behalf of Davis.

Guitars

Four guitar-makers were interviewed in Victoria and one in Tasmania. These people ranged from local specialists involved in repairs, to a small business producing 20 guitars a year, to large-scale makers producing 7000 guitars annually. All favour using fiddleback material that costs from \$20 000–\$50 000 m⁻³. Blackwood is not the premium material for guitar backs, although it produces acceptable tones and ranks very highly on the scales for aesthetics. The blackwood is cut into strips 5 mm thick that are generally 220 mm wide.

Fiddleback

Fiddleback is a rarity and eagerly sought. There is almost a black market for it, as most is squirrelled away by mill owners for their own use. Valued at up to \$50 000 m⁻³, it is no wonder that it is not retailed. In

Victoria some bushmen specialise in marketing fiddleback. Propagation of trees producing fiddleback is reported to have been successful, but any success in producing fiddleback timber is unknown. Fiddleback blackwood has seldom been encountered in New Zealand.

Suggested uses of non-clear blackwood

One of the objectives of the study tour was to identify innovative uses of non-clear blackwood, or natural-feature blackwood as it is called in Australia. A myriad of responses was received ranging from ‘fire up the boiler’, don’t use it, to use it where it is not seen or in smaller pieces. In Australia several processors and/or manufactures are keen to use sapwood as a feature, but regulations say this must be treated for use on the mainland. The uses identified (Table 2) tend to reflect small-labour intensive items, and while some do have high value, most are not likely to be industry drivers with the exception of laminating, feature wall panelling or flooring. The last is probably the use with the most potential.

New Zealand

To date nine people or companies in New Zealand have been interviewed. Currently the market in New Zealand processes just over 84 m³ y⁻¹ of sawn timber, utilising plantation-grown material from New Zealand and imported timber from Tasmania and Victoria. The total accounts for about 2% of the estimated Australasian market.

Table 2. Suggested use of non-clear blackwood

Natural feature	Heart and sapwood
Flooring	Feature wall panelling, 85 × 12 mm
Furniture	Flooring
Chopping boards,	Kitchen utensils
Feature drawer fronts	Chopping boards, knife blocks
Shelving in cabinets, door panels	
Laminating	
Run the boiler	
Finger-joint lengths for panels, furniture, wood carving, turning	
Head veneers for interesting grain, interesting pieces for electric guitar caps	
Flooring and decorative panelling	

As with Australia, the most important blackwood characteristic for New Zealand is colour. Current issues in New Zealand are supply, markets and colour. Future issues are dominated by supply. New Zealand processors favour dealing with growers, just ahead of merchants and sawmillers.

New Zealand processors suggest that a potential end-use of non-clear timber is in flooring as well as decorative panelling. However, several of those interviewed did not handle non-clear blackwood, preferring to use only clear material.

Discussion

The blackwood market in Australia handles about 14 000 m³ of logs and 4000 m³ of sawn timber per year. Most of this is sourced from Tasmania, where it is processed into sawn timber and exported to mainland Australia or China. The survey interviewed processors of about 10 180 m³ y⁻¹ of logs and 5300 m³ y⁻¹ of sawn timber. Because of trading in timber, the total sawn timber handled by people surveyed is greater than the actual amount sawn. Processors interviewed accounted for about 72% and 130% of the log and sawn timber markets, respectively. Most of the trade in blackwood is for select or clear timber, often in short lengths, which creates problems for many users.

The most important blackwood wood characteristic recognised by those interviewed was wood colour, with 42% nominating this attribute, followed by timber quality (31%). Supply was the most important factor both now (46%) and in the future (60%).

The Australian market has shrunk over the last decade and blackwood is no longer the main kitchen joinery timber of choice. To compensate and to provide an outlet for non-clear timbers, a market has been set up by Brittons and other traders with China: China processes knotty timber into clear lengths more cheaply than Australia. About 400 m³ has been sent to China in the last five years. Blackwood is now coming back to Australia as made-up furniture for major retail stores.

The Chinese market developed because of declining sales into the joinery market, especially kitchen joinery. This was the dominant market in the 80s but now plays second fiddle to laminates. The loss of furniture makers in Australia and New Zealand has been influenced by cheaper Asian imports of furniture made from a range of timbers. The upside of the new Asian blackwood trade is that blackwood is maintaining a position or profile in the market. The use of blackwood for flooring was often mooted as a new market, but there has been no effort to date to make this the focus of any individual company.

Differences between Australia and New Zealand

The first major difference is that in Australia blackwood supply from native forests is very political: in New Zealand there is almost no political agenda because it is an exotic plantation species. Blackwood has a greater acceptance in the Australian domestic market, whereas blackwood in New Zealand has a very small market niche. Because of a decline in demand, Australia has developed offshore markets, especially in China. Some New Zealand manufacturers have exported blackwood to Hawaii. New Zealand plantation logs are fetching higher prices (>NZ\$300 m⁻³ at the mill) than native forest logs in Tasmania, which start at AU\$70 m⁻³ stumpage royalty for the better grades. As a consequence there is a greater interest and a better understanding of plantation management in New Zealand, where most of the small resource is of well-tended stands. The market in Australia has an interest in sapwood as a feature, and there is a strong local market for highly-figured material used for guitar-making: neither of these markets is present in New Zealand. Australia produces a significant amount of short clears, although this is a frustration to some manufacturers on both sides of the Tasman.

Similarities between Australia and New Zealand

Similarities between Australia and New Zealand in marketing blackwood are that both have a similar price for clear-grade sawn timber, about AU\$3000 m⁻³, but lack a consistent use of knotty-grade boards. Both countries are exploring export opportunities, but to a lesser extent in New Zealand because of resource constraints. Both Australians and New Zealanders see potential in marketing blackwood as a flooring material using knotty and clear 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 Australia or New Zealand.

Conclusion

Blackwood is recognised as a high-quality furniture timber mostly because of its colour attributes. However, the major concern for all involved in the industry is supply: in Australia continuity of supply from native forest and in New Zealand the lack of a sufficient plantation resource. 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 Australia or New Zealand.

The issue of exporting low-grade blackwood to China has large implications for furniture manufacturers in both Australia and New Zealand, who are grappling with problems of imported furniture undercutting domestic furniture products (Halkett 2006). There is a strong interest in developing flooring markets in both countries, and an opportunity for them to work together on a special product utilising feature-grade timber for flooring.

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. All blackwood processors and manufacturers should endeavour to keep blackwood as a premier timber in both the Australian and New Zealand markets.

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Session 2: Marketing and Investment Paper 6

The Blackwood Resource in Victoria: History, Production, Prices and Sustainability

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Abstract

Victoria has a history of blackwood sawlog production that commenced with land clearing, particularly in the Otway and Strzelecki Ranges in the 1870s. More recently, the main area of production was the Otway Ranges, producing 89% of the state's public land production from 1990 to 2005. This sustainable production will cease following the declaration of the Otway National Park. Blackwood sawlogs have been priced administratively using the Royalty Equation System that attempts to equalise prices between licensees. Open-market prices match or exceed these prices. Future production levels will fall dramatically and the market in Victoria may collapse unless demand stimulates more production, particularly from the Strzelecki Ranges.

History

The history of production of blackwood logs follows a path different to that of the production of other native forest timbers in Victoria. The main areas of production of blackwood were the Otway and Strzelecki Ranges (Fig. 1). The initially-high rate of production was due to logs that were produced from the clearing of land for agriculture.

In the 1860s the land south of Morwell was opened up to settlement, and the provision of rail transport started a long and heart-breaking process of clearing the dense forest for farms. By 1884 the town of Boolarra was

prospering and blackwood timber milling was one of its main industries.

By the 1920s the prosperity had ended (Fig. 2). Rabbits, weeds, steep slopes and isolation took their toll on many farmers who began abandoning farms and moving elsewhere. In the 1930s the Forests Commission began buying back offered properties at rates that increased until 1951. This land was reforested with plantations of mainly *Pinus radiata* and *Eucalyptus regnans* (FCV 1976). This land today is mostly held by Grand Ridge Plantations.

The Otway Ranges experienced a similar history of over-clearing and reforestation. Most of the Otway Ranges remain crown land under the control of the various land management agencies.

Production

Blackwood logs are graded using a system similar to that for eucalypt sawlogs but individual grades are not recorded or priced. The system recognises the arrangement and quantity of defects and the log diameter in determining if the log is above the minimum standard. A defective quarter is a section of the log 2.4 m long which has one-quarter of its circumference affected by a visible surface defect such as a limb or bump that might reasonably be expected to affect the quality of wood within the log. Small logs, <35 cm small-end diameter (sed), can have only two defective quarters. Larger logs, >35 cm sed, can have three defective quarters. The minimum sed for sawlogs is 25 cm, although craftwood or hobbywood is often sold at smaller diameters.

The Timber Industry Strategy of 1986 saw the issue of 15-y licences to sawmills in Victoria at levels similar to their intake over the previous 5 y. A number of licences for blackwood were issued under this arrangement.



Figure 1. Early pioneer life in the Strzelecki Ranges



Figure 2. The Strzelecki Ranges after the town and farms were abandoned (FCV 1976)

These licences have formed the major driver for blackwood production from State forest during the last two decades: the average production during the nineties was $2250 \text{ m}^3 \text{ y}^{-1}$. More recently the production of blackwood has declined to very small quantities. The sales in 2004/05 were a mere 123 m^3 . The volume production by Forest Management Area for the period 1990–2005 is provided in Figure 3: the total during this 15-y period was $24\,871 \text{ m}^3$ (Logsals 2005). There are no consolidated estimates of volume available for production from private property.

The main area of production was the state forests of the Otway Ranges, which produced 89% of the total volume. The next most significant areas were East and Central Gippsland which produced 6% and 5% of the total volume, respectively. The balance of the production (<1%) came from the Central, Dandenong, Portland and Tambo Forest Management Areas.

During this period, sales were made to 31 companies and individuals either on long-term licences, short-term licences or spot sales by tender. The most significant buyers processed the timber from the Otway Ranges. The largest buyer over this period was Otway Hardwoods Pty Ltd, which purchased 67% of the total volume produced. The next main buyer was WH Bennett and Sons Pty Ltd which purchased 7% of the total volume produced. The only other significant single purchaser of blackwood in Victoria during this period was Max Reynolds based at Marlo, who purchased 5% of the total volume.

Blackwood logs are not graded but are priced according to the centre diameter under bark and the log length. Diameter is the single log characteristic that most affects recovery. There are three diameter classes as described below:

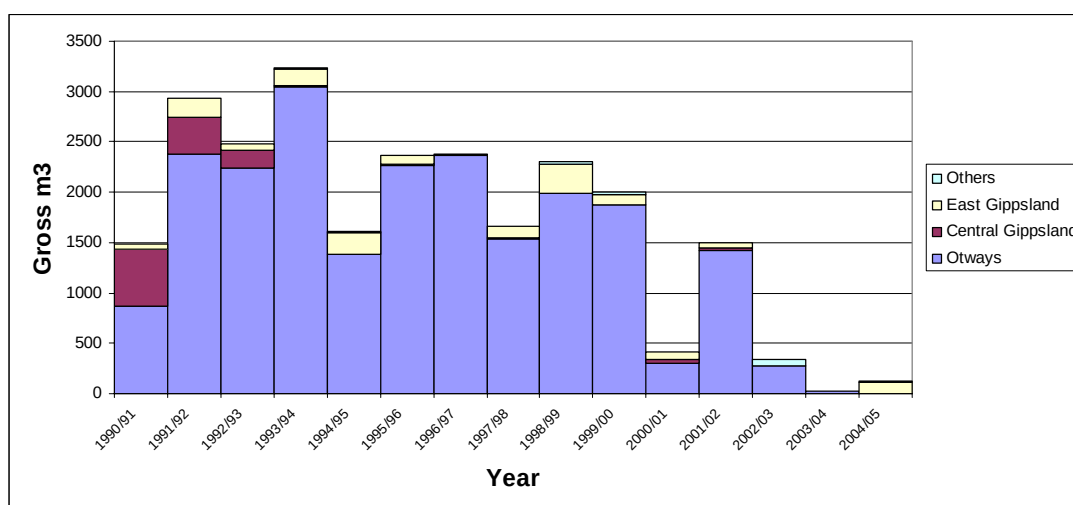


Figure 3. Volume production of blackwood in Victoria for the period 1990–2005 by Forest Management Area (Logsals 2005)

- Class 1A cdub = 34 cm and less
- Class 1B cdub = 35–44 cm
- Class 2 cdub = 45 cm and greater

The minimum log length for sawlogs in Victoria is 2.4 m. There was a demand for shorter logs in blackwood, so a short log class was recognised. Blackwood logs of Class 2 diameter can be 1.8 m long and are sold at a lower price if they are <2.6 m. The following price discounts are offered for logs compared to the Class 2 long logs and are dependant on the area and zone:

- Class 1A
Price discount range = 68–90% off
- Class 1B
Price discount range = 25–50% off
- Class 2 Short
Price discount range = 49–63% off

The distance from the forest to the mill is determined by the establishment of royalty zones. The zones represent concentric rings of cartage distances from a hypothetical mill location in a major town within the forest management area (FMA). The cartage distances are calculated on 20-km bands of road distances equivalent to cartage on the best roads (Class A). Distances on lower-class roads are multiplied by a weighting factor to allow for the slower travel. The zones are described by their mid-point, so 'zone 20' is for distances of 0–30 km and 'zone 40' is for 31–50 km. The price of a class of log decreases by about 2% for each increase of cartage by 20 km.

The distance from Melbourne of the theoretical sawmill site also affects the price determined by the royalty equation system. A log sold in the Central FMA is theoretically processed at Healesville, whereas a log in the far east of the state in the East Gippsland FMA is theoretically processed at Cann River. A 7% discount is offered for the Cann River logs to account for the extra expense of carting sawn timber to markets, assumed to be in Melbourne (VicForests 2005a).

The prices generated by the royalty equation system are indexed to account for movements in inflation, costs of production and timber prices. Traditionally indexation occurred once a year in July. Under the management of VicForests the prices are indexed every six months in July and January according to a predetermined indexation formula. The July 2005 price increase included a factor for market prices and a catch-up of previous underestimates of price indexation. Prices went up by 14–20% between June 2005 and July 2005. The January 2006 price indexation used the indexation formula and prices fell because of falling timber prices as determined by the Timber Pricing Survey conducted by State Forests NSW on behalf of the eastern states. Blackwood prices fell by about 1% as a result (VicForests 2006). The

prices in Appendix 1 are the July 2005 prices before this decrease.

VicForests is currently running an Expression of Interest process for specialty timber from East Gippsland. Last year 118 m³ of blackwood was sold using this process. The logs were in parcels of about a truckload, each lot being 22–24 m³. The average size was 38–46 cm cdub. These logs were purchased from a sawmill site, so prices included harvesting and partial delivery costs. Prices varied from \$120 to \$135 m⁻³ for the lots with average diameters >40 cm, and \$68 m⁻³ for the lot with an average diameter of 38 cm (VicForests 2005b). No blackwood is scheduled for sale this year using this process.

Prices from privately-owned forests are more difficult to determine. A reported case study from 2003 indicates that blackwood logs from private native forest around 80 y old sold for \$130–\$160 m⁻³ loaded on the truck, depending on log quality. The mill was effectively 150–180 km from the forest. The log diameter averaged 70 cm and was up to 100 cm (ANU 2003). After deducting the harvesting and loading costs of \$22–\$30 m⁻³, the stumpage from these sales would have been \$100–\$138 m⁻³, similar to the prices from state forest.

Sustainability

The main supply area for blackwood logs in Victoria was the Otway Ranges. It is unlikely that sustainable volumes of logs will be produced from here in the future following the government decision to expand Otway National Park. The park includes most of the productive southern slopes of the ranges that grow the best blackwood. The areas that remain outside the park will also not be used for timber production after 2008 when the current remaining sawlog licence expires. It remains to be seen if any timber production can be reintroduced after this date.

The remaining areas of the state can produce sustainable quantities of harvestable blackwood logs, and this level may increase in the future. The exact quantities that are available have never been assessed, as the volume has not been considered sufficient to warrant investment in resource inventory or growth modelling. The recent review of sawlog availability for the policy 'Our Forests Our Future' did not include estimates for blackwood (NRE 2002). The Statewide Forest Resource Inventory does identify stands of blackwood, but very few have been identified (NRE 2000). Most of the harvested blackwood logs occur as understorey to the main eucalypt canopy, not as recognisable stands. The State of the Forests Report (DSE 2005) identifies that Victoria has 63 000 ha of *Acacia* forest. Most of this is expected to be silver wattle and other scrubby wattle species.

The current harvesting coupes in suitable areas often include blackwood trees containing logs that remain uncollected. Contractors can recover these logs if

provided with sufficient incentive and a market. Sustainable production is possible from East Gippsland, Central Gippsland and Central FMAs in particular. Past recoveries and current harvesting rates suggest that each of these FMAs could produce $200 \text{ m}^3 \text{ y}^{-1}$ on average. Actual production may vary depending on the exact coupes scheduled for harvesting.

The production of blackwood logs may increase in the future. This is because many of the trees suitable and available for harvesting in the Central and Central Gippsland FMAs are regrowth from the 1939 fires, but are only just of merchantable size at present. Over the next 10 y many of these trees will reach merchantable size. In 20 y, they will be of optimal size for harvesting and processing. After this time the amount of defect and decay may increase to levels that start to reduce the merchantability of the logs. The Strzelecki Ranges, that have produced large quantities of blackwood in the past, may produce increased quantities in the future as trees established during the reforestation programs in the 1950s and 1960s become of merchantable size.

A sustainable production of 600–1000 m^3 of blackwood logs from state forests could supply an ongoing small niche market for blackwood in Victoria that could then be exploited by private growers of blackwood. Without this production, all blackwood markets may be lost to alternative timbers and private growers will have to rebuild markets from scratch. This will take longer, and larger reliable quantities of timber. The potential for blackwood log production from the Strzelecki Ranges needs to be explored with Grand Ridge Plantations, who control most of the forest that is potentially available for timber production.

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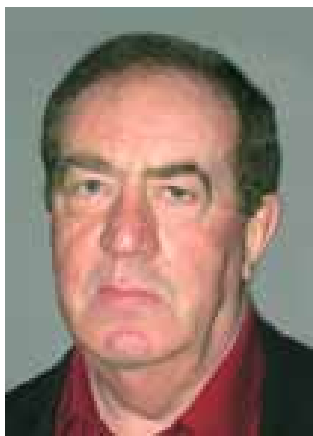
Appendix 1. Blackwood log prices from State Forest as at July 2005

FMA	PRD	Distance (km)	Date	Zone	Size class			
					1A	1B	2	2 Short
Central	Healesville	68	Jul-05	20	44.87	105.29	140.28	71.96
				40	42.56	102.98	137.86	69.54
				60	39.97	100.39	135.14	66.83
				80	37.48	97.91	132.54	64.23
				100	34.95	95.37	129.89	61.57
				120	31.77	92.19	126.56	58.24
				140	28.48	88.90	123.11	54.79
				160	25.19	85.61	119.66	51.35
				180	21.90	82.32	116.22	47.90
				200	18.61	79.03	112.77	44.45
				220	15.41	75.74	109.32	41.00
Central Gippsland	Traralgon	163	Jul-05	20	44.73	105.16	140.15	71.83
				40	42.42	102.85	137.72	69.41
				60	39.83	100.25	135.01	66.69
				80	37.35	97.77	132.41	64.09
				100	34.81	95.24	129.75	61.43
				120	31.64	92.06	126.42	58.11
				140	28.35	88.77	122.98	54.66
				160	25.05	85.48	119.53	51.21
				180	21.76	82.19	116.08	47.76
				200	18.47	78.90	112.63	44.32
				220	15.28	75.61	109.19	40.87
Tambo	Bairnsdale	281	Jul-05	20	44.54	104.97	140.01	71.70
				40	42.23	102.66	137.59	69.27
				60	39.64	100.06	134.87	66.56
				80	37.16	97.58	132.28	63.96
				100	34.62	95.04	129.62	61.30
				120	31.45	91.87	126.29	57.97
				140	28.16	88.58	122.84	54.53
				160	24.86	85.29	119.40	51.08
				180	21.57	82.00	115.95	47.63
				200	18.28	78.71	112.50	44.18
				220	14.99	75.41	109.05	40.74
				240	13.89	72.12	105.61	37.29
				260	13.89	68.83	102.16	33.84
				280	13.89	65.54	98.71	30.39
East Gippsland	Orbost	375	Jul-05	20	42.22	100.19	134.31	86.13
				40	39.91	97.88	131.89	65.71
				60	37.31	95.29	129.17	62.99
				80	34.83	92.81	126.57	60.39
				100	32.30	90.27	123.91	57.74
				120	29.12	87.09	120.59	54.41
				140	25.83	83.80	117.14	50.96
				160	22.54	80.51	113.69	47.51
				180	19.25	77.22	110.24	44.07
				200	15.96	73.93	106.80	40.62
East Gippsland	Cann River	461	Jul-05	20	40.44	96.48	129.91	65.42
				40	38.13	94.17	127.49	63.00
				60	35.54	91.57	124.77	60.29
				80	33.06	89.09	122.17	57.69
				100	30.52	86.55	119.51	55.03
		461	Jul-05	120	27.34	83.38	116.19	51.70

FMA	PRD	Distance (km)	Date	Zone	Size class			
					1A	1B	2	2 Short
East Gippsland contd.	Cann River contd			140	24.05	80.09	112.74	48.25
				160	20.76	76.80	109.29	44.81
				180	17.47	73.51	105.84	41.36
				200	14.18	70.21	102.40	37.91

Explanation of entries in Appendix

Source	VicForests Sawlog Price list as current at 1 July 2005 and published at www.vicforests.com.au (VicForests 2005a)		
FMA	Forest Management Area Prices have not been provided for FMAs that rarely produce blackwood.		
PRD	Point of Royalty Determination = Location of the theoretical site of a sawmill used for the determination of the cartage zones. East Gippsland FMA has two PRDs, all other FMAs have one.		
Distance	Distance from the PRD to the Melbourne GPO		
Date	The date from which the rates are current		
Zone	Royalty zone = The 20-km classes of A-class-road-equivalent distances from the forest to the PRD		
Size	Size classes as determined by the centre diameter under bark (cdub) and by length:		
	Class 1A	cdub = 34 cm and less	
	Class 1B	cdub = 35–44 cm	
	Class 2	cdub = 45 cm and greater	
	Class 2 short	cdub = 45 cm and greater	
	Log length.	1.7–2.6 m	
Price	Price in AU\$ and excluding GST, licence fees, access charges and any other harvesting or delivery charges. There is no longer a separate roading charge which is now incorporated in this timber charge. The prices are per cubic metre gross volume with no allowance for the defective volume within the log		



Session 2: Marketing and Investment Paper 7

Blackwood Lessons Learnt and their Application to Marketing for the Future

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GLENN BRITTON is Managing Director of Britton Timbers, a family company based in Smithton, Tasmania. Britton Timbers has been harvesting, processing and marketing Tasmanian blackwood continuously for the past 99 y. Glenn has spent his 40 y in the business working at all different levels and activities. His main objective has been to secure the future of the blackwood industry in Tasmania and the Australian mainland and more recently, to do this through the development of markets for blackwood overseas. Glenn served for 10 y as Chairman of the Forest Industries Association of Tasmania and is currently a director of that Association.

Abstract

Blackwood is a well known and respected species in Australia. This paper describes the history of the industry in Tasmania and how changes have been made to lift the industry out of a difficult period and respond to current markets for blackwood. A broader base is required to secure the future of the industry, but this must be at the right price in niche markets that leads to increased returns for the grower, processor, manufacturer and retailer. Promotion of the attributes of Tasmanian blackwood in these markets and the production of first quality, clear-grade wood of good colour have to be part of this strategy.

History

Britton Timbers processes about 70% of the blackwood production in Tasmania, primarily from the crown forest resource. Ever since my direct involvement, commencing in 1965, our company has consistently harvested, milled, dried and processed blackwood into the available market places (month in, month out; year in, year out). Most of our blackwood has been sourced from blackwood swamps, which means there has been a heavy focus on a short dry summer harvesting season and consequently large stockpiles of logs to tide us over the ensuing 12 months.

In the 60s and 70s our main markets were furniture manufacturers in Sydney and Adelaide. The Melbourne and Tasmanian markets were primarily serviced by

blackwood timber from private sources, particularly APPM/Burnie Timbers from their Woolnorth properties in the Smithton area. Also at that time Kauri Timber Company had crown rights to blackwood; when blackwood demand was really strong Kauri would exercise that right and harvest and mill large quantities of blackwood in one season — completely flooding the market and in effect, wrecking it for the following two to three years. There were many reputable, excellent manufacturers such as Elite Furniture in Sydney, T.H. Brown and Son in Adelaide, Tessa in Melbourne and others whose blackwood furniture was retailed in stores Australia-wide. Blackwood was well known and respected.

In the mid 1970s Brittons relocated, upgraded and expanded their entire sawmilling operation from the bush into the town of Smithton. Subsequently, they arranged with Forestry Tasmania and Kauri Timber Company to take up the entire crown blackwood allocation in the Circular Head area. This consolidation was very good for the industry — and it still is, simply because at least one reasonably responsible major producer is necessary to give stability to the overall industry in terms of log stock, sawn rack stock, processed pack stock and servicing. This ensures a constant, regular flow of product to manufacturers, giving them the confidence to invest in whatever various blackwood furniture or products they desire. No manufacturer of reasonable size is prepared to make this investment and commitment without the comfort of knowing that the necessary volume of sawn wood is available at all times to meet their manufacturing capabilities and orders. They spend a lot of money in tooling, profiles, designs and marketing.

Most of the smaller blackwood millers do not have a year-round supply of timber for the market, and are therefore vulnerable. They will always find a market for their product somewhere, however, primarily because they have a cost advantage of lower overheads, in particular not having the large cost of stocking logs and sawn timber for 12 months of the year. The blackwood industry will never survive as a cottage industry.

In the early 1980s Brittons installed a small veneer slicing and drying plant, primarily to have veneers to augment the solid timber in furniture. At this time blackwood furniture manufacturing grew rapidly in Tasmania, but declined in the mainland states. At one stage there were 8–10 manufacturers of reasonable size in Tasmania, mainly in Ulverstone and Launceston. Brittons supplied about 70% of its sawn blackwood into this market. However, the problem was that most production was destined for the Tasmanian market, either domestic and commercial. The manufacturers were all fishing in the same local creeks, and of course these eventually dried up overnight, with the inevitable result that most went out of business, including Pipers whom Brittons owned at that time.

In addition, Australia suffered Paul Keating's recession that we 'had to have'; when the economy improved in the early 90s unfortunately the Tasmanian blackwood industry did not. At the same time many other solid timber furniture manufacturers throughout Australia, all using different species of wood, also collapsed. This was primarily due to the influx of much cheaper, very chunky solid timber furniture from Asia manufactured from tropical hardwoods and rubberwood.

The late 80s also saw the emergence of kitchen cupboard furniture from solid timber which boosted the demand for blackwood timber — in fact, with the demise of the solid furniture market, it was kitchen furniture which carried blackwood for the next decade, albeit at a much lower overall level. Supply exceeded demand, which obviously put a lot of downward pressure on price and upward pressure on quality and specification. In fact, blackwood demand, and prices, have been very depressed for the past 10 y. During this time Brittons, whilst not being able to increase our overall prices even by CPI, have not succumbed to price cutting. We have been very tempted to do this, but we realise that whilst it may give us one month of increased sales, all we would do is reduce the overall price of blackwood by that discounted amount because other sellers will rush to meet the lower price. Some producers/stockists are selling into the market at prices up to 20% below the current depressed level. This is utterly ridiculous and totally unnecessary. However, because in most instances blackwood is not their core business, they take this laissez-faire approach. These traders have always been there and probably always will be, so we must carry on business at our chosen level beside them.

During the past four to five years, Brittons have been pursuing blackwood business in China, primarily in conjunction with an Australian furniture importer. As a result, reasonable volumes of good quality furniture are now being stocked and sold in stores such as Harvey Norman and Berkowitz. We are confident that overall sales will increase because of the widespread exposure and advertising that these stores are undertaking regarding Tasmanian blackwood furniture. I expect that most of this furniture is replacing imports of the tropical hardwood and rubberwood furniture that I

mentioned earlier. We still have a long way to go to consolidate this business for a solid long-term future, but with much more emphasis on marketing — for example, the Tasmanian Brand — I'm sure it has great potential. Interestingly, over the past 12 months there has been a considerable increase in the production and sale of blackwood furniture by Australian manufacturers. This appears to be a result of overall increased activity and demand arising from increased exposure in Harvey Norman and other stores. A number of local manufacturers are having two bob each way: whilst producing in Australia, some of their product lines — principally chairs which are the most labour-intensive — are made in China.

In the past two years there has been a large increase in the demand for synthetic-type kitchen furniture (laminates, vinyls and painted products), in lieu of solid timber: this has obviously affected sales of blackwood.

Brittons have had some success in producing and selling blackwood flooring, particularly overlay flooring. We remain involved in high-quality commercial fitouts with solid and veneer products in Melbourne. In recent times these have included the Victoria County Court House (70 court rooms), the RACV building and the Long Room at the MCG. Again we must capitalise on this exposure to enhance the future of our blackwood industry.

With the foray into China we are hopeful of finding markets for lower-grade shorts and narrows from our blackwood stock that no-one in Australia has been interested in for years. This is important for our future, particularly as overall log quality is decreasing. For all of us to be successful, we must maximise recovery and utilise all products from our available resource.

In the future

It is imperative that as an industry we create increased demand for quality blackwood furniture and products in selected niche markets around the world — places such as Los Angeles, Las Vegas, Hawaii, San Francisco and Europe.

China itself also has this potential as a result of the burgeoning upper class — there are large numbers of BMWs and Mercedes Benz cars in places like Shanghai and Beijing. To pursue this opportunity, Brittons have sent free samples — for example a half to one cubic metre of sawn timber — to various manufacturers in the US, China and Denmark to enable them to fully appraise the quality of blackwood as a furniture timber and give them a showpiece to present to prospective retailers and buyers. We definitely need to broaden our horizons for blackwood products outside Australia, but only in niche markets at the right price for us.

In creating demand based on quality, service and marketing, we hope to gradually move the overall price

of blackwood to where it rightfully belongs. By this, I mean price to the grower, the processor, manufacturer and the retailer.

Marketing

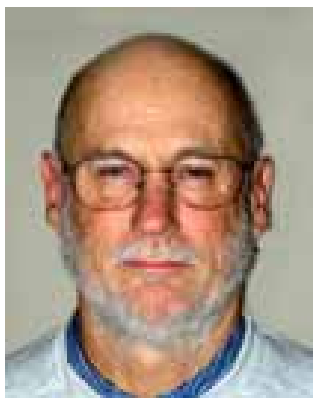
It should be obvious to all that in this day and age to be successful in the product market you must be active in marketing. This is very difficult in a small industry such as ours. Until recent times virtually nothing had been done to promote and market the attributes of blackwood: we must rapidly change this approach. Brittons have recently spent considerable funds on brochures and are currently producing a CD. The main purpose of the latter is to present the Tasmanian blackwood history and attributes as a medium to assist manufacturers and retailers to produce generic material promoting and marketing blackwood at retail points of sale. This approach can also be used for presentations to buyers, architects and specifiers.

Conclusion

Whilst I have portrayed the road that our industry has traversed over the past 15 y as rocky, I am confident

now that we can look forward to a great future — provided that all in the industry are committed to the same goal of excellence. This obviously applies to the trees that are grown, processing, design and manufacture of products, marketing and retailing.

I emphasise that we must elevate blackwood to a world-renowned niche market product, and not have it wallowing in the commodity lines — there will be no future there. As this workshop has a major focus on the growing of quality blackwood logs, I cannot overemphasise the need to produce the maximum first quality, clear-grade wood of good colour for the future of this industry. I have seen problems in the teak industry which we must avoid. In our warehouses we stock native forest teak which sells for \$4000–\$6000 m⁻³ sawn wood, compared to plantation wood from New Guinea which fetches \$1200 m⁻³ — and that is quite frankly all it's worth. In fact, it really is another species — its past reputation and name will not assure a smooth transition from native forest wood to plantation wood. Let us make sure that blackwood does not go down this path.



Session 2: Marketing and Investment

Paper 8

Blackwood Timber: Marketing at Present and in the Future

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DENIS BROWN is a geologist by training and worked in mining. In 1992 he moved on and established Corsair Sustainable Timbers, a company that successfully supplies the premium cabinet-making and furniture trade in Australia. Originally a one-man show, the company now employs six people. Denis developed the first Australian-made dehumidifying drying kilns and low-temperature drying systems. Denis and his wife have also planted large numbers of trees, including several thousand blackwoods, on their 230 acre property, though the successive droughts of recent years have compromised the performance of the blackwood.

Abstract

Blackwood is one of the best cabinet timbers, yet it is very cheap because the current market fails to recognise its true value. This paper explores changes in current consumption patterns, notes that manufacturing of blackwood in China is providing the Australian market with more blackwood furniture, and recommends that new overseas markets should be targeted either through sawn timber or value-adding.

Introduction

Australian blackwood sells into an immature timber market (the Australian market!) that does not recognise the true value of premium timber or the quality of products that are made from it — cf. to a mature market as exists in the USA (see Dudley pp. 97–100 this volume). As a cabinet timber it ranks alongside oak, teak, mahogany and walnut as being one of the five best, yet in spite of being in the least supply, it is by far the cheapest. Its low value also hinders further investment in growing blackwood.

Current consumption

Furniture, and kitchen cabinets and benchtops, are the two principal areas of consumption of blackwood in Australia at present. Some flooring is also produced.

For furniture there are six major and five minor consumers as well as numerous craftsmen. It is estimated that of the total blackwood furniture sold in Australia, 30–40% is made from sawn blackwood exported to China and imported as finished products. Australian retail outlets that have promoted blackwood furniture made in China have demonstrated that this is an important mechanism for providing the Australian market with more blackwood furniture.

Consumption of solid timber in kitchens has declined in recent years. This is in part due to costs but also a reflection of changes in fashion. For example, Corsair has not sold blackwood for kitchen cabinets for the last seven months.

Future sales

Australia-based manufacturers of blackwood are getting fewer every year, so it remains unclear whether there are opportunities for expanding the consumption of sawn blackwood in this country. An alternative is further exploitation of the new market in China, either through log sales or sawn boards. The current export of sawn timber to China has shown that if a market is there, it is important to sell into it.

Entirely new markets could be created through sawn timber or by greater focus on value-adding. For sawn boards, the most likely customers are in North America (both USA and Canada), Saudi Arabia and the Gulf States. For value-adding, the best opportunities are through strip and parquet flooring, panel wood and feature walls, stair treads, and picture frames. Exporting blackwood in Australian-made furniture is not an option, as Australian manufacturers do not have the capacity to make this possible.



Session 2: Marketing and Investment Paper 9

Marketing a Blackwood Stand in New Zealand: A Case Study

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PETER HARINGTON is the Central North Island Regional manager for Woodmetrics Ltd and part-owner and Director of the company, founded in 2001. Woodmetrics markets private forests and woodlots using competitive stumpage tender as the primary marketing system. While most of the wood volume sold is *Pinus radiata*, Woodmetrics has applied competitive stumpage tendering to other forest species including blackwood. Peter has been in the forest industry in New Zealand for 29 y in the areas of nursery management and genetics, plantation establishment, silviculture and protection, and has worked for most of the significant forestry corporations at different times, reflecting the general upheaval in the NZ forest industry throughout this period.

Abstract

In 2001 Woodmetrics Ltd was asked to market a 41-y-old 2.5-ha stand of blackwood (*Acacia melanoxylon*). It was considered that competitive stumpage tendering offered a useful option for selling the stand. The stand was assessed and a sample of logs sawn to facilitate the tendering process. It was estimated that the stand was carrying about 420 m³ ha⁻¹, but that it had a significant portion of small-diameter sawlogs. The stand characteristics were less than perfect, reflecting a lack of management. The pilot sawing study demonstrated the importance of large log diameter for successful sawing for both conversion and out-turn of premier board grades.

The stand was successfully sold. However, the bidders were unfamiliar with competitive stumpage tendering and the qualities of the wood were unknown. Thus the process followed did not provide a perfect solution for establishing a fair market price for this species. However, the competitive stumpage tender process does provide an option for the future when more larger managed stands come on the market. As the scale of the industry increases, it might be expected that the level of buyer understanding of the product will increase accordingly. It could also be expected that the tools to better understand and describe the wood properties in standing trees will be refined.

Background

In 2001, Woodmetrics Ltd was asked to market a stand of blackwood (*Acacia melanoxylon*) on behalf of its client, Carter Holt Harvey Ltd (CHH). The isolated 2.5 ha stand was situated in Kinleith Forest, near Tokoroa, and surrounded by mainly *Pinus radiata* forest. The land under the stand had been sold to a private farmer for conversion to dairy farming, with a contractual requirement for vacant possession the following year.

Woodmetrics is now a privately-owned forest marketing company, although at the time it was a subsidiary of Carter Holt Harvey Ltd. Woodmetrics has distinguished itself in the New Zealand market by promoting competitive stumpage tendering as an alternative to the traditional graded log sale. Most of the Woodmetrics volume is *Pinus radiata*, reflecting the focus of the New Zealand forest industry, although the system has been applied successfully to several other species. Stumpage selling shifts the risk from the forest owner to the buyer, who has the power to affect the outcome through log optimisation and marketing skills.

Discussion

The blackwood market in New Zealand is immature and undeveloped. It can barely be called a market in the true sense, being typically a series of infrequent sales with minimal information from any one sale available to influence subsequent sales. The usual method of sale involves the buyer taking the logs to his mill and agreeing to pay on a formula based on recovery achieved when the logs are sawn. All the risk rests with the seller, who has no influence over the outcome.

When Woodmetrics were contracted to sell this stand in Kinleith Forest, it was decided to test whether a competitive stumpage tender would be successful as a method to sell this species. We reasoned that this was a relatively large resource contained in a contiguous stand. It should therefore be able to be described with

sufficient accuracy to allow bidding with confidence, without discounting for risk.

Prior to Woodmetrics being commissioned to sell this stand of blackwood, CHH had arranged an in-depth survey of the resource. A MARVL assessment of a 10% sample of the stand was conducted (see Nicholas *et al.* pp. 79–85 this volume for details of MARVL). The MARVL report stated: ‘The stand had been highly stocked for a long time, and hence diameter growth had been compromised. The stand was made up of many small-diameter stems mixed with larger dominants of variable form. Approximately one-quarter of the volume was reasonable form logs, and a further quarter of swept logs. Almost half the stand volume was considered lower grade material.’

The stand was estimated to be 41 y old. Mean stand values determined from the measurement of three plots were stocking at 474 stems ha^{-1} , MTD (mean diameter @ 1.4 m of fattest 100 stems ha^{-1}) of 42.2 cm, MTH of 32.4 m, volume of 420 $\text{m}^3 \text{ha}^{-1}$ and a basal area of 35 $\text{m}^2 \text{ha}^{-1}$. Nicholas and Brown (2002, see p. 70) describe some of the potential out-turn from this stand.

Financial analysis of the MARVL data revealed that the value of the stand would be affected considerably by the volume of the small top-log component unlikely to make sawlog, but potentially a valuable arising for firewood. It was argued that the composite-price sales method usually employed by Woodmetrics risked not capturing this value. This composite price pay-as-cut method means buyers pay the same price for all logs, by weight, as they are harvested. The difficulty lay in setting a minimum log specification which is critical to a composite sale. If a log specification was set which included all the firewood material, then it would disadvantage a sawmiller who was able to pay a high price for the sawlog component, but had no market for the firewood. If a minimum log specification was set which excluded the firewood, then any potential revenue from this volume would be lost.

It was decided to sell as a lump-sum sale. With this method the buyer pays a fixed price for cutting rights to the whole block, regardless of what he harvests from it. A deposit level and payment schedule was put in place which recognised that the buyers were likely to be smaller operators. When marketing the stand, Woodmetrics produced a prospectus for the market which incorporated the stand description data collected in the MARVL survey. The Woodmetrics Prospectus is a document which is effectively the conditions of tender, incorporating the MARVL data to assist bidders.

When the stand went on the market there was a good response, with several interested parties visiting the site. Most proceeded to bore a large sample of trees to test for sapwood depth. Immediate feedback came in from buyers looking at the stand. There was an acknowledgement that this was a relatively large resource of wood which was going onto the market as

one parcel. This appealed to buyers who were used to surviving on a resource usually consisting of small numbers of trees on a haphazard supply basis. On the negative side, there were questions about the wood characteristics, especially the ratio of white sapwood to usable heartwood. These buyers were used to dealing with larger-diameter trees and older age-class trees. They perceived risk in dealing with an unknown log product, especially as they were incurring the risk themselves. Boring gave some indication of sapwood depth, but sawmillers had difficulty extrapolating this into a board recovery percentage for logs of the relevant diameter.

In response to this feedback, which appeared likely to materially affect the bidding process, it was decided to carry out a mill study of a sample of logs. It was agreed with one of the potential bidders that one truckload would be harvested and delivered free of charge. This buyer would then saw the logs in a mill study and supply the board recovery data to Woodmetrics who would make it available to other bidders. This was to be done in conjunction with Forest Research who had an interest in extending their knowledge of blackwood processing.

A sample of 12 blackwood logs was sawn to indicate potential output from the stand. These showed that output from logs in the 20–30 cm sed range provided little clear wood recovery, the only grade recognised by the main blackwood processor. Conversion of seven logs with an average sed of 403 mm and an average length of 4 m had an average conversion of 34%, ranging from 29% to 40%, depending on sed. The sawing of one group of logs was terminated because of tension and poor grade recovery. Heartwood volume averaged 67%, but ranged from 52% to 98%.

Sawing summary

Although not conducted as a full research trial, the sawing evaluation of a sample of logs from the stand provided an interesting insight into sawing smaller-diameter logs (200–300 mm sed). The sawn output from logs of this size 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. The small sample of larger-diameter logs sawn (400–500 mm sed) showed that logs of this size produce a higher percentage of acceptable timber.

An interesting outcome of this sawing exercise was the lack of grades recognised by the processor. Because of the nature of their main market, they were recognising only one grade, clear on two faces, with a minimum length of 80 cm. All other grades were rejects. The business logic for this is real but unfortunate for the blackwood industry.

Under this scenario, small logs are very marginal in terms of sawn outputs and returns. Hence the processor was interested only in larger logs. This is unfortunate

and reflects a market immaturity that does not recognise other potential markets for clear-cutting material. This outcome from the pilot study was the spur for Ian Nicholas to apply to the NZIF for a travel award to evaluate blackwood marketing in Australia and New Zealand (Nicholas pp. 21–26 this volume).

In the days leading up to bid-close there was an unusually high level of communication, with frequent questions and requests for further information, when compared to a standard *Pinus radiata* sale of this size. This indicated to Woodmetrics a level of insecurity among bidders involved in the process. Bidders indicated they were not sufficiently familiar with either the bidding process or the type of log, which was outside their usual parameters. On the day of bid-close three bids were submitted. A wide spread of bids was received, possibly reflecting the issues discussed surrounding the process and resource. The seller was very happy with the highest bid and this was accepted.

Conclusion

The current method of selling blackwood in New Zealand is flawed in that risks are not shared appropriately. The sale process described in this paper tried to address the inadequacies in the market by using a competitive stumpage tender process to extract a fair price from the market. From the sellers perspective this was achieved. However, the process exposed difficulties as bidders were unfamiliar with the process

as well as the unknown qualities of the wood. The stand characteristics were also less than perfect, reflecting a lack of management. The process did not prove a perfect solution to the problem of establishing a fair market price for this species.

The competitive stumpage tender process does, however, provide an option for the future when more larger managed stands come on the market. As the scale of the industry increases, it might be expected that the level of buyer understanding of the product will increase accordingly. It could also be expected that the tools to better understand and describe the wood properties in standing trees will be refined. At this time, competitive stumpage tendering could be a useful option to consider when selling larger contiguous managed stands.

Acknowledgements

The significant input and sharing of data by Ian Nicholas in preparing this paper is appreciated.

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Session 2: Marketing and Investment

Paper 10

Tropical Acacias: An Expanding Market for Solid Wood^a

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STEPHEN MIDGLEY is Director of Salwood Asia Pacific Pty Ltd which offers a professional commitment to partnerships between Asian and Australian forest industries and organisations through services relating to the commercial use of Australian trees, forest industries and rural development. He has spent 32 y on projects with Asian partners and 13 y living in Laos, Nepal, Sri Lanka and China. He was Program Leader, Tree Improvement and Genetic Resources, with CSIRO Forestry and Forest Products.

Abstract

Tropical ‘Australian’ acacias now form part of a rapidly expanding plantation estate, particularly in SE Asia. Part of this estate is being managed for solid-wood products. The timber is competitively priced and is being converted into ‘acacia’ furniture that is sold in western as well as domestic markets. This paper summarises the current position of this tropical acacia solid-wood industry, with particular reference to Indonesia, Malaysia and Vietnam.

Introduction

The genus *Acacia* consists of about 1300 species in three subgenera: *Acacia*, *Aculeiferum* and *Phyllodineae*. About 1000 species of *Acacia* (almost all in subgenus *Phyllodineae*) are native to Australia and neighbouring Indonesia, Papua New Guinea (PNG) and some Pacific Island nations. As over 95% of these species are endemic to Australia, they are referred to collectively as ‘Australian acacias’ (Midgley and Turnbull 2003). Some of the tropical Australian acacias are now used in commercial plantations in SE Asia and have created the basis for substantial plantation-based industries. Within this region, plantations of tropical acacias have been established in China, Malaysia, Indonesia, Papua New Guinea, the Philippines, Thailand, Vietnam, and in Melville Island in Australia. The total area planted exceeds 1.5 Mha (Table 1).

Most of these estates are used as feedstock for kraft pulp mills. However, substantial quantities of wood are now finding their way into markets based on high-value solid timber.

This switch in focus has much to do with the demand for plantation-grown wood which can meet the certification requirements of furniture industries in Europe and North America, the reduced availability of logs from native forests in the countries listed in Table 1, and the suitability of these *Acacia* species for plywood, furniture, flooring and light construction.

This paper summarises the current selection and management of this solid-wood resource, and then considers the emerging markets that are beginning to buy and process quite large quantities of tropical acacia logs as well as dried and sawn timber.

Species selection and silviculture

Three tropical acacia species, *Acacia auriculiformis*, *A. crassicaarpa* and *A. mangium* and a hybrid *A. auriculiformis* × *A. mangium* (referred to as *Acacia* hybrid) are the focus of the current planting programmes. The predominant species planted to date has been *A. mangium*. The largest plantation estate is in western Indonesia, where 1.2 Mha of acacias, mostly *A. mangium*, are planted as exotics, mainly in Sumatra

Table 1. The tropical *Acacia* plantation estate in round figures

Country	Area ('000 ha)
Australia	10
Brazil	40
China	40
India	30
Indonesia	1200
Malaysia	200
Papua New Guinea	10
Vietnam	300–400

^a In the absence of Stephen Midgley, this paper was presented to the Workshop by Chris Beadle

and Kalimantan. Large estates of *A. mangium* have also been established in Malaysia and new plantings are in progress.

In these environments *A. mangium* is fast-growing. In Indonesia, a rotation length of around 10 y for solid-wood products is, on average, expected to produce a total stem volume of at least 200 m³ ha⁻¹: minimum tree diameter at breast height will be 30 cm and about 30% of the wood harvested will be for solid wood (Fig. 1, Hardyanto 2006).

In Vietnam, the total size of the plantation estate based on acacias is smaller, probably 0.3–0.4 Mha. Current plantings are dominated by *Acacia* hybrid; by the end of 2004 this species accounted for 127 kha: in 2004, 46 kha of the hybrid were planted though the other species referred to above continue to be planted as well (van Bueren 2005). The intention is to establish 1.2 Mha of plantation in Vietnam specifically for furniture and special products by 2010 (van Bueren 2005). Current planting rates suggest that a large proportion of this resource will be based on acacias. The performance of these acacia species varies with the quality of the planting stock, silviculture, site quality and environment (C. Harwood, CSIRO-ensis, *pers. comm.*, April 2006). All species are harvested to some extent for solid wood. *Acacia* hybrid is the most popular species for planting because the best selected hybrid clones have been shown to have marked heterosis for growth in many regions of Vietnam (Kha 2001).

To date, silvicultural inputs into acacia plantations managed for solid wood have not included pruning and thinning though the potential of these practices for a species like *A. mangium* has been recognised for some time (Srivastava 1993). Unlike *Acacia melanoxylon*, these tropical species have some apical dominance. However, variable numbers of individuals become multi-stemmed at the base after planting, and their conversion to single stems is routinely undertaken at age 4–6 mo. Persistent branches have led to the development of lift-pruning regimes with the intention of converting the bottom log to clear or knot-free wood (Mead and Speechly 1991; Weinland and Zuhaidi 1991). Form pruning that removes large branches and branches forming an acute angle with the stem has been shown to significantly improve form (Table 2, Beadle 2006). These pruning practices are now being introduced to the estates being developed in Indonesia and Vietnam. As the plantations are established at around 1000 stems ha⁻¹, thinning is also required (Fig. 1). It is anticipated that final-crop stocking will be around 300 stems ha⁻¹ for crops being harvested when tree dbhob is 30 cm (Beadle 2006).



Figure 1. A 10-y-old-thinned stand of *Acacia mangium* in Merbau, South Sumatra. Average dbhob, height and total stem volume were 36.6 cm, 26 m and 228.7 m³ ha⁻¹ respectively (after Hardyanto 2006).

Timber processing and markets

One Indonesian-owned company growing *A. mangium* in South Sumatra (PT Musi Hutan Persada (MHP)) is committing up to about 10% or 30 000 ha of its concession area to solid-timber production (E. Hardyanto, PT MHP, *pers. comm.*, November 2004).

MHP's current potential for solid-wood production from *A. mangium* is about 165 000 m³ y⁻¹ (Arisman and Hardyanto 2006). The timber is of medium density (420–483 kg m⁻³) and dries without serious defects with an appropriate kiln schedule (Abdul-Kader and Sahri 1993). The wood is also stable, with shrinkage from fresh to air-dry of around 6.4% tangentially and 2.7% radially, and fibre that is relatively straight and only in certain cases is found to have interlocked grain (Yamamoto 1998). The timber attracts a competitive export price (US\$100 m⁻³ FOB of dried, quarter-sawn boards; E. Hardyanto, South Sumatra, *pers. comm.*, 2004). The wood is used for finger-jointing. In

Table 2. Fraction of assessed trees by kink class between 0–3 m height, 18 mo after pruning at a plantation in South Sumatra. The class codes for kink were (1) no kinks, (2) slight kinks, (3) stem deviation stays within the centre line, (4) stem deviates outside the centre line. The trees had been lift-pruned to about 1.5 m or form pruned to a height of 3 m. Note that >80% of the trees were in classes 1 and 2 following form pruning.

Pruning treatment	Fraction of trees by class code (%)			
	1	2	3	4
Control	25.0	36.2	19.4	19.4
Lift pruned to ≤1.5 m	25.0	36.1	13.9	25.0
Form pruned to 3 m	55.6	27.8	8.3	8.3

domestic markets the wood is used for furniture and other appearance-grade products.

A large market for acacia wood is developing in Vietnam. In 2005, the value of exported finished wood products from Vietnam was around US\$1.5 B, more than all of Australia's exports of wood and wood products, and apparently growing rapidly (Fig. 2).

However, 80% of the raw material is currently imported sawlogs, including *A. mangium* logs of Malaysian origin. While most acacias grown in Vietnam are still used for woodchips, there is an attractive market for small sawlogs that services an expanding wood-based furniture industry.

These sawlogs are small by Australian standards, rarely exceeding 30 cm dbhob and as small as 10 cm small-end diameter (sed). The type of piece sizes produced from small logs is illustrated in Figure 3.

The prices received at the mill gate for acacia logs are quite variable (Table 3). In 2003, prices were US\$35–80 m⁻³. At one mill, a premium was paid for larger logs. The price being offered for acacia pulp wood during the same period was US\$14–26 m⁻³. Imported logs of *A. mangium* from Malaysia were being landed at the port near Ho Chi Minh City (Saigon) for about US\$85 m⁻³ — the top end of the price range being offered for local logs at the mill gate.

As noted above, Malaysia has a long history of planting *A. mangium* (Pinyopusarek 1993) and is currently a major exporter of acacia wood. Several companies actively export both logs and sawn timber that has been processed to a greater or lesser extent. For example, log prices were around \$50 m⁻³ and finger-jointed timber \$900 m⁻³ FOB in 2005 (Table 4).

Manufactured products

Acacia indoor and outdoor furniture is produced in Indonesia, Malaysia and Vietnam and sold in Europe (particularly Germany, the United Kingdom and Sweden) and the United States. It is positioned in the market as having the same characteristics as teak but is more competitively priced. A substantial number of acacia furniture manufacturers also provide certified products. According to Vietnamese furniture companies, about 20% of all contracts signed in 2003 required certification (Williams 2005). Williams' study found that companies with certification and eco-labelling could differentiate their products more easily, an important marketing strategy in a competitive environment. A growing number of overseas buyers, especially from Europe, were requesting certified and eco-friendly products.

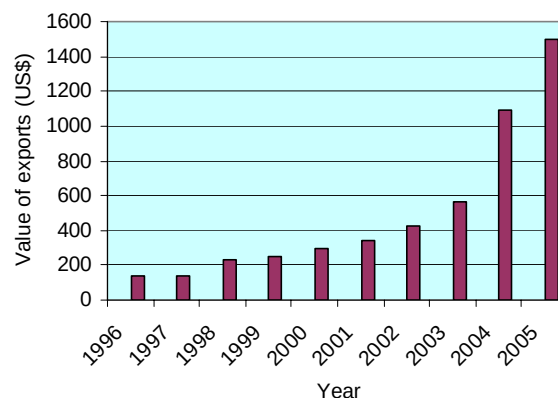


Figure 2. Vietnam's wood-product exports for the period 1996–2005. Note the rapid increase in the last two years. In 2005, 80% of this production was supported by imported logs, including *Acacia mangium*.



Figure 3. An example of small piece sizes (400 mm × 75 mm × 25 mm) that have been sawn from small logs (about 15 cm sed) of *Acacia* hybrid and *A. auriculiformis* at a mill near Dong Hoi in central Vietnam. The price per cubic metre green was about US\$175. The market is the local furniture industry.

Table 3. Some examples of prices paid for acacia logs in Vietnam and used as solid timber for furniture. The data were provided mainly by provincial forestry officials but were largely corroborated in the field.

Date	Site	Product	Price (US\$ m ⁻³)
Apr 2003	Quang Tri	At farm gate: about 30 cm dbhob	43
Sep 2003	Hue	At mill gate: 15–20 cm sed	38
Sep 2003	Hue	At mill gate: 20–30 cm sed	45
Sep 2003	Hue	At mill gate: >30 cm sed	52
Sep 2003	Ho Chi Minh City	At mill gate: 20 cm sed	80
Sep 2003	My Xuyen (near Hue)	At mill gate: >20 cm sed	35–40
Sep 2003	Hue City factories	At mill gate: >20 cm sed	45–58

Table 4. Some examples of the marketing of ‘acacia’ wood in Malaysia in 2005. Prices are per cubic metre unless otherwise stated.

Company	Product	Capacity (per month)	Price (US\$ FOB)
High Quality Wood Sdn Bhd	Logs >20 cm sed	3000–6000 m ³	52
	KD S4S lumber	10–50 containers	450–480
	KD tiles	10–20 containers	490
	KD finger-jointed laminated T&G timber	5–20 containers	900
Dagangan Hdn	Sawn timber in various lengths to 1 m		250
Amazon Timber Sdb Bhd	Air-dried sawn timber 2" × 3" to 2 m length		230 t ⁻¹

Rubberwood markets influence those for tropical acacia wood

Large increases in international oil prices to >US\$70 per barrel have boosted prices for synthetic rubber. This, in turn, has fostered price increases and volatility in international markets for natural rubber latex. From lows of US\$520 t⁻¹ in 1991 and US\$600 t⁻¹ in 2001, the price of natural rubber latex now is around US\$2000 t⁻¹.

Rubber growers are unwilling to cut rubber trees while rubber latex prices are high, and this has resulted in a tightening of supply, making rubberwood furniture manufacturing costlier. The international trade in processed rubberwood has been estimated to exceed US\$8 B. Malaysia's interests in rubberwood furniture alone are substantial; exports of processed rubberwood exceeded US\$1.2 B in 2005. In response to recent log shortages and the need to support local rubberwood industries, the Malaysian Government instigated a ban on the exports of rubberwood logs in late 2005.

In 2000, the price for sawn rubberwood timber was just over US\$200 t⁻¹. According to the Malaysian Timber Industry Board, the price has been averaging about US\$342 t⁻¹ in 2006. In September 2004, the price for rubberwood logs of sawlog quality was US\$75–85 m⁻³

ex log yard, similar to that in October 2005 (US\$95–100 m⁻³), but by April 2006 the price had reached US\$160–175 m⁻³ (ITTO 2006).

It appears likely that rubberwood supplies will remain tight and that the furniture industries based on this resource will seek substitutes. Plantation-grown acacias are an obvious choice, having good wood properties and being in plentiful supply, as well as being competitively priced.

Are hybrid products possible?

Anecdotal evidence from the industry in SE Asia suggests that some manufacturers are using acacia in the interior of their teak furniture because acacia and teak have similar characteristics and because acacia costs less. Similar opportunities may be available for processors of temperate acacias.

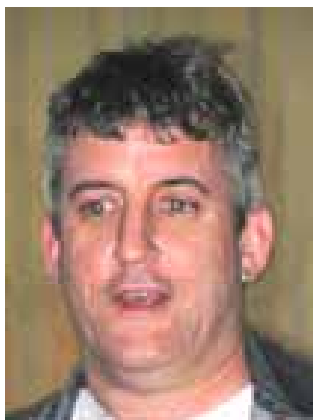
Conclusion

Acacia timber is being grown and processed on our doorstep. The volumes being produced are large by Australian standards. Substantial and increasing volumes are being sawn and converted into furniture. The extent to which such products might compete with products made from blackwood, and indeed other acacias from the southern distribution in countries like Australia and New Zealand, remains unclear. The levels of price competition that countries like Indonesia and Vietnam can mount in western markets does suggest that blackwood growers and processors target their products towards high-value niche markets.

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Session 2: Marketing and Investment Paper 11

The Use of Blackwood in the Australian Guitar-Making Industry

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PATRICK EVANS first became involved with the manufacture of musical instruments — banjos, mandolins, dulcimers and guitars — working for Doole Custom Industries in Geelong in the early 1980s. This was also his first exposure to the potential for incorporating Australian timbers into musical instruments. He then worked in music retail for seven years, though keeping his hand in by building custom-made instruments and doing repairs. He joined Maton Guitars in 1993 and has worked in most areas there, becoming Manager, Production and Projects, in 2003. All his learning has been on the job.

persistence of Murray Kidman of Colac, who has been cutting timber for musical instrument makers since the early 1980s. He remains Maton's major supplier of blackwood. Because of Murray's involvement, Otway's blackwood is used almost exclusively by the company. Black wattle from old trees has also been used, but there have been major problems bending the wood and it was found to be less complex harmonically than blackwood.

Abstract

Australian timbers have been incorporated into hand-crafted guitars since Maton Guitars was formed 60 y ago. It is only since the early 1990s, however, that these timbers have been taken seriously as tonewoods. This paper explores how blackwood has contributed to this new development in the guitar industry, the potential problems that must be overcome, and the status of blackwood's acceptance in the market.

Background

Maton has been using Australian timbers in its large range of hand-crafted guitars since the company was formed in 1946. It is only in the last 15 y, however, that the mainstream market has taken Australian timbers seriously as tonewoods. Blackwood has played an important role in this rise in acceptance.

Probably the three most important Australian timbers for instrument makers in Australia in times gone by were Queensland walnut (*Endiandra palmerstonii*), Queensland maple (*Flindersia brayleyana*) and silver silkwood (*Flindersia acuminata*), the last two being used for electric guitars. Blackwood was used by independent luthiers (e.g. Peter Coombes and Ray Black) for many years, but did not really have much of a presence at Maton till the early 1990s with the birth of the 'Australian' series of guitars (Fig. 1).

The level of importance that blackwood has achieved in the guitar industry is largely due to the passion and



Figure 1. A 2006 example of the 'Australian' series of guitars, featuring blackwood

Blackwood as a tonewood

A tonewood is any timber that has a resonance making it suitable for a musical instrument. Tonally blackwood possesses a rich and powerful lower mid-range which contributes overall to a warm, dark tone. This contrasts with the drier, crisper tones that are realised if Queensland maple or mahogany is used. As a tonewood, blackwood sits somewhere between the fullness of rosewood and the brightness of mahogany. An unexpected bonus is the contribution blackwood makes to tone when used as a neck. A blackwood neck will consistently provide greater volume and clarity than either Queensland maple or mahogany. Maton guitars are looking to further develop this attribute of blackwood.

The company also uses blackwood as a laminate top on carved and semi-hollow electric guitars. This laminate adds upper partial harmonic frequencies to string vibrations, adding sparkle to the sound. It is in this capacity that fiddleback blackwood becomes an extremely important part of the process of guitar-making.

There is a great degree of interest overseas in the incorporation of blackwood into Maton guitars. Unfortunately this interest is restricted to figured timber only, an attitude that is derived from the close similarity of blackwood to Hawaiian koa. Our professional view is that the plain, straight-grained blackwood sounds better but the market just happens to be hooked on figure.

Issues

Drying blackwood presents a serious issue for the company. When Maton receives its timber it is saturated, and a period of more than three months is often required to reduce the moisture content to the 6% desired. The timber is used after being re-hydrated to 8% moisture content and settled in a manufacturing environment of 50% relative humidity. A second issue is the wear and tear that blackwood causes on tungsten carbide cutters: the wood very quickly blunts the cutters, leaving a burnt finish which can be very difficult to 'sand out'. Third, sap or dust from the wood is potentially strongly allergenic to staff, so particular attention to workplace cleanliness and ventilation is necessary.

Current position of blackwood

Maton currently uses blackwood on less than 30% of its guitars, but it is nevertheless one of our strongest selling points. Total wood consumption is less than $20 \text{ m}^3 \text{ y}^{-1}$. The company makes about 6500 guitars every year, so blackwood ends up in about 2000.

Maton remains committed to continuing and expanding the use of blackwood; it is replacing Queensland maple, supplies of which have diminished greatly. Personally, I consider that it is probably my favourite tonewood. It may not appear to be amazing at first but it is refined and beautiful — endlessly fascinating in both sound and appearance.



Session 2: Marketing and Investment

Paper 12

Making Private Forests a Business

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ROB DE FÉGELY was Principal at Pöyry Forest Industry in Melbourne and has extensive practical and consulting experience in plantation development, log price reviews, market analyses, feasibility studies and strategic planning. He has undertaken forest industry projects in all states of Australia, North and South-East Asia and in North America. Rob has a sound understanding of the critical challenges facing the Australian forest and wood products industry and has provided advice to industry and government at both the state and national level.

Abstract

Private forestry has never been mainstream in Australia, and this is basically due to the dominance of the public sector and the lack of market transparency and the fragmented nature of the private forest resource. This paper reviews some of the factors that have caused private forest owners to play a secondary role in providing resources to industry. Based on a project in Queensland called Agforests, the author identifies four main problems facing private forest growers. The first is the lack of unity which makes it hard for industry to secure supply in the same cost-efficient manner it does from the public sector. Secondly, for private growers the issue of marketing has been a problem, and particularly the lack of transparency in log markets and prices. Thirdly, providing good management information is critically important to allow industry or a grower group to harmonise the supply with the market demand. Finally the image of the industry is not good, and while difficult for small growers to change it is a responsibility for all members of the industry to ensure the environmental benefits of forests are understood and accepted by the community.

Introduction

Private forests¹ and private native forests in particular have traditionally played a very secondary role to publicly-owned resources in the supply of forest

products to industry. Too often private forests are harvested opportunistically, are often under-priced and unfortunately undervalued by both government and industry.

Despite the considerable debate and pressure on the sustainable supply from public forests, it is very disappointing that such little consideration has been given to the alternative supply potential from private sources. Too often the forest industry receives compensation for resources lost from public forests without any sensible consideration of alternative supply options from private forests.

The continual pressure to reduce the harvest in public native forests, combined with a slow-down in the expansion of long-rotation plantations, is making the goal of supplying future demand from our own resources harder to achieve. The long-term demand in Australia for sawlogs and specialty timbers continues to grow, and if not addressed it will continue to be supplied by imports.

Over the last 25 years the author has viewed with interest the development of private forestry and the general lack of acceptance of the private resource within the mainstream industry. Unfortunately it has been, and still is, difficult to compete with the 'one-stop shop' service of the government forest agencies. However, there are increasing opportunities for private forests in today's market.

A project in Queensland called AgForests is seeking to develop stronger and more formal links between private growers and industry. AgForests is developing a framework for the sustainable management of private native forests and combines the interests of both industry and landowners through their main industry associations, which are respectively Timber Queensland and Agforce.

This paper will explore some of the factors that have caused private forests to play such a secondary role, and how private growers can attempt to improve their prospects. In simple terms, to make private forests a better business, a number of critical issues must be addressed:

1. Unity
2. Marketing
3. Management of the investment
4. Image.

¹ Private forests in the context of this paper refers to non-industrial private growers

Unity

Private forest growers tend to be enthusiastic individuals who know and understand their forests, but their forests are generally small operations and in isolation they cannot provide a continuous supply for a processing facility. To be of value to the industry, log supply needs to be sustainable in terms of volume and quality. This means that forest owners need to work together to satisfy these criteria.

One of the characteristics of private owners is that they tend to be fiercely independent, and consequently working with other growers can be difficult. Cooperatives can provide a structure for working together, but most landowners — possibly with good reason — view these suspiciously. A review of private forest organisations in the Agforests project suggested that a co-op would not be a successful solution in Queensland.

Alternatively, industry can undertake the collation of private resources, and this option could work. However, growers will need to accept that they are potentially giving away some of their individual value to make the collective work. Hence, a sense of realism on the part of landowners is important, and they need to understand that their resource is only as good as the industry's capacity to pay. Growers also need to accept that industry is not the enemy — they both need each other.

Good forest production information is vital for private growers. For forest growers to have any real opportunity to optimise their returns, they must know what the supply potential of their forest is, and realise that there is no need for this to be kept as a trade secret! Reliable forecasts of supply from private forests allow existing and potential industry to consider such supplies in the context of the market, other supply options and industry processing capacity.

Grower unity, like industry unity, has real benefits and brings leverage and a degree of market power.

Marketing

Access to markets has often been a problem for private growers, and there are too few success stories. Understanding the markets and how to access them is a vital step in securing the financial success of private forests. Australia is littered with examples of 'plant now and hope the market will come'!

One of the great disappointments in the forest industry is the lack of transparency in log and product prices. Unlike most other agricultural commodities where prices are publicly available, discovering the current price for various forest products ranges from difficult to almost impossible. There is no recognised forum for the average investor to review prices of log products. The ANU Market Report prepared by U.N. Bhati attempts to address this lack of knowledge, but even these data are incomplete.

For industry, the prospect of harmonising the supply from growers who have varying resources and objectives has usually been viewed as 'just too hard', particularly when public-sector agencies arrange the supply for them and increasingly deliver to their mill door. However, with the decreasing supply from public sources there is an opportunity to find a solution. The solution may be in the form of agents, co-ops or even industry-based options contracts. To make the business pay for private growers, this problem needs to be overcome. Forest processing is a supply-driven business, and future certainty is very important.

The lack of uniformity of log grades continues to be one of Australian forestry's biggest marketing problems — it affects pricing and confounds market knowledge. A consistent approach to log grading is urgently required.

The lack of pricing information and a poor understanding of the end markets can reduce both the industry's capacity to pay and the price paid to growers. Understanding the market and how it works is an extremely valuable investment for any grower, as the gains can be significant. It is not always a case of the grower versus the sawmiller. In the case of specialty products, it is sensible if the grower and sawmiller work together to extract the value from the end markets. For instance, following the signing of the Regional Forest Agreement on the NSW north coast in 1997, the price of brush box flooring rose dramatically from around \$1100 m⁻³ to around \$2300 m⁻³ in 2001. The current price is around \$2500 m⁻³, and scarcity will keep this price high. Many Australian hardwoods are scarce in national and international terms.

It is expected that the hardwoods in the Queensland AgForests project such as spotted gum and ironbarks, with high strength and excellent durability, will follow a similar trend.

Similarly, the stumpage for hardwood pulpwood from plantations has risen from expectations of around \$15 m⁻³ in the early 1990s² to close to \$40 m⁻³ in 2006. However, in the same period the export price for hardwood chips has been flat or declining in real terms.

Certification and branding are also becoming increasingly important. The two systems available in Australia are run by the Australian Forestry Standard and the Forest Stewardship Council. However, I would caution small growers on hastening into certification — it has advantages, but will not provide any market premiums and should be viewed as a last step rather than a first step.

Management of the investment

Too often private forests and particularly plantations are developed with initial enthusiasm which wanes over time. One can speculate that this is because investors view factors other than the plantation, e.g. tax

² The hardwood pulpwood supply in Australia in the early 1990s was nearly all from natural forest — this figure was a projection.

deductions, as the initiative to invest. In the case of private natural forests, it is often a case of not being able to see the wood for the trees. Many landowners don't know what they have in timber value.

Management of the resource over time for all its values — environmental, economic and social — is extremely important, but often the landowner or the investor are not in the best position to understand or provide this. Securing this management can be expensive but is important.

Gaining practical and cost-efficient information on silviculture has not always been easy for private growers, and this obviously affects how the resource is treated over time.

Continual investment in research and development is important, and there is currently a proposal before the industry for growers to pay a levy of 5 cents m⁻³ to the Forest and Wood Products Research and Development Corporation (FWPRDC). I urge you to support this. There is also a proposal to convert the FWPRDC to an industry-based corporation to allow it to undertake marketing and promotion, and I urge you to support this as well.

In terms of management, the most critical aspect is a good management information system — how much wood, and of what quality, do you expect to produce over time? This is one of the first questions you will be asked by industry if you are trying to market your resource.

Image

The community image of the forest industry is not good, despite the great environmental benefits of growing trees and using wood products, especially when compared to energy-hungry alternatives such as aluminum, steel and concrete. There is a strong disconnection by the end-product consumers, who love wood and buy forest products, and their understanding of where and how it gets to them.

Images of mass forest destruction seem to appear in the community's mind when forestry is mentioned, and the words clearfall logging, old-growth destruction and

woodchip exports are brought into the conversation.

The industry has continually and steadfastly defended its actions on the basis of science. This is logical and morally correct, but unfortunately the battle is a political one, mainly due to the role of government in the industry. Politics works, and even thrives, on perception. So, unfortunately, it is the battle for the community's perception that the industry needs to win, not the science. Change the community's perception and the political battle is won.

Promoting plantations at the expense of natural forest is not the answer, because the management of forests is a continuum from natural to planted and native to exotic — there are no boundaries, just different management requirements. This continuum is well illustrated in Figure 1, which was developed by Dr Sadanandan Nambiar of CSIRO.

Summary

The reasons why private forest has not been a great business can be summarised as follows:

- Competing with governments is tough, particularly on supply continuity and pricing.
- Private forest owners often lack unity in supplying, and funds to manage, promote and present their resource to industry, and they find it very difficult to 'see' the market in terms of prices.
- In natural forests, the landowners often do not understand the value of what they have and lack knowledge on how to manage it optimally.
- There are too few success stories to give the industry critical mass.

However, the supply dynamics have changed and hardwoods, particularly those with special qualities like blackwood, should enjoy a very positive future if the industry participants are prepared to work together, manage the resource professionally, market their product and promote their industry.

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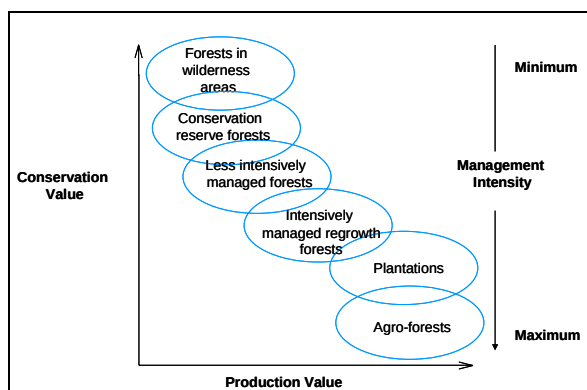


Figure 1. Forest, plantation and agro-forest estates — relative value and management as a continuum (Nambiar 1996)



Session 2: Marketing and Investment Paper 13

Barriers to Investment in Blackwood Forestry

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Abstract

Blackwood (*Acacia melanoxylon*) is a species with significant appeal given its esteemed timber value in Australia for more than a century. A variety of plantation trials have attempted to replicate natural forest conditions in order to positively influence blackwood growth and form. However, the conundrum remains of how to grow straight tall specimens in planted systems. Premium sites and intensive silviculture are required to achieve 6-m sawlogs in 35-y rotations.

The keys to successful long-term forestry investments are low establishment costs, low risk of failure, low management costs, high returns, stable markets, a viable resource and strong R&D support. Blackwood currently rates poorly against all these criteria except stable markets. In a real economic comparison with a 2006 Woollybutt Pty Ltd shining gum plantation in West Gippsland, it was concluded that blackwood was not a viable alternative. Its 24% higher establishment costs, 18% higher management costs and its inability to produce commercial thinnings contributed to this conclusion. Blackwood logs would need to achieve a stumpage of \$580 m⁻³ at current prices to compete with shining gum on the same site. This price is about nine times higher than the current government royalty paid for blackwood logs in Victoria. Blackwood is therefore a species with limited commercial plantation investment potential in Australia.

Introduction

As blackwood (*Acacia melanoxylon*) is a difficult species to grow commercially, questions remain about its suitability for forestry investment. Generally, large-scale forest investments are designed around species with large market potential and desirable growth characteristics. Blackwood, in contrast, is a species with a small fraction of the timber market, given that its end use is primarily in feature products such as furniture. It is also a species requiring premium site conditions to achieve a commercial size. It is often used in riparian zones where high moisture and fertility enable it to grow to such a size. It also has a high value in erosion control.

The question of whether blackwood has a place in commercial forestry investments in Australia is worth further consideration. In recent years, various forestry and investment companies in Australia have explored investment opportunities in longer-rotation specialty species. Species such as teak (*Tectona grandis*), red mahogany (*Eucalyptus pellita*) and southern silky oak (*Grevillea robusta*) are currently offered to the general public with Australian Tax Office product rulings. The success of these investments, or their attractiveness to the public, is yet to be evaluated.

Background to blackwood plantation forestry

Blackwood has been grown in commercial plantations for a relatively short time in Australia, the earliest trial plantations being established in the 1970s and 1980s — although this has also been the case for many indigenous hardwood species as native forest utilisation has decreased. Internationally, blackwood plantations have had a longer history, having been tested in commercial trials as far back as 1891 in South Africa. On a world scale, to date, blackwood has not been successful as a broad-scale commercial plantation species. In New Zealand, Nicholas and Brown (2002) estimated that about 3000 ha of blackwood may exist in plantations. In Australia, the area of blackwood plantations is unknown, but is unlikely to exceed that

in New Zealand. Trials have historically found mixed results in blackwood growth and form, which have led to a low-key quest to discover the secret(s) that might improve its performance in plantations.

A common frustration with blackwood is the observation of tall, straight specimens in wet sclerophyll forest areas of south-eastern Australia. In a plantation environment, this growth is difficult to replicate. Over the years, a variety of ad hoc trials (both published and unpublished) have been undertaken to unlock the mystery of blackwood growth (Nicholas and Gifford 1989; Medhurst *et al.* 2003; Pinkard 2003; Jackson *et al.* 2004). Genetics, site selection and an array of nurse crops have all been investigated with no clear answers to solving the conundrum of how to grow straight, tall trees. In a native forest environment, a complex arrangement of staged competition and light competition from the overstorey produces the best trees.

Work by Nicholas and Brown (2002) has provided a silvicultural formula to successfully grow plantation blackwood in New Zealand. This formula, however, relies on a number of years of intensive pruning to guarantee 200 6-m logs ha⁻¹ over a period of about 35–40 y on suitable sites.

The keys to successful long-term forestry investments

Forestry, like any investment, requires a number of key attributes to ensure a successful venture. These requirements are:

1. **Low establishment costs.** Money spent early in the investment will affect the returns considerably. In a forestry sense, this means that species with fast initial growth (less chance of browsing damage or weed competition) and low initial maintenance costs are more attractive for investment. The requirement for high-quality land is also a significant establishment cost if it is to be acquired specifically for the forestry investment.
2. **Low risk of failure.** On any given site, species that reduce the risk of failure from frost, browsing, wind throw, disease, insect attack or drought are more attractive for investment.
3. **Low management costs.** Some species are more difficult to manage than others given their propensity to require expenditure on specialist advice, particularly in the fields of nutrition, pests and diseases. This is often the result of limited research on particular species.
4. **High returns.** In a forestry sense, this is particularly important where intensive management costs or long rotations are required. Returns will also be reduced if high extraction costs are encountered. This can often be the case for species that prefer high-rainfall or riparian sites.

5. **Stable markets.** Species that are tried and proven in the market place are more secure investments. In many cases, plantation-grown species require their own market testing, since wood densities, timber stresses and colours are often different to those of native forest resources.
6. **Viable resource.** Species with highly specific site requirements are often found only in very small, fragmented plantations. Without a viable resource, markets are often difficult to find in local areas. This, in turn, forces a higher extraction cost to deliver the logs (or processed wood) to markets. Species that are easy to grow and have adaptability to a range of sites (particularly those that do not compete for the best land) have a better chance of being used to establish a viable resource.
7. **Support from research and development.** Although few investments will ever proceed without some component of research and development (R&D), it is the ongoing commitment to R&D that often precipitates investment uptake. Species with low R&D support are difficult to sell because of the unknowns in their growth and management, in addition to the difficulty of accurately assessing economic returns.

Commercial blackwood establishment and management techniques used by Woollybutt Pty Ltd

Commercially in Australia, blackwood requires the very best sites, which combine high rainfall (>1000 mm y⁻¹ is regarded as the threshold by Woollybutt Pty Ltd unless riparian areas are considered), deep and well-drained soils and freedom from moderate frost and exposure to wind.

Blackwood requires intensive management almost from the moment it is established. Seedlings are highly palatable to stock, vermin and marsupials and therefore require thorough browsing control to ensure survival. Blackwood also struggles to grow beyond (dominate) grass competition in the first 2 y. Therefore, a sequence of herbicide applications is required to allow competition-free growth in the initial years.

Intense silviculture is required to manipulate the form of blackwood in plantations. Form pruning is often required four to six times (annually from age 2 y) in the early years of growth. This task is difficult to outsource commercially as it involves complicated decision-making that is beyond the capacity of some contractors, and is difficult to price on a per-hectare basis. When outsourced, this operation is usually 60% more expensive than form pruning of eucalypts. Lift pruning (stem pruning) is also required, but this is less complicated and a standard three-lift system (with the standard accompanying costs) generally applies.

Assessing blackwood as a long-term forestry investment

Blackwood rates poorly against the first three key requirements for successful long-term forestry investments. It is a species with high costs of establishment due to the additional browsing control, weed control and form pruning required. It is also a high-risk species when compared to alternatives such as shining gum (*Eucalyptus nitens*) which can generally be planted on sites of similar quality in Victoria and Tasmania. Furthermore, blackwood incurs high management costs because so little is understood about its growth and management in comparison to mainstream species.

On the contrary, in terms of high returns and stable markets, blackwood rates very well. Blackwood yields a valuable timber that has enjoyed a steady niche market for more than a hundred years. Blackwood timber also enjoys international recognition and has been tested in New Zealand markets from plantation material. It is not a difficult species to 'sell' to potential investors in terms of timber value.

Blackwood, because of its site requirements, has an extremely limited ability to develop as a species that can be part of a viable plantation resource in Australia. It is more likely to be planted by hobby growers in small, isolated plantations around the southern and mountain areas of Victoria and Tasmania. Markets for blackwood are therefore likely to remain small and fragmented.

Research and development is severely lacking for most long-rotation hardwood plantation investments in Australia. Blackwood is certainly no exception, although management and silvicultural guidelines have been developed for this species in recent years (Nicholas and Brown 2002; Pinkard and Beadle 2002). Further R&D gaps remain in the areas of nutrition, insect and disease management, herbicide application and techniques for browsing control.

Economic facts and figures: a case study

It is difficult to assess (with any accuracy) the economic returns for commercially-grown blackwood investments. Existing markets in Victoria and Tasmania purchase logs according to native forest royalties (although some tendering has commenced in recent years), which are incompatible with the returns that could be demanded for pruned plantation resources. In saying this, however, a comparison can be undertaken between blackwood and alternative forestry investments to ascertain the likely value of blackwood logs needed to make the species a competitive alternative. For the sake of this report, a comparison will be made against a real shining gum plantation to be established by Woollybutt in 2006.

The property is located in West Gippsland with average rainfall of 1100 mm y⁻¹, deep, well-drained soil and a low incidence of frost. The property is about 350 m above sea level and the proposed site is well sheltered from strong winds. The native vegetation is predominantly mountain ash (*Eucalyptus regnans*). The main species recommended for the site is shining gum (*E. nitens*), which is to be grown over 25 y yielding two commercial thinnings for predominantly pulpwood and a clearfall for predominantly sawlogs. The proposed plantation has a net area of 15 ha and an estimated average growth rate of 30 m³ ha⁻¹ y⁻¹ over the life of the plantation³.

An economic analysis was completed on the proposed plantation prior to establishment. This assessment used current prices for all management and silvicultural costs (Woollybutt known rates) and ignored inflation and taxation. No land costs or carbon credits were included in the assessment. All stumpages⁴ were based on prices currently available to Woollybutt for plantation-grown shining gum in central and south Gippsland (Table 1).

The analysis on this plantation investment concluded that an internal rate of return of 10.5% would be achievable, based on the conditions listed above.

To assess the economic performance of blackwood on the same site the general assumptions ignoring land costs, inflation, taxation and carbon credits would remain. However, the establishment costs would be 24% higher to allow for additional browsing control, higher stocking and additional weed control. Silvicultural costs would also increase by 18% to allow for additional form pruning requirements⁵.

Using these figures and growth data from Nicholas and Brown (2002), it is likely that a successful blackwood plantation would produce 300 m³ ha⁻¹ of high-value sawlogs in 35 y on the same site. To achieve an internal rate of return equivalent to that of shining gum, a stumpage of about \$580 m⁻³ would be required for the logs. This is about nine times higher than the current equivalent government stumpages paid for the highest grade native forest blackwood.

Table 1. Shining gum (*Eucalyptus nitens*) stumpages

Product	Stumpage (\$ m ⁻³)
Pruned sawlog	62
Unpruned sawlog	39
Pulpwood	22

³ Growth rates are based on rainfall, soil pit analysis and known shining gum data relevant to the site.

⁴ Stumpage is the net value of the log. It is equivalent to the mill door price minus harvesting and haulage costs.

⁵ Each of these price increases is based on actual rates charged to growers who invest in blackwood.

Conclusion

Blackwood is a species with limited plantation investment potential in south-eastern Australia. Its slow growth, demand for premium sites and requirements for intensive management provide a poor return in comparison to alternative mainstream hardwood species that are considered of low risk. As an indigenous specialty timber its quality is unmatched, but blackwood could not be considered for forestry investment based on economics alone. Where erosion or riparian values are considered, the species will always have a role in small-scale plantings.

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Session 3: Advances in Silviculture

Paper 14

Blackwood Plantation Silviculture: Progress or Procrastination?

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IAN NICHOLAS has been involved in research at the Forest Research Institute (now Scion) since 1975 on species identification and evaluation for specialist uses. He has managed the Special Purpose Species Programme, with responsibility for research on eucalypts, acacias, walnuts, cypresses and paulownia. His work has included their establishment, genetics, silviculture and health. He is a foundation member and currently editor of *AMIGO*, **Acacia Melanoxylon Interest Group Organisation**, a New Zealand Farm Forestry Association Action Group, and a founding member of the BIG (Blackwood Industry Group) committee, formed in 1996.

Abstract

Australia and New Zealand have both developed expertise in blackwood (*Acacia melanoxylon*) management. Blackwood is an exotic crop in New Zealand, while the Australian expertise in native forest management is well documented and unique to that country. This paper looks at blackwood plantation silviculture and how the knowledge is being applied across the two countries. Where relevant, information from other blackwood-growing countries, especially South Africa, is also included.

It is suggested that the silvicultural objective for growing blackwood in plantations be to ***produce a quality log that will sustain a blackwood industry.***

Australia and New Zealand have applied their plantation silvicultural knowledge in different directions. Australia is still considering growing blackwood in mixtures, whereas New Zealand has left this practice behind and concentrates on pure plantations with intensive silviculture, especially form pruning. The acceptance in New Zealand of form pruning and thinning-to-waste has led to a large number of small-scale, well-managed stands being established throughout the country. In Australia, the focus on commercial nurse crops has resulted in very few examples of well-managed pure-species stands.

Both countries have initiated genetics trials to test a range of seedlots. However, these trials have not been well monitored or much reported in the literature. Although Victoria has an excellent series of trials, they

appear to have been neglected in recent years. New work in Tasmania could see valuable new information coming on-stream in a few years.

The development of silvicultural regimes for pure-species plantations is more advanced in New Zealand, where a series of regime trials and active permanent-sample-plot measurements are providing a strong data base. To help develop a better profile for well-managed blackwood stands in Australia, New Zealand and other blackwood-growing countries, it is recommended that an international series of best-practice trials be initiated under the auspices of BIG to provide a demonstration of the best international knowledge on growing blackwood as a plantation timber tree.

Background

Blackwood plantation silviculture: progress or procrastination? To set the scene for this session on silviculture, this paper provides some personal observations on blackwood-plantation silviculture, with an emphasis on plantations in New Zealand and Australia. The silviculture applied to native forests has been left out of this discussion because it is uniquely Australian by definition. Some excellent research, based near Smithton in north-western Tasmania, has been developed by Jennings (1991) of Forestry Tasmania. Forestry Tasmania has also developed a management system to produce quality blackwood logs (Jennings and Dawson 2001; Jennings 2004).

Knowledge of blackwood plantation silviculture is also available from other countries such as South Africa (de Zwaan 1982; Geldenhuys 2004), while new reports from Chile (Pinilla *et al.* 2004) and China (Fanqui *et al.* 2004) demonstrate an interest in blackwood in these countries. China now has a resource of 15 000 ha established (Z. Fanqui, Guangdong Academy of Forestry Research, *pers. comm.* 2005), and it is likely that more information will emerge from this program.

Several Australian authors have provided summaries on blackwood silviculture: Allen (1992), Neilsen and Brown (1997), Brown (2001) and perhaps the most comprehensive on silviculture, Pinkard and Beadle (2002), while the most detailed on growing blackwood in New Zealand is a bulletin by Nicholas and Brown (2002).

Blackwood silviculture

Where are Australia and New Zealand with their level of knowledge on the silviculture of blackwood? Let us assume that the silvicultural objective is to **produce a quality log that will sustain a blackwood industry**. This statement implies that the wood quality will be sufficient for the desired end-use and that the land manager's objectives will be met. These objectives could be economic, environmental or aesthetic. If we accept the objective, the following are some of the main issues to address before we can achieve it.

Establishment

This is certainly one of the major issues in Australia, as young blackwood requires protection from native wildlife. This requires fenced coupes in areas adjacent to native vegetation, or expensive individual-tree protection. Considerable effort has identified a number of advanced systems for doing this. New Zealand does not have the same problems, although damage from rabbits and hares can be severe. Most establishment research in New Zealand has focused on fertiliser application (Knight 1986; Fairweather and McNeil 1997). Nicholas and Gifford (1989) have examined the effects of seedling size on after-planting performance.

Genetics

Both Australia and New Zealand have initiated blackwood genetics trials, but little work has been conducted on them in recent years. Victoria has an excellent series of trials established in both the west and north-east of the state (Stackpole 2001; Jackson *et al.* 2004), but follow-up research appears to be slow. Trials newly established by Dr John Goy of Gippsland, Victoria, are the most comprehensive yet in Australia. A new PhD study by Gordon Bradbury in Tasmania will now provide some insight into the performance of the Tasmanian trials. The development of clonal material initially selected on the basis of good form and wood properties in New Zealand has not shown immediate benefits for form: the issue of wood properties requires further investigation (I. Brown, AMIGO, *pers. comm.* 2006).

Form

New Zealand has been very active in overcoming poor form of plantation blackwood through form pruning while the butt log develops (Barton 1993; Nicholas *et al.* 1994; Nicholas and Gifford 1995; Brown 1997,

2001; Nicholas *et al.* 2001; Nicholas and Brown 2002). The success of branch-gauge pruning has been demonstrated in New Zealand: the average butt-log length from 304 18-y-old trees thinned in New Zealand regime trials was 5.6 m (Nicholas *et al.* pp. 14–20 this volume).

The Australians have used some of these principles to demonstrate the success of form pruning. Examples are the blackwood stand at Lardner Park in Gippsland and on some sites in Tasmania (A. Warner, Private Forests Tasmania, *pers. comm.* 2001). However, Australians appear to still consider that such intensive effort is not warranted and too expensive for managing blackwood, although Swanson (2001) has recommended the use of careful pruning techniques.

Mixtures

Planting blackwood in mixtures can improve blackwood form (Nicholas 1982), but the stands must be well managed. Many forest managers have adopted species mixtures in an attempt to solve the form problems of blackwood (Nicholas and Steward 2004). While these mixtures have little or no support as a silvicultural system in New Zealand (Nicholas and Brown 2002), they are still favoured as an option in Australia. While this acceptance of mixed-species systems persists, support for planting blackwood in Australia could decline as failed and suppressed stands are considered a typical outcome. It is interesting that a failed mixture, but one resurrected just in time, the Abbotsham stand, is one most commonly reported in Tasmania. Does this mean there are no show-piece stands in Tasmania?

While considerable areas of mixed-species plantations with blackwood have been established and researched in Tasmania (Pinkard and Beadle 2001; Beadle *et al.* 2004; Pinkard *et al.* 2004), some researchers now admit that mixtures are not a preferred option. Despite this, literature produced by Private Forests Tasmania on growing blackwood still seems to give credibility to mixtures as a viable option for land owners (Private Forests Tasmania 2004), although correctly pointing out the pitfalls. Bird (2000) also suggests the use of mixtures. Some optimists still consider that a commercial forest crop can be grown as a mixture with blackwood in plantations, but a successful outcome remains to be demonstrated on any scale.

Economics

The future of blackwood as a commercial crop lies in its economic strength. Internal Rates of Return (IRR) have been quoted ranging from 5% to 9% (Cavanna and Glass 1985; Herbert 1994; Nicholas and Brown 2002; Maclaren 2005). The most recent analysis by Maclaren (2005) suggests an IRR of 7% for New Zealand conditions, but he reports that there is a lack of robust data on log grades. Nicholas and Brown (2002) suggest an IRR of 9–11%, although this does not

include land acquisition costs. Warner (2004) suggests that Tasmanian royalties would need to increase substantially to return 4%: he predicted that a stumpage of \$200 m⁻³ would generate an IRR of 5.5%. The current royalty system, with lower prices paid for blackwood logs in Tasmania (Foss 2004) compared to New Zealand (Nicholas and Brown 2002), severely handicaps any direct economic comparison between the countries.

Regimes

As stated above, most of the Australian documentation considers mixed stands as the standard regime: one of the most recent economic analyses was based on a mixed planting (Warner 2004). In contrast, the regimes in New Zealand focus on pure plantations with no nurse crop. Inherent in this philosophy is the need to combine form pruning with clearwood pruning. Reports from New Zealand, however, also mention the use of mixtures.

The latest reports on regimes in New Zealand (Nicholas and Brown 2002; Hay *et al.* 2005) differ slightly. In pure stands, Hay *et al.* (2005) suggest an initial stocking of 1111 stems ha⁻¹, and three thinnings down to 600, 400 and 200 stems ha⁻¹ at ages 6, 8 and 10 y, respectively. To provide more useful guidance, Hay *et al.* (2005) also suggest that thinning operations occur at mean stand heights of 8, 10 and 13 m. Nicholas and Brown (2002) suggest an initial stocking of 800 stems ha⁻¹ with two thinnings down to 400 and 200 stems ha⁻¹ at ages 7–8 y and by age 10 y, respectively. Both regimes recommend regular form pruning while the butt log is developed, and clearwood pruning, to produce a bole of about 6 m. Form pruning is based on an annual visit to remove branches larger than 30 mm measured with a gauge. For clearwood pruning, the recommendation is to leave 3 m of green crown at each lift. While the concern is that form pruning is expensive, the flip side is that subsequent clearwood pruning is much cheaper as all heavy branches have been removed during the form pruning. Rotation lengths in New Zealand are expected to be 35–40 y, depending on the site. Rotations in Australia are considered likely to be longer, 30–70 y, depending on site.

Final-crop stocking

Thoughts on blackwood final-crop stockings have evolved over the years. Nicholas (1988) suggested 100 stems ha⁻¹, but this has since been revised. Current thinking in New Zealand is that 200 stems ha⁻¹ is the preferred final crop stocking for a 35–40-y rotation (Nicholas and Gifford 2004). It is interesting to note that Jennings (1991) suggests that 200 stems ha⁻¹ reflects the natural stocking of blackwood in native stands. Trials in South Africa have suggested final-crop stockings of 300–400 stems ha⁻¹ (de Zwaan 1982), though 300 stems ha⁻¹ appears to be the current recommendation (Geldenhuys 2004).

Yields

The lack of mature well-managed plantations makes estimates of yield from blackwood difficult. Nicholas and Brown (2002) suggest that total stem yields at rotation will be about 500–550 m³ ha⁻¹, and that 300 m³ ha⁻¹ of this will be sawlog. This is 55% of total stem yield in sawlog and probably conservative. Nicholas *et al.* (pp. 80–86 this volume) suggest that the figure could be 60–66%. Warner (2004) estimated a total stem yield of about 260 m³ ha⁻¹, slightly more than the 215 m³ ha⁻¹ estimated by de Zwaan (1982).

Models

A prototype blackwood growth model has been developed in New Zealand, but is not yet in the public domain (Berrill *et al.* 2007.). Outputs from the model were used by Nicholas and Brown (2002) to help in the development of regimes. The Farm Forestry Tool Box developed by Private Forests Tasmania provides outputs that can help in developing regimes, tree volumes and silvicultural options (Warner 2004). The Tool Box uses both Tasmanian and New Zealand volume and taper equations, although the outputs from the New Zealand functions predict slightly lower volumes compared with the Tasmanian functions (A. Warner, Private Forests Tasmania, *pers. comm.* 2005). Sands (2004) outlined the opportunities for a physiological growth model for blackwood, but this model has not been further developed since his retirement (C. Beadle, CSIRO-Ensis, *pers. comm.* 2005).

Wood quality

The quality of wood of blackwood grown in plantations has been of concern in Tasmania. For many years New Zealand has used plantation blackwood, mostly from untended stands, with no indications that the material will be much different from that harvested from native forest in Australia. Detailed studies by Nicholas *et al.* (1994), Bradbury (2005) and Nicholas *et al.* (pp. 14–20 this volume) appear to confirm that material from plantations and natural forest is similar and that both systems have wide natural variation that overlaps for most wood characteristics. Manufacturers in New Zealand suggest that material from South Africa is not as good as Tasmanian or New Zealand blackwood. Wood from Tasmania has the best colour. Although some New Zealand material is comparable, the supply of such material is inconsistent (G. Benjamin, Everwood, *pers. comm.* 2005).

Regeneration

The management of plantations after harvesting raises several issues. Regeneration from root suckers or ground-stored seed will mean that unless a spraying operation is undertaken, there is little need for planting a new crop. Such regeneration becomes more of a problem, however, if improved genetic material is

available for planting. Conversion of regeneration into a commercial crop in New Zealand could well mimic the fenced regeneration systems currently being used in north-western Tasmania. South African regimes based on regeneration include early thinning to about 800 stems ha⁻¹ by the time saplings are 1.8 m tall, followed by periodic thinning to a final-crop stocking of 300 stems ha⁻¹ (Geldenhuys 2004).

Summary

The title of this paper is ‘Blackwood plantation silviculture: progress or procrastination?’ What is the answer to this question? I would suggest that there are areas of silviculture where more progress has been made in New Zealand than in Australia. However, both nations are guilty of procrastination in the sense that there has been very little large-scale investment in blackwood forestry in either country. Is this a lack of confidence in the species, a lack of confidence in the market, or just a lack of information? It is probably a combination of all three.

One major difference is that farm foresters in New Zealand have embraced blackwood forestry and are well on the way to developing a small well-managed resource, while the emphasis in Australia remains on managing native forest for blackwood values. Australians need to clarify their thinking on mixtures, and to be able to provide data on alternatives to nurse crops. New research in Tasmania looking at genetics and wood quality is a potentially significant activity that will benefit plantation silviculture.

The question of what happens to the blackwood industry in Australia if access to the native forest resource in Tasmania is lost does not seem to have been asked or treated seriously. Victoria lost access to its main native forest resource, the Otways, and now imports wood from Tasmania! A greater emphasis on plantation blackwood that is well managed would improve conversion rates, reduce the problem of shorts and offer an opportunity to market wood from plantations. Silvicultural knowledge and examples of well-managed stands in both Australia and New Zealand exist. The future lies in increasing investment in blackwood plantations. Would an international series of best-practice plantations assist this aim?

I suggest that an international series of best-practice trials be initiated under the auspices of BIG to provide a demonstration of the best international knowledge on growing blackwood as a plantation timber tree. This will help meet our objective to **produce a quality log that will sustain a blackwood industry** and demonstrate progress rather than procrastination.

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Session 3: Advances in Silviculture Paper 15

Approaches to Thinning in Naturally-Regenerated Blackwood–Eucalypt Stands

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SUE JENNINGS is a Technical Forester with Forestry Tasmania. She has spent most of the past 25 y based in the native forests of north-western Tasmania, working on blackwood and rainforest research. During this time, the fenced-intensive-blackwood program for regenerating young blackwood–eucalypt forests was pioneered and developed. Her research now focuses on stand management systems for these multi-species regrowth forests.

Abstract

Native blackwood–eucalypt forests in north-western Tasmania are managed for high quality timber. This is based on silvicultural systems that utilise ground-stored blackwood seed, large-scale disturbances to stimulate germination of this seed, and whole-coupe fencing to protect the seedlings. Good blackwood stem form is encouraged by the very high densities of naturally-occurring understorey species such as *Pomaderris apetala*. These regrowth forests also carry a young *Eucalyptus obliqua* overstorey. Research over the past 10 y has primarily focused on the light competition between the eucalypt overstorey, the blackwood understorey and the dense co-dominant *Pomaderris* vegetation, with the aim of developing a thinning regime which will produce both blackwood and eucalypt sawlogs. This paper describes the approaches being used to capture blackwood values in this forest type.

Introduction

Blackwood occurs in many vegetation types in Tasmania, but management for high-quality timber is concentrated on just two major types. In the swamps of north-western Tasmania, blackwood dominates the forest and grows with *Melaleuca* and *Leptospermum* species in younger even-aged forests, with an increasing component of rainforest species in older stands. About 5000 ha of this blackwood swamp forest is managed on a sustainable basis, with small areas harvested and returned to blackwood production on a planned 70-y rotation.

In the second type, blackwood-rich wet eucalypt forests are actively managed to **increase** the

blackwood sawlog resource. The blackwood commonly occurs as an understorey species with *Pomaderris apetala* in forests dominated by *Eucalyptus obliqua*. These forests are clearfelled, the resulting slash is burnt, and the cleared area enriched with sown eucalypt seed. The whole coupe is then fenced with wire netting to protect the naturally-regenerating blackwood seedlings from browsing. This practice is known as fenced-intensive-blackwood (FIB) and its silviculture forms the subject of this paper.

Managing the regenerated forest in FIB systems can be complicated because:

- Blackwood in native forest does not occur at a regular spacing, or with the relatively even spread that is observed with eucalypts following aerial sowing. Instead, the blackwood regenerates densely from ground-stored seed wherever it was present in the previous forest.
- FIB is undertaken in the context of a multi-species forest. The distribution of light throughout the canopy is an important consideration if blackwood of good form is to be produced. The way overstorey and understorey species are combined therefore becomes an important consideration in the way the stand is managed.

In these FIB forests, well-formed blackwood saplings are scattered sparsely or densely through the eucalypt regrowth overstorey and dense *Pomaderris* understorey. *Pomaderris apetala* grows to a natural height of 8–10 m and competes vigorously with the blackwood stems for light, encouraging rapid height growth of the blackwood and suppression of its lower branches, resulting in good stem form.

Current stand management research

Blackwood release

The first investigation of the effects of competition between the blackwood, eucalypts and *Pomaderris* was a release trial in a 6-y-old FIB coupe that had been established near Smithton in north-western Tasmania in 1989. In the trial area, the eucalypt component of the stand was killed by stem injection of herbicide (the 'No eucs' treatment). In addition, the dense sub-canopy (mainly *Pomaderris*) was removed mechanically in two gap treatments that were either 3.6 m in diameter ('Small gap') or 7.2 m in diameter ('Large gap'). There was also an untreated control. The results showed that both the eucalypt overstorey and the co-dominant *Pomaderris* significantly affected the diameter growth of the blackwood saplings.

During the 6 y following the release treatment, periodic annual increment (PAI) of blackwood stem diameter increased from 0.8 cm y⁻¹ in the untreated area to 1.4 cm y⁻¹ where the eucalypts only had been removed (Fig. 1). The additional removal of the *Pomaderris* increased the PAI of blackwood stem diameter to 1.6 cm y⁻¹ in the small gaps and 2.1 cm y⁻¹ in the larger gaps (Jennings *et al.* 2003).

In contrast to the first 6 y after treatment, over the following 3 y the PAI of blackwood stem diameter dropped to 0.75 cm y⁻¹ for the untreated trees and 1.0 cm y⁻¹, 1.0 cm y⁻¹ and 1.1 cm y⁻¹, respectively, for the release treatments. Removal of the *Pomaderris* improved blackwood diameter growth greatly in the short term, but the single biggest long-term improvement resulted from removal of the eucalypts.

In addition, the larger gap treatment produced heavier and broader blackwood crowns, increased branch size and retention (Fig. 2), and reduced the length of branch-free bole (Jennings *et al.* 2003). Maximum blackwood diameter and volume gains were therefore achieved at the expense of good tree form and future log quality.

Stand dynamics

During her Honours project with the University of Tasmania, Eyles (2004) investigated stand composition of the FIB stand that had been used for the Release Trial above and that was then 15 y of age. She compared the composition and size of the main species (including the *Pomaderris* component) with an adjacent but similar part of the same coupe where eucalypt seed had not been aerially sown.

Table 1 shows that the eucalypt stocking did not significantly affect the number of blackwood stems per hectare, although the blackwood growing in the regrowth without eucalypts were, on average, much larger in diameter (8.2 cm) than those with eucalypt cover (4.9 cm). The frequency of *Pomaderris* stems was significantly different with and without eucalypt

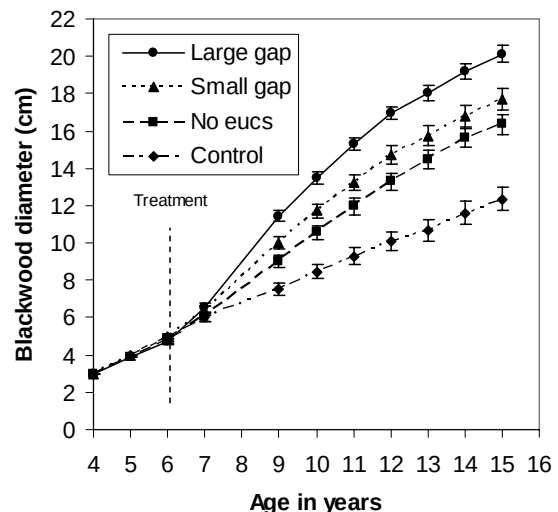


Figure 1. Mean diameter growth of blackwood stems for each treatment. Bars show standard error ($n = 27$ trees per treatment).

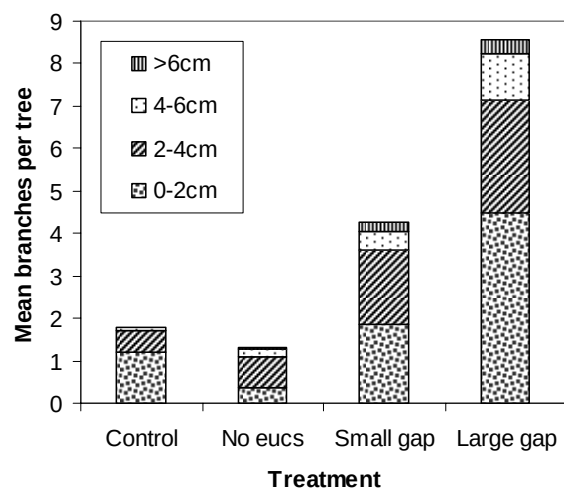


Figure 2. Mean number of branches in lowest 6 m of blackwood stems. Legend shows branch diameter classes ($n = 27$ trees per treatment)

cover, with many more, much smaller stems where eucalypt regrowth was present (Eyles 2004).

Table 2 shows the basal area per hectare of the three major species on the same plots. The blackwood basal area in the regrowth without eucalypts was three times that of those in the regrowth dominated by eucalypts. The *Pomaderris* basal area followed the same pattern, increasing by 66% in the regrowth without eucalypt treatment despite occurring on 33% fewer stems.

The mean height to the lowest green branch (an indicator of current potential sawlog height) for blackwood in the regrowth plots without eucalypts was almost double that of those in the regrowth plots with eucalypts (7.25 m and 4.58 m respectively) (Eyles 2004).

Table 1. Mean number of stems per hectare and diameter at breast height (dbh) for the three major species in a 15-y-old fenced-intensive-blackwood (FIB) coupe (± 1 SE) ($n = 3$ plots)

Stand type	Species		
	Eucalypt	Blackwood	<i>Pomaderris</i>
Regrowth with eucalypt			
Stems ha ⁻¹	2900 (± 872)	1370 (± 88)	42 630 (± 2674)
Dbh (cm)	11.6 (± 0.7)	4.9 (± 0.4)	1.4 (± 0.2)
Regrowth without eucalypt*			
Stems ha ⁻¹	100 (± 58)	1500 (± 252)	28 400 (± 1572)
Dbh (cm)	13.4 (± 4.2)	8.2 (± 0.3)	2.3 (± 0.2)

*These areas were accidentally missed in the aerial sowing operation, but a few eucalypts are present on the margins of the unsown areas.

Table 2. Mean basal area (m² ha⁻¹) for the three major species in a 15-y-old fenced-intensive-blackwood (FIB) coupe (± 1 SE) ($n = 3$ plots)

Stand component	Species		
	Eucalypt	Blackwood	<i>Pomaderris</i>
Regrowth with eucalypt	31 (± 5)	3 (± 1)	9 (± 2)
Regrowth without eucalypt	1 (± 1)	9 (± 2)	15 (± 2)

These results suggest that the ideal system for producing blackwood sawlogs with the best form, relatively quickly, would be to not sow the eucalypt component of the stand. There are, however, two important reasons why Forestry Tasmania (FT) chooses not to follow this option:

- Blackwood regeneration comes up only where there was blackwood in the previous forest. As FIB is established on high-quality soils at low altitudes and close to timber markets, FT cannot afford to have unstocked areas on these sites. The eucalypts are therefore sown as insurance against the variable distribution of blackwood seed.
- Forestry Tasmania has a commitment to regenerate native forests with species and provenances found in the area to maintain local gene pools and species mixes (AFS 2003).

Therefore, we expect the FIB regrowth to produce blackwood sawlog plus high-value eucalypt sawlog. Current research is aimed at determining the level of eucalypt retention that allows good blackwood growth but still produces a commercial eucalypt crop.

Pre-commercial thinning trial

Two levels of pre-commercial thinning (PCT) were applied to a 9-y-old FIB stand in north-western Tasmania. These were (1) the standard PCT prescription for highly-stocked young eucalypt stands that involved removal of 50% of the eucalypt basal area (Forestry Tasmania 2001) and (2) a heavier PCT treatment that removed 75% of the eucalypt basal area.

Retained trees were selected using standard criteria of form, size and spacing (Forestry Tasmania 2001) and the remainder thinned to waste using stem injection of Glyphosate. Responses to thinning by both eucalypt and blackwood were compared to that of an unthinned control.

Over the 5-y period following treatment, the mean annual diameter increments of the final eucalypt crop trees (the best 250 stems ha⁻¹) in the two PCT treatments (PCT50% — 1.2 cm y⁻¹; PCT75% — 1.15 cm y⁻¹) were almost twice that of a similar sample from the untreated area (0.65 cm y⁻¹) but were not significantly different from each other (LaSala and Jennings 2007).

Mean blackwood diameter growth over the same period in the PCT75% (0.83 cm y⁻¹) showed a significant increase of 42% over that of the control (0.58 cm y⁻¹), while the PCT 50% treatment (0.66 cm y⁻¹) was not significantly different (LaSala and Jennings 2007) (Fig. 3).

Thus heavier thinning (PCT75%) was required to increase blackwood diameter growth, but did not improve diameter growth of the eucalypt crop trees over that of the standard PCT50% treatment. Because the removal of more eucalypt trees provided no additional growth benefit to this species, productivity of the eucalypt stand (as indicated by eucalypt stand basal area) was reduced by the heavier treatment (Fig. 4).

The PCT 75% still retained >350 eucalypt stems ha⁻¹ at age 14 y (5 y after thinning). This is a stocking level that would benefit from future commercial thinning, and modelling showed that the minimum piece size for an economic return should be reached at age 28–30 y in this stand (LaSala and Jennings 2007).

However, experience of commercial thinning in blackwood plantation stands on state forest in Tasmania is not positive. The outcome in both a mixed eucalypt–blackwood plantation in the south-east of Tasmania and a mixed *Pinus radiata*–blackwood stand in the central north of the state was of unacceptable damage to the understorey blackwood stems during the thinning operation, followed by windthrow and bending of the retained blackwood stems.

We might avoid such a problem in FIB stands by getting blackwood to be a more significant component of the stand at an earlier age.

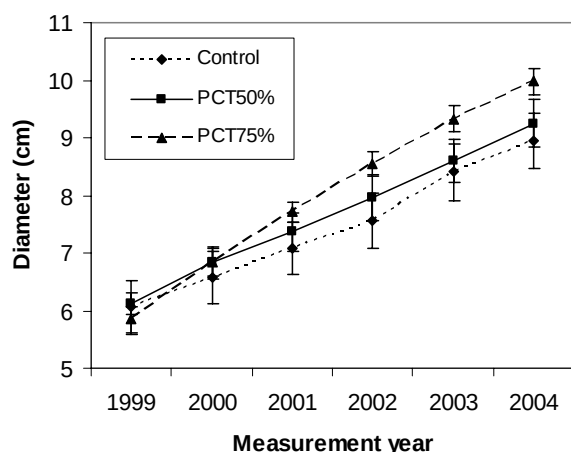


Figure 3. Mean blackwood diameter for the 5-y period after thinning. Bars show standard errors of the plot means ($n = 3$).

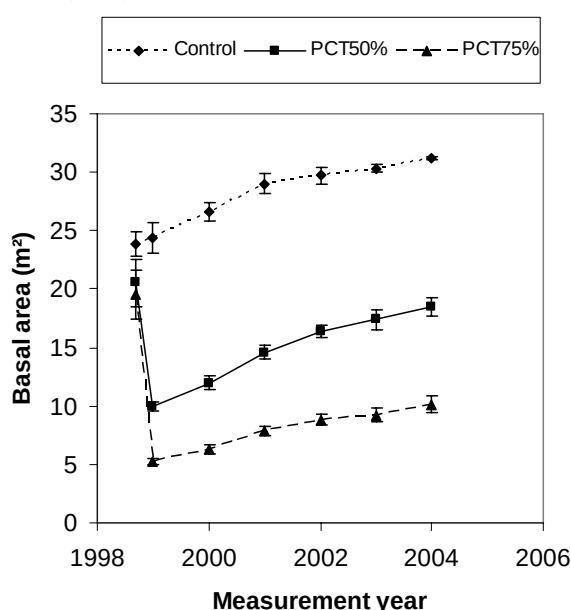


Figure 4. Mean eucalypt stand basal area for all treatments over the 5-y period after thinning. Bars show standard errors of the plot means ($n = 3$).

Heavier early thinning by stem injection of the dominant eucalypt layer should allow the blackwood saplings more light, resulting in better growth rates and sturdier trees, thus removing the requirement for a later commercial machine-thinning of the eucalypts.

Future approaches to stand management

In a small trial established in a 13-y-old stand in 2002 the eucalypts were thinned to 250 stems ha^{-1} (equivalent to 80% eucalypt basal area reduction in this stand). This retention rate is at the upper end of the range of final-crop stockings expected for eucalypts

after commercial thinning (Forestry Tasmania 2001). Data from this trial have not yet been analysed.

As this thinning level may still be too conservative for FIB stands, one further thinning trial is planned. The heaviest thinning is likely to be down to 100 retained eucalypt stems ha^{-1} , and for the first time competing blackwood will also be removed.

The timing of thinning in mixed blackwood stands as represented by FIB is important for several reasons:

- The earlier the blackwood saplings are released from competition, the less likely they are to be suppressed by the eucalypt overstorey.
- If the *Pomaderris* component of the stand is retained intact, it will continue to influence the blackwood stem form and improve sawlog length after eucalypt thinning.
- If blackwood is thinned, thinning should be delayed until the future form of the blackwood stems is apparent.
- Heavy thinning of the eucalypts reduces them to final crop stocking at a very early age. However, this thinning should occur only when crop trees can be chosen with confidence.

A compromise between the requirements of blackwood growth and eucalypt sawlog selection seems likely. Thinning of the eucalypts will probably take place somewhere between age 10 and 15 y. We hope to keep blackwood diameter growth rates above 0.8 cm y^{-1} after thinning, thereby producing sawlogs of 50 cm diameter in 60–65 y. Rotations of this length should also produce regrowth eucalypt sawlogs suitable for harvest.

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Session 3: Advances in Silviculture

Paper 16

Environmental Dynamics of Blackwood Regeneration in Regrowth Forest, NW Tasmania

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Abstract

This paper reports on the dynamics of the blackwood light environment in relation to early stand development in multi-species regrowth forest in NW Tasmania. Observations were made of the competitive light environment in a vigorous regenerative mix of three co-dominant tree species (including two species which are valuable cabinetwood species). The results provide useful new evidence of the environmental dynamics of these regrowth stands and of multi-species competitive effects in the internal light environment. Such relationships are found to be especially complex when more than two species with differing growth rates, growth habit and successional behaviour are involved.

The analysis shows that effective self-pruning in the lower bole of blackwood is achieved only through a marked reduction in direct and diffuse sunlight incident on the lower crown. This result also has implications for the improved design of mixed-species plantation nurse systems using these or functionally similar species.

Study site and stand history

The study site in NW Tasmania (40°55'S, 144°57'E) was described by Jennings *et al.* (2003). In the older of

the two stands (known as Compartment (Cpt) 21A), three silvicultural growth-release treatments (plus an untreated control) were applied in young regrowth *Eucalyptus/Acacia* forest on a 1.5 ha experimental site which was located within a 37 ha regrowth forest coupe (Fig. 1). During 1988–89, the sparsely stocked high forest was harvested by clearfelling and burned of debris. It was then regenerated by aerially sowing with additional *E. obliqua* of local provenance and fenced with wire netting (to preclude seedling injury and removal by browsing mammals). The second and neighbouring site known as Cpt 9E was similarly converted to fenced intensive blackwood (FIB) management in mixed-species regrowth forest established in 2000.

Analysis of light environment

The principal objective of the environmental analysis was to measure and compare conditions of irradiance in the respective subcanopies, following each of the silvicultural (small gap) release treatments (Fig. 2 and Table 1, after Jennings *et al.* 2003). Measurements were designed to quantify, at least in simple terms, the contrasts and comparisons in growth-related light environments within and beneath the *Eucalyptus/Acacia* regrowth canopies whose competitive growth responses were previously identified. Comparative light measurements were made at age 10.5 y, in randomly selected blocks (replicates) of the original control and small-gap treatments (Unwin *et al.* 2006).

Oft-repeated instantaneous measurements of irradiance were made externally in the open surrounds (taken to represent above-canopy external conditions), and within the mixed-species subcanopy and understorey (Fig. 3), during intervals of maximum insolation in early summer of 1999–2000, 4.5 y after the silvicultural treatments were applied at stand age 6 y.



Figure 1. Young regrowth *Eucalyptus obliqua* / *Acacia melanoxylon* forest, Coupe 21A, Togari, NW Tasmania, at age 10 y. Emergent eucalypts reach 14–15 m height, above the codominant blackwood at 10–11 m, and a continuous, dense subcanopy of the small tree *Pomaderris apetala* at 9–10 m height. (a) *Pomaderris* stems have been removed in the centre foreground to show the branch-free bole of young blackwood. Emergent *E. obliqua* appear on the skyline in the upper rear of the photograph. (b) Fisheye view of the dense subcanopy of *P. apetala* which surrounds a gap, 7.2 m in diameter, established to contain a single-tree replicate plot of *A. melanoxylon* (Treatment A).

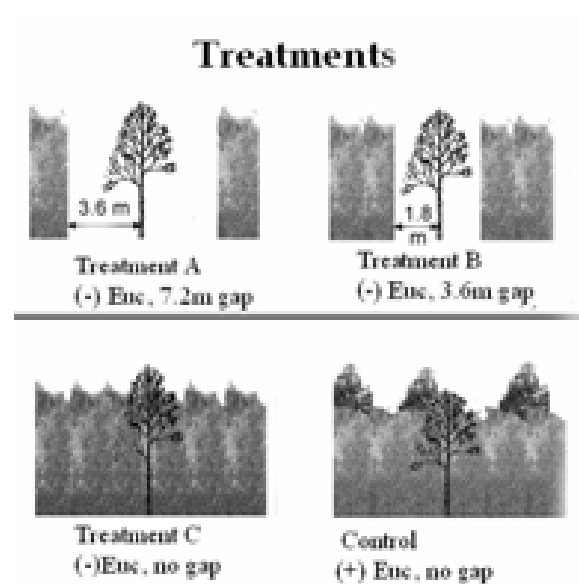


Figure 2. Schematic profiles of silvicultural treatments A, B and C and the Control, applied at age 6 y (after Jennings *et al.* 2003)

This response interval proved to be a critical period for inter-specific, competitive interactions which strongly influenced the structure, composition and future commercial value of the advancing mixed-species stand. For further details of sampling strategy and measurement of irradiance see Unwin *et al.* (2006).

Results

Young stand development

Both of the two adjoining stands achieved a high stocking of *E. obliqua* and *A. melanoxylon* regeneration. From the beginning, these codominant tree species were mixed with a very high density of naturally-regenerated seedlings of the small tree *Pomaderris apetala* and occasional, less frequent subcanopy species such as *Phebalium squameum*, *Leptospermum* spp. and other *Acacia* spp. (Fig. 1). In Cpt 21A, replicated plot samples indicated that at age 6 y, the average stem density of *E. obliqua* regeneration was 3500 stems ha⁻¹, with average height of the tallest eucalypts 10.5 m; blackwood (*A. melanoxylon*) 1100 stems ha⁻¹ with average height 5.4 m, with *Pomaderris apetala* estimated to be in the range of 20 000–>60 000 stems ha⁻¹ and average height about 5.0 m (Jennings *et al.* 2003).

Table 1. Summary of silvicultural treatments applied in the regrowth forest, Coupe 21A, Togari, NW Tas (adapted from Jennings *et al.* 2003)

Treatment	Emergent <i>Eucalyptus obliqua</i>	Subcanopy <i>Acacia melanoxylon</i>	Subcanopy <i>Pomaderris apetala</i>	No. of replicates	Equivalent treatment no. (Jennings <i>et al.</i> 2003)
A	Culled at age 6 y	Single tree plots	Gap cleared 7.2 m diameter	27	(4)
B	Culled at age 6 y	Single tree plots	Gap cleared 3.6 m diameter	27	(3)
C	Culled at age 6 y	Single tree plots	Retained, no gap	27	(2)
Control (D)	Retained intact	Single tree plots	Retained, no gap	27	(1)

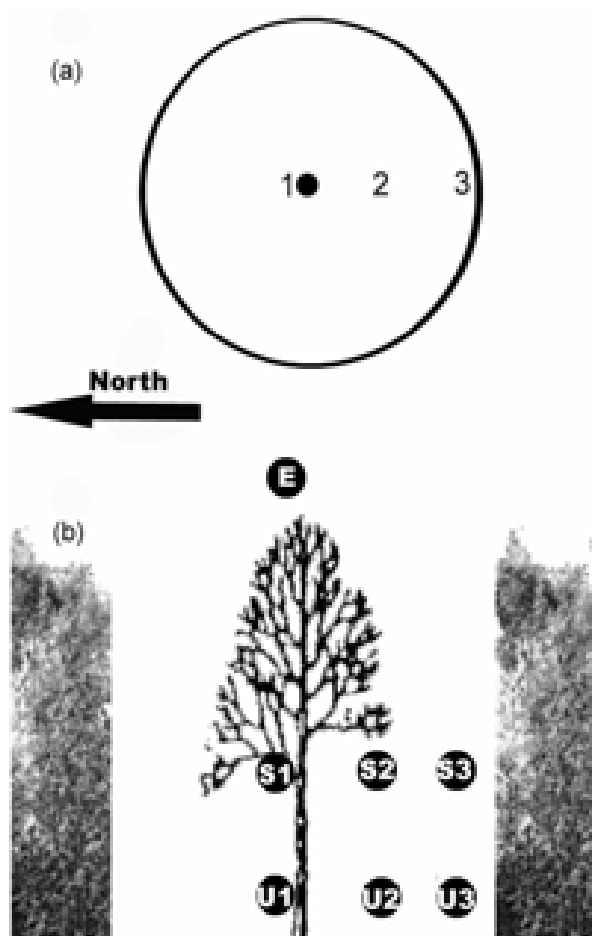


Figure 3. The plan view (a) and elevation (b) show locations of irradiance measures recorded in subcanopy positions S1–S3 at 4.0 m above ground, and understorey positions U1–U3 at 1.3 m above ground, for four replicates of each treatment and control. Sample positions S1 and U1 were located 0.1 m on the northern side of each blackwood stem (solid circle). S2 and U2 were located vertically beneath the average limit of crown projection on the southern side. S3 and U3 were located at the edge of the subcanopy gap on the southern side of blackwood stems in Treatments A and B, and at 1.8 m south of blackwood stems in Treatments C and the Control. Irradiance measures at external position E, above the canopy, were inferred using flux density values recorded at 1.3 m height above ground in open grassy conditions, at the centre of a large road intersection (30–50 m opening) adjacent to the regrowth forest coupe.

At age 15 y, a census of woody stems in $3 \times 100 \text{ m}^2$ sample plots of intact regrowth forest in Cpt 21A indicated average stem densities of 2900 stems ha^{-1} (*E. obliqua*) and 1370 stems ha^{-1} (*A. melanoxylon*) in the forest canopy, and 42 600 stems ha^{-1} of *P. apetala* in the dense, closed subcanopy (Eyles 2004).

During the first 5–10 y, early height growth of *Pomaderris* was comparable to that of young blackwood (*A. melanoxylon*), and both taxa were significantly overtopped by young *E. obliqua* (Fig. 1).

Accordingly, in the first 10–12 y of regeneration, the very dense stocking of *Pomaderris* effectively functioned as a ‘native nurse’ species, preventing the passage of direct sunlight (side-light) to virtually all mid- and lower crown portions of the young blackwood.

Subcanopy light environment

Analysis of the light environment showed evidence of inter-specific interaction of the codominant *A. melanoxylon* and the densely stocked native nurse species *P. apetala*, with and without the emergent eucalypts. In Table 2, mean irradiance values for each treatment and control are expressed in terms of fully sunlit, above-canopy flux of photosynthetically active radiation. For each sample position in the subcanopy (S1–S3) and understorey (U1–U3), mean values of irradiance are recorded as a fraction of recorded full-sun irradiance in corresponding open (above-canopy) conditions. Subcanopy and understorey irradiance was recorded only during intervals of maximum (full-sun) exposure of the canopy and during diffuse, fully clouded (6/8–8/8) overcast conditions, respectively. Values shown in brackets are Standard Error (S.E.) estimates of mean irradiance, quoted for $n = 25$ –70 measures at each sample position. All observations were recorded during 1100–1400 h standard time, on each of five cloud-free days during the period 18.11.99–8.12.99. Average external irradiance (quanta, PAR) for $n = 102$ measures made in open conditions during the several fully sunlit days of sampling was $1965 (\pm 35) \mu\text{mol m}^{-2} \text{s}^{-1}$. This peak mean value, recorded in wide-open conditions at a road intersection adjacent to the forest coupe, was taken as the summer benchmark for global (full-sun) irradiance above the adjoining regrowth canopy (position E in Fig. 3b).

Table 2. Above-canopy and subcanopy irradiance (PAR). The latter is expressed as a fraction of fully sunlit conditions above canopy. Average irradiance (PAR) above canopy in fully sunlit (FS) conditions = 1965 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (SE = 35.3); in overcast conditions = 873 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (17.9). Sample positions S are 4.0 m above ground, and positions U 1.3 m above ground. Shaded columns show irradiance values during overcast, diffuse external conditions, as a fraction of fully sunlit (FS) global denominator. SE = Standard Error of mean; sample size = *n*.

		Position in subcanopy (see Fig. 3 for diagram of location)					
		1		2		3	
		Full sun	Overcast	Full sun	Overcast	Full sun	Overcast
External irradiance: mean $\pm$ SE ($\mu\text{mol m}^{-2} \text{s}^{-1}$)		(1965 $\pm$ 35.3)	(873 $\pm$ 17.9)	(1965 $\pm$ 35.3)	(873 $\pm$ 17.9)	(1965 $\pm$ 35.3)	(873 $\pm$ 17.9)
Subcanopy treatment	Sample & ht (m)	(%FS, SE, <i>n</i>)	(%FS, SE, <i>n</i>)	(%FS, SE, <i>n</i>)	(%FS, SE, <i>n</i>)	(%FS, SE, <i>n</i>)	(%FS, SE, <i>n</i>)
A (7.2 m gap, euc. culled)	S 4	50.2 (6.3, 40)	7.8 (0.5, 40)	34.9 (3.7, 65)	6.8 (0.4, 40)	41.5 (4.3, 60)	5.0 (0.5, 45)
	U 1.3	53.0 (6.5, 51)	3.8 (0.2, 40)	24.1 (3.7, 70)	4.2 (0.4, 40)	14.5 (1.9, 70)	1.4 (0.1, 40)
B (3.6 m gap, euc. culled)	S 4	13 (1.7, 50)	2.5 (0.1, 30)	32.6 (5.9, 43)	2.9 (0.4, 30)	25.0 (3.5, 50)	3.0 (0.6, 30)
	U 1.3	8.4 (1.9, 60)	1.66 (0.10, 25)	24.6 (5.0, 50)	1.43 (0.14, 30)	18.4 (2.7, 62)	0.9 (0.04, 30)
C (No gap, euc. culled)	S 4	4.14 (0.40, 50)	0.88 (0.02, 40)	3.04 (0.39, 50)	0.99 (0.04, 40)	4.21 (0.37, 57)	1.11 (0.04, 40)
	U 1.3	3.61 (0.68, 40)	0.68 (0.02, 40)	3.01 (0.51, 45)	0.64 (0.02, 40)	1.71 (0.16, 44)	0.59 (0.04, 40)
D (Control; no gap, no culling)	S 4	9.55 (1.92, 60)	1.49 (0.08, 30)	3.77 (0.62, 45)	1.67 (0.08, 30)	4.17 (0.44, 56)	1.67 (0.09, 30)
	U 1.3	8.21 (1.54, 54)	0.98 (0.04, 30)	1.56 (0.16, 40)	0.81 (0.04, 30)	1.56 (0.22, 41)	0.87 (0.07, 30)

Minimal irradiance was observed within and beneath the dense subcanopy of the native nurse species (*Pomaderris apetala*) which closely surrounds young blackwood regeneration. Unlike current plantation nurse systems, the dense foliage of the native broadleaved *Pomaderris* all but eliminated direct side-light and low-angle illumination of the young blackwood from the beginning of tree establishment. The results demonstrated that retention of these densely-stocked native codominants effectively suppressed both size and frequency of blackwood branches on the lower bole, through effective and persistent interception of sunlight. Vigorous young blackwood crowns later overtopped the codominant nurse species, achieving a predictable length of branch-free bole.

Table 2 provides a broad overview of comparisons and contrasts in the competitive light environment for each treatment and control, at each subcanopy (S) and understorey (U) position, during full-sun vs. overcast (diffuse only) exposure of the canopy. As anticipated, there is a sharp decline in irradiance from canopy to subcanopy to understorey (as defined for this study) during fully-sunlit external conditions and during overcast (diffuse) conditions at comparable peak times of day and year. The most severe reduction (interception) of radiation in the canopy occurred during diffuse, overcast conditions when a mere 1.5–

1.7% of global (full-sun) irradiance was received in the subcanopy (S) of the intact control, reducing even further to 0.8–1.0% at the understorey height of 1.3 m above ground.

Culling of emergent young eucalypts only (Treatment C) showed small reductions in subcanopy and understorey irradiance 4.5 y after treatment. This muted response is attributed to partial release of the dense subcanopy of *Pomaderris*. Small-gap Treatments A and B showed a marked increase in subcanopy and understorey irradiance, over and above any hidden effects of eucalypt removal at age 6 y, recording mean values of 13–33% of full-sun irradiance across 3.6 m subcanopy gaps and 35–50% of full-sun irradiance across gaps 7.2 m in diameter. However, during overcast skylight conditions when canopy light attenuation was maximised, small-gap clearance provided only 2.5–3.0% and 5.0–7.8% of full-sun irradiance at subcanopy level across the gaps of 3.6 m and 7.2 m respectively.

Branch habit in relation to subcanopy light intensity

Branch size and frequency distributions in the lower 6 m bole of blackwood were seen as relevant indicators of current stem form and future merchantability (Jennings *et al.* 2003). In Figure 4, average aggregate branch sectional area for lower boles of young blackwood trees is plotted against corresponding mean values of peak summer irradiance (% of above-canopy, full-sun flux density). Irradiance values were averaged for the three subcanopy positions (S1–S3) for each treatment. The relationship confirms that effective restriction of branch size and branch density in the lower bole of blackwood is achieved only with a very marked reduction in direct sunlight to less than 10–15% of full sunlight incident on the lower crown.

Discussion

In terms of growth phenology and regenerative behaviour in native forests, blackwood may be described as a subcanopy opportunist. When grown in open conditions (with direct sunlight from the side and above), short stems and heavy lateral branches are produced to support a broad, low, umbrageous crown with minimal central axis and little or no merchantable bole (Brown 1997; Neilsen and Brown 1997; Unwin *et al.* 2001; Pinkard and Beadle 2002). By comparison, this study demonstrates that in native regrowth forests, side-light may be reduced to very low levels by dense foliage of competing canopy and subcanopy species and that direct sunlight is usually incident only from above. Results confirm that in this competitive environment the regrowth blackwood stem normally grows tall and straight to emerge above height-limited codominants, without persistence of lateral branches in

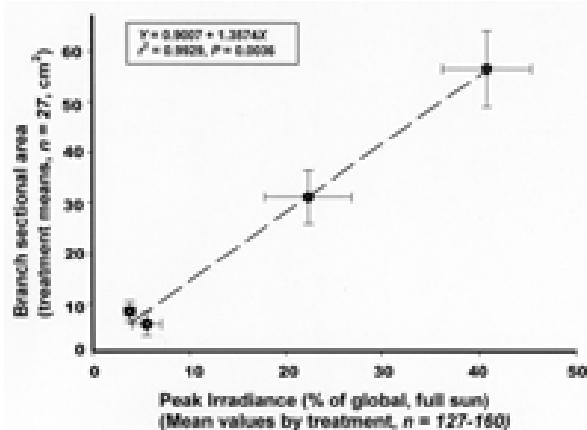


Figure 4. Mean branch sectional area on the lower 6.0 m bole of young blackwood trees (y-axis) in relation to peak photosynthetic irradiance recorded at 4.0 m height in the subcanopy, during conditions of maximum insolation (x-axis). Bars show S.E. of the mean values for each treatment, for both the dependent and independent variables. The simple linear regression model is shown in the box at upper left. A similar relationship was indicated for overcast, fully clouded conditions, excepting that peak irradiance values (on the x-axis) were reduced by about one order of magnitude.

the lower bole (see also Unwin *et al.* 2001; Jennings *et al.* 2003).

In the absence of direct side-light, the senescence of lower branches of blackwood (and *Pomaderris*) was rapid and the occlusion of dead branches was both prompt and effective (Jennings *et al.* 2003). The retention of the dense subcanopy of *Pomaderris* at age 6 y significantly increased the length of the branch-free bole of blackwood by age 10–12 y, compared to those blackwood trees where the densely-shading subcanopy of *Pomaderris* had been removed in small circular gaps (Treatments A and B). Conversely, the limited removal of *Pomaderris* in small gaps led to marked increases in stem diameter increment, and size and frequency of lower branches, in proportion to gap size, within the tested range of gap diameters, 3.6 m and 7.2 m (Jennings *et al.* 2003).

Removal of the young eucalypts (only) in Treatment C appears to favour added foliage development of, and hence light interception by, competing *Pomaderris*, thereby reducing branch retention in blackwood, in comparison to the Control.

The sampling strategy for light measurement was designed to capture the apparent contrasts and differences in irradiance with respect to subcanopy position and silvicultural treatment. This strategy also allowed for comparison of subcanopy conditions during intervals of maximum external irradiance versus fully clouded, overcast external conditions, at similar times of day near solar noon, within a three-week period in early summer. The results showed very low levels of irradiance within and beneath the forest subcanopy during overcast conditions, even during summer when solar angle and hence global insolation are maximised. Very low levels of irradiance within the forest subcanopy were accompanied by reduced variability and much-reduced contrasts among treatments (Table 2). Due to location and latitude, NW Tasmania is regularly exposed to prevailing moist westerly airflow from the Southern and Indian Oceans, and heavily overcast or wet conditions are common.

Even during fully sunlit external conditions, there was minimal irradiance within and beneath the dense subcanopy of the native small tree *P. apetala* (Table 2, Treatments C and D, Figs 1 and 4). During periods of peak insolation, only 3.8–4.2% of external irradiance was recorded in the small sunflecks and broad shade areas found beneath the emergent *E. obliqua* and the intact subcanopy of *Acacia* and *Pomaderris* (Table 2, Treatment D, positions S2 and S3). The sampling height of 4 m was located near the base of the green crown of blackwood and close to the point of active lower branch senescence among all treatments (Fig. 3).

Compared to the Control, the culling of the eucalypts only (Treatment C) resulted in further reductions in subcanopy and understorey light intensities, principally on the northern side of blackwood stems. Only in the enhanced light conditions recorded in the subcanopy

gaps was there sufficient irradiance to enable young blackwood to take maximum advantage of release from competing young eucalypts. Competition for light was therefore the over-riding limiting factor at this stage of blackwood development, even if culling of the young eucalypts resulted in some (untested and unobserved) benefits to nutrition and tree water relations.

Conclusion

This investigation provides functional insight into future directions and possibilities for mixed-species silviculture of regrowth *Eucalyptus/Acacia* forests of south-eastern Australia. The results also point to the likely complexity of multi-species interactions in growth and development of mixed-species plantation forests. The strong relationship observed between retention and size of blackwood branches in the lower bole and peak irradiance of the subcanopy is a case in point. Plantation nurse systems for blackwood will need to achieve at least 85–90% interception of maximum direct and diffuse sunlight if self-pruning in the lower bole is to emulate the effectiveness of the native broadleaved nurse system demonstrated here. In higher-intensity subcanopy light environments, there is an apparent trade-off between the observed stem diameter increase and hence early volume growth of young blackwood, and the associated increase in size and retention of lower branches (Jennings *et al.* 2003).

The above analysis of light environment suggests a suitable silvicultural strategy to overcome this problem. The native nurse species is capable of maintaining intense competition for sunlight from the very beginning of blackwood establishment. This should be seen as a priority during the first decade of growth. Based on demonstrated stem diameter responses to Treatment C (Jennings pp. 60–63 this volume), the early non-commercial culling of limited numbers (only) of nearby competing eucalypts at age 5–6 y is likely to provide significant added diameter increment on selected blackwood without jeopardising either the native nurse effect or the future stand densities of remaining eucalypts. Indeed, the native nurse species will be expected to maintain or even enhance the self-pruning benefit during critical early

years of blackwood crown and branch development. Silviculturally at least, it would appear both possible and practicable thereafter to rely on traditional tree selection and thinning practices to accelerate diameter growth in superior blackwood stems. Ideally this would occur just as the blackwood crowns overtop the native nurse species whose height is limited to about 10–12 m.

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Session 3: Advances in Silviculture

Paper 17

Silvicultural Management of Australian Blackwood (*Acacia melanoxylon*) in Plantations and Multi-Purpose Forests

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Abstract

Australian blackwood (*Acacia melanoxylon*) is arguably one of the most challenging, yet rewarding, tree species to grow for high-quality sawlogs. Inherent genetic variability in stem form and its susceptibility to exposure suggests that growers should consider high initial stocking rates from which to select trees of good form and vigour for pruning. Once established, the species does not self-thin well so, without intervention, stands can become overstocked resulting in very slow diameter increment.

Based on data from both native and planted forests of blackwood, this paper proposes the use of Reineke-style stand density diagrams as an aid to designing appropriate management regimes that reflect growers' particular interests. The ratio of diameter to basal area is then presented as a simple, practical, yet effective tool for guiding the thinning of blackwood plantations.

Introduction

Australian blackwood (*Acacia melanoxylon*) is a useful species for inclusion in multi-purpose forests on farms and a promising commercial timber. Its propensity to sucker from exposed roots and spread by seed makes it an ideal tree to grow along an eroding creek or unstable slope for soil conservation. The dense foliage offers refuge for small birds and can help shade creek lines, thereby improving their habitat value. As a timber species, its high value suggests that it could be viable to selectively harvest and market in small

volumes, thereby negating the need for invasive harvesting techniques. Regeneration from the stump or seed following harvesting can occur in relatively low-light conditions, leading to multi-aged, multi-value permanent forests.

Whilst multi-purpose forests strategically integrated in the agricultural landscape can be managed to produce commercial sawlogs, the mix of objectives and small scale mean that viable harvesting requires high individual log values to offset poor economies of scale. The most important factors that determine the standing value of blackwood sawlogs are likely to be tree diameter and knots. Nicholas and Brown (2002) recommend a target tree of 60 cm dbhob with a pruned butt log of 6 m. Because pruning is essentially a fixed cost per tree, the return on the investment is directly related to diameter increment and hence stocking rates. Being able to effectively manage the competition between trees is therefore critical to the viability of pruned sawlog management regimes.

Stocking rates from planting to final crop

Data from natural and planted stands of blackwood provide a basis for understanding how diameter growth is affected by competition in single-species stands. Jennings (1991) provides measurements of native stands of blackwood in Tasmania (Fig. 1). Adding data from measurements of plantations provides some indication of the position of the self-thinning curve for blackwood. As the stand approaches the self-thinning line, individuals must succumb in order for the mean diameter to increase. Jennings (1991) suggests that a basal area limit of $45 \text{ m}^2 \text{ ha}^{-1}$ may approximate the self-thinning line and provide a useful guide for stand management. Although basal area incorporates both stocking rate and tree diameter and can be quickly assessed before and after a thinning operation, it is worth reviewing its effectiveness as a thinning guide for blackwood forests.

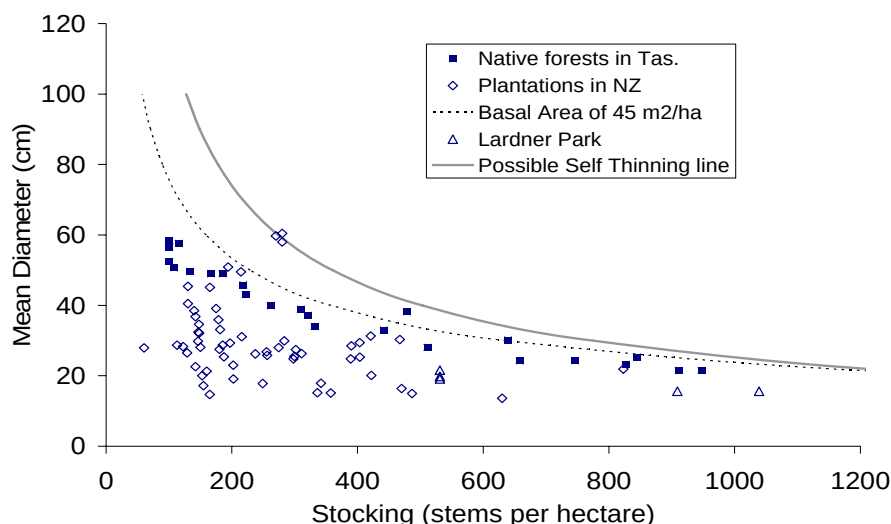


Figure 1. Measurements of both native and planted forests of blackwood

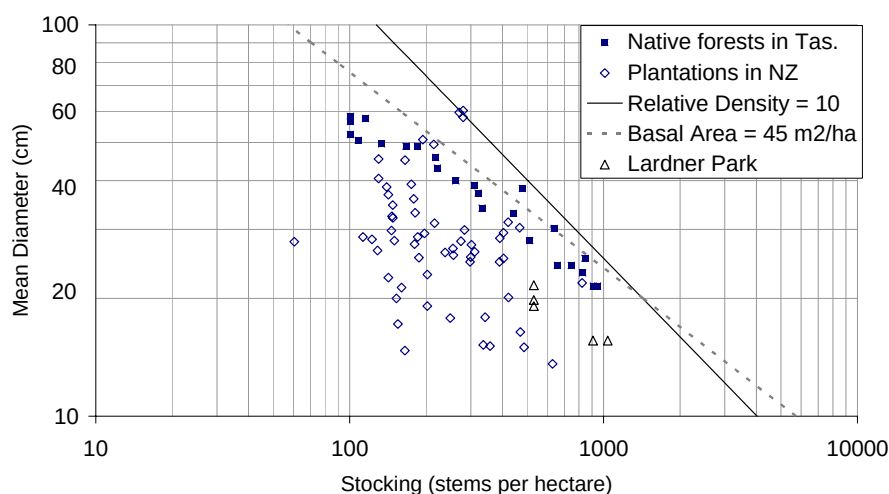


Figure 2. The same data as presented in Figure 1 plotted on a log-log scale along with a line representing a relative density (RD) equal to 10 ($RD = BA/DBH^{0.5}$) and a basal area of $45 \text{ m}^2 \text{ ha}^{-1}$

Stand density diagrams for blackwood

Reineke (1933) proposed that the natural self-thinning curves comparing quadratic mean diameter (D_g) and stocking rate (N) in even aged forests approximated a linear line when plotted on a log-log scale and that the gradient for different species was very similar (-0.625). Each species' self-thinning line was thought to be independent of site quality and management, and that only the position of the line varied with species, thus indicating their relative tolerance of competition. Although the relationship may not be as robust as originally proposed by Reineke, many authors do argue that Reineke-style stand density diagrams provide a better basis for understanding competition in even-aged forests than basal area (Lonsdale 1990; Zeide 2005).

Curtis (1982) demonstrates how the Reineke model can be translated into a relationship between the basal area (BA) and quadratic mean diameter (D_g):

$$BA = a_1(D_g^b) \quad (1)$$

Whereas Reineke's model (self-thinning line gradient of -0.625) infers that $b = 0.4$, Curtis points out that for natural stands of Douglas-fir (*Pseudotsuga menziesii*) b is in the range of 0.45 to 0.5. Rounding out to $b = 0.5$, Curtis also suggests that the constant, a_1 , might be a useful measure of both relative and absolute density:

$$RD = BA/(D_g^{0.5}) \quad (2)$$

where RD is the relative density. In a recent paper (Reid 2006) the author explored the use of stand density diagrams and equation 2 as a guide for thinning of eucalypt sawlog plantations, and found that using $b = 0.5$ provided a better match with the available data than did Reineke's model. Although there are fewer data available pertaining to blackwood, a similar approach may

be useful. Figure 2 presents the same data as in Figure 1 plotted on a log-log scale along with a line of relative density (RD) equal to 10 (based on equation 2) and a line of basal area equal to $45 \text{ m}^2 \text{ ha}^{-1}$.

The potential limit of blackwood growth appears to be well represented by a relative density of 10 (based on equation 2), particularly at stockings above 400 stems ha^{-1} . At lower stockings the line may be optimistic, particularly in natural stands. This could reflect the age of the lower-stocked natural stands (they are yet to reach their full potential) or their uneven spacing.

The managed blackwood plantation near Rotorua which is now approaching 100 y of age is represented by the three data points close to where the relative density line intersects the 60-cm average-diameter line. Being managed, the mature trees are well distributed across the site and appear to have been able to achieve a higher yield for the same stocking than noted in the native forests of Tasmania.

Figure 2 does suggest that a plantation managed at a constant basal area will tend to become less competitive over time. This is because tree basal area includes the area of both sapwood and heartwood, whereas only the sapwood area is related to leaf area, tree growth and hence competition (Medhurst and Beadle 2002). As a stand develops it is therefore able to carry a higher basal area for the same growth potential (leaf area). It is for this reason that the value of basal area alone as a guide for managing stocking in plantations has been seriously questioned (Zeide 2005).

Competition zones

A number of authors, including Reniecke (1933), suggest that it is possible to use the stand density diagrams to define the degree of competition in an even-aged forest using a series of lines drawn parallel to the self-thinning line (Dean and Baldwin 1996). Theoretically there are five competition zones for plantations ranging from a *zone of excessive exposure*, within which tree height growth is retarded due to a lack of mutual shelter, through to a *zone of imminent mortality* which is presumed to be unobtainable. Within the *zone of free growth* individual-tree diameter increment is maximised whereas in the *zone of full stocking* stand productivity is maximised. Once the forest passes into the fully-stocked zone, the volume increment is simply distributed over a greater number of stems. Between the free-growth and fully-stocked zones there is presumably a *zone of increasing competition* in which individual-tree growth is increasingly restricted.

Based on the limited available data it is difficult to judge at what RD a blackwood plantation may move from one competition zone to the next. Figure 3 presents the diameter increment between age 14 and 15 y for blackwood grown at a range of stocking rates in a trial near Rotorua (Nicholas and Kimberley 2002). The mean diameter in these stands varied from 22 to 29 cm at age 15 y. Assuming a maximum RD of 10, the lines delineating the theoretical zones have been arbitrarily drawn at 50%, 25% and 12.5% of the maximum. Figure 4 shows the same zones on a Reineke-style stand density diagram along with data showing the history of the 20-y-old Hosking's plantation in New Zealand (Gilchrist *et al.* 2002), the regime trial near Rotorua (Nicholas and Kimberley 2002) and the recent measurements of the 14-y-old Lardner trial in Gippsland (measured by Reid and Hirst in 2006).

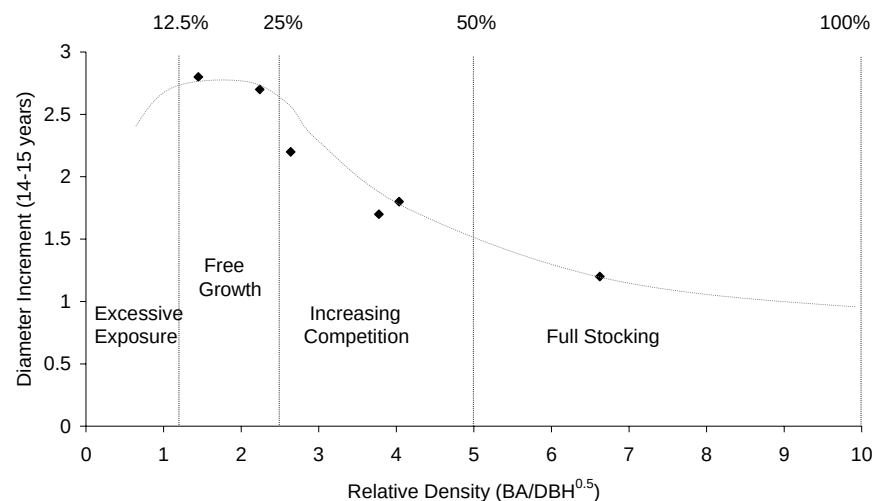


Figure 3. Annual increments (from age 14 to 15 y) of blackwood growing under different management regimes in New Zealand provide some indication of the different competition zones

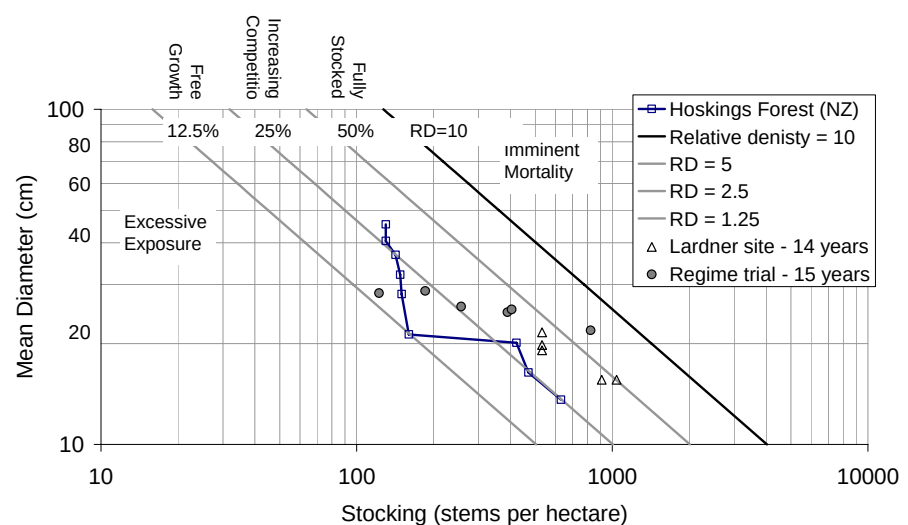


Figure 4. The competition zones shown on the log-log scale along with data showing the past management of the Hosking blackwood plantation in New Zealand and plot measurements of the Rotorua regime trial (NZ) and Lardner site (Gippsland)

Target stocking rates for blackwood sawlog plantations

Stand density diagrams provide a useful guide for the selection of appropriate initial and final-crop stocking rates. For example, a grower primarily focused on producing large pruned blackwood butt logs (of say 60 cm dbhob) may judge that a final stocking of about 150 stems ha^{-1} is not only feasible but will also ensure the forest is close to fully stocked at the time of harvest. To avoid excessive exposure, an initial stocking of at least seven times that expected at harvest may be required, particularly on poorly-sheltered sites. Over-planting also provides the opportunity to select the trees of best form and vigour through a series of thinning operations.

Diameter:basal area ratio (D:BA)

Whereas a plantation held at a constant basal area tends to become understocked over time, the opposite is true of a plantation held at a constant ratio of mean tree diameter to stand basal area (D:BA) (Fig. 5). For example, a blackwood plantation managed at a constant mean diameter (in cm) to basal area (in $\text{m}^2 \text{ha}^{-1}$) ratio of two might be free-growing until the trees are about 25 cm in diameter (stocking of around 250 stems ha^{-1}) after which time diameter growth and branch development will presumably be restricted by increasing competition.

In practice, maintaining a D:BA ratio of between two and three during the early years may be an ideal route for growers who intend to prune, since they are able to concentrate their pruning costs on a smaller number of free-growing trees than that required by a constant basal area regime. Having established sufficient trees to achieve mutual shelter and an adequate selection ratio, the stocking would be reduced to around 500 stems ha^{-1} at the time of the first pruning lift. Form pruning during this establishment phase is useful to improve the number of suitable trees for stem pruning (when the trees are 8–10 cm in diameter). Subsequent thinnings, timed to coincide with the selection of superior trees for pruning, would reduce the stocking to around 220 high-pruned stems ha^{-1} by the time the mean diameter was 20 cm (pruning phase). Allowing for natural mortality, wind damage and disease, these 220 stems would then be left to grow on and provide the basis for the final crop whether they are to be harvested as a clear fell or selectively logged.

Balancing harvesting and non-timber benefits

Whilst most plantation regimes assume the plantation will be clear felled at a particular age, farmers who have established the trees for multiple values may prefer to harvest small areas, or even individual trees, in an attempt to retain the non-timber values the forest provides. By aiming to produce 220 high-pruned stems ha^{-1} , the trees are expected to be relatively free growing until the mean diameter approaches 30 cm (basal area of about $15 \text{ m}^2 \text{ha}^{-1}$). The farmer could then begin selectively harvesting some of the largest trees as they reach a useful size (say 40–50 cm) to maintain a D:BA ratio of around two. At this stocking there would be sufficient light available at ground level to allow natural regeneration or replanting in order to develop an uneven-aged forest providing ongoing non-timber benefits as well as the opportunity for regular harvests of high-quality logs.

Spot measurements of D:BA ratios

Using the basal area sweep method (Reid and Stephen 2001) individual D:BA ratios can be estimated quickly for each tree in a stand by comparing tree diameter to the basal area around that individual.

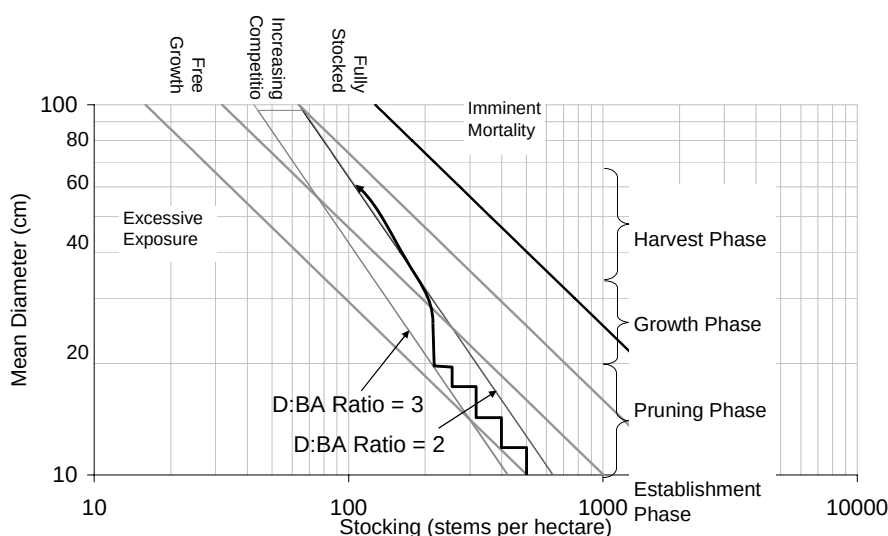


Figure 5. A possible management regime for blackwood based on thinning to maintain a diameter:basal area (D:BA) ratio of between two and three

This is an especially useful technique in irregularly-shaped forests of the type commonly grown on farms and possibly even mixed-species plantings. Figure 6 compares the D:BA ratio of individual blackwood trees growing in an irregular, mixed-species riparian buffer strip on the author's own farm. In this case most of the competition is from taller eucalypts. Diameter increment measurements in future years will help build an understanding about how to manage the overstorey component in order to allow the blackwood to develop well.

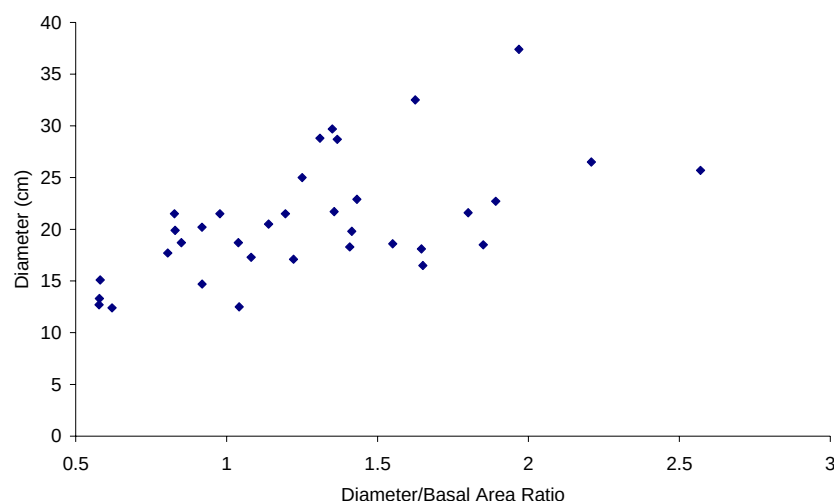


Figure 6. Individually-assessed diameter:basal area (D:BA) ratios for blackwood trees growing under a canopy of widely spaced, pruned eucalypts in a riparian buffer. Basal areas were measured around each tree using a two-factor basal area wedge.

Conclusion

Farmers committed to the management of blackwood plantations for commercial sawlog production have lacked practical tools for planning initial and final-crop stockings and for guiding stocking during the rotation. They seldom have access to detailed growth functions relevant to their tree species or sites and, if they do, such models are rarely adaptable to irregular farm plantings of the type farmers want to grow. The D:BA ratio is a simple and practical tool for guiding stocking management in such plantings.

Landholders can easily determine an appropriate ratio based on their target log diameter, whether they wish to prune or not, and the relative importance they place on either maximizing yield or maximizing the return on management costs such as pruning. As the forest grows, simple measurements of tree performance can be used to refine their choice of D:BA ratio. Use of the ratio promotes the establishment of sufficient trees to provide mutual shelter in the early years whilst encouraging growers to thin heavily during the pruning phase in order to concentrate their investment and the available site resources on the most promising individuals.

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Session 3: Advances in Silviculture
Paper 18

Silvicultural Management Options for Blackwood (*Acacia melanoxylon*) with a Black Wattle (*Acacia mearnsii*) Nurse Crop

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Abstract

The effects of levels of light and water competition from a black wattle nurse crop on blackwood form and growth were examined on a water-limited site. The growth of many nurse-crop species used to date often outstrips that of the blackwood, leading to suppressed blackwood growth because of excessive shade and competition for water. Black wattle displays rapid early growth but quickly reaches its maximum height. It therefore has potential as a blackwood nurse crop. Two years after nurse-crop thinning to three densities, no differences in blackwood form were observed. There were no significant differences in either height or diameter growth between treatments, but height:diameter ratio (86:1) was significantly lower in the heaviest-thinned (two out of three trees removed) nurse-crop treatment. Volume increment ($<0.5 \text{ m}^3 \text{ ha}^{-1} \text{ y}^{-1}$) was not significantly different between treatments over the trial period, but there was a trend towards decreasing volume with increasing nurse-crop density. The results highlight the compromise between growth and form of the blackwood when nurse crops are used where water is limiting growth.

Introduction

Acacia melanoxylon (blackwood) is a difficult species to grow commercially. Achieving straight stems with a low incidence of branching has proven difficult for many growers in Australia and New Zealand (Beadle *et al.* 2004), often requiring four or five stand entries for form pruning alone. In natural stands containing blackwood, competing overstorey creates a 'light well' and encourages maintenance of blackwood apical dominance (Unwin *et al.* 2001). Consequently the use of nurse crops and fertiliser application to provide shelter and competition for light has been considered to encourage better form and reduced branching (Pinkard 2003). A careful balance is required to make certain the nurse crop is thinned at a time and to a level that maintains rapid growth in the blackwood, yet does not reduce the competition to the point of allowing poor form (Beadle *et al.* 2004).

Many nurse crops have been found to be unsuitable in Tasmania and New Zealand because they are too vigorous and eventually suppress the blackwood (Nicholas and Brown 2002). As blackwood is most often planted in small areas in Victoria, the commercial harvesting of the nurse crop is often not viable. The ideal nurse crop therefore would display rapid early growth but reduced competition with age. Woollybutt Pty Ltd is currently managing several blackwood plantations in Victoria. Some of these plantations have been established with nurse crops of *Acacia mearnsii* (black wattle) to improve blackwood early growth and form, but not continue to compete beyond a certain age. Blackwood also continues to be offered as a specialty timber plantation investment option with Woollybutt. This project investigates growth and form of a blackwood plantation in Kilmore, Victoria, under different levels of competition from a black wattle nurse crop.

Site description and trial establishment

The trial was established in an existing 4-y-old blackwood–black wattle plantation, about 60 km north of Melbourne near Kilmore, Victoria (AMG E 312000 N 5877000). The site is an alluvial plain previously used for grazing. Long-term rainfall for the region is $\sim 700 \text{ mm y}^{-1}$.

The nurse crop in each of the three treatments was thinned by hand in May 2004 from the initial stocking of 625 stems ha^{-1} to either about 417 (one in three thinned), 313 (one in two) or 208 (two in three) stems ha^{-1} . In all treatments the blackwood was left at its original stocking of about 694 stems ha^{-1} ($8 \times 1.8 \text{ m}$). Therefore from an initial planting density of 1320 stems ha^{-1} , total stockings for the three treatments were about 1111, 1007 and 902 stems ha^{-1} . Plots contained four rows of eight blackwoods, alternating with five rows of black wattle nurse trees, plus buffer trees around the perimeter. The three treatments were assigned randomly within each of three replicate blocks. The measurement plot size was 0.0461 ha ($4 \text{ rows} \times 8 \text{ m} \times 8 \text{ trees} \times 1.8 \text{ m}$).

In March 2006 at age 6 y (T+23 mo where T refers to when the nurse crop was thinned), diameters at breast height (dbhob) of the blackwoods were measured: the heights (H) of 10 of the trees with largest diameter were also measured using a Forestor 'Vertex' hypsometer. Similar measurements had been taken previously at T+8 and T+18 mo. Volume per hectare was calculated using the cone formula ($1/3 \times \text{height} \times \text{plot basal area}$).

A visual form assessment developed by CSIRO (see Field Trials Handbook. Establishment, Assessment and Analysis, CSIRO Forestry and Forest Products, p. 42, unpublished) requiring a rating out of 6 for both axis persistence (AP) and straightness was carried out for all trees. The two figures were multiplied to describe 'form'. Axis persistence measures the point on the stem where apical dominance is lost. Continuing apical dominance is rated as 6. Loss of apical dominance in the top quarter of the tree is rated as 5 etc. The plantation had been form pruned twice prior to the establishment of the trial, and was form pruned again between T+8 and T+18 mo.

Significant differences between treatments were identified using one-way ANOVA and Tukey pairwise comparisons at a level of $P = 0.05$ unless otherwise stated.

Results and discussion

There was a trend of decreasing volume increment with increasing nurse-crop density over the study period, but total volumes were not significantly different between treatments at age 6 y. The mean annual increment at age 6 y was $<0.5 \text{ m}^3 \text{ ha}^{-1} \text{ y}^{-1}$ and

lower than the $0.7 \text{ m}^3 \text{ ha}^{-1} \text{ y}^{-1}$ reported by Pinkard and Beadle (2002) in a blackwood plantation of similar age in northern Tasmania, which was also considered to be under-performing. This is most likely due to water being a limiting factor for growth at the site used in this study ($\sim 700 \text{ mm y}^{-1}$): rainfall at the Tasmanian plantation was 1178 mm y^{-1} .

The ratio of height to diameter (H:dbhob) at age 6 y, 23 mo after nurse-crop thinning treatments were applied, was significantly lower in the 902 stems ha^{-1} treatment than in the 1111 stems ha^{-1} treatment (Fig. 1). The 902 stems ha^{-1} treatment had a lower initial H:dbhob ratio than the 1111 stems ha^{-1} treatment; but the 902 stems ha^{-1} treatment showed the greatest decrease in H:dbhob over the study period, from 102 to 86 (Table 1). Across a range of plantation species, an H:dbhob of 80:1 is considered ideal for stability. The reduction observed is assumed to be the combined effect of greater dbhob increase and less height increase in the 902 stems ha^{-1} treatment compared to the treatments with higher densities. Over the study period, mean diameter of individual stems increased by between 2.1 and 2.4 cm, and mean height by between 1.1 and 1.3 m (Table 1). There appeared to be slightly greater diameter gains in the two lower-density treatments and greater height gain with increasing density, but these differences were not significant.

There was no effect of thinning the nurse crop on stem form of the blackwood, even at the highest thinning intensity that resulted in increased, though not significantly increased, diameter growth. This result indicates there is no value in including a nurse crop in blackwood plantations on medium-rainfall sites. There would be more chance of achieving a desirable number of trees of good form by substituting more blackwood for the nurse crop, thereby doubling the number of initial candidates. Blackwood has large natural genotypic variation (Searle 2000). The nurse crop densities required to exert any environmental control over straightness and axis persistence of the crop trees would strongly negatively affect the already-low growth rate. These effects have been noted at much higher-rainfall sites with greater light competition (Medhurst *et al.* 2003).

Growth of the black wattle nurse crop was far more rapid than that of the blackwood (data not shown). Therefore potential exists in this nurse-crop system for offsetting the initial cost of establishment at high stocking rates, with few potential crop trees, by commercial thinning of the nurse crop. This would require enough area of the nurse crop species, either within the blackwood or in combination with adjacent commercial plantations of the same species, to make the thinning operation commercially viable. Many of the pulping qualities of blackwood and *Acacia dealbata* (silver wattle), for example, have been shown to be superior to those of *Eucalyptus globulus* (Santos *et al.* 2006). However, there are currently no premium markets in Victoria for pulp from such species. Neither

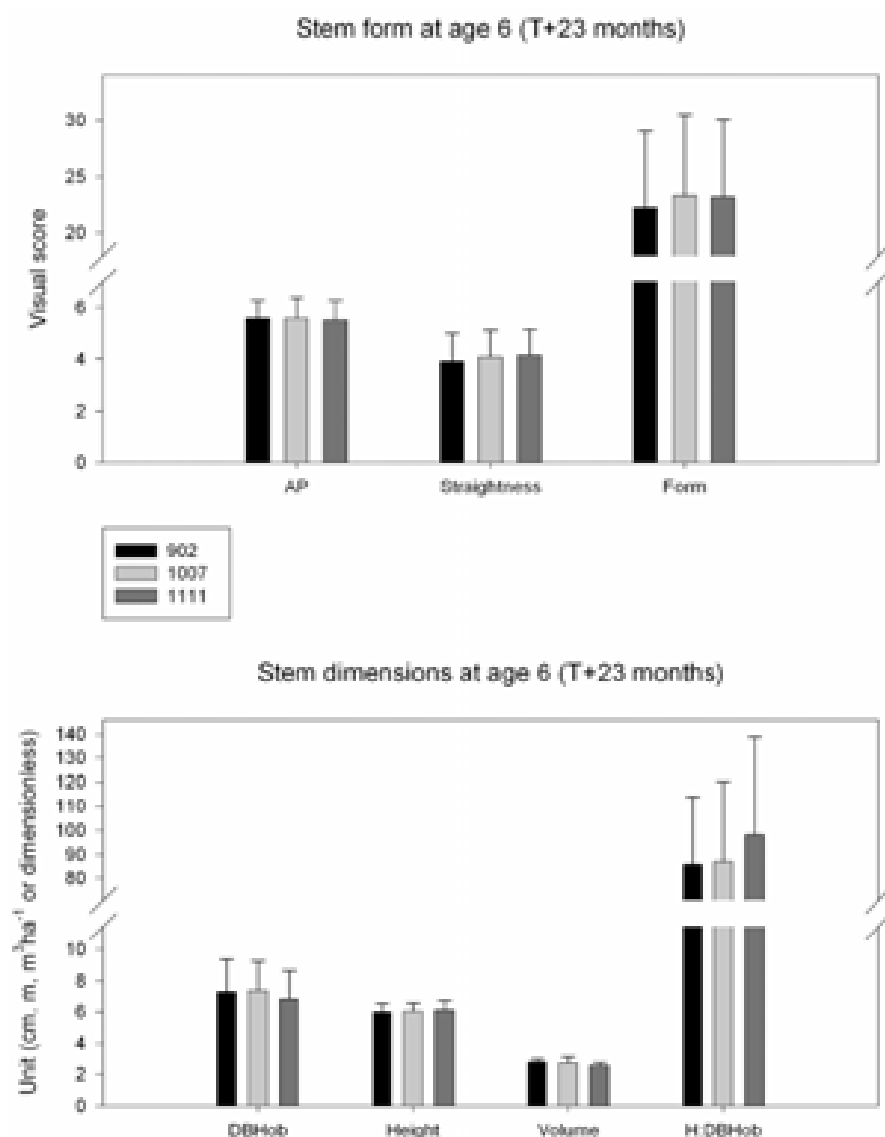


Figure 2. Stem form and stem dimensions for blackwoods at age 6 y, and 23 mo after thinning of the black wattle nurse crop, resulting in total site stocking rates of 902, 1007 and 1111 stems ha⁻¹. Error bars are pooled standard deviations.

are wattles widely recognised as firewood species, and biofuel is not an option in Victoria. The bi-pinnate foliage of wattles can also decompose relatively quickly, supplying additional nutrients to the site (Forrester *et al.* 2005), or fodder for livestock.

Operational form pruning carried out at age 4–5 y resulted in a large decrease in straightness, offset by a increase in AP due to the elimination of ‘double leaders’ (Table 1). Between age 5 and 6 y, AP fell slightly, and straightness improved in all treatments. The transient effect of form pruning was also noted in a blackwood plantation in northern Tasmania (Medhurst *et al.* 2003). Although there were no significant differences in overall stem form between treatments at age 6 y, it was slightly lower in the

lowest-density treatment. The blackwoods in this trial have now been thinned to reflect current operational practice. As individual stems increase in diameter they are likely to appear to ‘straighten up’ and consequently the scores for straightness and form should improve in all treatments.

Conclusions

Blackwood is a slow-growing species with large variation in form. Black wattle was thought to be suitable as a nurse crop, considering the criteria of faster height growth than the blackwood to induce a ‘light-well’ effect, and quickly reaching its maximum height so that the suppressive effect of its dominance on growth of the blackwood would eventually stop. Nurse-crop density was high enough to reduce blackwood growth, but still not high enough to have a significant effect on straightness and axis persistence in the first 2 y after nurse crop thinning. The lowest-density treatment produced H:dbhob ratios that were closest to the value generally desired for stability, 80:1.

By age 6 y, stand density on sites such as that used in this study should be no higher than 900 stems ha⁻¹, and preferably less. Diameter growth is probably reduced when high nurse-crop densities are maintained beyond age 4 y, i.e. during the first 23 mo following thinning. Due to slow growth on this relatively low-rainfall site, the observed treatment effects on growth and H:dbhob ratios could be greater over a longer measurement period. The value of using the black wattle nurse crop to improve apical dominance and height growth of blackwood can not be assessed due to the absence of a control treatment with no nurse crop in the trial design.

Table 1. Summary data for measurements shortly following thinning (T+8 mo) of black wattle nurse crop, and 18 and 23 mo later. Thinning treatments were 1/3, 1/2 or 2/3 of black wattles. Stocking rates in the table are the resulting site total (694 blackwood stems ha⁻¹ plus black wattles). AP = axis persistence (out of 6); Straightness is out of 6, Form = AP × straightness; Dbhob = diameter at breast height; Volume is of blackwood only based on the sum of individual trees multiplied by a constant plot size of 0.04608 ha. Numbers in italics are standard deviations.

Treatment (stems ha ⁻¹)	Age (y)	Months after thinning	AP	Straight- ness	Form	Dbhob (cm)	Height (m)	Volume (m ³ ha ⁻¹)	H:dbhob
902	4	T+8	4.9	4.5	21.6	5.0	4.9	1.36	102
			<i>0.9</i>	<i>0.8</i>	<i>7.4</i>	<i>1.7</i>	<i>0.5</i>	<i>0.24</i>	<i>34</i>
	5	T+18	5.7	3.6	20.6	6.6	5.5	2.22	90
			<i>0.6</i>	<i>1.1</i>	<i>6.1</i>	<i>1.7</i>	<i>0.6</i>	<i>0.18</i>	<i>31</i>
	6	T+23	5.6	3.9	22.2	7.3	6.0	2.81	86
			<i>0.7</i>	<i>1.1</i>	<i>6.9</i>	<i>2.1</i>	<i>0.6</i>	<i>0.29</i>	<i>28</i>
1007	4	T+8	5.1	4.5	23.1	5.0	4.8	1.38	99
			<i>0.8</i>	<i>0.8</i>	<i>6.4</i>	<i>1.6</i>	<i>0.6</i>	<i>0.22</i>	<i>27</i>
	5	T+18	5.7	3.6	21.1	6.5	5.4	2.21	87
			<i>0.9</i>	<i>1.2</i>	<i>6.9</i>	<i>1.8</i>	<i>1.2</i>	<i>0.41</i>	<i>26</i>
	6	T+23	5.6	4.1	23.4	7.4	6.0	2.75	87
			<i>0.8</i>	<i>1.1</i>	<i>7.2</i>	<i>1.9</i>	<i>0.5</i>	<i>0.52</i>	<i>33</i>
1111	4	T+8	5.1	4.6	23.2	4.7	4.8	1.31	109
			<i>0.8</i>	<i>0.8</i>	<i>7.4</i>	<i>1.7</i>	<i>0.3</i>	<i>0.14</i>	<i>51</i>
	5	T+18	5.8	3.6	20.6	6.0	5.4	2.01	103
			<i>0.5</i>	<i>1.1</i>	<i>6.1</i>	<i>1.7</i>	<i>0.4</i>	<i>0.22</i>	<i>54</i>
	6	T+23	5.5	4.1	23.2	6.8	6.1	2.57	98
			<i>0.8</i>	<i>1.0</i>	<i>6.9</i>	<i>1.9</i>	<i>0.6</i>	<i>0.26</i>	<i>41</i>

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Session 3: Advances in Silviculture Paper 19

Assessing Recoverable Yields in Blackwood Plantations^a

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KEES WEYTMANS, pronounced 'case' as in suitcase, gained a Diploma of Forestry in the Netherlands in 1980 and then worked for seven years as a volunteer forester in Surinam, Zambia, Somalia and Nepal in development projects. He met Kay, his partner, in Nepal, and emigrated to New Zealand. He first grew melons for export on the fertile Gisborne flats before setting up Forest Care (Gisb.) Ltd (now Forest Measurement NZ), providing forest data collection and information. He and Kay manage a 32-ha farmlet near Gisborne on permacultural principles, and Knapdale Eco Lodge, an ecotourism and hospitality venture. About 40% of the farmlet is in radiata pine, 40% in *Cupressus lusitanica*, 10% in blackwood and the remainder in other species. He is currently restoring native forest in a 400 m riparian area along a creek running through their property. He is secretary/treasurer to AMIGO, the Gisborne East Coast branch of the NZFFA, and the Indigenous Forest Section of the NZFFA. At the 2006 NZFFA Annual Conference, Kees and Kay received the NZFFA 2005 Husqvarna North Island Farm Forester of the Year award.

simulate expected tree sizes at clearfelling, the sawlog component was reduced to two-thirds. This supports published figures that suggest a mature stand of blackwood will have 55–60%, or about 300 m³ ha⁻¹, of sawlogs. Comparison with the MARVL results from other stands 25- and 35-y-old suggests these simulated data are conservative, but data from rotation-age stands need collecting to verify this, as well as further investigation of the functions used in this analysis to grow the crop forward. The levels of recoverable sawlog were insensitive to log prices of the prime butt logs.

This study has shown that pruned stands produce around 40% of high-quality pruned butt-logs, as well as 20–30% of branched sawlogs. This refutes the perception that blackwood is a 'butt log species' only, highlighting the fact that blackwood with a dbhob of about 60 cm and 38 m tall will produce recoverable sawlog having a range of qualities. However, the best quality material is in the butt log; this observation emphasises the need for careful management and adequate pruning.

Abstract

The potential of plantation blackwood (*Acacia melanoxylon* R.Br.) to produce sawlog material is accepted, but estimated recoverable yields are not well documented. To increase the understanding of recoverable yields, 24 plots of 18-y-old tended blackwood across four sites were evaluated using MARVL (Method of Assessing Recoverable Volume by Log type). A second software package (Atlas Cruiser) was used to assess recoverable yields under a number of scenarios for both the original data and for the stand 'grown-on' to clearfelling. The results were compared to previous MARVL data from 17, 25 and 35-y-old stands.

For the mid-rotation data, stands were carrying nearly three-quarters of the total stand volume as sawlog. When the data for the 24 plots were grown forward to

Background

Australian blackwood (*Acacia melanoxylon* R.Br.) is regarded as one of New Zealand's premier exotic timber trees for the production of high-quality furniture. Blackwood has been established in New Zealand from Northland to Southland to provide a future resource of furniture timber. Blackwood requires intensive silviculture to produce trees of good form, and for this reason it has not been favoured as a large-scale plantation species in New Zealand: it is estimated that about 3000 ha of blackwood have been established (Nicholas 2004).

Considerable effort has gone into researching the

^a This paper was presented to the Workshop by Kees Weytmans

silviculture of blackwood. However, the data base on recoverable yields is small, with yield estimates made from only a small number of plots (Nicholas and Brown 2002). These estimates suggest that blackwood stands at maturity will have a total stem yield of 500–550 m³ ha⁻¹ and that at least 300 m³ ha⁻¹, or 55–60%, will be sawlogs. During 2005, a project to estimate recoverable yields was undertaken in blackwood regime trials aged 18 y.

Methods

The most recently developed tool for assessing recoverable yields is Atlas Cruiser (Gordon and Baker 2004; Gordon and Lambert 2005). However, the stands were first assessed using MARVL (Method of Assessing Recoverable Volume by Log type, Deadman and Goulding 1979) to permit valid comparisons with previous yield estimates from other blackwood stands. MARVL recognises the potential of stands to yield different products if crosscut using different bucking scenarios. A sample of standing trees was assessed and the stem qualities of the trees recorded (Table 1).

Data analysis and scenario evaluations were then carried out using Atlas Cruiser, which was developed from and is compatible with MARVL in its use of data (Deadman and Goulding 1979; Gordon *et al.* 1995). The effect of crosscutting to a set of log product specifications was then analysed by Atlas Cruiser in such a way that the optimal value was recovered from each merchantable stem. Although a prototype blackwood growth model has been developed, it has not yet been set up to run in Atlas Cruiser. To simulate blackwood stands at maturity, Atlas Cruiser was used to grow the measured plot data forward in time. Stem growth was represented by increases in measured stem diameters at breast height and on the upper stem, and increases in stem height. A radiata pine growth model (SGM3) was used to apply these increases until a mean dbhob of 60 cm was reached. SGM3 was used as it produced a plausible dominant height for mature

blackwood stands of around 38 m. This equates to a high-site-index stand of blackwood in New Zealand (Nicholas and Brown 2002). The grown stems were then merchandised by applying blackwood volume and taper functions to calculate stem piece volumes.

Sites assessed

Regime trials. Four regime trials (aged 18 y) were assessed for log grades using MARVL before the plots were thinned. These blackwood regime trials were established in 1987 across six sites: five in the North Island were used in this study. The trials were all divided into plots of five final-crop stockings × two thinning treatments, with two replicates of each final-crop stocking at most sites, and four replicates at Whakarewarewa (Nicholas *et al.* 2001). Plots varied in size, depending on final-crop stocking. All plots had the same selection ratio applied across all sites (1:6) with about 30 trees remaining in each treated plot before the 2005 thinning. Six plots were sampled in the main trial at Whakarewarewa, near Rotorua, and all six plots in three other trials (at Okareka near Rotorua, Hunua Farm near Auckland, and Cumberland near Te Kuiti). Therefore a total of 24 plots was assessed across stockings ranging from 70 to 806 stems ha⁻¹. The site with the poorest growth, Hunua Forest (Nicholas *et al.* pp. 14–20 this volume), was not assessed.

Sample plots. Sample plots from three other locations were also assessed by MARVL. These included five sample plots at Hosking plantation near Whangarei aged 17 y, two from Malloy plantation near Warkworth aged 25 y, and two from Athenree Forest near Katikati aged 35 y. Hosking and Malloy were selected because of excellent management and pruning history, while Athenree was selected as an example at rotation age.

Analysis

All MARVL files were analysed using Atlas Cruiser applying the base-case strategy (Table 2). For plots thinned in 2005, the data were re-analysed with crop trees only. For sensitivity analysis, the following changes were made to the base strategy:

- Branch-free straight log price was increased to \$300 m⁻³
- Log specification was changed from random-length 3–8 m, to fixed length, 4.4, 2.2 and 1.1 m
- Firewood price was reduced from \$47 to \$5
- Minimum small-end diameter (sed) was increased from 200 mm to 300 mm
- Branch-free straight log price was increased to \$600 m⁻³ and small-branched straight sawlog was increased from \$120 to \$450 m⁻³.

This was done to investigate the sensitivity of log-making to price and SED, and to capture different log lengths. Changes in prices were used to guide the software for priority-setting during its value optimising.

Table 1. Description and code for each log quality class (sections of trees)

Description	MARVL code
Pruned or naturally unbranched section, straight	Branch-free straight
Pruned or naturally unbranched with sweep greater than 1/3 stem diameter	Branch-free swept
Section with branches <7 cm in diameter, straight	Sm br str sawlog
Section with branches >7 cm in diameter, straight	L br str sawlog
Swept section with branches <7 cm in diameter	Sm br sw sawlog
Swept section with branches >7 cm in diameter	L br sw sawlog
Sections with large branches and/or highly swept — firewood	Firewood
Waste (rot, malformed, excessively large branch)	Waste

Table 2. Log sizes and price for each log quality class in the base-case strategy

Log quality class*	Minimum SED (mm)	Minimum length# (m)	Price (\$ m ⁻³)
Branch-free straight	200	2.5	150
Branch-free swept	200	2.5	120
Sm br str sawlog	200	3.0	80
L br str sawlog	200	3.0	70
Sm br sw sawlog	200	3.0	50
Firewood	150	2.0	47
L br sw sawlog	200	3.0	40
Waste	na	na	0

*See Table 1 for key

#Maximum length set at 8 m

Prices do not necessarily reflect market conditions, only cutting priorities. The 24 regime-trial plots were run with the base-case analysis; this is the same as used in previous evaluations of blackwood.

For statistical analyses, the stocking was grouped into categories: e.g. stockings from 385 and 433 stems ha⁻¹ were grouped as 425 stems ha⁻¹. Stockings which did not fit into the three groups used (125, 200 and 425 stems ha⁻¹), like the 70 and 285 stems ha⁻¹ at Whakarewarewa, were omitted from the analysis. Timing of thinning was not taken into account. This should have had only minor effects on the percentage of logs in each grade, although it would have had greater effect on actual volumes.

Analysis of variance was carried out using Proc GLM of the SAS® software package (SAS Institute 1989). The model included site, stocking and a site × stocking interaction, with all effects treated as fixed. Tukey's multiple-range test was used to calculate least significant differences between entry means. Thinned plots were grown-on to an average diameter of about 60 cm in an attempt to reflect the stand at a rotation age of about 35 y.

Results and discussion

Regime Trial base case

Sawlog volume at age 18 y of plots on the three sites was nearly 75% of total recoverable volume (Table 3). This result is a very similar to that from an analysis of five 17-y-old plots in the Hosking plantation near Whangarei (Nicholas and Brown 2002).

When the trees were grown-on to about 60 cm dbhob, the total sawlog component dropped to 58% and firewood increased to 42%. This is surprisingly high, but possibly reflects how the original MARVL assessment was conducted — non-sawlog material was coded as firewood rather than as branched sawlog. Hence when the stand was grown-on there was no corresponding increase in sawlog grades. The reduction in percentage of sawlog may also be influenced by the use of pine functions within Atlas Cruiser: blackwood volumes may have been underestimated, despite the use of blackwood volume and taper functions.

Stocking and site influences

Statistical analysis of the plot means for thinned and grown-on data showed no significant differences between stocking treatments, although the branch-free straight log value at 125 stems ha⁻¹ was almost significantly different from that of the 425 stems ha⁻¹ stocking (Table 4). Data from more plots would have given a greater opportunity to assess effects of stocking. As entries in the category of large-branched swept logs were few, there were insufficient data from this category for statistical analysis.

Analysis of the data for common regimes showed there was almost no statistical difference between the four sites (Table 5) except for small-branched straight sawlog at Okareka, where that grade was significantly greater than at the other sites.

Increase in log prices

Sensitivity to increased prices was tested by increasing the price of branch-free straight log from \$150 to \$300 m⁻³. The classification of logs into classes was insensitive to price, the two prices producing 57.6 and 56.6% of sawlog material, respectively (Table 6). No output from large-branch swept sawlogs was recorded in this analysis.

Sensitivity to log length — original data

Log specifications were changed from random length 2.5–8 m used in the base case to fixed lengths of 4.4, 2.2 and 1.1 m for each log type before data analysis (Table 7).

Table 3. Distribution of total yield among log quality classes for base-case, unthinned original plot data compared with thinned and grown-on estimates. Sawlog at \$150 m⁻³; firewood at \$47 m⁻³.

Log quality class*	Unthinned: original data for individual sites — stands 18 y old					Thinned
	Cumberland (%)	Okareka (%)	Whakarewarewa (%)	Hunua farm (%)	Mean (%)	All plots thinned and grown-on to about 35 y (%)
Branch-free straight	58.6	58.2	62.2	48.1	56.78	37.60
Branch-free swept	11.0	17.6	8.3	27.2	16.03	9.46
Sm br str sawlog	1.2	1.3	0	0.4	0.73	2.82
L br str sawlog	0.7	2.0	2.6	0.7	1.50	6.05
Sm br sw sawlog	0	0	0	0	0.00	1.70
L br sw sawlog	0	0	0	0	0.00	0
Firewood	28.6	20.8	26.9	23.5	24.95	42.36

*See Table 1 for key

Table 4. Distribution of total yield among log quality classes, by stocking

Stocking (stems ha ⁻¹)	No. plots	Log quality class* and fraction of volume (%)					
		Branch-free straight	Branch-free swept	Sm br str sawlog	L br str sawlog	Sm br sw sawlog	Firewood
125	7	31.49a [#]	15.03a	2.06a	5.58a	0.53a	45.3a
200	8	37.95a	9.19a	2.59a	4.73a	1.32a	43.7a
425	7	38.47a	9.79a	3.32a	6.33a	2.43a	39.7a
Least significant difference ^{\$}		7.32	9.26	2.82	5.25	2.63	8.40

*See Table 1 for key; [#]Within each column, values followed by the same letter do not differ significantly ($P=0.05$)

^{\$}Proc. GLM Tukey's test

Table 5. Distribution of total yield among log quality classes, by site

Site	No. plots	Log quality class* and fraction of volume (%)					
		Branch-free straight	Branch-free swept	Sm br str sawlog	L br str sawlog	Sm br sw sawlog	Firewood
Whakarewarewa	4	39.6a [#]	5.76a	1.63b	6.34a	2.10a	44.5a
Hunua farm	6	38.8a	12.21a	1.31b	7.06a	0.68a	40.0a
Okareka	6	33.8a	11.60a	5.73a	6.34a	2.10a	40.4a
Cumberland	6	33.3a	13.57a	1.60b	2.58a	1.04a	47.2a
Least significant difference ^{\$}		9.56	12.09	3.68	6.86	3.43	10.97

*See Table 1 for key; [#]Within each column, values followed by the same letter do not differ significantly ($P=0.05$)

^{\$}Proc. GLM Tukey's test

Table 6. Distribution of total yield among log quality classes for thinned and grown-on estimates, at two prices for branch-free straight log, \$150 and \$300 m⁻³

Log quality class*	Price and fraction of volume (%)	
	\$150 m ⁻³	\$300 m ⁻³
Branch-free straight	37.6	39.08
Branch-free swept	9.46	7.35
Sm br str sawlog	2.82	2.7
L br str sawlog	6.05	5.75
Sm br sw sawlog	1.7	1.71
Firewood	42.36	43.42

*See Table 1 for key

Sawlog was again about 70% of the total volume (Table 3), with most of the material being allocated to the branch-free straight long log length of 4.4 m. The percentage of swept branch-free logs was considerably less at Whakarewarewa than at the other sites. Both Cumberland and Hunua Farm had large swept-log components. This may not be directly related to exposure: while the Cumberland is quite exposed, Hunua Farm is not.

Table 7. Distribution of total yield among log quality classes for logs of fixed lengths: thinned stands, reduced price for firewood, original data

Log quality class* and length (m)	Log price (\$ m ⁻³)	Site and fraction of volume (%)			
		Cumberland 246 stems ha ⁻¹	Okareka 270 stems ha ⁻¹	Whakarewarewa 217 stems ha ⁻¹	Hunua Farm 237 stems ha ⁻¹
Branch-free straight 4.4	300	36.23	39.82	40.86	41.48
Branch-free straight 2.2	250	9.97	10.52	9.54	9.47
Branch-free straight 1.1	200	6.69	6.30	8.10	6.98
Branch-free swept 2.2	150	11.94	6.45	1.50	11.92
Branch-free swept 1.1	125	3.21	2.34	1.99	2.22
Sm br str sawlog 4.4	120	0.00	0.00	0.00	0.00
Sm br str sawlog 2.2	110	0.25	0.94	0.12	0.16
Sm br str sawlog 1.1	100	0.38	1.28	1.98	0.39
Sm br sw sawlog 4.4	90	0.00	0.28	0.25	0.96
Sm br sw sawlog 2.2	80	0.42	1.09	3.23	2.29
Sm br sw sawlog 1.1	70	0.65	1.32	1.40	2.08
L br str sawlog 4.4	60	0.00	0.00	0.00	0.00
L br str sawlog 2.2	50	0.00	0.00	0.00	0.00
L br str sawlog 1.1	40	0.00	0.31	0.10	0.00
L br sw sawlog 4.4	30	0.59	0.00	0.00	0.98
L br sw sawlog 2.2	20	0.43	0.77	0.55	0.16
L br sw sawlog 1.1	10	0.96	0.68	0.46	0.51
Firewood	5	28.29	27.90	29.95	20.40

*See Table 1 for key

Table 8. Distribution of total yield among log quality classes for logs of fixed lengths: thinned and grown-on stands, with increased prices for long log lengths. The three classes in which prices were changed are shaded.

Log quality class* and length (m)	Base prices		Revised prices		Change in percentage yield
	Price (\$ m ³)	Fraction of yield (%)	Price (\$ m ³)	Fraction of yield (%)	
Branch-free straight 4.4	300	25.83	600	25.80	-0.03
Branch-free straight 2.2	250	6.49	250	3.23	-3.26
Branch-free straight 1.1	200	5.1	200	4.31	-0.79
Branch-free swept 2.2	150	5.46	150	0.79	-4.67
Branch-free swept 1.1	125	1.70	125	1.15	-0.55
Sm br str sawlog 4.4	120	1.16	450	10.70	9.54
Sm br str sawlog 2.2	110	1.59	110	1.33	-0.26
Sm br str sawlog 1.1	100	1.38	100	1.23	-0.15
Sm br sw sawlog 4.4	90	2.27	90	2.32	0.05
Sm br sw sawlog 2.2	80	2.97	80	3.07	0.1
Sm br sw sawlog 1.1	70	1.51	70	1.43	-0.08
L br str sawlog 4.4	60	0.65	300	0.98	0.33
L br str sawlog 2.2	50	1.10	50	0.94	-0.16
L br str sawlog 1.1	40	0.55	40	0.52	-0.03
L br sw sawlog 4.4	30	2.39	30	2.39	0
L br sw sawlog 2.2	20	2.16	20	2.18	0.02
L br sw sawlog 1.1	10	1.20	10	1.18	-0.02
Firewood	5	36.49	5	36.46	-0.03

*See Table 1 for key

Table 9. Distribution of total yield among log quality classes: summary from plots thinned and grown-on

Log quality class	Site and fraction of volume (%)			
	Cumberland	Okareka	Whakarewarewa	Hunua Farm
Total, branch-free straight	34.49	36.97	39.79	38.44
Total, branch-free swept	10.74	5.78	2.48	9.63
Total, small branch	4.84	15.26	12.02	11.37
Total, large branch	9.61	6.68	9.04	6.87
Total sawlog	59.68	64.69	63.33	66.31
Firewood	40.32	35.28	36.69	33.68

Sensitivity to log length — data grown-on

Analyses of the thinned and grown-on data set were undertaken on fixed log lengths with the price for branch-free straight log increased from \$300 to \$600 m⁻³ and the small-branched straight sawlog price increased from \$120 to \$450 m⁻³. At these prices, the volume of small-branched sawlog increased greatly (Table 8). This suggests that a considerable portion of this material is made up of shorter pruned lengths. Table 8 also confirms the trend for stands grown-on to 60 cm dbhob to have a lower percentage of pruned sawlog than younger stands.

However, there is still a significant portion of sawlog material, on average 63%, although in comparison to mainstream forestry species in New Zealand (e.g. radiata pine and Douglas-fir), these proportions are very low (L. Knowles, Ensley, *pers. comm.* 2006).

Nearly two-thirds of the total stand volume was estimated to be sawlog material, with over half this, or about 37% of the volume, prime pruned sawlogs (Table 9). These values are lower than those assessed from two plots in the 35-y-old stand near Katikati, where nearly half the volume was in branch-free straight sawlogs (Nicholas *et al.* 2004). This difference may be an artefact of using MARVL data with the functions used in Atlas Cruiser to grow the stands to rotation age, and it highlights the need for more MARVL-type analyses of stands close to maturity.

When data are collected for future stand-alone analyses that do not entail comparisons with previous MARVL data, we recommend that Atlas Cruiser methodology is used rather than MARVL, as Atlas Cruiser data is more versatile in growing-on scenarios. There are also implications in assessing sweep at age 18 y, e.g. sweep of SED/3 at this age would be different using age 35-y stem sections. This also highlights the need to have some understanding of the crown structure in blackwood stands, especially as it relates to thinning and stocking. Relevant data have been collected from the regime trials with AMIGO support, but they have yet to be evaluated.

Conclusion

The assessment of the potential recoverable sawlog volume from four blackwood regime trials aged 18 y showed that 60–70% of the volume is in sawlogs. Similar figures have previously been recorded for other stands of similar age.

When the Atlas Cruiser was used to simulate the stand grown-on to about 35 y, the anticipated age at clearfelling, the sawlog component was reduced to 60–66%. This is similar to the figure used by Nicholas and Brown (2002), who suggested that a mature stand of blackwood will have 55–60%, or about 300 m³ ha⁻¹, of sawlogs. A small data set collected from mature stands suggests this figure may be conservative. More data from rotation-age stands should be collected to extend the data base. The reduced percentage of sawlogs at rotation may also be due to the use within Atlas Cruiser of pine functions that have underestimated blackwood volumes, despite using blackwood volume and taper functions. This aspect requires further investigation. There appears to be no significant effect of stocking or site on the percentage of swept logs.

This study has shown that pruned stands produce around 40% of high-quality pruned butt logs as well as 20–30% of branched sawlog. This refutes the perception that blackwood is a butt-log species only, and confirms that blackwood with a dbhob of about 60 cm and about 38 m tall will produce sawlog of a range of qualities. The best material, however, is in the butt log, and the need for careful management and pruning cannot be over-emphasised.

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Session 4: *Acacia* Species and Resource Management
Paper 20

***AcaciaSearch*: Evaluation of *Acacia* as a Woody Crop Option for Southern Australia**

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Abstract

The almost 500 native species of *Acacia* which occur in the southern Australian agricultural zone (250–650 mm y⁻¹ rainfall zone) were assessed for their suitability as new woody crops for large-scale planting, primarily in recharge areas as a means of salinity control. Emphasis was given to fast-growing species with potential for producing large amounts of wood biomass that may find uses in solid and reconstituted wood products, and for bioenergy, and which may possess commercially attractive by-products. Thirty-five species were identified as having some potential and each was ranked as to how well they met selection criteria that indicated their ability to deliver anticipated end products. Species ranked most highly included *A. decurrens*, *A. lasiocalyx*, *A. leucoclada* subsp. *leucoclada*, *A. linearifolia*, *A. mearnsii*, *A. microbotrya*, *A. pycnantha*, *A. retinodes*, *A. salicina* and *A. saligna*. The *AcaciaSearch* volume provides comprehensive information for each of the 35 prospective species.

Introduction

The aim of *AcaciaSearch* was to identify, evaluate and present detailed information for *Acacia* species that may have potential as woody crop plants for large-scale commercial planting in the 250–650 mm y⁻¹ rainfall zone of southern Australia, primarily for use in recharge areas as a means of salinity control.

Revegetation with perennial plants is a well-accepted tool in salinity control (Bartle *et al.* 2002), but the scale of plantings needed is so large that it must involve extensive change in the commercial plant base of agriculture. Hence an array of profitable perennial plants must be developed to complement existing annual crop plants. Apart from their role in salinity control, new perennial plant crops can bring a range of other benefits to agricultural areas, including improved erosion control, protection and enhancement of biodiversity, diversification of farm incomes, and regional development resulting from local processing of perennial plant products. These factors provided the rationale for undertaking the *AcaciaSearch* project.

In *AcaciaSearch*, emphasis was given to fast-growing species with potential for producing large amounts of wood biomass that may find uses in solid and reconstituted wood products and for bioenergy, and which may yield commercially attractive by-products such as extractives (especially tannin and gum) and fodder in addition to the environmental benefits derived from planting such crops.

Target area

The target area for the study encompassed the states of Western Australia, South Australia, Victoria and New South Wales, and included the predominantly winter-rainfall region (south of the Lachlan River, NSW) from about 650 mm annual precipitation down to the limits of agriculture, which coincide with the 250 mm isohyet in eastern Australia and the 300 mm isohyet in Western Australia (Figs 1 and 2). Species were considered for selection if their natural distribution occurred wholly or partially within the target area, although a few species with known agroforestry potential that occurred just outside the region were also assessed.

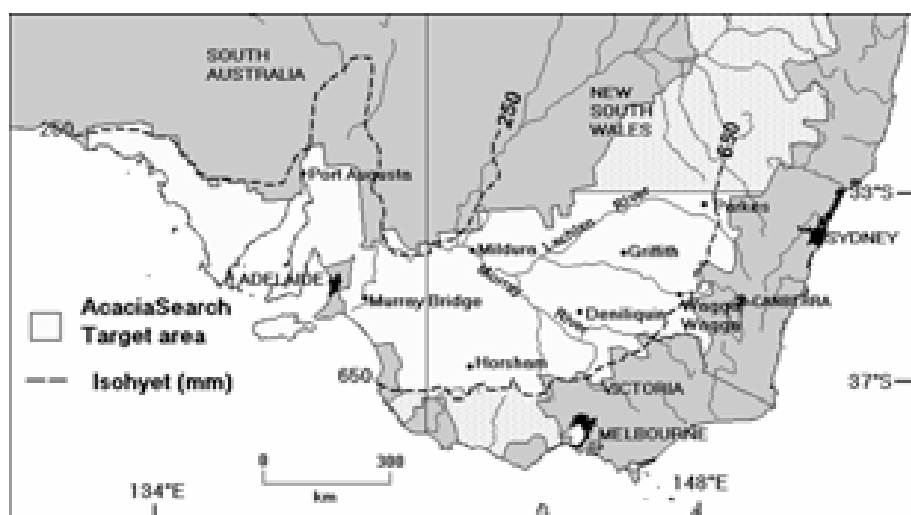


Figure 1. Eastern Australian target area. The 650 mm y^{-1} isohyet approximates the eastern and southern boundaries, and in New South Wales and Victoria corresponds roughly to the 500 m contour.

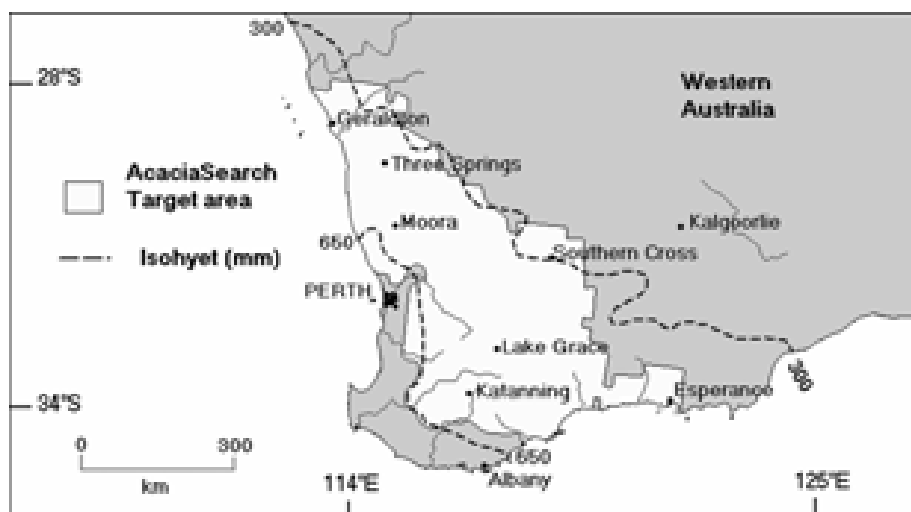


Figure 2. Western Australian target area. The inland boundary corresponds approximately to the 300 mm y^{-1} isohyet whereas in eastern Australia it approximates the 250 mm y^{-1} isohyet.

asterisk in the list below); these missing data will be obtained only from further technical testing, field trials and detailed study of plants in their native habitats.

- Plant form: habit, size, wood/crown ratio, stem structure*, bark characters*, root architecture*
- Plant growth*: growth rate, longevity, coppice/suckering ability
- Wood*: colour, density, extractives content, fibre attributes
- Weediness: seed production and phenological precocity*, age of plant harvest, suckering propensity
- Soil: broad edaphic preferences
- Taxonomy: species relationships, variation and hybridization
- Distribution: geographic range and abundance, avoid rare taxa; predicted climatically-determined growing area
- Biology: flowering biology/phenology, seed phenology/production
- Silviculture*: established management data, propagation methods, pests and disease.

Selection criteria

Species were evaluated against a set of plant characteristics that indicated their potential suitability as feedstocks for selected products. Emphasis was given to products that have large markets, require large amounts of biomass for their manufacture, and for which short-rotation *Acacia* crops could provide suitable feedstock. Therefore, the most important plant characteristics were the ability to rapidly produce commercial volumes of harvestable wood biomass, particularly low-density wood. Species with low wood density were rated highly, as this is a desirable trait for many of the targeted wood products.

The attributes considered for evaluating the species are listed below, but in a number of cases there was very little (or no) information available (marked with an

Identification and ranking of prospective new crop species

Four hundred and sixty-two species of *Acacia* occur naturally within the target area and 35 (listed below) were identified as having some crop potential. Because these species varied considerably with respect to how well each met the selection criteria, they were (rather subjectively) ranked to indicate their expected performance as crop plants capable of delivering anticipated end products. The rankings are provisional and should be treated with caution because they may change in the light of future studies. Furthermore, it is not expected that all 35 species will become new crop plants. Some will undoubtedly be eliminated after testing their growth rates, wood attributes and performance under cultivation, or by their inability to

meet end-product requirements. In some cases their potential weed risk may constrain use to their native range.

In the list below, the species ranked 1 and 2 are considered the most prospective. They can be expected to display fast or moderately-fast growth and produce high or moderately-high volumes of wood biomass. They have potential to be cultivated over a reasonably wide geographic area, although in a number of cases this area is restricted to the temperate outer peripheral regions of the target zone.

Species ranked 3 and 4 are regarded as less prospective. While these species possess acceptable growth characteristics, they display certain attributes that tend to reduce their potential for crop development (most commonly these attributes are poor growth form, reduced wood biomass production, or relatively slow growth). Nevertheless, they should not be discounted at this early stage of testing.

The following provides the species ranking and Australian states of occurrence for the 35 species identified in the *AcaciaSearch* project as prospective for crop development in the southern Australian agricultural zone:

Category 1

A. saligna (WA)

Category 1–2

A. leucoclada subsp. *leucoclada* (NSW); *A. linearifolia* (NSW); *A. retinodes* ‘typical’ variant (SA); *A. salicina* (NSW, NT, Qld, SA, Vic., ?WA)

Category 2

A. decurrens (ACT, NSW); *A. lasiocalyx* (WA); *A. mearnsii* (ACT, NSW, SA, Tas., Vic.); *A. microbotrya* (WA); *A. pycnantha* (ACT, NSW, SA, Vic.); *A. retinodes* ‘swamp’ variant (SA, Vic.)

Category 2–3

A. dealbata subsp. *dealbata* (NSW, Tas., Vic.); *A. murrayana* (NSW, NT, Qld, SA, WA); *A. neriifolia* (NSW, Qld); *A. rivalis* (SA, ?NSW); *A. bartleana* (WA)

Category 3

A. acuminata (WA); *A. baileyana* (NSW); *A. doratoxylon* (ACT, NSW, Vic.); *A. filicifolia* (NSW, Qld); *A. hakeoides* (NSW, Qld, SA, Vic., WA); *A. implexa* (NSW, Qld, Tas., Vic.); *A. melanoxylon* (ACT, NSW, Qld, SA, Tas.,

Vic.); *A. parramattensis* (ACT, NSW); *A. retinodes* ‘Normanville’ variant (SA); *A. retinodes* var. *uncifolia* (SA, Tas.); *A. rostellifera* (WA); *A. stenophylla* (NSW, NT, Qld, SA, Vic., WA); *A. victoriae* (NSW, NT, Qld, SA, Vic., WA); *A. wattiana* (SA)

Category 3–4

A. argyrophylla (SA, ?Vic.)

Category 4

A. cyclops (WA, SA); *A. dodonaeifolia* (SA); *A. euthycarpa* (SA, Vic.); *A. affin. redolens* (WA).

Comprehensive information derived from both published and unpublished sources was presented for each of the 35 prospective species. These data included plant growth and morphological characteristics, taxonomy, phenology, biology, ecology, distribution, silviculture and utilisation. The crop potential of each species was also discussed. Maps showing both natural distribution and predicted growing areas were provided for each species. Figure 3 is an example from the study showing the prediction for *Acacia saligna*.

While all the 35 prospective species produce at least reasonable quantities of wood biomass, the largest volumes of wood are generally found in the arborescent species which grow in (or just outside) the temperate periphery of the target area in eastern Australia (e.g. *A. dealbata*, *A. decurrens*, *A. implexa*, *A. leucoclada*, *A. linearifolia*, *A. mearnsii*, *A. melanoxylon*, *A. neriifolia*, *A. retinodes*). In the drier inland regions of NSW, SA and WA most of the species are smaller in stature and often develop a ‘mallee’ growth form with many rather slender stems (e.g. *A. argyrophylla*, *A. euthycarpa*, *A. hakeoides*, *A. murrayana*, *A. rivalis*, *A. wattiana*). However,

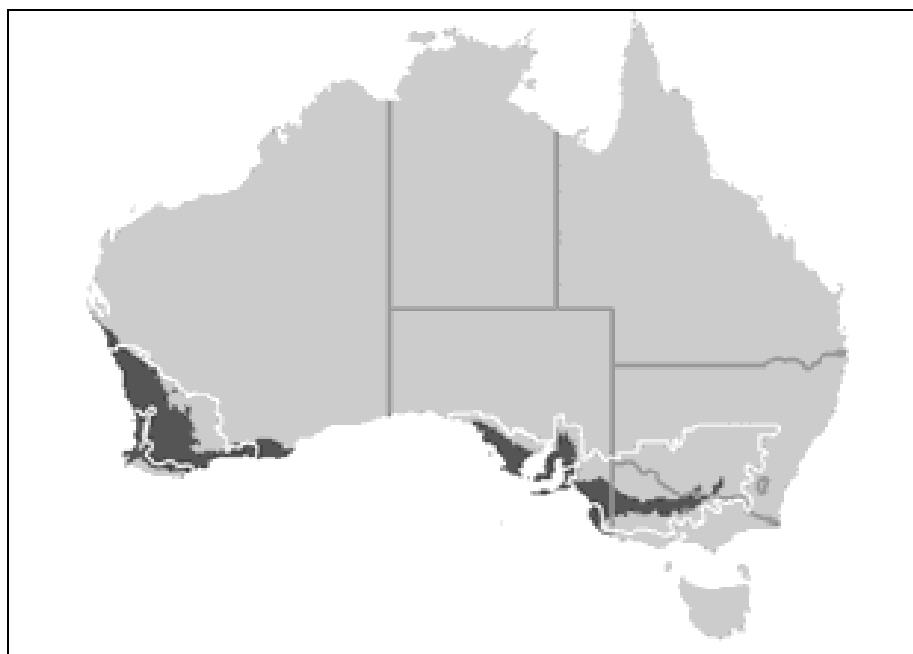


Figure 3. The area predicted to be climatically suited (shaded black) for the cultivation of *Acacia saligna* over the area targeted in the *AcaciaSearch* study (white line)

A. salicina and *A. stenophylla* are notable exceptions in that they develop into substantial trees, despite growing (along watercourses) in the driest inland parts of the eastern target area. Some arborescent species do, however, occur in the drier semi-arid parts of the target zone (e.g. *A. lasiocalyx*, *A. microbotrya*, *A. pycnantha*, *A. retinodes* ‘typical’ variant, *A. saligna*, *A. subfalcata*).

Crop types for salinity control

Although woody crops could take many forms, there are three commercial crop types likely to be suitable for salinity control in southern Australian agricultural systems. These three types were briefly defined thus:

1. Long-rotation crops: trees of erect form selected and managed over a growth period of 10–100 y
2. Coppice crops: long-lived species that readily resprout or coppice from the cut stump after harvest. These crops could be harvested every 2–5 y. Usually grown in narrow belts within annual agricultural crops.
3. Phase crops: short-lived woody species used as a de-watering phase within the crop rotation, harvested at 3–6 y after which the land reverts to annual crops or pasture. Usually planted in large blocks.

Long-rotation crops are most likely to be grown for solid wood products such as fence posts, firewood and sawn timber, while coppice and phase crops would produce smaller-dimension material suitable for reconstituted wood products, chemical extracts and bioenergy.

Current indications are that most (31 species) of the prospective *Acacia* from the southern Australian agricultural zone have potential as phase crops, 13 species may possibly have prospects as long-rotation crops, while only 8 species appear to have any prospects as coppice crops. Plant establishment by direct seeding is essential for the commercial viability of phase crops, and also confers a cost advantage in the establishment of coppice crops and long-rotation crops. Therefore, one of the attractive attributes of *Acacia* species as potential crop plants (apart from their rapid growth rate, nitrogen fixation capability, etc.) is their large seeds that are amenable to direct-seeding technology.

The ability to reliably and vigorously resprout after harvest is an essential character for coppice crops. Although very little is known about this characteristic in *Acacia*, it is seemingly uncommon among the 35 prospective species. *Acacia saligna* would appear to have the best potential as a coppice crop, although *A. implexa*, *A. linearifolia*, *A. microbotrya*, *A. murrayana*, *A. retinodes* ‘Normanville’ variant, *A. salicina* and *A. stenophylla* may have some prospects.

Some potential difficulties for the management of *Acacia* as a tree crop include the early prolific seed production and/or the capacity to root sucker that occur in a number of the species. Precocious seed production in cultivated stands may create a soil seed bank that may cause weed problems in adjacent or subsequent annual crops. However, in an agricultural context such regeneration might be regarded as fodder or green manure, or be easily controlled by modifying existing weed control methods.

Vigorous or moderately-vigorous root suckering appears to be common in a number of the highly ranked species, namely, *A. leucoclada*, *A. microbotrya*, *A. retinodes* ‘typical’ variant, *A. salicina* and *A. subfalcata*. However, very little is known about this character in *Acacia*. The ability to root sucker may or may not be advantageous in cultivation. It depends upon whether or not this attribute is desirable in the farming system in which the species is placed. Suckering may be advantageous where soil stabilization is required, or where regeneration by this method has a commercial advantage, but it also has the potential to complicate the management of *Acacia* as a tree crop. If ways were devised to manage suckering to advantage in crop systems, it would substantially increase the value of about one-third of the species listed above.

Weed potential

Many *Acacia* species have the potential to display various aspects of weediness. A primary strategy adopted in the *AcaciaSearch* study to minimize the environmental weed risk was to assess only those species that occurred naturally within, or very close to, the target zone. It was considered inappropriate at this early stage of the selection process to preclude or unduly negatively weight species on the basis of weed potential. To do so would pre-empt the development of effective control measures through management, breeding and other strategies, should these be deemed necessary. As crop development progresses, knowledge of the biology and ecology of the species will expand, thus allowing a more rigorous prediction of weed risk that might occur should species be considered for translocation outside their natural area of occurrence. This strategy is considered to provide a safe development pathway for *Acacia* crops. Relevant here is the program established in 2004 by Cooperative Research Centre for Plant Based Management of Dryland Salinity to develop a weed risk assessment protocol that will be used prior to release of any new woody crop plant (see <http://www.crcsalinity.com.au/programs/index.php?displaytype=projects&id=16>).

Based on existing knowledge, the following eight *AcaciaSearch* species perhaps have the greatest weed potential: *A. baileyana*, *A. cyclops*, *A. dealbata*, *A. decurrens*, *A. mearnsii*, *A. melanoxylon*, *A. pycnantha* and *A. saligna*. However, half of these

species express weediness in relatively-high-rainfall areas, so it is not known to what extent (if at all) they will develop similar tendencies in the drier, semi-arid environments of the target area. It is important therefore to assess weed risk within the environment where species may be cultivated. The three species that might pose greatest weed risk in the target area are *A. cyclops*, *A. pycnantha* and *A. saligna*. Notwithstanding the above, a number of prospective species grow naturally in disturbed agricultural landscapes with no recorded weed problems, e.g. *A. argyrophylla*, *A. acuminata*, *A. doratoxylon*, *A. microbotrya* and more. Weed issues are discussed in the introduction to the *AcaciaSearch* report (where some weed reduction strategies are suggested) and also under each of the 35 species profiles.

Concluding remark

Identification of the 35 species that are detailed in the *AcaciaSearch* report provides the crucial first step in the development of acacias as potential new crops for the southern Australian agricultural zone.

Acknowledgments

The information presented here was abstracted from the *AcaciaSearch* publication (Maslin and McDonald 2004), where individuals and organizations who provided invaluable assistance to this project are acknowledged.

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Session 4: *Acacia* Species and Resource Management
Paper 21

Variation in *Acacia saligna* (Mimosaceae) has Implications for its Domestication

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Abstract

The Western Australian Department of Conservation and Land Management's Revegetation Systems Unit is evaluating *Acacia saligna* for biomass production on farmland affected by dryland salinity. This species is characterised by high levels of morphological variation, some of which has a taxonomic basis. To facilitate the effective evaluation of the potential of this species, work is in progress to formally resolve this variation. This paper provides a brief overview of this task and discusses differences between variants in some important economic attributes, such as growth form, biomass production and suckering propensity, in relation to its successful domestication.

Introduction

Acacia saligna (Labill.) H.Wendl. (coojong) is a Western Australian endemic tree or shrub with a long history of use in Australia and many overseas countries. In Australia, coojong was widely used for coastal sand dune stabilisation, mine site and landscape rehabilitation and as an amenity plant (see Maslin and McDonald 2004). Many early plantings have resulted in it becoming naturalised in South Australia, Victoria, Tasmania, New South Wales and south-eastern Queensland; in Western Australia some populations may represent provenances introduced from other areas. Coojong has also become naturalised in numerous overseas countries such as South Africa, California and Chile, and those that fringe the Mediterranean Sea. In many of these countries it was introduced as a fodder, sand stabiliser, fuelwood or

windbreak species (Midgley and Turnbull 2003). Its success in these roles is due to its ability to develop into a robust woody shrub or small tree and to grow rapidly on a wide range of often adverse soils.

In the wheat belt of Western Australia, coojong has recently shown potential as a fast-growing source of biomass for energy, wood composites and charcoal, on farmland affected by dryland salinity. It is now considered a priority species in this role (refer *Search* project, Olsen *et al.* 2004; and *FloraSearch* project, Hobbs *et al.* 2007) which is being implemented by the Revegetation Systems Unit of the Western Australian Department of Conservation and Land Management (CALM)⁶. The impetus for targeting coojong in this role arose from the species having been highly ranked (category 1) in the *AcaciaSearch* study (Maslin and McDonald 2004; Maslin and McDonald pp. 86–90 this volume).

For a species that has had a long history of use in Australia and overseas, it came as somewhat of a surprise that four main variants of coojong have only recently been recognised. Although coojong had been studied by Maslin (1974), the main outcome of that investigation was a change in its botanical name from *A. cyanophylla* to *A. saligna*. Thirty years later Maslin and McDonald (2004) reported in the *AcaciaSearch* study that coojong consisted of four main variants, and these were subsequently the basis of a genetic study by George *et al.* (2006). The four variants differ from one another by a combination of subtle morphological traits. They also show age-dependant differences, where phyllode and bark characters differ depending on whether plants are juvenile, adolescent or adult. We are currently working to more fully understand the nature of this variation in coojong and to resolve the taxonomic status of the four main variants.

⁶ The *FloraSearch* project is currently co-funded by the Joint Venture Agroforestry Program, and the CRC for Plant-Based Management of Dryland Salinity

Resolving variation within coojong has particular relevance for its domestication and the effective use of its genetic resources. Differences in growth form, biomass production, suckering propensity and fodder value are evident among variants (Maslin and McDonald 2004). Some of these are important economic attributes which are likely to become the focus of future breeding programs if coojong is to become successfully domesticated. The aim of this paper is to provide a brief overview of variation in coojong and highlight the implications this has for the domestication of the species.

Natural distribution

Coojong is endemic in south-western Western Australia where it extends from near Kalbarri, north of Geraldton, south-east to near Mount Ragged, which is well to the east of Esperance. It is bounded by the Indian Ocean in the west and approximately the 250–300 mm rainfall isohyets in the east (Fig. 1). There are outlying populations about 200 km east-north-east of Kalbarri on Meka, Murgoo and Jingemarra Stations. Its distribution encompasses a range of bioregions from the semi-arid shrublands and woodlands of the wheat belt to temperate open forests in the higher-rainfall zone of the south-west. It also extends to coastal dunes and has outliers in the arid zone.

Although coojong is widespread in south-western Western Australia, it is only locally abundant as it is often restricted to depositional sites close to watercourses, rainfall run-on sites at the base of rock outcrops, the inter-dune swales of coastal sand dune systems and along roadsides where run-off from rainfall accumulates. Soils are sometimes moderately saline at depth, have pH reactions that range from acidic to alkaline and include sands, sandy loams or sandy clays. Rocks in the area of occurrence are typically limestone, granite or laterite.

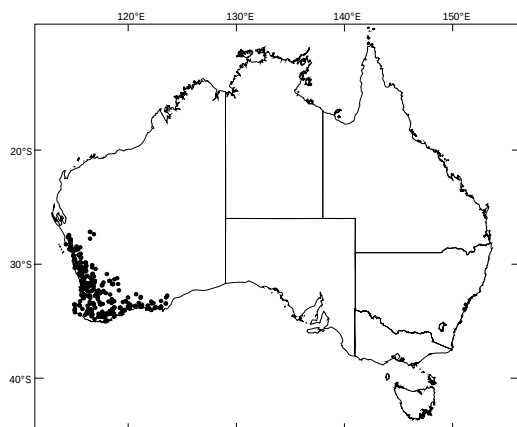


Figure 1. The natural distribution of *Acacia saligna*

Main variants recognised

The following provisional assessment of variation in coojong follows the treatment presented in *Acacia Search* by Maslin and McDonald (2004). This treatment was based mainly on morphological characters that have been observed in the field in both natural populations and cultivated plants. Our work in progress, which is assessing more ‘fine-grained’ morphological traits such as inflorescence and fruiting structures, may bring to light information that could have a bearing on concepts presented here. Currently, over the natural range of coojong, four main variants can be defined.

The ‘Typical’ variant

This is the most widespread variant of *A. saligna*. It extends throughout the wheat belt from the Murchison River to the Esperance region and is displaced by the ‘Cyanophylla’ variant along the western extent of its range. It is recognised by its glossy, narrowly elliptic seedling phyllodes, often straight, subglossy to glossy green adult phyllodes and the adult phyllodes. It is usually a shrub 2–5 m tall with a dbhob of 5–10 cm; sometimes around granite rocks it may reach 10 m tall with a trunk to 20 cm dbhob. Propensity for root suckering appears to be variable. It flowers during mid-October.

The ‘Cyanophylla’ variant

This variant is restricted to the Swan Coastal Plain and has dull green to grey-green adult phyllodes that are usually slightly curved. It grows as a tall erect shrub or tree 3–10 m tall. It is either single-stemmed or has a short main stem which branches near the base; the stems are robust and reach about 20–40 cm dbhob. The crown is notably dense and bushy compared to other variants. Some plants of this variant are known to root sucker but seemingly not as aggressively as the two variants below. Flowers are present from August to September.

The ‘Tweed River’ variant

This variant occurs in the Collie–Manjimup–upper Kalgan River region and differs in having large, pruinose, elliptic juvenile phyllodes and glaucous, often pruinose adult phyllodes that are relatively short, broad and straight. It has white pruinose branchlets. It grows to a tree 3–10 m tall with either a single stem or with a few main stems from the base. The trunk is up to 35 cm dbhob on the oldest trees. This variant is most readily identified by the white pruinose stems and distinctly bluish phyllodes, particularly on juvenile plants. It suckers aggressively and flowers during late September.

The ‘Forest’ variant

This variant occurs in the Manjimup–Lake Muir–Lake Clifton region, in the higher rainfall, ‘forested’ parts of the range of *A. saligna*. It is most similar to the

‘Typical’ variant and may represent part of the provenance variation of this variant. It usually has more or less straight adult phyllodes which are highly variable in colour, and juvenile foliage that tends to be notably elongated. This variant grows as a shrub or crooked tree 3–8 or 10 m tall. It is single-stemmed or has a few main stems from the base, and trunks that are 10–20 cm dbhob. This variant is notable for its aggressive root suckering habit. Like the ‘Typical’ variant, flowers are present during mid-October.

Support for the recognition of these variants was recently presented in a genetic study based on neutral RFLP molecular markers (George *et al.* 2006). While this study showed genetic support for the morphological differences between three of the variants, there was no support for the differentiation of the ‘Cyanophylla’ and ‘Tweed River’ variants. This is despite these two having strong morphological differences. This result may reflect rapid and relatively recent origins for one of these variants or may have been an artifact of the sampling strategy used in the study, as the ‘Tweed River’ and ‘Cyanophylla’ variants were represented by a limited number of populations compared to the other variants. With new information from further field and herbarium-based surveys we are now in the position to build on our understanding of genetic variation in coojong established by this study.

Differences in seedling morphology between variants, expressed once seedlings attain around 6–10 nodes in height, are also evident. While clear differences in phyllode gloss, colour, shape and dimensions are evident between the ‘Typical’, ‘Cyanophylla’ and ‘Tweed River’ variants, seedlings of the ‘Forest’ variant are more ambiguous in these respects. At this stage of our understanding, cultivated seedlings of the ‘Forest’ variant tend to resemble either ‘Typical’ or ‘Cyanophylla’ seedlings, or appear intermediate between the two. This suggestion of hybrid origin for the ‘Forest’ variant is a conundrum as there was no evidence for this in the RFLP data presented by George *et al.* (2006). Further work is in progress to clarify this anomaly.

Implications for domestication

From a domestication perspective, some important differences in phenotypic traits are evident among variants (Table 1). For example, evidence from natural populations indicates that the ‘Cyanophylla’ variant consistently shows a favourable growth form and has high levels of biomass production. The clear differences in suckering propensity among variants also have implications for their silvicultural management and potential weed management. While root suckering is potentially advantageous in some circumstances, such as the rehabilitation of excessively sandy sites or as a cropping strategy for stock fodder, it could make harvesting a woody biomass crop difficult if suckering individuals reduce the uniformity of the crop. Aggressive root suckering is clearly evident in the ‘Forest’ variant, but in contrast rarely occurs in populations of the ‘Typical’ variant. Information on other traits, such as coppicing or pollarding ability, is scant for some variants and requires augmentation. If strong coppicing proves to be a reliable characteristic trait of the ‘Cyanophylla’ variant, this will have implications for its potential as a coppice crop. There are clear economic advantages in having the option to conduct multiple harvests of a biomass crop rather than having to re-establish seedlings after each harvest.

Variation between variants

Some of the above traits were reviewed in a recent trial near Dalwallinu established for the *Search* project by CALM’s Revegetation Systems Unit in the northern wheat belt of Western Australia (Fig. 2). The performance of 15 populations of coojong is being assessed on a site in the 360 mm mean annual rainfall zone that formerly supported wheat crops. At age 18 mo, variation between and within variants in growth was clear.

Table 1. An assessment of traits considered important from a domestication perspective for the *Acacia saligna* variants, based on observations from natural populations

Trait	Variant			
	‘Typical’	‘Cyanophylla’	‘Forest’	‘Tweed River’
Plant form (e.g. stem/branch straightness)	Poor to good	Good to excellent	Poor to good	Fair to good
Plant height	Low to tall	Tall	Low to tall	Low to tall
Woody biomass production	Poor to good	Excellent	Poor to good	Fair to good
Coppicing ability	?Poor to good	Excellent	?Fair	?Fair
Suckering	?Weak to moderate	Weak to moderate	Aggressive	Strong
<i>Uromycladium</i> susceptibility	Low to moderate	Moderate	Low to moderate	High

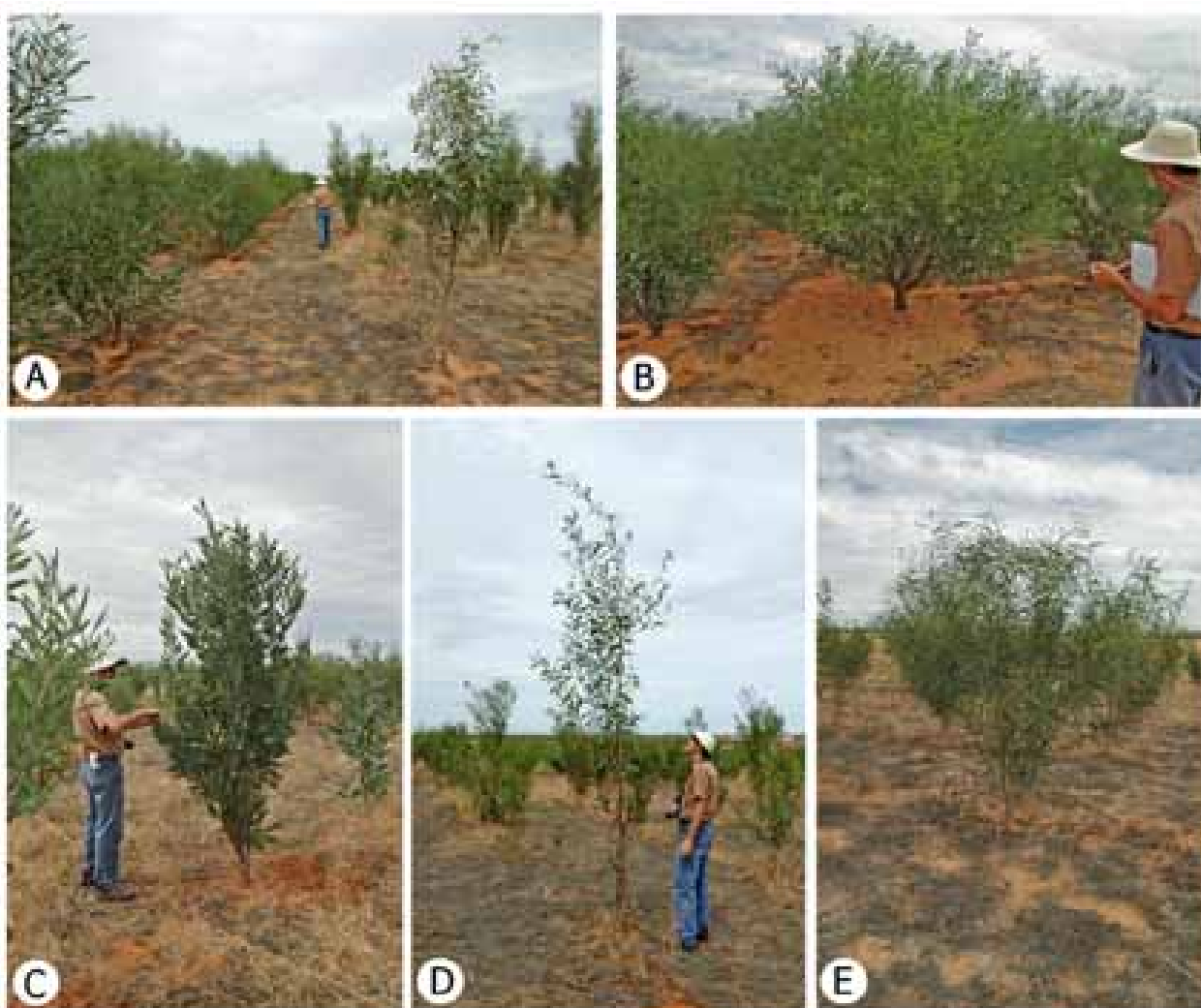


Figure 2. Performance of *Acacia saligna* variants at age 18 mo in the trial near Dalwallinu: A — Plots of the ‘Cyanophylla’ variant (left row) in this trial were notable for their tendency to take over the site, particularly when compared to the ‘Typical’ variant shown in the rows on the right; B — The Muchea provenance of ‘Cyanophylla’ was conspicuous for high levels of biomass production; C — A plant of the ‘Tweed River’ variant readily recognised in the trial due to its crown of large, pruinose phyllodes; D and E — There was clear provenance variation in the ‘Typical’ variant with the Parkeyerring provenance having a tall spindly habit in this trial (D) in contrast to the shrubby Wongan Hills provenance (E).

While an analysis of the trial will be reported elsewhere by CALM’s Revegetation Systems Unit, some observations on growth as it relates to Table 1 are worth noting here. Trial plots of the ‘Cyanophylla’ variant comprised densely foliated, robust plants which contrasted sharply with the sparse habit usually exhibited by other variants in the trial.

Individual plants typically had crowns touching or nearly touching and appeared relatively consistent in their biomass production.

While this observation needs to be validated by statistical support, the performance of ‘Cyanophylla’ to date provides indirect evidence that it has a more aggressive root system at this site compared to the other variants. It also raises the important question of whether or not this variant will be able to maintain its performance if it depletes the available ground water at this site.

Variation between variants in flowering times is another factor that could have implications for breeding programs if maintained under cultivation. Current evidence suggests that under natural conditions pollen movement, and hence gene flow, may be limited in a number of key areas where variants occur in close geographic proximity. There was some evidence for this in data presented by George *et al.* (2006). Differences in flowering times could affect breeding to combine traits from different variants and on the management of stands established for seed production.

Provenance variation within variants

While the growth of plants in the Dalwallinu trial highlighted the morphological differences among variants, it also showed that provenance variation for phenotypic traits within variants is considerable. This was particularly evident in the ‘Typical’ variant, which is not surprising given that it has the most extensive

geographic range and the largest geographic distances between natural populations. These early observations on provenance variation in growth habit within the ‘Typical’ variant suggest that, of all coojong variants, it represents the largest and most variable genetic base that will warrant evaluation. This may be seen in Figure 2 by comparing the growth habit of the relatively tall spindly Parkeyerring provenance and the bushy habit of the Wongan Hills provenance.

Provenance variation in susceptibility to the rust fungus *Uromycladium tepperianum* could become a factor in the domestication of coojong. This fungus has a relatively high incidence in some populations and can reduce growth. The fungus can form numerous galls (clumps of brown deformed growth) in the crowns of infected plants which eventually cause crown dieback. Heavily infested trees have a shortened lifespan. While the fungus is most prevalent in populations of the ‘Tweed River’ variant (Table 1), populations of the other variants are also known to be severely affected. It is not known at what level susceptibility to this pathogen manifests itself in coojong, but if susceptibility operates at the individual genotype level then selection for non-susceptible genotypes may be required.

Climate differences

Some differences in climatic parameters are evident in data representative of the natural populations of each variant (Table 2). ‘Typical’ is the most widespread variant and its populations experience the hottest, driest conditions and have the widest range in climatic parameters. ‘Cyanophylla’ has a narrow geographic range and shows a fairly narrow range in climatic parameters. As would be expected from its coastal or near-coastal occurrence, this variant experiences the warmest winters. Both the ‘Tweed River’ and ‘Forest’ variants occur near the highest-rainfall areas in Western Australia and have relatively narrow climatic parameters and relatively cold winters, particularly when compared to ‘Cyanophylla’.

The difference among variants for mean annual rainfall is likely to have a significant bearing on performance on planting sites where ground water availability becomes a limiting factor. Natural occurrences of coojong are restricted to depositional sites where ground water availability is usually not a critical limiting factor for plant growth. Water in the soil profile at these sites is supplemented by rainfall run-on events and lateral movement of water through the soil profile to lower parts of the landscape. On recharge sites (like the one at the Dalwallinu trial) where the only available water in the profile comes from seasonal rainfall, the variants adapted to areas that experience higher rainfall may perform poorly in the long term. Differences in performance among variants (or provenances) could also be expected if sites targeted have consistently lower mean minimum winter temperatures than those experienced over their natural ranges.

Future developments

To further investigate the agroforestry potential of coojong, CALM’s Revegetation Systems Unit has a wide-ranging program to evaluate this important natural genetic resource. Using sampling strategies and trial designs based on current knowledge of morphological variation within this species, comprehensive provenance and family trials will be established on a range of sites in the wheat belt of Western Australia during the winter of 2006. These trials will use a wide range of representative provenances to further explore phenotypic differences between and within variants. This work will provide a more accurate and effective evaluation of this species than that now available. Our work on a taxonomic revision of *A. saligna* aims to interpret variation in this species to underpin future domestication research.

Table 2. Climate profiles for the four main variants of *Acacia saligna* based on meteorological data representative of natural populations (data generated from Houlder *et al.* 2000 and the Bureau of Meteorology website http://www.bom.gov.au/climate/averages/tables/ca_wa_names.shtml)

Variant	Altitudinal range (m)	Mean maximum, hottest month (°C)	Mean minimum, coldest month (°C)	Lowest minimum temperature recorded (°C)	Mean annual rainfall (mm)
‘Typical’	100–350	28–39	5–9	–5	250–650
‘Cyanophylla’	0–90	28–33	8–10	0	750–900
‘Tweed River’	150–300	30–31	4–6	–4	700–1000
‘Forest’	5–300	27–30	6–8	–4	800–1000

Acknowledgements

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Session 4: *Acacia* Species and Resource Management

Paper 22

Koa, the Hawaiian *Acacia*

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NICK DUDLEY has been engaged in koa research in Hawaii for over 15 y and has investigated the genetics, silviculture, utilisation and marketing of this species. His current research focus is the identification of pest-resistant koa seed sources for ecosystem restoration and reforestation. The goal is to develop the technologies so that it possible to move away from wild harvesting to sustainable management of koa. He is a member of the board of the Hawaii Forest Industry Association.

Abstract

Koa (*Acacia koa*) is endemic to the Hawaiian Islands and a dominant canopy tree that can grow to 35 m in height. In Hawaii, koa is the most ecologically and economically important forest tree as it provides habitat for many native plants and animals, and a highly figured wood with striking colouration. Koa may share a common ancestor with *Acacia melanoxylon* (blackwood) as both species are phyllodinous. However, koa is tetraploid ($2n = 52$) and blackwood diploid ($2n = 26$). High levels of variation are found in the figure and colour of koa wood — from pale blonde to dark chocolate, with reddish brown being the most common. Koa is a medium-density timber that is easy to work and will finish to a high polish. It is the preferred species in the Hawaiian specialty hardwood market and is used for producing fine furniture, veneers, musical instruments and crafts. Current harvest levels are about 250 000 board feet (bd ft) or $600 \text{ m}^3 \text{ y}^{-1}$. Standing koa timber is currently priced from \$1000–1300 US m^{-3} . Koa lumber ranges from \$4.50 to over \$65.00 US per bd ft depending on the colour and figure of the wood at the retail level. The forest industry in Hawaii was valued at \$30.7 million US in 2001 and derived at least 90% of its value from koa. Providing an adequate supply of koa is a major concern to the Hawaiian forest industry and there is extensive interest from landowners and land managers to re-establish koa on many under-utilised lands to renew this depleted resource.

Introduction

In forests of the Hawaiian Islands, endemic *Acacia koa* A.Gray is a dominant canopy tree that can grow to 35 m in height. *A. koa* (commonly called koa) is present on all six of the main Hawaiian Islands, growing in moist habits at altitudes of 90–2100 m (Whitesell 1990). Large koa trees (Fig. 1) were traditionally used by Hawaiians to construct seafaring canoes (Cuddihy and Stone 1990). In Hawaiian ecosystems, koa trees provide habitat for many native plants, insects and birds. Today, because of koa's highly-figured wood with striking colouration, it is used in high-quality furniture, cabinets and veneers. This makes koa one of the most highly prized and economically important native tree species in the Hawaiian Islands.

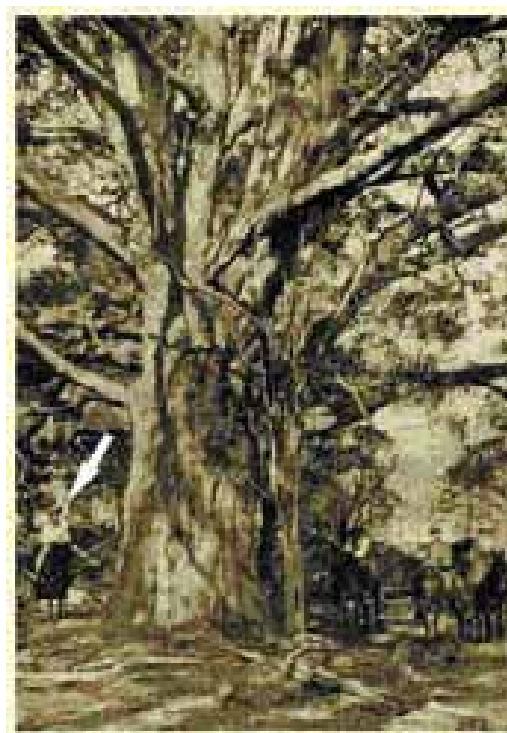


Figure 1. Old growth koa, *Acacia koa*. The arrow draws attention to the size of a person on horse-back.

Genetic variation

The evolutionary relationship of *A. koa* to other *Acacia* species is uncertain, but it has been placed in the subgenus *Heterophyllum* and may share a common ancestor with Australian species such as *Acacia melanoxylon* (blackwood) (Wagner *et al.* 1999). Both species are phyllodinous, initially bearing primary leaves that are replaced in the sapling stage, and are members of the subfamily Mimosaceae of the Leguminosae. Interestingly, koa is a tetraploid with $2n = 52$; many other phyllodinous acacias have a diploid chromosome complement, including *A. melanoxylon* with $2n = 26$ (Atchison 1948; Bukhari 1998).

Early taxonomists noted phenotypic differences among koa populations on different islands and across altitudinal gradients (Hillebrand 1888; Rock 1919; Judd 1920). Phenotypic variation among trees for a number of traits is substantial. An isozyme survey showed substantial polymorphism within koa populations (Conkle 1996). Populations from Oahu, Maui and Kauai shared similar allele frequencies, while trees sampled from the island of Hawaii had substantially different allele frequencies and some unique alleles (Conkle 1996). This high level of variation is found in many of koa's traits such as seed shape (Fig. 2), stem form, disease and insect resistance, and wood properties. Many of these traits are highly heritable and considered to be under genetic control (Sun 1996). This variation leads to potential for significant genetic improvement of koa through selection and breeding.

Utilisation

One of the most striking examples of this variation is in the colour and figure of koa wood. The colour varies from pale blonde to dark chocolate, with reddish-brown being the most common (Fig. 3). The most sought-after koa wood is highly figured with a light-refractive luster known as chatoyance (Potter 2005). This three-dimensional effect adds significantly to the visual appeal of finely finished wood. Evidence to date suggests that high levels of figure in koa wood are under both environmental and genetic control. Pockets

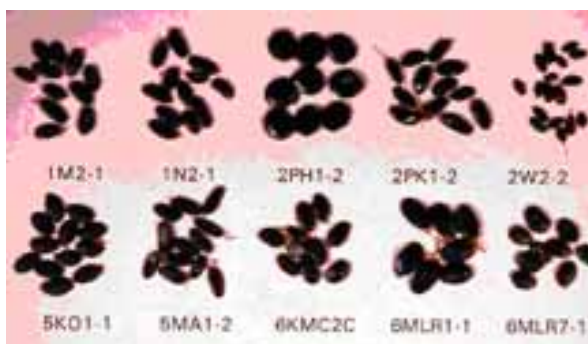


Figure 2. A diverse collection of *Acacia koa* seed

of figured wood can be found where environmental conditions create compression wood, such as under a heavy branch, or at the foot of a large tree trunk.

Alternatively, in certain koa trees, figured wood is found systemically throughout the entire tree. This indicates that figure may also be under genetic control (Dudley and Yamasaki 2000).

However, more extensive sampling is needed to fully support this finding.

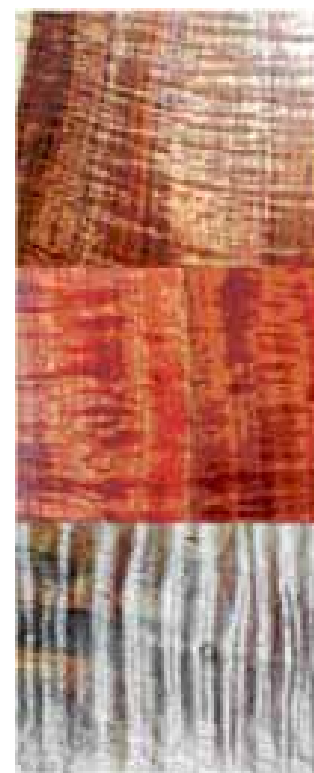


Figure 3. Variation in koa wood colour

Wood properties of koa (after Skolmen 1974)

Density: 609 kg m^{-3}

Shrinkage and stability: Owing to nearly equal shrinkage in radial and tangential directions, koa is readily kiln dried.

Strength and hardness: Koa is often compared to black walnut as their mechanical properties are strikingly similar (Skolmen 1968). The strength of koa is adequate for furniture and table legs (Gerry 1955). Koa is not considered to be hard enough for flooring, but it is more than adequate for scratch-resistant furniture (Harrar 1942).

Workability and seasoning: Most sawmilling or wood turning is performed when koa is green as this facilitates proper seasoning. When dry, the tannic exudates in koa make milling more problematic. Koa wood seasons well, with very little surface checking or warping if good drying procedures are followed.

Durability: Both heartwood and sapwood are highly susceptible to attack by both the Formosan subterranean and dry wood termite. The wood is not resistant to decay.

Finishing: Koa will finish to a high polish. It is considered easy to work and carve. However, high

figured, curly grain wood is very difficult to machine and is subject to tearout, due to varying orientation and interlocking of the grain. In the presence of bright sunlight, koa will quickly yellow. Because of this, it is not well suited for exterior applications.

Processing: Because the koa resource is widely dispersed, increasingly limited and of high value, micro-scale in-field milling with small portable sawmills is often feasible and economically viable. However, typical yields of usable wood are smaller and wastage is greater than in larger fixed mills.

Grading: In general, grading of koa lumber is ambiguous. It is often selected and graded to fit the requirements of the particular end use. Grade and price are often determined on a tree-by-tree basis between buyer and seller. However, broadly accepted koa grades range from #2 Common to Premium curl-instrument quality (Table 1).

Products: Koa products range from fine furniture, cabinet making, interior trim and molding, to fancy veneers, musical instruments, craftwood items and carving.

Marketing and markets

Koa is the preferred species in the Hawaiian specialty hardwood market where it is used for producing fine furniture, veneers, musical instruments and handicrafts. Koa represents at least 90% of the value of the Hawaiian forest products industry which in 2001 generated an estimated \$30.7 million US in revenues with a total employment of slightly more than 900 people full time (Yanagida *et al.* 2004).

There is also significant demand for koa in the Pacific region, notably Japan and the West Coast of the United States. From the 1970s through the early 1990s about 500 000 bd ft or about 1200 m³ of koa lumber entered the marketplace on an annual basis (Skolmen 1974; Yanagida *et al.* 1993). However, indications of increasingly tight supplies are escalating retail prices for koa, up by 50–100% today compared to a decade ago, depending on the grade (Dudley and Quinn 2004). The current annual harvest is estimated to be about half of the historic levels, or about 250 000 bd ft or 600 m³.

Accordingly, standing timber or stumpage is currently priced from \$1000 to \$1300 US m⁻³. Koa lumber prices now vary from \$4.50 to \$65.00 US per bd ft and more at the retail level, depending on the colour and figure of the wood (Table 1). There is a significant relationship between visual attractiveness and economic value.

Table 1. Koa grades and prices in US\$ per board foot (144 cubic inches i.e. 1" × 12" × 12") in 2005*

Grade		Size	
		4/4** 1" thick	8/4** 2" thick
#2 Common	2C	4.50	4.50
#1 Common	1C	10.00	10.00
Select/better	SB	18.00	18.00
Select curl (lightly figured)	SC	25.00	25.00
Full curl (medium figured)	FC	30.00	30.00
Premium curl (highly figured)	PFC	45.00	45.00
Premium curl (instrument quality)	PFCI	65.00	65.00
Koa logs		6.00	6.00

*Source: Aloha Woods Inc, Kailua-Kona, Hawaii 96740

**This is a Hawaiian grading measure that approximates the continental US standards developed by the National Hardwood Lumber Association. This measure for thickness is based on units of 1/4" width, thus 4/4 = 1", 8/4 = 2".

Makers of products that utilise large volumes of wood, such as solid wood furniture or surfboards and canoes, are finding it increasingly challenging to locate affordable koa wood. In contrast, there is an active market for products using small-dimension wood.

Ensuring an adequate supply of koa is a major concern of the industry. The natural range of koa has been greatly reduced from historic levels due to logging and land clearing for agricultural production and cattle pastures. Currently, there is extensive interest from both private landowners and public land managers to re-establish koa on many under-utilised lands to renew this depleted resource.

Conclusion

Koa is a medium-density timber that is easy to work and will finish to a high polish. It is extremely variable in most of its characteristics, especially wood colour and figure. These attributes give koa its unique visual attractiveness and economic value. Interestingly, blackwood is considered to produce wood similar to koa, although blackwood has a straighter trunk and shorter phyllodes (Whitesell 1990). All koa timber currently harvested comes from old-growth stands. At the current harvest rate, severe shortages will occur unless there are increases in both managed natural forests and plantations. Koa adapts readily to plantation management (Fig. 4) and should continue to be an important source of high-quality timber if current knowledge gaps are filled through research. Thus, in the longer term, it is likely that koa will continue to occupy niches at the high end of the appearance-grade wood products market.



Figure 4. Twelve-y-old koa in a plantation at Maunawili, Oahu. The height and diameter (bhob) of this tree were 15 m and 40 cm, respectively.

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Session 4: *Acacia* Species and Resource Management
Paper 23

Genetic Resources in Blackwood: A Mini-Review

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GORDON BRADBURY has been a forester with Forestry Tasmania (FT) since 1988, working primarily on strategic wood-resource planning issues. In 2003 he moved to FT's Division of Research and Development and undertook research into blackwood timber quality, comparing young regrowth from fenced intensive blackwood, swamp and plantation-grown blackwood. In late 2005, he commenced a PhD at the University of Tasmania looking at the effects of environment and genetics on blackwood wood quality.

Abstract

This brief review of blackwood (*Acacia melanoxylon*) considers seed collections and progeny trials, and published results from these trials. Extensive family and provenance seed collections have been made both within Tasmania and mainland Australia, with over 200 collections. The published literature contains reference to over 60 progeny trials established since the mid-1970s in both Australia and overseas. There are few published papers reporting results from these trials. Generally results indicate significant provenance variation, although within-provenance and family variation is also large. Greater collaboration and commitment is needed between members of the small international blackwood community for greater gains to be realised from existing and future investment in blackwood genetic research.

Background

There is a small but growing body of literature on blackwood provenance research. Interest in blackwood at this level comes as no great surprise, given the enormous geographic range of the species and its adaptation to a range of environments. The disciplines of genetics and ecology are therefore likely to be very useful in improving the value of blackwood to production forestry. However, although blackwood is a species with a long history of use as a fine cabinet timber, this has always been into a small if well-established market. This has meant that the resources available for tree improvement programs have been limited and progress in this area of research very slow.

This short review focuses on available information on seed collections, provenance trials and published data from these trials. Much of the information from Tasmania can be found in Neilsen and Brown (1996), who summarised blackwood research up to that date. Information from other sources is more thinly spread and for some trials is non-existent. A broader summary of blackwood research that includes genetic resources can be found in Searle (2000), with updates from recent literature in the proceedings from the Blackwood Industry Group (BIG) workshops in 2000 and 2002 (e.g. Stackpole 2001; Jackson *et al.* 2004; Pinilla *et al.* 2004; Zhang *et al.* 2004).

Seed collections

The available information on blackwood seed collections is mainly based on those collected in Tasmania and by the CSIRO Australian Tree Seed Centre (ATSC). For many years the Forest Research Institute in New Zealand has had an interest in blackwood, and has maintained a blackwood seed collection.

As seed collections are the basic source of material for research into blackwood genetics, it is important to maintain accurate records of where the seed comes from, particularly its geographic location, and the number and distribution of parents.

Forestry Tasmania

Forestry Tasmania made extensive collections of blackwood seed between 1988 and 1991 when local interest in planting blackwood was high. Seed was collected from a total of 127 trees from native forest around Tasmania. In 1988 and 1989 seed was collected from single trees of superior phenotype. In 1991 seed was collected to supplement those obtained previously from high-altitude groups and to provide additional trees so that comparisons between and within groups could be undertaken. The 1991 collections were from random trees provided that seed trees were at least 100 m apart and each tree was not isolated or of poor form. Most trees were felled during seed collection.

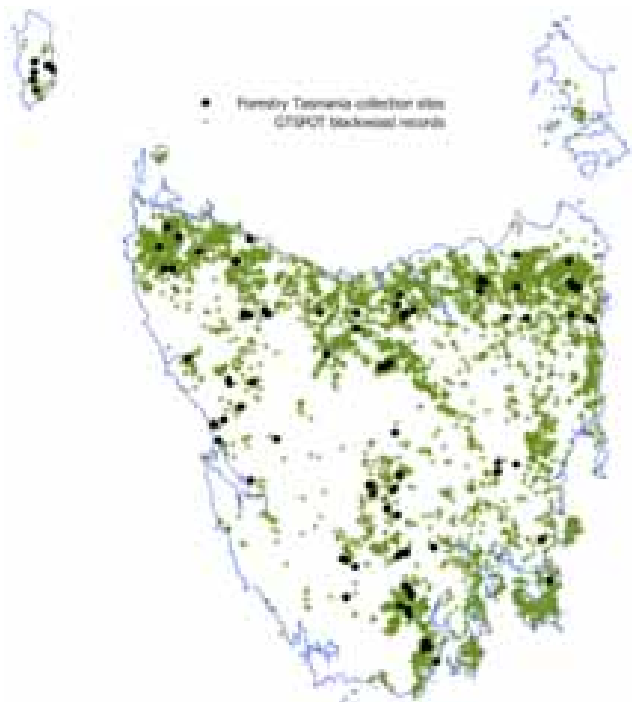


Figure 1. Forestry Tasmania blackwood research seed collection locations within Tasmania, together with GTSPOT blackwood records

Some of the seedlots were from trees exhibiting fiddleback figure in the wood.

Of the 127 seedlots, 108 contain at least 10 g of seed. This was deemed the minimum quantity necessary for future trial work. Neilsen and Brown (1996) arranged these 108 seedlots into 22 groups based on location, climate, soils and altitude. Figure 1 shows the location of the 127 collection sites around Tasmania, together with the known distribution of blackwood (GTSPOT 2005). The 127 seedlots represent a remarkably good sample from this distribution, with the possible exception of that found in the south-east of the state and Flinders Island.

ATSC

Since the 1970s the ATSC has had a significant tree seed collection program (Fig. 2). During that time 89 seedlots of blackwood are known to have been collected with 29 blackwood seedlots composed of 347 families currently listed in the ATSC catalogue. These include examples from the full geographic range of the species from northern Queensland to southern Tasmania.

All seedlots must meet minimum standards of documentation. These standards are: seed collected from natural stands (unless specified), location of collection (including latitude, longitude and altitude), date of collection, number of trees in collection, minimum spacing of 100 m between trees and a minimum standard for seed cleanliness. For ATSC collections, additional documentation includes soil data, associate vegetation information, tree descriptions, phenological data, photographs and botanical specimens (ATSC 2006). A useful history of the ATSC is provided in FAO (2002).



Figure 2. Past and currently available ATSC blackwood seed collection sites

New Zealand

New Zealand has had an interest in growing commercial blackwood since the late 19th century. This interest was given a new focus in 1981 when blackwood was included in the official New Zealand Forest Service Policy for Special Purpose Species. Since that time it has been adopted by an increasing number of New Zealand farmers who are taking up the market in growing and supplying premium-grade timbers. The Forest Research Institute of New Zealand (FRI) (formerly the New Zealand Forest Service) maintained a low-level blackwood research program, including a blackwood seed bank, until recently. This was made up of local sources and material from Tasmania, the ATSC, South Africa and Chile.

Provenance trials

Tasmania and Victoria, New Zealand and China have been the major contributors to the small body of published research literature on blackwood provenances.

Tasmania and Victoria

Fourteen blackwood provenance trials at seven sites have been established in Tasmania since 1988 (Table 1). Of these, ten are considered in more detail by Neilsen and Brown (1996). Of the four additional trials, two are at Westfield in the Florentine Valley and include a pure planting and one with a nurse crop. The third is a major trial established at Togari, west of Smithton (114 families), and the fourth is a blackwood

seed orchard at Oigles Road near Geeveston that has the potential to contribute to valuable genetic research. These four trials have not been measured since establishment.

Seven blackwood provenance trials were established in Victoria in 1993/1994 in the south-west and the north-east of the state. Early results from some of these trials have been published (Table 2).

ACT and Queensland

A major acacia species and provenance trial was established in the Australian Capital Territory (ACT) in 1994. The trial included five provenances of blackwood. Unfortunately the replicate of the trial at the better site (at Uriarra) was destroyed by wildfire in 2003. Applegate and Nicholson (1986) report the early results of two acacia species trials in Queensland that included two Queensland provenances of blackwood (Table 2).

New Zealand

Three blackwood provenance trials were established in New Zealand in 1960 (Table 2). The history of these quite small trials and results from their measurement have yet to be published, although Nicholas and Brown (2002) comment that their form was no better than that of trees from unselected sources. Subsequent trials, one established in 1983 and a major series of 15 trials established in 1984, represent a significant resource for genetic research (Table 2). The limited venture into blackwood clonal research in New Zealand represents the first tentative step into the next phase of genetic research in blackwood.

Table 1. Blackwood provenance trials established in Tasmania. The first ten are referred to in Neilsen and Brown (1996).

RP_no	Location	Type	Nurse crop	Families	Replicates	Trees per plot	Total trees	Latitude (°)	Longitude (°)	Estab year
RP266/1/1	Meunna*	Block	<i>P. radiata</i>	20	2	80	3200	41.08	145.47	1988
RP226/1/2	Meunna*	Row	None	23	5	20	2300	41.08	145.47	1988
RP266/2/1	Meunna	Block	<i>P. radiata</i>	25	2	80	4000	41.08	145.47	1989
RP266/2/2	Meunna	Row	None	37	5	20	3700	41.08	145.47	1989
RP266/3/1	Smiths Plains	Block	<i>P. radiata</i>	7	2	26	364	41.43	146.00	1988
RP266/3/2	Smiths Plains	Row	None	9	5	20	900	41.43	146.00	1988
RP266/4/1	Virginstow	Block	<i>E. globulus</i>	15	2	80	2400	41.30	146.60	1988
RP266/4/2	Virginstow	Row	None	17	5	20	1700	41.30	146.60	1988
RP266/5/1	Round Hill	Row	<i>E. nitens</i>	39	3	15	1755	41.52	146.00	1993
RP266/6	Meunna	Row	<i>E. nitens</i>	48	2	10	960	41.08	145.47	1993
RP266/9/1	Westfield	Row	<i>A. dealbata</i>	24	1–6	20	630	42.65	146.43	1993
RP266/9/2	Westfield	Row	None	?	?	?	?	42.65	146.43	1993
RP266/10	Togari*	Row	<i>E. globulus</i>	114	5	5	2850	40.88	144.95	1997
Seed orchard	Oigles Rd SO	Row	None	114	6	3	2052	43.17	146.85	2000

*Trial includes mainland provenances

Table 2. Known blackwood provenance trials established outside Tasmania

State or country and location	Established	Reference	Nurse crop	No. of families or provenances	No. replicates	Trees per plot
Victoria						
Tallangatta	1993	Stackpole 2001	Yes	25	5	6
Euroa	1993	Stackpole 2001	Yes	25	6	6
Euroa	1993	Stackpole 2001	No	25	9	6
Hensley Park	1993	Bird <i>et al.</i> 1996, Jackson <i>et al.</i> 2004	Yes	20	2	10
Vasey	1993	Bird <i>et al.</i> 1996, Jackson <i>et al.</i> 2004	Yes	20	2	10
Gringegalgona	1994	Bird <i>et al.</i> 1996	No	4	4	10
Dunkeld	1994	Bird <i>et al.</i> 1996	No	4	4	10
Bunyip	2003		?	70		
Queensland						
Tuan	1985	Applegate and Nicholson 1986	No	2	2	16
Kuranda	1985	Applegate and Nicholson 1986	No	2	0	4
Australian Capital Territory						
Uriarra	1994	Searle and Owen 2005	No	5	4	10
New Zealand						
Waitangi	1960			10		
Kaingaroa	1960			10		
Te Wera	1960	FRI 1978		10		
Tauranga (Reynolds)	1983	Nicholas <i>et al.</i> 1994	No	4		
Tairua NI	1984	Stebbens 1992	No	30		
Whakarewarewa NI	1984	Stebbens 1992	No	30		
Kaingaroa (I) NI	1984	Stebbens 1992	No	30		
Kaingaroa (II) NI	1984	Stebbens 1992	Yes	30		
Wairau (Blenheim) SI	1984	Franklin 1987	No	30		
Longwood (Otatau) SI	1984	Franklin 1987	No	30		
Golden Downs (Nelson) (I) SI	1984		No	30		
Golden Downs (Nelson) (II) SI	1984		Yes	30		
Reefton (I) SI	1984	Franklin 1987	No	30		
Reefton (II) SI	1984	Franklin 1987	Yes	30		
Mawhera (Greymouth) SI	1984		No	30		
Mahinapua (Hokitika) (I) SI	1984		No	30		
Mahinapua (Hokitika) (II) SI	1984		Yes	30		
Strathallan (Dipton) (I) SI	1984		No	30		
Strathallan (Dipton) (II) SI	1984		Yes	30		
Clonal plantings (<i>Gibson-Smith</i>)	1991	Nicholas and Brown 2002				
China						
Shangyong forest farm, Hainan Island	1987			2 provs		
Zhuhai, Guangdong	1988			3 provs		
Longtouxue forest farm, Guangdong	1989			3 provs		
Longtouxue forest farm, Guangdong	1990			4 provs		
Hekou forest farm, Guangdong; Ruijin County, Jiangxi	1991			21 provs		
Timian Huadu, Guangdong; Longdong forest farm, Guangdong	1992			6 provs		
Shixing, Guangdong and Ganzhou, Jiangxi	1994			5 provs		
Shixing, Guangdong	1995			5 provs		
Conghua, Kaiping, Enping; Jiangmen Guangdong	1995			4 provs		

State or country and location	Established	Reference	Nurse crop	No. of families or provenances	No. replicates	Trees per plot
China (contd)						
Gudoushan, Longdong; Shunao forest farms Guangdong	1996	Zhang <i>et al.</i> 2004	No	35 p 178 f	8	3
Dongguan Guangdong	1997			20 fam.		
Luofeng Guangdong	1998			2 provs		
Shantou Guangdong	1999			2 provs		
Jiangmen Guangdong	2000			35 clones		
South Africa						
Blueliliesbush	1976	de Zwaan and van der Sijde 1990	No	12	6	49
Jonkersberg	1976	de Zwaan and van der Sijde 1990	No	12	6	49
Spitskop	1977	de Zwaan and van der Sijde 1990	No	12	4	36
Chile	2005?	Pinilla <i>et al.</i> 2004		12		

China

Since the late 1980s China has developed a series of provenance trials that include blackwood (Table 2). A major blackwood trial containing 178 families was established in 1996.

Others

Three blackwood provenance trials containing 12 provenances were established in South Africa in 1976 and 1977 (Table 2). These are some of the oldest blackwood provenance trials.

Chile has recently commenced a blackwood improvement program. They have identified blackwood as having commercial potential in the small private-grower market. Progeny trials containing 12 provenances are currently being established (Pinilla *et al.* 2004 and pp. 108–113 this volume).

Published data

While Tables 1 and 2 show an impressive list of blackwood provenance research trials, the list of published results emerging from these resources is disappointingly small.

Australia

The early results from the ten provenance trials in Tasmania referred to in Neilsen and Brown (1996) indicate significant differences between provenances for height and survival for most trials. There were no substantial differences in growth and survival between Tasmanian, Victorian and southern New South Wales (NSW) provenances. For Tasmanian provenances, there was no consistent trend between the effect of groupings by provenance origin on the variables measured, except for frost: the high-altitude north-eastern and far north-western provenances were consistently more susceptible to frost than other provenances. Since this publication, many of these

trials have not been managed as originally planned, and consequently there has been a reduction in their research value.

Stackpole (2001) published early results for the Victorian trials at Euroa and Tallangatta. He found significant differences in both basal area growth and form between provenances at both sites. Some provenances were identified that exhibited superior growth and form, and therefore were potential targets of further investigation.

Jackson *et al.* (2004) published early results for two blackwood trials in south-western Victoria. At both sites there were significant differences ($P < 0.05$) in height, dbhob and form between the provenances tested. There was no significant interaction between provenance and nurse-crop treatments. Provenance rankings were different between sites. There were some differences in provenance performance, based on groupings of provenance origin by altitude and rainfall.

Applegate and Nicholson (1986) reported results at age 12 mo from acacia species trials in Kuranda and Tuan, Queensland. The provenance from Nambour, south-eastern Queensland, performed better at both sites than the provenance from Atherton, far-northern Queensland.

Searle and Owen (2005) reported results at age 8 y from a set of acacia species trials in the ACT that included blackwood provenances from Queensland, South Australia, Tasmania and Victoria. This analysis included wood basic density and percentage heartwood measurements. Whole-tree, volume-weighted mean basic densities were not significantly different between the five provenances tested. There were highly significant differences ($P < 0.001$) in percentage heartwood among the provenances. One provenance had 0% heartwood but also had the highest mean basic density of the five provenances.

Other

Data at age 10 y from the Tauranga trial in New Zealand (Table 2) are presented in Nicholas *et al.*

(1994). There were statistically-significant differences between four seedlots, two from South Africa and two from Tasmania, in dbhob, basic density and green moisture content. No significant differences between seedlots were observed in percentage heartwood and heartwood colour.

Franklin (1987) showed that there was wide variation in frost resistance of individuals within provenances across the 1984 trials in New Zealand at age 2 y (Table 2). It was not uncommon to find seedlings killed by frost located quite close to others of the same origin showing little or no frost damage. No statistical analysis was undertaken. However, in general, Tasmanian seedlots were more frost-hardy than other Australian, New Zealand, Chilean or South African seedlots, although the Tasmanian seedlots had below-average height growth on the sites assessed. Stehbens (1992) also reported early results from four of the sites of this 1984 trial series. A complete assessment of the New Zealand 1984 trial series remains a significant opportunity for the blackwood research community.

In 1988 the New Zealand Forest Research Institute identified 74 trees of good form from North Island plantations and collected root cuttings from them. Of the 35 clones that were successfully rooted, 26 were archived on two sites north of Auckland in 1991. Measurements at age 6 y showed considerable variation in stem form amongst individual clones within sites and none had the good form that was a feature of the mother trees (Nicholas and Brown 2002). The reason for this outcome remains uncertain. Appleton *et al.* (1997) have suggested that blackwood form may be as much a function of insect attack as genetics and physical environment.

In the South African trials (Table 2) de Zwaan and van der Sijde (1990) found significant differences between provenances in dbhob up to age 10 y. Seedlots from Stawell in Victoria, Collingwood River in Tasmania and Tallaganda in NSW were the poorest performers in all trials. Identifying the best performers was more difficult. A later-age remeasurement of this series of trials would provide a very useful set of data, particularly if it included an analysis of wood properties.

In the large trial established in 1996 in Guangdong Province, China, Zhang *et al.* (2004) showed that there was significant provenance and family variation for survival, height and stem number. Variation for these traits was greatest within families, followed by that between families and then between provenances. Queensland and NSW provenances performed best at this tropical high-rainfall site. Results from the other provenance trials in China remain to be published.

Conclusion

This review indicates that the major focus in blackwood genetic research in the past 40 y has been in seed collection (over 200 collection sites) and trial

establishment (over 60 trials). The few published results from these trials have generally been for trees aged 10 y or younger. Significant differences in growth between provenances and between families have been demonstrated. Surprisingly, only two studies have examined genetic differences in wood properties. This is despite the fact that variation in wood properties has been well documented, and producing wood of known, high and consistent quality is the goal of all blackwood producers.

There are considerable research opportunities to be realised from the experimental trials already established. An obvious example is the re-measurement of the more comprehensive Tasmanian, New Zealand and South African trials, including wood sampling and analysis. Given the continuing issues that surround growth and particularly form in blackwood, more detailed studies on factors affecting form such as insect predation would yield significant benefits.

Given the national and global spread of the tiny blackwood research community, a collaborative approach can only benefit all players. Links with other acacia research communities, for example those based on tropical acacias like *Acacia koa*, will also be of benefit. Those jurisdictions that are reducing their interest in blackwood research but retain significant assets, for example South Africa, should be encouraged to at least retain their assets until final measurement and sampling can be arranged.

There is no doubt that the momentum in blackwood genetic research is increasing. Does the Blackwood Industry Group have the desire or the credentials to be the focus of this interest? Is a product development and marketing strategy needed for blackwood that can form the focus for this research and a means of attracting continuing research investment?

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Session 4: *Acacia* Species and Resource Management

Paper 24

New Opportunities for the Use of *Acacia melanoxylon* in Chile

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Abstract

Research at Instituto Forestal (INFOR) has provided the basis for exploiting the adaptability of *Acacia melanoxylon* to Chilean environments and its use as an alternative forest species for wood production. Lack of a reliable wood supply and a formal market have meant that blackwood has been little used as an industrial wood to date. This paper summarises outcomes of research undertaken by INFOR that is providing users with relevant technical information and which should lead to the further expansion of an industry based on planted *A. melanoxylon* in Chile

Introduction

Chilean forestry and its associated forest industry area are mainly based on *Pinus radiata* plantations and, to a lesser extent, eucalypt plantations. *Acacia* species currently feature very little in the forestry scene, but there is great interest in setting up a commercial resource. *Acacia* species were first planted in Chile in the early 1950s when *Acacia melanoxylon* was brought into the country. It remains the most widely-planted *Acacia* species, and the area of the estate will soon reach 4 kha (Fig. 1; INFOR 2004; Loewe *et al.* 2004). INFOR (2004) shows that about 1.8 kha of this total area has been established through a subsidy granted by the National Forest Corporation (CONAF).

In the 1980s, Chilean companies began to saw *A. melanoxylon* for mainly export 'blackwood' markets, including Australia. The average timber price has been about US\$400 m⁻³ (range US\$130–1200 m⁻³).

Existing mill facilities that saw pine and eucalypts are used. Colcura SA was primarily responsible for this initiative, using its *A. melanoxylon* stands located in the Colcura valley. A second company, J.G.B. Stock at Temuco, has purchased blackwood sawn timber from third parties and exported it, while a third company, Ernesto Stück and Brothers Ltd, has provided sawn timber for the domestic market. The products made from *Acacia* wood have diversified since the 1990s, and now include veneers, flooring timber, furniture, moldings, debarked chips and firewood. However, the volumes processed are small, the wood supply is uneven and it has proved impossible to maintain continuity of supply. The debarked chips have been incorporated as 5% of pulpwood mixtures with *Eucalyptus globulus*, although there is no evidence that this benefits pulping, bleaching or pulp characteristics compared to 100% eucalypt (Pinilla 2004).

Acacia melanoxylon is recognized in Chile as a valuable species for furniture production. The wood has a high tensile and compression strength and is suitable for carpentry, veneers and flooring and can be turned on a lathe. It can also form parts of items that are subjected to shock and vibration (Torrealba 1987). Excellent qualities for sawn timber production start to be expressed between ages of 15 and 20 y in Chile (Pinilla 2000).



Figure 1. An *Acacia melanoxylon* forest stand in Chile

Species that compete with acacia

For sawn timber and veneers, the competitors are those woods featuring good structural and working characteristics, and that have similar light-brown to reddish colouring. Chilean native woods of the *Nothofagus* genus, mainly lenga (*N. pumilio*), have these attributes, already serve established markets, and are more generally available than *Acacia* woods. *Nothofagus* species also compete in the market for furniture, but Chile also relies on other introduced species like walnut, chestnut and oregon, and even poplars and radiata pine, to supply this market. There is an expectation that blackwood should be able to compete in these domestic markets as well as being a competitive export as sawn timber.

Forest management

Pruning and thinning have formed a crucial part of silvicultural regimes in pure stands of *A. melanoxylon* managed for sawn timber. Thinning is performed frequently to prevent severe intra-species competition. Optimum final stand densities are 300–400 stems ha⁻¹ (see de Zwaan 1981). The highest yield to date in Chile is 215 m³ ha⁻¹ standing volume from a 34-y-old stand that had been gradually thinned to 395 stems ha⁻¹.

Intensive pruning is also required to ensure knot-free timber and good form. Branches are eventually removed to 6 m, but at no time does the pruning intensity exceed 50% of crown length (FRI 1982, cited by INFOR 1988).

Spacing and thinning trials (INFOR 1997) suggest an initial stand density of 1111 stems ha⁻¹ (3 m within and between rows) is advisable to achieve the right combination of growth rate and good form. Lower densities led to unacceptable form. Higher initial planting densities of 1600–2500 stems ha⁻¹ have been recommended and do ensure faster site occupancy, but also require more frequent thinning (Siebert 1994). One such regime that requires a thinning every 6 y is summarised in Table 1.

Plantations in mixed forest stands

Mixed-species plantings that include *A. melanoxylon* have been considered in Chile. Eucalypts, oregon, radiata pine and *Nothofagus* are all considered potentially-suitable complementary species. To be successful, species mixtures must be compatible and not prejudiced by factors such as allelopathy (Wrann 1983).

Table 1. A thinning regime for *Acacia melanoxylon*. Thinning is scheduled to occur every 6 y when 250 trees ha⁻¹ are removed. The final crop is harvested at age 40 y when mean diameter is 40 cm. The harvested wood is converted to veneer, sawn timber and pulpwood. This table has been developed from Grosse and Kannegiesser (1989), Salinas (1995), INFOR-CONAF (1998) and Pinilla et al. (2002).

Year	Stems (ha ⁻¹)	Dbh ob (cm)	Heigh t (m)	Volume (m ³)		
				(tree ⁻¹)	Total (ha ⁻¹)	Cut (ha ⁻¹)
1	1600	1.2	0.9	0.006	9.19	
2	1600	2.4	1.8	0.006	9.69	
3	1600	3.6	2.7	0.007	11.09	
4	1600	4.8	3.6	0.009	13.85	
5	1600	6.0	4.5	0.012	18.45	
6	1350	7.2	5.4	0.016	21.39	4.0
7	1350	8.4	6.3	0.022	29.54	
8	1350	9.6	7.2	0.030	40.41	
9	1350	10.8	8.1	0.040	54.40	
10	1350	12.0	9.0	0.053	71.90	
11	1350	13.3	10.0	0.071	95.50	
12	1100	14.6	11.0	0.092	101.3	23.0
13	1100	15.9	12.0	0.118	129.3	
14	1100	17.2	13.0	0.148	162.4	
15	1100	18.5	14.0	0.183	201.0	
16	1100	19.8	15.0	0.223	245.5	
17	1100	21.1	16.0	0.269	296.3	
18	850	22.4	17.0	0.351	298.3	87.7
19	850	23.7	18.0	0.398	338.6	
20	850	25.0	19.0	0.451	383.6	
21	850	25.9	19.7	0.491	417.7	
22	850	26.8	20.4	0.535	454.4	
23	850	27.7	21.1	0.581	493.6	
24	600	28.6	21.8	0.630	378.0	157.5
25	600	29.5	22.5	0.682	409.5	
26	600	30.4	23.2	0.738	442.9	
27	600	31.3	23.9	0.797	478.5	
28	600	32.2	24.6	0.860	516.1	
29	600	33.1	25.3	0.927	555.9	
30	350	34.0	26.0	0.997	348.8	249.2
31	350	34.7	26.5	1.052	368.3	
32	350	35.4	27.0	1.110	388.5	
33	350	36.1	27.5	1.170	409.6	
34	350	36.8	28.0	1.233	431.4	
35	350	37.5	28.5	1.297	454.1	
36	200	38.2	29.0	1.365	272.9	204.6
37	200	38.9	29.5	1.434	286.8	
38	200	39.6	30.0	1.506	301.3	
39	200	40.3	30.5	1.581	316.2	
40	0	41.0	31.0	1.658	0.000	331.7

They also require an in-depth knowledge of juvenile growth dynamics so that they can be managed to maximise the benefits of having a mixture rather than a monoculture (Siebert 1994). Khanna (1999) has argued that mixtures of eucalypts and *Acacia* produce better wood-quality outcomes as well as environmental advantages. Studies conducted by Universidad Austral de Chile (Reinike 1996; Yáñez 1996; Toledo 1997) have reached the same conclusion.

A 6.1 ha, 13-y-old stand of *Eucalyptus globulus* and *A. melanoxylon* at Escuadrón Estate near Concepción was harvested (Toledo 1997). The ratio of biomass between the eucalypt and the blackwood was 72:28; the total standing biomass was 304.7 t ha⁻¹ and 82.7% of the biomass was in wood. The growth curves of both species were quite similar to age 4 y, after when that of the *E. globulus* exceeded that of the *A. melanoxylon* for the rest of the rotation (Prado and Barros 1989, cited by Toledo 1997).

Observed growth and performance

The performance of a range of blackwood stands in Chile shows that they reach a maximum dominant height of 30–35 m, a maximum basal area of 50 m² ha⁻¹, and a maximum standing volume of 450 m³ ha⁻¹. The best performing stands reach these values in 25 y (Figs 2, 3). As most of these stands have not been intensively managed and the seedling stock was unimproved, better performance should be possible in the future.

Industrial research outcomes

Research has been undertaken to explore the fitness of blackwood for various product options (INFOR 2006; Fig. 4).

Physical and mechanical characteristics

Bending strength was found to be in the same range as that of radiata pine which is used extensively in the construction industry, e.g. for joists. The performance of blackwood under parallel compression suggest that it is also suitable for posts and pillars.

Workability

Workability was generally acceptable under the ASTM D1666-94 standard, though performance was poor in relation to drilling. The best outcomes from planing were obtained at a 20° angle of attack under processing conditions that corresponded to 20 knife prints per inch of wood surface. Working the tangential face produced a better outcome than the radial face.

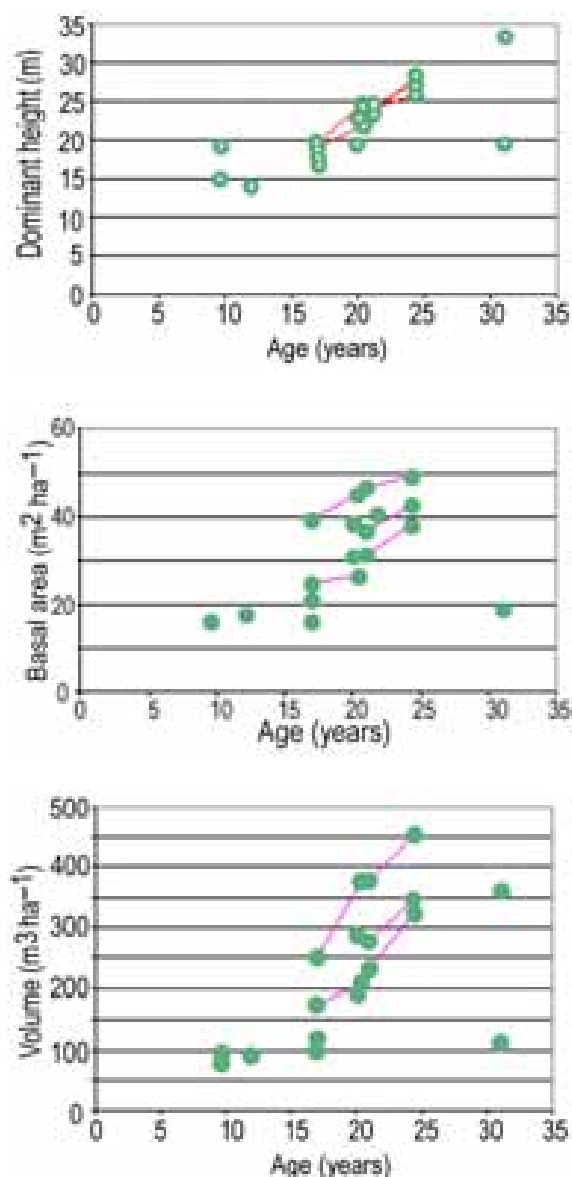


Figure 2. Dominant height, basal area and standing volume of wood across a number of plantations of *Acacia melanoxylon* growing in Chile

Gluing

At 12% moisture content solid blackwood reaches an average shear of 14.3 MPa. The D3 adhesive Korlock 255 used for the manufacturing of laminar joints does not, under mechanical test, meet the strength and wood fault percentage required by the ASTM D5751 standard. For finger-jointing, however, KorLock 255 fully meets the ASTM D5572 standard.



Figure 3. Examples of one of the best individual trees (top) and permanent plot (bottom) of *Acacia melanoxylon*

Drying

Tangential and radial pieces of two thicknesses were tested. Blackwood cut tangentially, radially or in a mixed pattern dried satisfactorily under a single kiln-drying program (Table 2). The drying process, from saturated wood to 10% final moisture content, took two days for wood of 25 mm thickness and three days for wood of 50 mm thickness.



Figure 4. Furniture manufactured from blackwood in Chile

Table 2. Conditions used for kiln-drying tangential and radial boards of two thicknesses

Thick- ness (mm)	Program			MC (start– final, %)	Time (h)
	MC (%)	DBT (°C)	WBT (°C)		
25	30–25	50	50	40–10	46
	25–10	75	50		
	10	75	75		
50	30–25	50	50	75–10	76
	25–10	65	50		
	10	65	65		

MC = moisture content

DBT = dry bulb temperature

WBT = wet bulb temperature

In a conventional air-drying system, initial pre-drying under a shed is recommended. Crossed shrinkage anisotropy decreases and no shakes and cracks show up. Warping is also very slight.

Fitness for particle board

The physical and mechanical characteristics of mixtures of blackwood and radiata pine were assessed. It was found feasible to use blackwood for particle board if radiata pine made up 10% of the mixture. Increasing the proportion of blackwood to 25% produced a board with decreased water absorption and swelling, increased elastic modulus, decreased perpendicular tensile strength, but adequate physical and mechanical properties. However, the addition of hydrophobes to the adhesives used is recommended to meet this satisfactory standard. The colour of particle board that includes blackwood is inevitably darker than that based only on pine.

Fitness for veneers

Veneers cut on the tangential plane from a log of 30 cm average diameter yielded 50.4 m² of veneer m⁻³ log. However, most were in category 'C' (lower quality) because of the inclusion of sapwood. Drying at high temperature created no problems and there was good colour differentiation between sapwood (light) and hardwood (dark). Shakes, hooks, coppicing, off-centered pith and high spring reduce the recovery of veneer-grade material. A second factor is the limited availability of large blackwood logs. Logs of *Eucalyptus globulus* and radiata pine, 65 cm in diameter, produce 550 m² veneer m⁻³ log.

Conclusion

Research in Chile suggests that *A. melanoxylon* is suitable for a number of end-uses, but systems for efficiently managing stands have not yet been developed. While what is known is being shared with all interested parties, much more research is required in the silviculture, utilisation and marketing of this

species if the best outcomes that blackwood offers are to be captured.

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Session 4: *Acacia* Species and Resource Management
Paper 25

Blackwood as an Environmental Weed in New Zealand

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IAN NICHOLAS has been involved in research at the Forest Research Institute (now Scion) since 1975 on species identification and evaluation for specialist uses. He has managed the Special Purpose Species Programme, with responsibility for research on eucalypts, acacias, walnuts, cypresses and paulownia. His work has included their establishment, genetics, silviculture and health. He is a foundation member and currently editor of *AMIGO*, *Acacia Melanoxylon Interest Group Organisation*, a New Zealand Farm Forestry Association Action Group, and a founding member of the BIG (Blackwood Industry Group) committee, formed in 1996.

Abstract

Blackwood (*Acacia melanoxylon* R.Br.) has been introduced to and planted in New Zealand as a potential timber tree, and this has led to the development of a 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. Timber plantations and enrichment plantings established within native forests were surveyed in Central North Island plantings (near Rotorua) in 1984. The same sites were revisited in 2001 to monitor regeneration. Plantings in Hunua Forest near Auckland and on the West Coast of the South Island were also assessed in 2001. The Central North Island sites showed a reduction in surviving regeneration between 1984 and 2001, although seedlings that had been noted on disturbed sites have now developed into saplings. No invasion of native forest has occurred on any of the sites visited, including enrichment plantings from 1960. The 2001 study has reinforced the conclusions from the 1984 study, namely ‘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’.

Seed health was also briefly assessed in 2001. Preliminary tests showed that in the North Island up to 50% of seed can be damaged by the insect *Storeus albocignatus*. The limited studies undertaken in both 1980 and 2001 indicate that seed predation is relatively absent in the South Island.

A survey of Regional and District Councils and the Department of Conservation (DOC) by Forest Research (FR) in 1999 showed that although other acacia species are considered to have weed status in many regions, blackwood does not. In South Africa, blackwood seed is dispersed by birds, but there are no seed predators. In New Zealand there is no confirmed evidence of bird dispersal but there are seed predators.

The weediness score for blackwood in New Zealand is 27, the same value as for radiata pine. Field assessments have shown that while blackwood will regenerate where light and soil conditions are suitable, there is no strong evidence that it will invade indigenous forest, despite being planted as an enrichment species. However, blackwood plantings are likely to remain in blackwood for a significant time due to root suckering and germination of ground-stored seed. If blackwood is not wanted on such sites it may be considered a weed problem. As blackwood is still considered by many to be a potential high-risk weed species, it would be prudent to continue monitoring regeneration.

Background

Records suggest that Australian blackwood (*Acacia melanoxylon*) was first planted in New Zealand at Taita in 1896 (Hosking 1999), with the earliest significant plantings at Whakarewarewa Forest, Rotorua, where 29 ha were established in 1903–1908. In the 1960s blackwood was tested as an enrichment species, with groups of blackwood placed in gaps in logged-over native forest to encourage improved form and to provide high cover to support native regeneration (FRI 1983). This was an attempt to mimic the system used in South Africa and observed by the late Harry Bunn on a trip there in the late 1950s.

Blackwood has been planted in New Zealand for a variety of reasons, mostly to provide high-quality furniture timber in the future. An estimated total of about 3000 ha of blackwood has now been established (Nicholas and Brown 2002). Blackwood is one of the highest-value sawn timbers imported into New Zealand, and a niche has developed for the manufacture of high-quality furniture (Nicholas pp. 21–26 this volume).

Blackwood is regarded as a species which is capable of strong regeneration through seed, root suckers or coppicing (growing again from a cut stump) following soil disturbance or fire (P. Millen, NZFFA, *pers. comm.* 2004). This attribute is part of the attraction of blackwood for special applications such mitigation of soil erosion (FRI 1982; MOW 1984; MOF 1995).

In South Africa, where blackwood is considered a weed species (Henderson 1995), the characteristics which have encouraged the spread of blackwood are reported by Geldenhuys (1996) as:

- Regular prolific production of seed with a high germination capacity
- The fatty reddish funicle surrounding the black seed which promotes extensive spread of the seed by birds such as *Knysna lourie* and the rameron pigeon, and flotation and spread of the seed by streams
- Hard-scaled seed which lie dormant for long periods and germinate in abundance after fire, logging or general soil disturbance
- Absence of seed predators in South Africa, compared to their abundance in Australia.

There is also debate in South Africa about the seriousness of the problem. Geldenhuys (1996) states ‘Blackwood has the characteristics of an aggressive invader plant, but it does not aggressively invade closed, evergreen forest’. Geldenhuys defined an invader plant in the indigenous closed forest as ‘one which will increase its numbers and biomass to the detriment of the forest substance and life support systems through various processes: continuous regeneration, suppressive growth rate, suppressive crown development, and or upsetting of the natural disturbance regime’. He concluded that ‘the ecological characteristics and requirements of the shade-intolerant blackwood should be considered in relation to the ecological processes of disturbance and recovery of the forest to reconcile its production from the forest as a timber tree with control of its invasion potential’.

In New Zealand, some factors that might encourage the spread of blackwood are the same, such as seed production and the longevity of seed. However, seed production by blackwood appears to vary from site to site. There is no clear or confirmed evidence of bird distribution of seed, although blackwood has been recorded through inventories of high-value reserves in 19 of 50 DOC areas, and birds are suspected of a role

in this (I. Popay, DOC, *pers. comm.* 2006). Also unlike South Africa, New Zealand has seed predators (C. Appleton, Forest Research, *pers. comm.* 2002). Although invasion into the fynbos vegetation is a concern in South Africa, this is very different from New Zealand vegetation (T. Shelbourne, Forest Research, *pers. comm.* 2003). Overseas literature reports that blackwood is considered a weed species in several countries (Cronk and Fuller 1995; Henderson 1995).

Recognition of the concern that blackwood and other timber tree species may regenerate in unwanted locations led to a field survey of stands near Rotorua in 1984 and to a survey by Forest Research (now Scion) staff in 1999, in cooperation with regional and district councils and the DOC. Concerns about the potential of blackwood to invade other vegetation were raised again in 2001. This paper reports on the 1984 assessment and follow-up assessments in 2001. It also includes some historical work on seed health.

Comparison of regeneration survey plots in 1984 and 2001

1984: In the early 1980s, the Forest Research Institute (FRI) recognised that regeneration was an issue with blackwood. To better understand the processes involved, a field survey was conducted by B. Moberly with the following objectives:

- To determine whether the interplanting of *Acacia melanoxylon* is likely to dominate the indigenous cutover it was intended to enrich
- To obtain an indication of the regeneration pattern of blackwood in both a pure plantation and an enrichment situation.

At the conclusion of the study Moberly stated that:

Indications were that seeds will usually only germinate and develop when falling on disturbed soil and that suckering is unlikely to occur unless the roots of mature trees have been damaged. Coppicing from stumps is frequent, but varies in height according to microsite, aspect and stump diameter. 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.

2001: Many of the original survey sites from the 1984 study were reassessed. Additional surveys were undertaken near Auckland, the Waikato and on the West Coast of the South Island.

The following sites were evaluated in 1984 and October 2001:

Mamaku Forest

In 1960 and 1961, FRI established blackwood in logged-over native forest. In 1984 Moberly assessed two untended and two tended groups in the trial. One shaded and one unshaded group was included in each category.

1984: 1960 planting, hand cut groups. A grid of 16 2 m × 2 m squares was established in one group to assess an area cleared in 1982 for photography. Only one seedling was found in the sampled area. Moberly noted a few suckers in another group where a windblown tree had been removed in September 1982. The suckers had grown from the roots of one of the final-crop blackwoods damaged by the vehicle which had been used to remove the felled tree.

Moberly located 10 seedlings and a sucker in an untended group in the 1961 planting of bulldozed lanes. Five small plots were established to assess this area. To monitor a further 26 seedlings on the edge of the planted area, he established three extra plots. This patch of regeneration was attributed to soil disturbance which occurred during track maintenance with a bulldozer in February 1982. Moberly also noted suckers (20–30 cm) on the track near this untended group.

2001: In the October 2001 assessment of the 1960 planting, no regeneration was found in the 16 plots established by Moberly. In an assessment of the other groups, a small root sucker from a damaged root was located in one group. Despite poor crown health and considerable light penetration into some of these groups, no other regeneration was located. Although flower heads were found on the ground, no seed could be located in the litter layer.

In the assessment of the 1961 planting, regeneration was located in four plots consisting of a total of 12 seedlings with heights of 19–210 cm. Most were carrying only juvenile foliage. This is considerably less regeneration than noted by Moberly who had counted 37 seedlings in the same defined area in 1984. In contrast, regeneration down the track had grown significantly since 1984 and the plants were now saplings. In a clearing on the edge of the interplanted area, young seedlings were also present.

Rotoehu Forest

1984: Of the blackwood planted as groups in native scrub in 1960, only four trees remained of the original planting, with logging and road works exposing three sides of the remaining trees. Two plots were established, one unshaded and in disturbed pumice from the roading excavation, the second directly beneath two of the remaining blackwoods and that contained 14 seedling and/or suckers. This second plot was also on disturbed soil. Moberly also added further plots between the original plots.

2001: Three plots were located. No regeneration was found on the undisturbed site. Of the other two plots, one had two saplings of 5.2 cm and 5.1 cm dbhob. The other plot, closer to the road, had one dead tree of 4 cm dbhob only. There were considerably more saplings outside the plots, probably a consequence of the soil disturbance. Near one of the original 1960-planted trees, root suckers of 4.2 and 4.5 cm dbhob were recorded.

Whakarewarewa Forest

1984: Moberly established two transects, one of 25 m in a 1906 planting, the other 60 m across a 1908 planting in an area that had been partly logged in 1983. He found only a few suckers within the 25 m transect. In the logged area, he located a total of 297 regenerating seedlings within 50 cm either side of the 60 m transect. He also noted blackwood regeneration across the road from this stand in a young (1978 planting) Douglas-fir – larch stand.

2001: The 1984 transect established by Moberly in the 1906 planting was assessed. The transect crossed an access road with banks on both sides. No regeneration was observed, although seed pods were found on a track that crossed the transect at right angles.

In the 60 m transect, of 30 blackwood stems located, 12 were dead. The 18 surviving stems were 6% of the 297 young seedlings noted by Moberly in 1984: they had a mean dbhob of 9.2 cm, quite small for 17-y-old seedlings. This highlights the high attrition rate of blackwood regeneration when light, soil and competing vegetation are less than ideal. Regeneration had developed into a blackwood stand in other parts of the 1983 logging area where light and soil disturbance provided a better growing environment for blackwood. The regeneration noted by Moberly in the Douglas-fir – larch stand appeared to be present, but may be overtopped and suppressed in the future.

North Island sites assessed in 2001 only

Hunua Forest

In the 1960s blackwood was established in the Hunua Ranges, south of Auckland. This forest planting of about 60 ha is the oldest managed blackwood forest estate in the country. For these reasons it was included in the 2001 study.

1969 Interplanting: In this 4.9 ha trial, blackwood had been established into native vegetation. The original vegetation was second growth, with the blackwood planted in strips cut in the vegetation which was 8–10 m tall, and mostly of tree ferns and scrub hardwoods with occasional kahikatea, rimu, miro, etc. The blackwoods thrived, in contrast to the other exotics planted on this site (eucalypt, alder, ash and walnut). Native species (rimu, kahikatea, totara) also

thrived. In the assessment of this planting, small blackwood saplings adjacent to parent trees were noted, apparently from root suckers. Freshly-germinated seedlings were also located in the litter layer under some trees, or on decaying logs. However, there were no surviving seedlings from the previous germination. A creek that runs through this planting was inspected for a considerable distance downstream to assess any streamside regeneration. None was located.

1967 Thinning trial: This pure blackwood plantation is located on a north-eastern ridge adjacent to native vegetation. An access track had recently been formed through part of the trial. Regeneration on the track was mostly from root damage, and there were a few emerging seedlings, but given light availability and soil disturbance, regeneration was sparse. On the edge of the plantation that abutts onto native vegetation, some regeneration was occurring where slips had occurred. It is possible that this could spread into the native vegetation, though there was no evidence of between-slip colonisation.

The current owner of Hunua Forest cutting rights, Mr Richard Harwood, was interviewed about weed problems. While he had noted road-side regeneration, and regeneration on a previously-felled area, he did not express any concern about blackwood as a weed in his forest. He was not aware of any down-stream invasion in the creeks that run through blackwood into water storage dams.

Waikato regeneration

Blackwood has been established and is regenerating in some gully systems of the Waikato River Catchment near Cambridge. The Horahora area was briefly inspected to assess spread from the older parent material. While there was considerable road-side regeneration, there was no indication of invasion into other gully systems away from the original plantings.

South Island assessment in 2001 at Westland

The blackwood estate of Timberlands was inspected in October 2001. Stands were assessed from Wanganui Forest near Harihari in the south to Oparara near Karama in the north, a distance of about 300 km. The Oparara sites are part of the DOC Estate. A total of 10 stands, 17–34 y old, was assessed for regeneration and invasion of surrounding vegetation. Known measurement plots or Permanent Sample Plots (PSPs) were targeted to provide area-bounded inspection sites. Stands adjacent to some of these areas were also inspected. These stands covered a range of establishment methods: a clear site; hand-cut or bulldozed lanes; and in mixtures with other vegetation (native and exotic). In nearly all locations native vegetation was adjacent to the inspected stands which were either within the plot boundaries or in the

adjoining vegetation. Diameters of regeneration, where of sufficient size, were measured to develop a profile of the regenerating population. Regeneration along roadsides was noted but not measured. This study found that:

A consistent pattern emerged from this field assessment; there was no evidence that blackwood will become a weed species invading native vegetation outside of planted areas in the Westland estate. Regeneration is occurring within existing plantings and is only likely to move out of these if light and soil disturbance occur within rooting distance and if seed is available. Even where regeneration is occurring, the active native vegetation is out-competing the young blackwood regeneration.

Blackwood has shown an ability to colonise road edges, but as described above is not expected to move into native vegetation unless light and soil conditions are favourable. Roadside colonisation occurs with a myriad of species in all forest areas of New Zealand because of the combination of light and soil disturbance. Because of ease of access, such colonisation can be managed by appropriate forest management.

Seed health

The extent of damage by insects, a chalcid, *Bruchophagus* (syn. *Eurytoma*) *acaciae* and a weevil, *Storeus albosignatus*, to *Acacia* seed was assessed by FRI staff in 1980. Both insects are of Australian origin, but more commonly associated with *Acacia mearnsii* (Noyes and Valentine 1989; Kuschel 1990). Seeds infected by the weevil show one or two holes on the outer skin. The weevil apparently chews these holes and deposits an egg in each of them. The larvae develop inside the seed and apparently emerge before probably pupating in the soil. Seed was obtained from six localities in the North and three in the South Island. No damaged seed was found in the South Island material; two sites in the North Island sites had damaged seed.

In 2001, 112 seeds were collected from seven stands or trees in the South Island: only 3% of this was found to be insect damaged. In contrast, 23% of 249 seeds from nine localities in the North Island was damaged: some collections had >50% damaged seed. A collection of seed from throughout the country by forest health officers in 2002 that was evaluated as part of a school project confirmed the earlier conclusions: South Island seed is in good condition while the North Island seed is consistently damaged (J. Nicholas, RBHS, *pers. comm.* 2001).

Tree weed survey in 1999

In 1999, FR staff conducted a survey to assess the concern of land managers on weed issues with exotic tree species. Letters seeking information on weed potential of exotic trees grown for timber or chip production were sent to plant pest managers in 15

regional and district councils identified as 'environmental'. The DOC (Science and Research Division, Wanganui) was also asked to participate.

Of the 13 responses, several raised concerns about some *Acacia* species: most of the concern was with the bipinnate species, not with blackwood. The only response to mention *A. melanoxylon* was that of the DOC, which listed it as a new species of concern on their National Weeds Database. However, they had not scored it for 'Biological Success Ratings' at that time.

Discussion

A range of forest and establishment conditions was assessed in the North Island and Westland (South Island). Even where blackwood had been established in native vegetation, there was no sign of invasion of surrounding native ecosystems. On some of these sites blackwood seed was found germinating on the forest floor, but no young surviving seedlings were noted, suggesting that lack of light, competition from native vegetation or browsing by forest animals provide conditions too severe for blackwood survival. When a hand-cut track was established in the mid-1990s in the 1980 planting at Westland, young regeneration was noted, but has since disappeared (R. Jackson, Timberlands, *pers. comm.* 2003). The reduction in regeneration between the Moberly assessment in 1984 and that in 2001 supports the view that blackwood will not readily invade native ecosystems. Blackwood has not spread consistently away from planted areas and there appears to be no suitable vector for seed distribution away from existing trees. In contrast with findings in South Africa, there is no clear or confirmed evidence as yet of seed dispersal by birds in New Zealand: wind and man appear to be the only vectors.

There is no doubt that blackwood regenerates from coppicing, root suckers and ground-stored seed if conditions provide the right opportunity, e.g. disturbance. This means that blackwood plantings are likely to remain in blackwood for a significant time. If blackwood is not wanted on such sites, it may be considered a weed. Forest managers in New Zealand have yet to resolve this issue to their advantage.

Nevertheless there are still valid concerns about the weed risk of blackwood. Most relate to its potential weediness and hinge on several issues (Ian Popay and Clayson Howell, DOC, *pers. comm.* 2006):

- **Invasiveness elsewhere:** Blackwood is a weed overseas and is likely to exhibit similar behaviour here.
- **Long established here:** Has blackwood been in New Zealand long enough to show weed characteristics?
- **Seed spread:** Has there been enough bird famine to force birds to eat blackwood seed? If enough trees are planted, seed may enter the food chain.

- **Weediness score:** Blackwood has been ranked with a weediness score of 27 in New Zealand, the same as radiata pine (Pheloung *et al.* 1999). This is slightly less than gorse (28) and *Clematis vitalba* (34), but higher than some other recognised New Zealand weeds such as *Berberis darwinii* (26), *Tradescantia fluminensis* (25) and *Cotoneaster glaucophyllus* (25). Cronk and Fuller (1995) also rate radiata pine as of similar risk to blackwood, with pine just ahead of blackwood.
- **Invasion of native ecosystems:** While it is accepted that blackwood is unlikely to invade healthy native systems as found in this study, the areas at risk are forests which are degraded or failing. Blackwood could be invasive of such areas.
- **Seed predation:** Blackwood is such a prolific seeder and seed remains viable for so long that seed predation is not very important.

These are valid and real concerns, but they are generally not supported by the evidence reported in this paper. However, the field assessments reported here are from high-rainfall ($>1500 \text{ mm y}^{-1}$) areas only and do not reflect all sites in New Zealand (C. Ecroyd, Ensis, *pers. comm.* 2006). It is therefore recommended that plantations be monitored on a regular basis to help understand the environmental threat of blackwood in New Zealand.

Conclusion

Blackwood has been established in New Zealand for over a century. During this period it has had ample time to demonstrate weed characteristics. Blackwood is also an integral part on the New Zealand landscape, with plantings occurring throughout the country from the early 1900s. Overseas literature reports that blackwood is considered a weed species in several countries. A survey of Regional and District Councils in New Zealand showed that although other acacia species are considered to have weed status, blackwood does not. The only respondent to the survey suggesting blackwood had weed characteristics was the DOC.

There is no known seed dispersal by birds in New Zealand. Preliminary tests show that, in the North Island, up to 50% of seed can be damaged by the insect *Storeus albocignatus*. South Island seed appears to be healthier than North Island seed.

Evaluations of FR regeneration plots established in 1984 and reassessed in 2001 showed a reduction in surviving regeneration, although where seedlings were originally noted on disturbed sites they have developed into saplings. No invasion of native forest has occurred even in enrichment plantings.

Weed risk scoring places blackwood at the same level as radiata pine. Field assessments have shown that while blackwood will regenerate where light and soil conditions are suitable, there is no strong evidence to

suggest that it will invade indigenous forest. However, it is acknowledged that blackwood plantings are likely to remain as such for a significant time. If blackwood is not wanted on such sites, it may be considered a 'weed problem'.

This study has reinforced the conclusions from the 1984 study: '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'. However, monitoring of blackwood regeneration should continue.

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Session 4: Acacia Species and Resource Management Paper 26

AMIGO (The NZFFA Acacia Action Group): Is it a Good Model?

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GRAHAM MILLIGAN describes himself as a dendrologist with a background in sheep farming. Much of his property that once carried sheep is now planted as a commercial forest comprising several species, including extensive eucalypt seed orchards with upwards of fifty species. Graham also has a small nursery specialising in New Zealand natives and eucalypts. He imports blackwood seed for distribution within New Zealand and has been active in the NZ Farm Forestry scene for many years.

Abstract

In 1989, under the guidance of the late Norval Gibson Smith, the Acacia Melanoxylon Interest Group Organisation (AMIGO) was formed under the umbrella of the New Zealand Farm Forestry Association (NZFFA). In view of the seventeen years that have now elapsed, it may be timely to ask 'has AMIGO achieved its aims as the original founders intended, what are its strengths and weaknesses, and does it serve as a useful role model for others to copy?'

Background

The New Zealand Farm Forestry Association (NZFFA) had its beginnings in 1950 when Neil Barr and friends formed the Farm Forestry and Horticultural (Lower North) Association at Kaukapaka, north of Auckland. Neil travelled around New Zealand to promote his concept and now at least one of its 29 branches are within reach of any tree enthusiast in the country. An annual conference, which alternates between the North and South Islands of New Zealand, attracts well over 300 participants and has a role of formal administration as well as field trips to view tree-related activities. The Lower North Branch of the NZFFA sponsored the launching of the Acacia Melanoxylon Interest Group Organisation (AMIGO) by holding a seminar at Warkworth for blackwood enthusiasts that attracted over 110 participants from the top half of the North Island (Gibson Smith 1990).

The idea behind AMIGO arose at the 1989 NZFFA Conference at Gisborne (Hosking 1999). Norval Gibson Smith, who was attending his third national gathering of farm foresters, began to realise that quite a

large knowledge-gap existed between local branch members of the Association and the Forest Research Institute (now Scion/Ensis) scientists who spent their careers working away at research projects related to successful farm forestry — particularly in the alternative species field. The research reports became available at national level and the minority of members who managed to attend annual conferences had the advantage of hearing and seeing the research work at conference field trips. However, the 'trickle-down' theory of information transfer to the general membership did not appear to be working in practice. What seemed to be needed was a mechanism for bringing together, into a direct information-sharing network, the growers of particular species of trees and the researchers working on the growing of those trees.

AMIGO has the following objective:

To encourage the dissemination of information concerning the propagation, silviculture, utilisation and marketing of *Acacia melanoxylon*.

Aims

- To share the latest findings of researchers (both Scion/Ensis and private) with blackwood growers
- To help develop improved genetic stock for planting
- To encourage the adoption of the best available silvicultural techniques
- To encourage communication between buyers and sellers of blackwood logs and timber
- To compile data, on a regional basis, on the NZ blackwood resource.

Activities

- To compile a mailing list of blackwood growers
- To publish a regular newsletter
- To identify an AMIGO liaison person within each NZFFA branch where blackwood is grown
- To encourage field days focusing on blackwood
- To provide a forum for NZFFA members to discuss blackwood issues.

Membership today is about 200. When renewing their annual subscription to the NZFFA, members have the option of joining, at an extra cost, a number of Special Interest Groups. Since the formation of AMIGO, the Indigenous Forest Section (1995), the Cypress Action Group (1997) and more recently the Sequoia Group and the Eucalypt Action Group have been formed — all under the umbrella of the NZFFA. To become a member of a special interest group one has to be a member of the NZFFA. The annual cost of belonging to the AMIGO group is \$15.00, which entitles involvement in all the activities of the group.

Newsletters on specific blackwood subjects are sent out twice a year and any member is invited to submit articles. A major field day is held each year — usually in conjunction with one or more of the other interest groups — to provide the forum to discuss blackwood issues, and there are numerous field days involving blackwood throughout the year at NZFFA branch level.

Success of AMIGO

It is imperative for the special-interest groups to keep in contact with the ‘grass roots’ membership if they are to function successfully. Office-bearers and the committee are elected annually at either the major special-purposes field day (AMIGO) or at the NZFFA annual conference (other groups). The committee has to be effective in keeping members regularly informed through newsletters. For instance, the Indigenous Forest Section has recently upgraded its newsletter to a glossy A4 publication of some substance and has gained membership as a result (John Wardell, Liaison Officer, *Indigena*, the official journal of the NZ Farm Forestry Association Indigenous Section, *pers. comm.*, March 2006). The newsletters also provide researchers with a conduit to relate their findings to growers. AMIGO enables a much greater chance to lobby for funding. Gaining funding from the ‘Public Good’ purse will always be greatly enhanced when presented from a well-organised group. The handbook assembled by Ian Nicholas and Ian Brown (2002), the bible for blackwood growers in New Zealand, was published in 2002 with funding assistance from both AMIGO and MAF Sustainable Farming Fund.

Weakness of AMIGO

To be a member of AMIGO one must also be a member of the NZFFA. Most would agree that because the NZFFA acts as an umbrella for the Special Interest Groups, this is probably fair and equitable. What AMIGO lacks is members from the utilisation and manufacturing end of the spectrum. This is inevitable at this stage of the development of a blackwood industry in New Zealand: there is hardly a resource to encourage manufacturers to commit to promoting the species. Log supply is spasmodic and unreliable. Some would question the single major field day a year, lack

of regional activity and the number of Special Interest Groups, but for the last at least, imitation is the sincerest form of flattery: the later groups were formed because of the success of AMIGO. AMIGO is dependent on too few key people, but commitment from a few will always win over lack of commitment from many.

AMIGO — is it a good model?

As mentioned before, a number of Special Interest Groups based on AMIGO have been formed since AMIGO’s birth in 1989. Many NZFFA members belong to two more of these groups. (Ian Nicholas is an elected member of three and produces the newsletters for two). Many consider these groups now to be the lifeblood of the association and that the NZFFA Annual Conference should have sessions and field trips showcasing each group’s merits.

Synergy of AMIGO and BIG

AMIGO works well in New Zealand for NZ blackwood growers. The dissemination of research and science is regularly trickled down to the growers. BIG is a small dedicated committee periodically organising international workshops generally based in SE Australia. BIG probably has the potential to develop regional groups based on the NZ model. With Australia’s commercial blackwood log supply diminishing, any attempt at plantation production has to be carefully plotted due to each countries/states peculiar problems. It is not an easy species to manage at the best of times, but for the grower, whether large or small, to be able to tap into and share knowledge and research has to be a positive step. Two hundred NZ blackwood growers would consider AMIGO as an excellent model. With the initial enthusiasm of Norval Gibson Smith and the steady helm supervised by the two Ians (Brown and Nicholas), there is much progress being made in growing blackwood in NZ, nearly all by the private sector.

Acknowledgments

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Field Visits: A Summary

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Goy property (Farm Trees Pty Ltd), Bunyip, Gippsland



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Delegates visited this property on the morning of 27 April. Annual rainfall at this site is about 900 mm. The *Acacia melanoxylon* provenance trial and seed orchard (the latter a very

encouraging first in Australia) was planted in 2002 with 58 seedlots (families from various provenances, or provenances) (with some repeated, leading to a total 71 'treatments' established). The material was obtained from the CSIRO Tree Seed Centre and Forestry Tasmania. The provenance spread stretches from Canberra to southern Tasmania. The trial design consists of three-tree family plots in eight replicates. The spacing is 1.5 m within and 3.5 m between rows. The total trial area of 0.843 ha is protected by a surround of *Corymbia maculata* (spotted gum).

An assessment of the trial in 2005 indicated distinct family characteristics in height, diameter and form (defect), as well as in colour and bark that were

attributed to provenance and site. A performance index showed that the better-performing seedlots came from Tasmania, with King Island provenance on top. If form was taken out of the performance index equation, one of the Mount Gambier seedlots ranked second for both height and diameter growth, although several King Island seedlots were in the top ten for these variables.

There is an expectation that form can be improved through breeding programs. This is only a first-generation trial, and it will be necessary to select the best-performing individuals for form and growth, and use these in subsequent second- and third-generation trials to further improve the traits of most value to the blackwood industry. Vigour is usually improved in both the first and subsequent generations through both selection and the reduction of inbreeding common in natural stands.

This trial area is also being managed as a commercial seed orchard. It was considered crucial to monitor the growth and form annually to exploit the benefits that the data offered for tree improvement, as there may be changes between seedlots in, for example, dominance. Because of this, it was considered important not to rush in too early and thin out the wrong provenance.



The trial is on a gently-sloping site with a somewhat-exposed northern aspect surrounded by 4-y-old spotted gum



Blackwood provenance trial and seed orchard. Each plot of three trees has already been reduced to two trees.

Lardner Park Agroforestry Demonstration Area, West Gippsland

Delegates visited this property on the afternoon of 27 April. Annual rainfall at this site is about 1000 mm. The 0.5 ha blackwood stand consists of two provenances (Smithton, Tasmania; and Strzelecki Ranges, Victoria). The trees were planted in 1992 at $2.5\text{ m} \times 3.0\text{ m}$ spacing (i.e. $1333\text{ stems ha}^{-1}$). Form pruning was rigorously undertaken to produce straight bottom logs. There are no significant between-provenance differences in growth rate. The stand was thinned in 2001 to 974 stems ha^{-1} and in 2006 to 531 stems ha^{-1} . The current stand statistics are: mean dbhob 20.2 cm; MAI $4.2\text{ m}^3\text{ ha}^{-1}\text{ y}^{-1}$; standing volume $59\text{ m}^3\text{ ha}^{-1}$.

This is an impressive stand with good form and growth rate. However, there was concern that stocking was so

high that the growth rates of individual trees were slowed because of severe inter-tree competition. This was clearly indicated by the long section of stem with dead branches above the pruned log, caused by a receding green crown. Acute competition for light had also induced very acute branch angles in the upper green crown. An immediate thinning to 250 stems ha^{-1} was recommended. This thinning should enable the final crop to maximise basal area and volume increment as well as shortening the rotation length to final crop size.

An older blackwood (22 y old) near this trial stand was felled and sawn into several long planks (using a chainsaw and guide; for a review of portable mills see the September 2006 issue of *Australian Forestry*, Volume 69 No. 3, pp. 223–232). This was used to demonstrate the colour of sapwood and heartwood, in both the tangential and radial sawn planes.



Blackwood: the stand height at age 14 y is 10 m



The stand thinned after the visit by workshop participants



Chainsaw and guide



Sapwood and heartwood in 22-y-old blackwood

McNab property 'Ardmona', Kilmore, north-eastern Victoria



Delegates visited this property on the morning of 29 April. Alan McNab's family farm has been converted to a predominantly forestry enterprise under the watchful management of Woollybutt Pty Ltd. The annual rainfall at the site is about 700 mm.

Of particular interest to the workshop group was a stand of blackwood with alternate rows of *Acacia mearnsii* (black wattle) as nurse crop. These species had been planted in 2002 at an initial stocking of 625 and 695 stems ha^{-1} , respectively. Black wattle appears a more suitable nurse crop than radiata pine or eucalypts, having only a marginally faster height growth than the blackwood.

A thinning trial had been established in three replicated blocks. The nurse crop only was thinned at age 2 y from its initial stocking down to either 417, 313 or 208 stems ha^{-1} . Twenty-three months after thinning (i.e. at age 4 y), there were no significant differences in form

or straightness between the blackwood growing within each of the nurse-crop thinning treatments.

Effective nursing of the blackwood by the black wattle had not occurred. The workshop group suggested that the two species should have been planted in a pattern that resulted in a more even distribution of each species e.g. in groups of three blackwood and black wattle alternately planted in a diamond-shaped pattern along all rows.

Ian Nicholas vigorously argued that a better strategy would have been to plant blackwood only, rather than mixed species.

Other details of the trial are given by Severino *et al.* pp. 75–78 this volume; Lambert pp. 50–53 this volume is also relevant.

The workshop group also visited other stands of well managed red ironbark, river red gum, Tasmanian blue gum, she oak and radiata pine, all of the same age as the blackwood.



Blackwood and black wattle



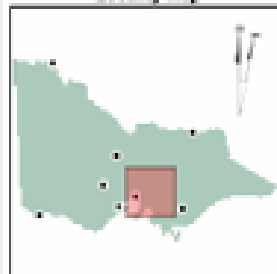
Blackwood and black wattle



Tasmanian blue gum



Red ironbark



Map Scale 1:768,790
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Table 1

Abstract

Conclusions

Research on *Acacia* species has been small in scale and fragmented. Until 1996, there was little communication between research workers, growers, processors and retailers, or between these people in south-eastern Australia, Western Australia or New Zealand. This workshop held in Victoria 26–29 April 2006, together with its predecessors in 1996, 2000 and 2002, provide an important opportunity to maximise the value of research by collating and disseminating existing information, as well as to focus new work in areas of high priority. It is also an opportunity for the acacia growers and processors to meet and consider their sector as a whole.

Conclusions from the workshop are that, in Victoria, supplies of blackwood logs are at a very low level following the transfer of production forest to reserves. The expectation that reduced log supplies from native forests in Tasmania might be offset by blackwood from mixed-species plantations is unlikely to be realised. There is, however, an opportunity, currently largely neglected, to better manage and utilise natural regeneration in corporately-managed forests and on farmland in Tasmania and Victoria, to sustain supply. Silvicultural techniques are available to improve the returns from natural regeneration.

In New Zealand, there is a lot of enthusiasm among farmers for blackwood, and the plantation area already established probably has a potential yield exceeding the present harvest in Australia. Blackwood logs in New Zealand have attracted prices higher than those in Australia, and interest among potential processors is strong. The essential feature of the market for blackwood is that logs must be of high quality.

Among other acacias, *Acacia saligna* is of particular interest because of its potential role in combating salinity over very large areas of agricultural land in southern Australia; the genetic variation in this species is a significant asset.

Understanding of silviculture has improved as a result of research in Australia and New Zealand, and this knowledge needs to be disseminated to current and potential growers. Lack of improved genetic material remains a constraint to future plantation productivity.

In 1989, the Acacia Melanoxylon Interest Group Organisation (AMIGO) was formed under the umbrella of the New Zealand Farm Forestry Association (NZFFA). The equivalent group in Australia is the Blackwood Industry Group (BIG). Participants felt that this fourth Acacia workshop had been very successful,

but it remains a concern that BIG is no way near AMIGO in its capacity to effectively coordinate the interest of blackwood growers in Australia ten years after its inception.

At the third Workshop in New Zealand in 2002, the discussion included the setting of research priorities. The most important of these were: the establishment of clonal trials that provided good information on site matching as well as providing a resource for evaluating important wood-quality variables; a better understanding of the consequences of pruning, thinning and nurse crops on productivity and the expression of density, defect and decay; knowledge of the processes that lead to formation and colour of heartwood; and promotion of blackwood for uses other than furniture. In the intervening four years progress was made in some of these areas, particularly relating to the measurement of wood-quality variables and more work in this area is currently active. New markets were developed for blackwood. Little progress had been made with tree improvement and progress towards our understanding of the expression of colour was minimal. Nevertheless a lot of new information across a range of areas was addressed at this fourth Workshop and this led particularly to a better appreciation of how research can better serve markets for blackwood and other acacia species.

The Blackwood Industry Group is an attempt to ensure the coordination of existing and new knowledge so that it can best serve what is a small though valuable industry serving niche markets. With the assistance and help of the Joint Venture Agroforestry Program, the dissemination of this knowledge has been made possible since 1996: four workshops, the publication of three proceedings and access to them through the Web is demonstration of this support. This has also occurred without any great institutional help and with a modest budget. We have recognised the problems in several areas and the need for ‘action research’. However finding resources to make things happen as quickly as they should has proved to be a problem, particularly in Australia. This is disappointing and there are no obvious solutions to this problem. Nevertheless, BIG is an example of a network in action, and might serve as a model for the challenges confronting small sectors that together can make a difference to the sustainability and beneficial use of a variety of Australia’s resources.

Recommendations

There is an established market for blackwood and other acacias, but with a shortage of supply in Australia and competition from Asian sources, it is important to develop the high value end of the market, and to increase supply from sustainably-managed regrowth stands in Tasmania and Victoria and plantations elsewhere. Future priorities are:

- In Australia, coordinated demonstrations of 'best practice' management in blackwood regrowth stands should be established to improve landholder understanding of this task, and encourage expansion of the area of this species that is in effective production.
- To help develop a better profile for well-managed blackwood stands, an international series of best-practice trials should be initiated.
- A lot of provenance trials of this species have been established — we need more effort to measure, analyse and write up the results for public use, and to apply the results to improve the genetic quality of seed used for planting.

- The task of domesticating *Acacia saligna* has barely begun; such initiatives require persistence for decades.
- Effective and valued communication between industry participants can be efficiently maintained by means of periodic workshops.
- To pursue a coordinated approach between all interested parties as a model for sustaining and utilising acacia resources in Australia.

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Fourth Blackwood Workshop

26-29 April 2006 Photo at 'Ardmona', Kilmore, Victoria, by Gordon Bradbury, 29 April