An Australian Government Initiative

Joint Venture Agroforestry Program

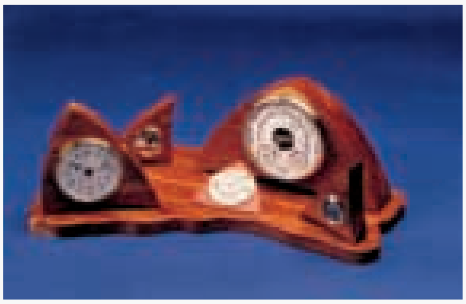
Rural Industries Research & Development Corporation

Forest & Wood Products Research & Development Corporation

Land & Water Australia

Murray-Darling Basin Commission

Utilisation of western Queensland hardwoods as speciality timbers



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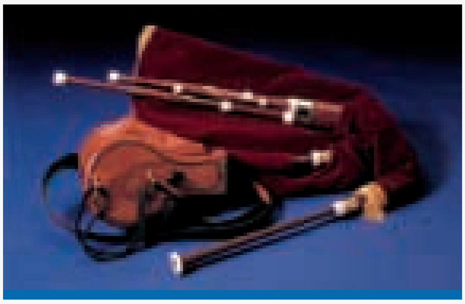
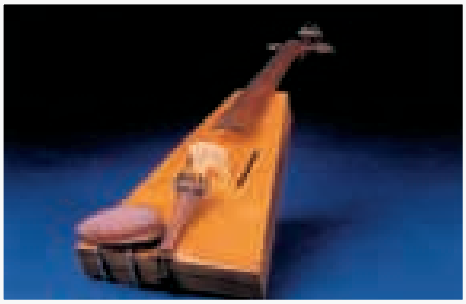
Compiled by T.J. Venn, R.L. McGavin and W.W. Leggate





RIRDC Publication No 04/132

RIRDC Project No PN99.2004

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September 2004

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RIRDC Project No PN99.2004

ISBN 1 74151 040 6
ISSN 1440-6845

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Project No. PN99.2004

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Published in September 2004
Printed on environmentally friendly paper by Canprint

Foreword

While not traditionally viewed as commercial timber species, western Queensland hardwoods from managed remnant woodlands have recently found application in high-value, niche markets such as fine furniture and musical instrument manufacture. While availability, small piece size and high levels of defect will limit the potential size of the industry, the inherent beauty of the wood of several of these species will command a premium price in specialised markets.

This investigation focused on characterising the extent and distribution of the resource, harvesting costs, recoveries, seasoning methods and markets, and on defining the commercial viability of production as a component of rural industries in these regions. A range of people were involved in researching the various aspects of this study, and the report is presented as a series of co-authored chapters.

This project was funded by the Natural Heritage Trust through the Forest and Wood Products Research and Development Corporation (FWPRDC), and the Joint Venture Agroforestry Program (JVAP). The JVAP is funded by three R&D Corporations — Rural Industries Research and Development Corporation, Land & Water Australia, and FWPRDC – and the Murray Darling Basin Commission. These agencies are funded principally by the Australian Government. The FWPRDC is 50% funded by industry.

This report, a new addition to RIRDC's diverse range of over 1000 research publications, forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems.

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- downloads at www.rirdc.gov.au/reports/Index.htm
- purchases at www.rirdc.gov.au/eshop

Simon Hearn
Managing Director
Rural Industries Research and Development Corporation

Acknowledgements

The impetus for this study principally arose from Mrs Jenny Crichton, a western Queensland landholder, who initially approached the CSIRO in 1990 with a proposal to assess potential opportunities for commercial utilisation of western Queensland hardwoods. Several years later, Mrs Crichton assisted in the development of the project proposal, *Utilisation of Western Queensland Hardwoods as Specialty Timbers*, written by Mr Myron Cause, wood utilisation scientist from the Queensland Forestry Research Institute (QFRI), part of the Queensland Department of Primary Industries' Agency for Food and Fibre Sciences. From 1997 to 1999, the Queensland Department of Natural Resources and Mines, the Desert Uplands Build-up and Development Strategy Committee, and the South West Strategy Committee funded wood property (chapter 3) and market research (chapter 8), and two seminars on western hardwoods held in Charleville and Barcaldine. This initial research was largely performed by Mr Myron Cause, Mr Gary Hopewell, Ms Leanne Stephens, Ms Ellie Fairbairn and Ms Katherine Whittaker. The majority of the research published in this report has been undertaken with Natural Heritage Trust funding through the Forest and Wood Products Research and Development Corporation (FWPRDC) over the period 1999 to 2002, which has been principally managed by Mr William Leggate and Mr Robbie McGavin of QFRI.

We would like to take this opportunity to thank the Queensland Department of Primary Industries, Natural Heritage Trust, and FWPRDC for their financial support of this research. We would also like to express our appreciation of the efforts made by the project steering committee, comprising Mr Henry Hinz, Mrs Jenny Crichton, Mr Michael McKellar, Mr Dennis Fahey and Ms Ellie Fairbairn, who generously gave their time and offered advice to assist the research. The members of this committee, with the exception of Ms Fairbairn, are the founders of the Outback Timbers Utilisation Committee.

The kind support and assistance provided by the following landholders is gratefully acknowledged:

- Robert and Jenny Crichton
- Marcus and Barb Arthur
- Michael and Helen McKellar
- Dennis and Jan Fahey
- Phil and Kate McKeering
- Bob and Leslie Marshall
- Margaret House
- Bill Cripps
- Jim and Jill Taylor
- Niki and Raymond Bolam
- Kingsley Ward
- Mike and Jo Wells
- Lesley and Andy Cowper
- Maria Forest
- Howard and Jean Hall
- Frank Vannie and
- John Chandler.

The project benefited substantially from the following timber product manufacturers who readily allocated their valuable time to discussions with QFRI research personnel:

- Robert Dunlop Woodcraft –Robert and Kym Dunlop
- F.H. Wiesner –Frank Wiesner
- M & M Jewellery –Morrie McCarthy
- Maton Guitars –Patrick Evans
- Rare Woods –Chris and Daid Poole
- Rings of Time –Eric Lewis
- Rice and Sons –Len and Christine Rice
- The Portable Sawmill Association – the late Murry Goodman
- Proveneer –Robin Edge and Earl Murray
- Ken Jackson –woodturner and
- Krugers -Stuart Rodger.

The considerable input and support provided by the following researchers is also greatly appreciated:

- Matt Armstrong, QFRI
- Ashley Cause, QFRI
- Myron Cause, formerly QFRI
- Terry Copley, QFRI
- Damian Cotter, QFRI
- Ellie Fairbairn, Queensland Department of Natural Resources and Mines (DNRM)
- Chris Fitzgerald, QFRI
- Gary Hopewell, QFRI
- Felix McDonald, QFRI
- Andy McNaught, QFRI
- Allie Muneri, QFRI
- Jack Norton, QFRI
- Graeme Palmer, formerly QFRI
- Adam Redman, QFRI
- Sandy Roberts, QFRI
- Howard Rodgers, DNRM
- Leanne Stephens, QFRI
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- Amanda Yeates, Department of State Development, formerly QFRI, and
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Executive summary

Traditionally viewed as an impediment to agricultural development, western Queensland hardwoods have recently found application in high-value, niche markets, including musical instrument manufacture. Many primary producers in the South West Strategy and Desert Upland regions of Queensland are seeking to diversify their grazing businesses with alternative or supplementary income streams and are keen to investigate opportunities to manage their remnant woodlands for timber production. However, there is a dearth of information about the timber resource, appropriate processing techniques, costs, markets and likely returns, which is stifling investment in this emerging rural industry. This research has aimed to remove much of the uncertainty surrounding opportunities for small-scale processing of western Queensland hardwoods. In particular, this investigation has focussed on:

- the timber resource, including its spatial distribution, estimates of merchantable wood volume and quantification of the wood properties of selected species
- costs and recoveries of harvesting and portable sawmilling operations
- appropriate seasoning methods and likely drying times
- graded (saleable) product recoveries
- potential markets for western Queensland hardwoods, including appropriate product types, quantities demanded and prices, and
- the commercial viability of western Queensland hardwood production, including a comparison with grazing.

Dozens of western Queensland hardwood species are potentially suitable for processing into products for niche markets; however, the wood property analyses and market research presented in this report has focussed on the following eleven: *Acacia aneura* (mulga); *A. cambagei* (gidgee); *A. coriacea* (desert oak); *A. excelsa* (ironwood); *A. nilotica* (prickly acacia); *A. shirleyi* (lancewood); *Archidendropsis basaltica* (red lancewood); *Corymbia similis* (Queensland yellowjacket); *Eremophila mitchellii* (sandalbox); *Eucalyptus populnea* (bimble box); and *Grevillea striata* (beefwood). Budget constraints necessitated the limitation of research into standing merchantable volumes, timber processing and commercial viability to two species only. Mulga and gidgee were selected because of their wide distribution, potentially large sustainably harvestable volumes and promising timber properties.

Undertaking preliminary timber inventories and employing the most comprehensive vegetation maps available, estimates of standing timber volumes have been made for western Queensland mulga and gidgee woodlands. The estimates indicate that total merchantable (sawlog, roundwood and craftwood) volumes are low (5 m^3/ha to 15 m^3/ha), which reflects the poor stem form of these species and past land management practices. Wood property research confirmed that, compared with other Australian and overseas timbers, western Queensland hardwoods are unique, particularly with regard to their high air-dry densities (1,000 kg/m^3 to 1,300 kg/m^3) and hardnesses (14 kN to 18 kN). Many of these species are deemed legally susceptible to the lyctid borer (*Lyctus brunneus*); however, this research has indicated that, with future studies, some species could be reclassified as non-susceptible. The gluing properties of all but three species were found to be satisfactory.

Portable sawmilling studies undertaken with mulga and gidgee suggested that standing sawlog volumes (minimum small end diameter under bark of 125 mm and 1.2 m in length) are in the vicinity of 1 m^3/ha in western Queensland woodlands. In this study, harvested sawlogs were generally about 2 m in length with centre diameters over bark of 20 cm. Defects, for example, caused by insect and fungal damage, were found to be common in the logs. Nevertheless, green-off-saw (GOS) recoveries of 34.6% and 27.6% were achieved from mulga and gidgee sawlogs respectively. Total variable cost of harvesting and portable milling mulga and gidgee in western Queensland is estimated to be between \$730/m^3 GOS and \$980/m^3 GOS, and shown to be highly sensitive to imputed labour cost and GOS recovery. The land tenure from which logs are harvested is also demonstrated to have a large impact on total variable cost. Processing costs for mulga and gidgee were found to greatly exceed typical costs of sawing east-coast Queensland hardwoods.

The suitability of unprotected air-drying, protected air-drying, solar kiln, dehumidifier kiln and conventional kiln drying was assessed for mulga and gidgee. Solar and dehumidifier kilns seasoned 25 mm boards to 12% moisture content within four to eight weeks, while air-drying required between nine and 27 weeks. The conventional kiln generally seasoned 25 mm boards within one to two weeks. Seasoned mulga and gidgee boards were appearance graded in accordance with *AS2796 – 1999 – Timber – Hardwood - Sawn and Milled Products*, which indicated high feature grade recovery in the order of 10% of log volume. Wane, insect damage and decay were found to be primarily responsible for this low appearance grade recovery. Seasoning grading[1] indicated that unprotected air-drying resulted in higher levels of drying degrade in boards than protected air-drying, solar and dehumidifier kiln-drying. There was no appreciable difference in seasoned board quality between the latter three seasoning methods. Appearance grading of conventional kiln-dried material indicated that the drying schedules adopted could produce boards of sound appearance quality, when the thickness of those boards was not greater than 25 mm. However, high levels of drying degrade were common in boards exceeding 25 mm in thickness, indicating a need for new conventional kiln schedules to be developed for western Queensland hardwoods. A financial analysis incorporating the opportunity costs of air-drying, found air-drying to be the most economically efficient seasoning technique for mulga and gidgee in western Queensland. Where a kiln is required, for example, because product specifications require it, this study highlighted that a solar kiln is likely to be the best investment option for a landholder.

Veneer production has the potential benefit of maximising the value of a timber resource through higher appearance recovery than is possible with solid wood products. Commercial veneer manufacturers have stringent billet quality specifications and preliminary investigations have indicated that supplying western Queensland hardwood billets of such quality would be extremely difficult. A small-scale veneering trial was conducted with mulga, which resulted in the majority of veneer leaves containing unacceptable levels of defects (*e.g.* splits, grain tear, knots and decay) for standard veneer manufacture. Nevertheless, sections within the veneer leaves may be appropriate for special applications where small pieces of veneer can be utilised.

In an effort to ascertain likely markets for western Queensland hardwoods, a postal survey was sent to 225 Australian and international wood product manufacturers, and discussions were held with several current and potential consumers of western Queensland hardwoods. Currently traded volumes of sawn western Queensland hardwoods were found to be small and unlikely to be more than about 200 m^3 per annum. Several reasons for the lack of uptake of these species were provided, including ignorance about the resource, the scarcity of information about their timber properties and a poor supply chain. Nevertheless, the majority of respondents expressed great interest in stocking or experimenting with western Queensland hardwoods. Parquetry flooring manufacturers, small-scale furniture manufacturers, musical instrument manufacturers and timber merchants were found to be the most likely purchasers of western Queensland hardwoods in the future. It was asserted by respondents and interviewees that dried, roughsawn western Queensland timber prices would initially be in the vicinity of $1,500/$m^3$ to $3,000/$m^3$. However, a potential opportunity for small volumes (perhaps only tens of cubic metres per annum) of the highest quality boards to be sold to domestic and international musical instrument and knife handle manufacturers at prices equivalent to between $20,000/$m^3$ to $30,000/$m^3$, was also frequently highlighted.

Feedback from domestic and international respondents to the postal survey highlighted opportunities for exporting western Queensland hardwoods, especially to North America and Europe. It was asserted that, with a well-funded, well-directed marketing campaign, the international demand for

[1] A grading technique developed by QFRI to assess drying degrade, which facilitates assessment of the suitability of different drying techniques for particular timbers.

high-quality western Queensland hardwood boards could greatly exceed the Australian market. Ringed gidgee, in particular, was believed to have high export potential. It was highlighted that ecolabelling of western Queensland hardwoods would be beneficial for marketing overseas.

Employing the portable sawmilling, seasoning, grading and market information generated by this research as base case values, financial analyses of eight small-scale western Queensland hardwood production scenarios were performed and returns compared with grazing. The net present value of clearing remnant woodland for grazing cattle in the South West Strategy and Desert Upland regions of Queensland was estimated to be in the vicinity of $20/ha to $40/ha. Specific scenarios that have been modelled include selling green roughsawn timber, a landholder co-operative manufacturing parquetry flooring, and a scenario producing dried and dressed boards for high-value markets, including for knife handle and musical instrument manufacturers. Under base case assumptions, only the latter scenario generated returns competitive with grazing, with the net present value of managed remnant woodland estimated at between $60/ha and $80/ha. When small improvements in western Queensland hardwood processing efficiency over the base case are assumed, then the landholder co-operative parquetry flooring scenario becomes competitive with grazing. If it is assumed that, in addition to improvement in processing efficiency, western Queensland hardwoods can be sold at a 20% price premium over the base case market price, then green roughsawn timber production was found to be competitive with grazing.

Portable sawmills have been identified as an effective method for graziers or others with limited timber industry experience, to value-add western Queensland timbers with minimal financial risk. Knowledge and experience gained throughout the project has indicated that, from the range of portable chainsaw mills, bandsaw mills and circular mills, the latter type are likely to be the most appropriate for small-scale production of western Queensland hardwoods.

It has been concluded that management of remnant western Queensland woodlands for hardwood production could potentially create a new rural industry generating substantial financial and environmental benefits. There was found to be considerable scope for future investigations into the western Queensland hardwood industry to maximise the benefits from sunk research expenditure, including a resource assessment incorporating studies on woodland regeneration and the potential for sustainable management, opportunities for agroforestry, appropriate processing techniques, markets and marketing, and a total economic valuation of the western Queensland hardwood industry.

1. The scope of this research on utilisation of western Queensland hardwoods

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This chapter presents the background and objectives of the current research into processing opportunities for western Queensland hardwoods. Landholders have displayed considerable interest in developing businesses based on the remnant woodlands on their properties; however, uncertainty about the resource, production processes, costs and markets has stifled investment. This research investigates these key issues with the aim of reducing or eliminating this uncertainty.

1.1 Introduction

There is a substantial timber resource in western Queensland that has been traditionally viewed as an impediment to agricultural and pastoral development. These timbers have been used on-farm for purposes such as fencing and firewood; however, small volumes have been used for specialty applications (*e.g.* musical instrument manufacture), where high prices have been paid. It has become evident that many hardwood species of western Queensland possess unique timber properties, such as high-density, and attractive colours, grain and figure (Hall *et al.* 1972; Fairbairn 1999). Nevertheless, the scarcity of straight-boled trees, their typically small stem diameters, the prevalence of timber defects, remoteness from major markets and lack of information about the resource and potential markets, have impeded the establishment of a more substantial industry based on western Queensland hardwoods. If these timbers could be marketed effectively and sold to consumers who demand timbers with these unique properties, then market prices could be achieved that would make management of remnant stands for timber production attractive to landholders. Opportunities may subsequently arise for western Queensland landholders to diversify their incomes and establish a new rural industry. There may also be flow-on environmental benefits to the wider community as a result of reduced land clearing.

Suppliers of western Queensland hardwoods to high-value markets are often not landholders themselves, and reportedly make only small payments to landholders in return for access to timber resources. Many landholders would like to become more involved in the supply of western hardwoods and potentially obtain a greater share of the high returns that can be generated by the sale of these species into niche markets. However, the literature suggests that people are, in general, risk averse and that uncertainty about future outcomes will drive people away from potential investments. Typical of many new industries, there is a dearth of information about production costs and likely returns to processing western Queensland hardwoods. Although several enterprises currently process these species, obtaining objective and meaningful cost and revenue information is difficult. The Queensland Forestry Research Institute (QFRI) has identified demand from western Queensland landholders for an independent assessment of the commercial viability of milling western hardwood timbers in the

South West Strategy and Desert Uplands regions of western Queensland. The research presented in this volume has focussed on these regions, which are illustrated in Figure 1.1.

1.2 The purpose of this study

This project was conceived with the aim of empowering western Queensland landholders with information about the potential to develop an alternative income stream from the timber resources on their properties. The research is intended to remove some of the uncertainty surrounding the opportunities for processing western Queensland hardwoods and aid landholder decision-making about future management of their properties and directions for their businesses. Specifically, project objectives were to provide information about:

- the timber resource, including its spatial distribution, estimates of merchantable wood volume and quantification of the wood properties of selected species
- costs and recoveries of harvesting and portable sawmilling operations
- appropriate seasoning methods and schedules
- graded (saleable) product recoveries
- potential markets for western Queensland hardwoods, including product types, quantities demanded and prices, and
- the commercial viability of western Queensland hardwood production, including a comparison with grazing.

To make the findings of this study accessible and adoptable by landholders, all research has focussed on processing opportunities appropriate for small-scale operations. For example, harvesting and portable sawmilling trials have been undertaken with a farm truck, tractor and a portable sawmill. Seasoning trials assessed the merits of air drying versus solar kiln and dehumidifier kiln drying, the latter two being low-cost kiln drying technologies. Finally, financial assessments of potential enterprises have been made assuming two-person operations and the types of equipment utilised in QFRI's research trials.

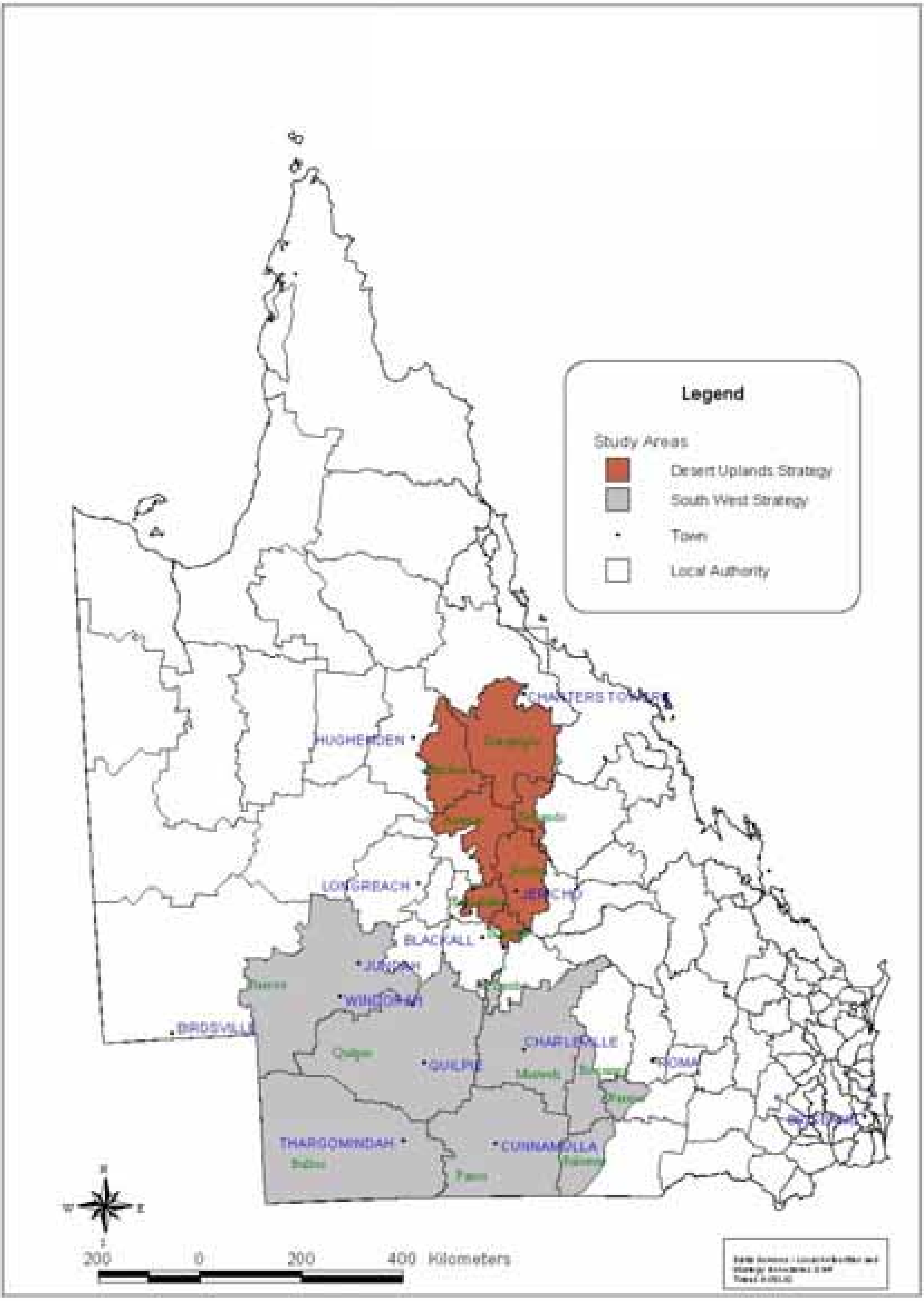

Figure 1.1 *Study areas in Western Queensland*

1.3 Western Queensland hardwood species examined in this study

There are dozens of hardwood species in western Queensland with timber properties potentially suitable for a range of products, including high value, specialty markets. However, budget constraints necessarily limited the focus to a manageable number of species. Information on wood properties and market opportunities has been collected for the following 11 species:

Table 1.1 *Western Queensland hardwood species examined in this study.*
Source: Cause et al. (1989) and Fairbairn (1999).

Scientific name	Trade name	Local name
Acacia aneura	mulga	mulga
Acacia cambagei	gidgee	gidyea, gidya, gidga
Acacia coriacea	desert oak	dogwood
Acacia excelsa	ironwood wattle	ironwood
Acacia nilotica	prickly acacia	prickly acacia
Acacia shirleyi	lancewood	lancewood
Archidendropsis basaltica	red lancewood	dead-finish
Corymbia similis	Queensland yellowjacket	Queensland yellowjacket
Eremophila mitchellii	sandalbox	buddha, false sandalwood
Eucalyptus populnea	bimble box	bimbil box, poplar box
Grevillea striata	beefwood	beef oak, beef silky oak

The timber processing trials and financial analyses have been limited to mulga and gidgee, because of their wide distribution, potentially large sustainably harvestable volumes and promising timber properties.

1.4 Layout of the report

Due to the contributions of various people throughout this study, this report has been prepared as a series of co-authored chapters. In spite of severe data limitations, Chapter 2 reviews total merchantable stand volumes, the spatial extent of mulga and gidgee in western Queensland and provides a discussion of some sustainability issues. Chapter 3 reports research into key wood properties of 11 western Queensland timber species, which has been published in Fairbairn (1999).

The outcomes of QFRI harvesting and portable sawmilling trials with mulga and gidgee, including a detailed estimation of the variable costs associated with producing green-off-saw timber, are presented in Chapter 4. In Chapter 5, the results of seasoning trials with mulga and gidgee are examined, and a financial assessment of air, solar kiln and dehumidifier kiln drying methods reported. The graded recovery[2] of mulga and gidgee boards milled and dried in Chapters 4 and 5 is presented in Chapter 6. Chapter 7 reports the findings of an investigation into the feasibility of producing sliced veneer from mulga.

Potential markets for western Queensland hardwoods are examined in Chapters 8 and 9. In Chapter 10, the findings of earlier chapters are employed in financial analyses of several western Queensland hardwood production scenarios. Comparisons of estimated returns are made with grazing.

[2] Graded to the Australian Standard *AS 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products*

For landholders interested in entering the western Queensland hardwood industry, factors to consider when purchasing a portable sawmill are outlined in Chapter 11. Chapter 12 reviews the findings of earlier chapters and details suggestions for future research to encourage growth of the western Queensland hardwood industry.

References

Cause, M.L., Rudder, E.J. and Kynaston, W.T. (1989), *Queensland Timbers: their Nomenclature, Density, and Lyctid Susceptibility*, Technical Pamphlet No 2, Queensland Department of Forestry, Brisbane.

Fairbairn, E. (1999), *Australian Timbers Volume Two: Western Queensland Trees and Their Timbers*, Department of Natural Resources, Brisbane.

Hall, N., Boden, R.W., Christian, C.S., Condon, R., Dale, F., Hart, A., Leigh, J., Marshall, J., McArthur, A., Russell, V. and Turnbull, J. (1972), *The Use of Trees and Shrubs in the Dry Country of Australia*, AGPS, Canberra.

2. Preliminary stand and bioregion assessment of the western Queensland mulga and gidgee timber resource for short-length timber production

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The vast woodland resource of western Queensland includes a range of ecosystems from which timber could potentially be harvested. No previous research has attempted to quantify this resource for timber production, nor have issues regarding the ecological sustainability of harvesting the resource been previously assessed. Merchantable volumes are presented for gidgee and mulga from selected regional ecosystems across the mulga Lands and Desert Uplands bioregions. Merchantable volumes were generally found to be low for both species, reflecting poor stem form. Although extensive areas of both species exist, it is not yet possible to estimate the standing volumes on a regional scale in western Queensland due to incomplete vegetation mapping. Ongoing research by the Queensland Department of Natural Resources and Mines is addressing issues of sustainability.

2.1 Introduction

This chapter presents a summary of inventory data for gidgee and mulga at the stand and regional level, and a brief discussion on sustainable woodland management. Two recent studies (Rogers in prep.; Swift *et al*. 2002) have assessed the standing timber volumes of the western Queensland hardwood resource. Both studies have primarily focussed on acacia species on account of their unique timber properties and potential for high value timber production. Swift *et al*. (2002) undertook an inventory of *Acacia cambagei* (gidgee) and *Acacia aneura* (mulga)[3], while Rogers (in prep.) focussed on an inventory and population dynamics study of *A. cambagei*, *A. shirleyi* (lancewood), *A. coriacea* (desert oak) and *Corymbia similis* (Queensland yellowjacket). Both reports provide preliminary data on standing merchantable volumes available for short-length timber production for speciality end uses.

The remaining western Queensland hardwood resource is primarily located in the three bioregions illustrated in Figure 2.1. The Desert Uplands, mulga Lands and Mitchell Grass Downs bioregions have total areas of 7,032,297 ha, 18,106,092 ha and 23,788,550 ha respectively. The western Queensland hardwood resource comprises a vast range of

[3] Copies of the resource survey undertaken by Swift *et al.* (2002) are available from the authors, Queensland Forestry Research Institute, Locked Bag 16, Gympie QLD 4570

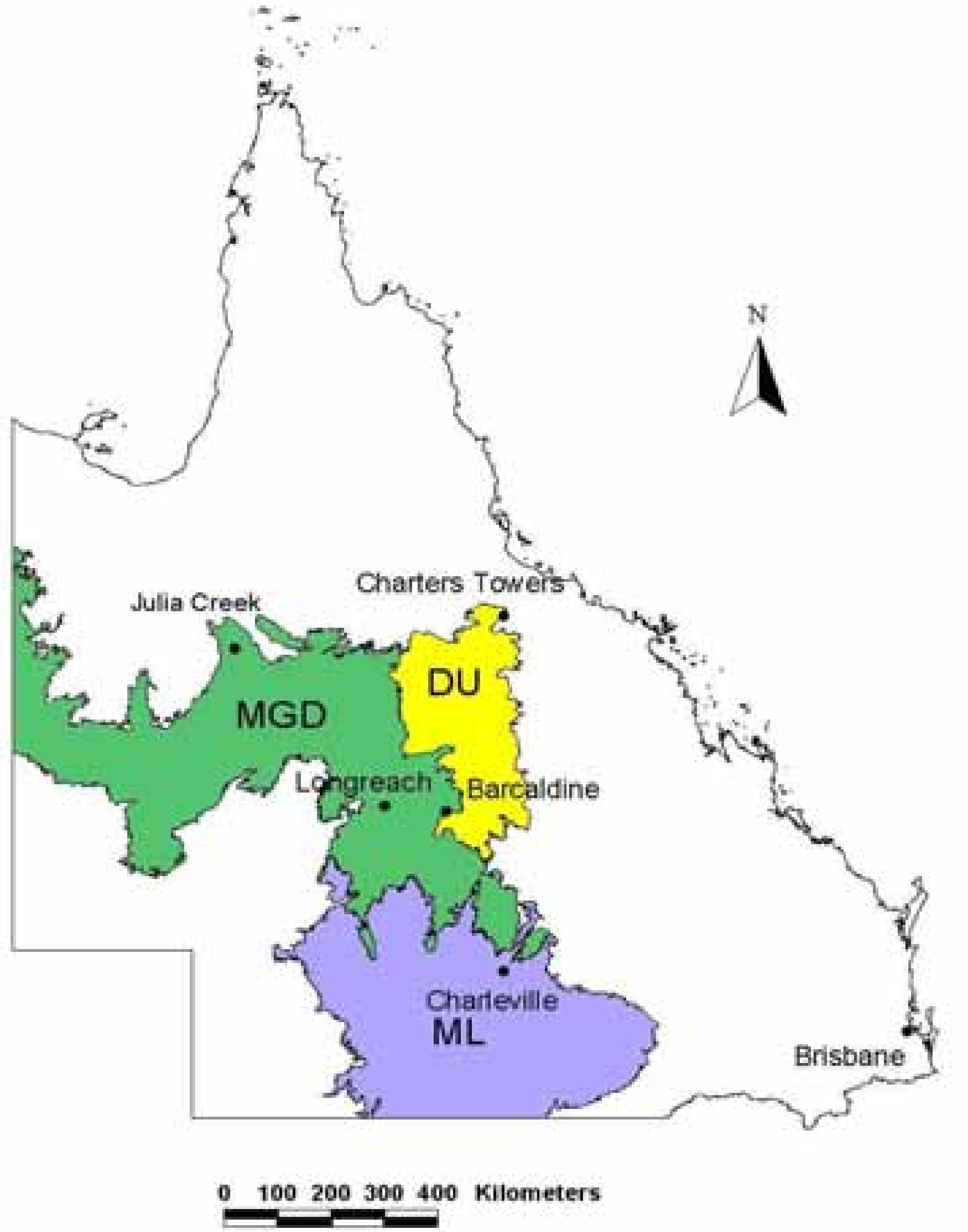

Figure 2.1 Location of the three main western Queensland bioregions that support semi-arid woodlands. DU = Desert Uplands, MGD = Mitchell Grass Downs, ML = mulga lands

semi-arid woodland types (dry savanna) that vary in structure and composition. Semi-arid woodlands have been classified into a range of structural formations by Specht *et al.* (1974) and into a variety of regional ecosystems (REs) for each bioregion by Sattler and Williams (2000). Stands in western Queensland vary from mid-high woodland (*e.g.* dense monospecific stands of *Acacia cambagei* up to 16.5 m tall), to low-density, mixed species stands characterised by scattered emergent *Corymbia* species with a range of lower stature species scattered in dense groves (*e.g. Archidendropsis basaltica* - red lancewood), or single stems (*e.g. Acacia excelsa* - ironwood and, *Grevillea striata* - beefwood), to low woodland savanna (*e.g.* stunted mallee form *Corymbia similis*). Individual species may occur in different structural formations ranging from low-open woodland to medium-open forest, reflecting a taller community with a higher foliage projective cover (FPC) (Specht *et al*. 1974).

2.2 Western Queensland hardwood resource assessment

There is little background information on best practices for assessing semi-arid woodlands for speciality timber production, although Temu (1985) highlights some general problems associated with inventory in tropical woodlands. While standard sampling design techniques apply in woodlands, the patchy species distributions, stand spatial configuration and tree morphology, create difficulties. Tree morphology varies widely between species and even amongst trees of the same species. Stem form is frequently poor for the production of sawlogs, with heavy branching common (*e.g.* in gidgee), and it is rare for a single stem to be capable of producing more than one short sawlog. In addition, some of the potentially commercial species in western Queensland are sparsely distributed, making inventory an expensive procedure. Stands are also highly variable reflecting the influence of rainfall, soils, competing vegetation, and management history (*e.g.* fence post and rail harvesting, and felling for drought fodder). Moreover, access to woodland areas can be poor.

2.2.1 Field procedure

The two studies of the western Queensland hardwood resource used similar sampling schemes, but different site selection criteria. Swift *et al*. (2002) conducted a limited survey on gidgee (three sites) and mulga (two sites), selecting sites that were characteristic of part of the regional distribution of these species across the mulga Lands and the Desert Uplands. Sample sites were stratified into different stand qualities (high, medium, and low) according to estimated timber production potential. Rogers (in prep.) sampled gidgee from six properties across the Desert Uplands bioregion from Barcaldine to Pentland, stratifying sample sites based on stand structure to reflect the natural variation within each sampling location (landholder property).

Swift *et al*. (2002) used both contiguous transects (50 m × 10 m) and fixed area (0.05 ha) circular plots originating from points randomly located to sample each forest quality class. Circular plots were located at 50 m intervals along fixed bearings. The bearings were subjectively chosen to best assess the strata and include any known variation. Rogers (in prep.) also used circular plots, varying the size between strata to ensure a minimum of 10 trees per plot.

The length of each transect was dependent upon the size, variation, and location of each strata. For example, a woodland type consisting of smaller patches of forest would have more transects of fewer plots than a large area which would have fewer transects with many plots. The number of plots per strata depended on stand variability. For gidgee, Swift *et al.* (2002) determined that between 5 and 10 plots were required to assess the variation within each strata. This was reduced to a range of 3 to 8 plots in mulga, as these stands tended to be more uniform.

Logs were assessed using visual segmentation (Born and Chojnacky, 1985). With this method, stems are assessed as if comprised of separate segments of merchantable and non-merchantable logs, according to the presence and severity of bends, twists, fire scars, dry sides, and borer holes.

The following variables were recorded for each measured tree within each plot: species, health class, diameter, total height, length and centre diameter for each log of merchantable size, log position and stem class.

Diameter
Tree diameter was measured at 30 cm above point of establishment for Swift *et al*. (2002) to allow data to be compared with the TRAPS (Transect recording and processing system) database (Back *et al*. 1999). Diameters less than 2 cm were estimated. Rogers (in prep.) used diameter at breast height (dbh) to allow comparison with a series of permanent sampling plots currently being established using the DPI native forest permanent plot system (DPI 1998).

Total height
In both studies total tree height was measured using a Vertex Hypsometer for trees over 3 m tall. Shorter trees were measured using height sticks. Total heights were measured by Swift *et al*. (2002) to quantify stand structure and also to correlate a height-productivity relationship.

Merchantable log length and log centre diameter
Merchantable log size was defined as a straight log with a minimum length of 60 cm, with increments of 30 cm for Swift *et al* (2002) and 10 cm for Rogers (in prep.), and a top end diameter over bark ≥ 10cm. Log length and log centre diameter was either measured using a height stick or estimated if out of reach. To calibrate the estimations, sample trees were periodically felled to determine actual volume. Tree volume was calculated for each log using Huber's formula, which is the cross-sectional area at the centre of each log, multiplied by log length.

Log position
The position of each log, whether in the stem or a branch of the tree, was recorded. This relates mostly to gidgee trees, since large branches of merchantable size are common in this species.

2.3 Preliminary estimates of merchantable volumes in mulga and gidgee stands

Table 2.1 reports the results of timber surveys undertaken by Swift *et al.* (2002) and Rogers (in prep.). The volumes reported are indicative of total merchantable volumes encompassing all products (*i.e.* sawn timber, roundwood and craftwood). Millable merchantable volumes are likely to be lower than this estimate, depending on the products being targeted and processing techniques employed. The volume of merchantable gidgee logs ranged from 5.3 m^3/ha to 31.2 m^3/ha with the percentage of merchantable stems varying from 9% to 79% of the stand. The upper value of the range reflects an exceptional stand dominated by large stems 30 cm to 40 cm in diameter. The range of merchantable volumes for each species reflects a variety of factors including, stage of stand development, stand structure, soil type, rainfall, and past management.

Mean merchantable volume of each tree ranged from 0.02 m^3 to 0.21 m^3 across the plots. Values from Swift *et al*. (2002) are site quality means, while data from Rogers (in prep.) are for individual sites. Log length varied from 0.6 m to 4.0 m, and log centre-diameter ranged from 10 cm to 60 cm. The median log centre diameter ranged between 15 cm and 19 cm (41% of logs), and the median log length was 1.0 m - 1.2 m (34% of logs). The maximum height of a stem was 16.5 m (15.9 cm dbh), and the largest dbh was 59.5 cm (8.8 m tall).

Table 2.1 *Merchantable volumes and stand data for gidgee and mulga (DU = Desert Uplands and ML = Mulga Lands)*

Bioregion	Species and quality class	No. plots	Mean merch. log volume (m^3)	Merch. volume (m^3/ha)	Merch. stems/ha	Non-merch. stems/ha	Logs/tree	Mean height (m)
Swift *et al*. (2002)								
DU & ML	gidgee (high)	na	0.0140	9.2	439	202	1.0	9
DU & ML	gidgee (medium)	na	0.0191	6.0	186	121	1.0	9.9
DU & ML	gidgee (low)	na	0.0224	5.2	139	140	1.6	8.5
	Mean		0.0160	7.3	278	155	1.7	9.2
ML	mulga (soft)	na	0.0147	5.3	233	55	1.5	10.5
ML	mulga (hard)	na	0.0245	10.3	235	8	1.8	13.3
ML	Mean		0.0188	7.2	234	38	1.6	11.7
Rogers (in prep)	Location (gidgee)							
DU	Sherwood	7	na	8.4 ± 4	57	15	na	na
DU	Milray	4	na	10.8 ± 3.3	88	89	na	na
DU	Milray	5	na	11.6 ± 3.4	106	159	na	na
DU	Hobartville	5	na	31.2 ± 4.4	216	77	na	na
DU	Hobartville	7	na	6.0 ± 7.4	73	245	na	na
DU	Garfield	7	na	16.2 ± 15.1	154	323	na	na
DU	Garfield	5	na	17.3 ± 13.4	311	212	na	na
DU	Garfield	5	na	20.7 ± 9.4	407	487	na	na
DU	Ulcanbah	5	na	22.5 ± 10.5	275	833	na	na
DU	Ulcanbah	7	na	5.2 ± 5	156	1528	na	na

Note: na indicates this information is not available

2.4 Bioregional merchantable volume estimates for western Queensland hardwoods

At present, with the exception of the Desert Uplands bioregion, it is not possible to provide bioregional estimates of the merchantable volumes of gidgee and mulga. This is due to incomplete geographical information system data sets for the Mulga Lands, and the Mitchell Grass Downs. Complete Desert Uplands RE area data was provided by the Department of Natural Resources and Mines and is presented in Table 2.2. The following points must be considered when interpreting this data set. Natural stand variation between REs makes generalisations about the merchantable volumes of a particular species problematic when based on data from another RE. REs define plant communities based on their floristics and landform characteristics, providing relatively little information on stand structure. Stand structure varies between REs, so volumes for one RE are unlikely to reflect those in another RE. Even within individual REs there are marked differences in stand structure. There are also marked differences in stand quality between similar stand structures due to previous management. While many of the remaining gidgee stands are intact, many others have been heavily harvested, removing most of the potentially commercial stems. There is no information on which areas have been harvested and which have not.

Although a complete data set is available for the distribution of REs across the Desert Uplands bioregion, the mapping dates from 1999, hence tree clearing since that time is not accounted for. Areas of gidgee and mulga REs are presented in Table 2.2, and the distribution of gidgee ecosystems is shown in Figure 2.2. The proportion of these areas available for forestry activities has not been determined yet.

Table 2.2 *List of Regional Ecosystems for the Desert Uplands (DU) bioregion containing potentially commercial gidgee and mulga communities, and an estimate of the mean merchantable sawlog volume per ha and total merchantable saw log volume for RE 10.3.4*

Species	RE	Original area (ha)	Current area (ha)	% remaining	Reserve (ha)	Mean volume/ha (m^3) (Rogers in prep.)	Volume for DU (m^3)
Acacia cambagei	10.3.4	165,275	93,578	56.6	1 000	14.98 ± 8	1,401,798
A. cambagei	10.4.4	Na					
A. cambagei, A. harpophylla, Eucalyptus cambageana	10.4.5	38,422	13,968	36	0		
A. aneura	10.7.6	3,245	3,214	99	0		
A. argyrodendron, A. cambagei	10.9.2	10,249	9,570	93	0		
A. cambagei, A. tephrina	10.9.4	Na					
A. cambagei	10.9.6	43,382	13,242	31	1,082		

Notes: Na indicates that this information is not available.
RE codes from Sattler & Williams (2000).
RE 10.3.4 is Low gidgee woodland with very open tussock grassland, on heavy clay and texture contrast soils. Associated with *Eremophila mitchellii*-sandalbox.

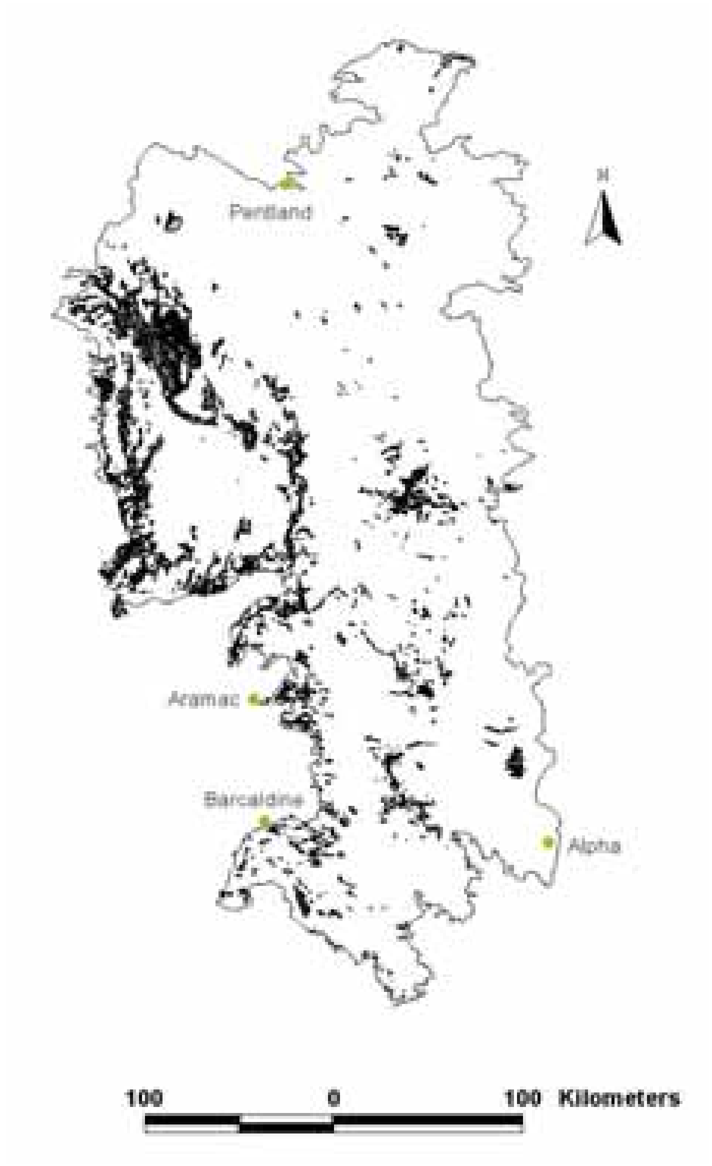

Figure 2.2 *The distribution of gidgee communities across the Desert Uplands bioregion based on the 1999 data set*

2.5 Sustainability of timber production from western Queensland woodlands

Once the extent of the merchantable resource has been established, the key issues in relation to the sustainable management of semi-arid woodlands are: (1) determining growth rates; (2) understanding the natural stand dynamics so that silvicultural prescriptions can be devised to ensure stand regeneration, and (3) understanding the potential impacts of harvesting activities on biodiversity. Ongoing research by the Department of Natural Resources and Mines is addressing these issues. Results will not be available until early 2003; however some important issues are discussed here.

Commercial harvesting of western hardwoods must address issues of sustainability on leasehold land before the Department of Primary Industries (Queensland) will agree to a sale. At present, this prerequisite stipulates harvesting no more than 5% of a stand's basal area at any one time. While this guideline will provide an interim measure to protect from overharvesting, the marked differences between the ecology of western hardwood species requires more species specific guidelines that reflect an understanding of natural stand dynamics and growth rates. Guidelines also need to reflect differences in bioregions and regional ecosystems. For example, gidgee generally displays prolific regeneration across much of the Mitchell Grass Downs, in contrast to gidgee stands across the Desert Uplands, which generally show a paucity or no regeneration.

2.5.1 Regeneration characteristics of gidgee

The population structures of gidgee stands in the Desert Uplands bioregion suggest that stands regenerate periodically and are even-aged (Rogers in prep.). Even-sized patches of trees have been identified that are in excess of 11 ha, indicating massive regeneration in response to a single event. A common feature of forests and woodlands is the requirement for natural disturbance events to promote successful regeneration. In western Queensland the most obvious natural disturbance event is fire, and less commonly localised flooding across alluvial landforms. There is no evidence to suggest that gidgee is adapted to fire, having thin bark, no ability to regenerate vegetatively, or germinate in response to heat treatment (Reynolds and Muller 1994). On the contrary, anecdotal evidence suggests successful gidgee regeneration is dependent upon rain, its seasonality, and the duration over which it falls.

Massive regeneration of gidgee occurred in areas of the Mitchell Grass Downs in the 1950s coinciding with high summer rain, resulting in seedling densities of 740,000/ha (Davidson, 1954). However, such regeneration is not evident across the Desert Uplands. This may partly be attributed to land clearance, since 46% of the main gidgee regional ecosystem (10.3.4) has been lost. Another factor may relate to stand structure. Gidgee stands have a higher FPC than many semi-arid woodland types. Successful recruitment of gidgee seedlings may require higher light levels than penetrates established gidgee woodland canopies.

2.5.2 Regeneration characteristics of mulga

No review of the regeneration characteristics of mulga has been undertaken yet.

2.5.3 Growth rates of gidgee

Growth rates of semi-arid woodlands are generally low due to the low rainfall (*e.g.* 450 mm/yr at Barcaldine), which results in growth being restricted to the summer rain period. Diameter growth rates for gidgee are very low, possibly as little as 1 mm/yr to 2 mm/yr (Burrows 2001), which suggests that some of the largest gidgee trees in the region could be 400 years old or more. No review of the growth rate of mulga has been undertaken yet.

2.6 Concluding comments

An important constraint facing a western Queensland hardwood processing industry is the limited resource information. Further woodland inventory is required to refine resource estimates at the stand and bioregion level. A hierarchical approach should be adopted in future inventory, whereby the resource is stratified acording to the bioregion, rainfall, regional ecosystem and management history. It is particularly important to ensure that any regional ecosystem sampled is representative. This can be determined using a rapid reconnaissance survey technique. Long-term sustainability of the resource is partly reliant on obtaining accurate merchantable volume estimates. However, accurate resource estimates must be complimented by detailed studies of stand dynamics, and measurements of stand growth rates across the natural range of each species.

The small sizes of the merchantable logs available from gidgee and mulga stands, in conjunction with the relatively low stand volumes of saw logs, reflect important constraints to the utilisation of the western Queensland hardwood resource. Consequently it will be necessary to develop high value, low volume niche markets that can utilise small dimension timber.

References

Back, P. V., Burrows, W. H., and Hoffman, M. B. (1999), 'TRAPS: a method of monitoring the dynamics of trees and shrubs in rangelands', in D. Elbridge and Freudneberger (eds), *People and Rangelands: Building the Future, Proceedings of the VI International Rangeland Conference*, Vol. 2, pp. 742-744, Townsville.

Burrows, W. (2001), personal communication, Scientist, Department of Primary Industries, Tropical Beef Centre, Rockhampton.

Born, J. D., and Chojnacky, D. C. (1985), *Woodland tree volume estimation: a visual segmentation technique*, US Department of Agriculture, Forest Service, Intermountain Research Station.

Davidson, D. (1954), The Mitchell Grass Association of the Longreach District-with notes on gidgee and coolibah communities, *University of Queensland papers / Dept. of Botany*, **3**(6).

DPI (1998), *Native forest permanent plot establishment*, Department of Primary Industries-Forestry, Brisbane.

Reynolds, J., and Muller, K. (1994), *Background notes on gidgee: its biology and management*, Department of Primary Industries, Longreach.

Rogers (in prep.), *Resource assessment of western hardwood species in the Desert Uplands bioregion for short length timber production*, Department of Natural Resources and Mines, Barcaldine, Queensland.

Sattler, P., and Williams, R. (2000), *The conservation status of Queensland's bioregional ecosystems*, Environmental Protection Agency, Brisbane.

Specht, R. L., Roe, E. M., and Broughton, V. H. (1974), 'Conservation of major plant communities in Australia and Papua New Guinea', *Australian Journal of Botany, Supplementary Series* **7**.

Swift, S., Taylor, D., Fairbairn, E., and Cotter, D. (2002), 'Preliminary resource survey of gidgee (*Acacia cambagei*) and mulga (*Acacia aneura*) forests in the Desert Uplands and Southwest Strategy regions', unpublished report, Queensland Forest Research Institute, Gympie.

Temu, A. B. (1985), 'Inventory problems of tropical woodlands-can multi-stage sampling be applied', *Journal of World Forest Resource Management* **1**, 177-181.

3. Assessment of wood properties of selected western Queensland hardwoods

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Many western Queensland hardwood species are potentially capable of producing valuable timber; however, there is a substantial lack of published wood property information for many of these species. The wood properties determined through this research will greatly assist in the identification of suitable end-products and assist marketing campaigns for western Queensland hardwoods. Wood property data collected for several common western Queensland hardwood species includes basic density, air-dry density, Janka hardness, shrinkage and lyctid susceptibility. It was found that the high density (1,000 kg/m^3 to 1,300 kg/m^3) and Janka hardness (13 kN to 18 kN), and low shrinkage (generally 1% to 3% radial and 1% to 4% tangential) of western Queensland hardwoods distinguished these species from 'mainstream' commercial Australian and international timbers.

3.1 Introduction

Many hardwood trees and shrubs in western Queensland, including species such as *Acacia aneura* (mulga), *A. cambagei* (gidgee), *A. shirleyi* (lancewood) and *Grevillea striata* (beefwood), are of interest to graziers and others, who are curious about the potential for utilising these timbers in high-value, niche timber markets. Despite the great interest in western Queensland hardwoods that has developed in recent years, little is known about their wood properties. To encourage and facilitate efficient and effective utilisation and marketing of this resource, the Queensland Forestry Research Institute (QFRI) has undertaken research to establish key wood property information for several common western Queensland hardwood species. This chapter reports findings from this research.

The chapter begins with a description of the wood property testing methodology, including a listing of the species studied. This is followed by a presentation of results and a discussion, including a comparison of some wood properties with other Australian and international commercial timber species.

3.2 Wood property testing methodology

Within the constraints of available time and budget, it had been decided that the western Queensland hardwoods project would benefit most from the estimation of the following characteristics of selected species:

- green moisture content
- air-dry density
- basic density
- seasoned hardness

- shrinkage
- gluing, and
- lyctid susceptibility.

The meaning and usefulness of these characteristics, and the test methods employed to estimate them are described below.

3.2.1 Wood sample collection

The aim of sampling for wood property assessment is to provide a representative and reproducible sample of the timber resource for laboratory testing. The main factors considered in the collection of a representative sample are that the sample must be unbiased and sampling should be efficient (*i.e.* the best possible sample should be collected with the available resources and time constraints). Bias can be introduced, for example, by attempting to sample only 'average trees', by selecting trees close to each other, or near established roads. The solution is to select trees at random and sufficiently far from roadsides to avoid edge effects. Since site affects tree growth, and usually influences wood quality, samples should be collected from several sites.

Sampling efficiency is concerned with capturing the natural variation in the properties of interest within a population while minimising sampling cost. There are standard methods for estimating sample means to within a desirable level of confidence (*e.g.* see Snedecor and Cochran 1967). These methods require prior indication of the variability in the population, which is usually obtained from a preliminary study. In sampling wood for property testing, it is usually the natural variability of the most variable property under investigation or the property of most interest that determines the number of wood samples to be collected. Due to the universal acceptance of density as a measure of wood quality (Tsehaye *et al.* 1995), the variability of this property has been employed to determine sample size for wood property testing.

The variability of western Queensland hardwood properties were not known prior to this study. Adequate sample sizes for wood property testing were estimated following a review of relevant literature. Hamza and Lewark (1994) determined that seven sample trees were necessary to estimate the mean basic density of 16 to 17 year old plantation grown *Eucalyptus tereticornis*. Downes *et al*. (1997) reported that the mean basic density of young *E. globulus* and *E. nitens* could be estimated with 95% confidence by four sample trees, and that there was minimal gain in precision from increasing the sample beyond seven trees. Variation in basic density between trees in a natural stand is likely to be greater. Research on eucalypts in New South Wales (Balodis *et al*. 1976), *Acacia harpophylla* (Budgen 1981) and *A. crassicarpa* (Kingston and Risdon 1961) has suggested that minimum samples sizes of 10 trees are required to estimate mean basic density with 95% confidence. It was, therefore, decided that a minimum of 10 sample trees would be harvested for each western Queensland hardwood species to be assessed.

Field collection was undertaken in August 1998 by the QFRI in collaboration with the Department of Natural Resources (DNR) and landholders. At least 10 samples were collected of each of the following western Queensland hardwood species:

- *Acacia aneura* (mulga)
- *Acacia cambagei* (gidgee)
- *Acacia coriaceae* (desert oak)
- *Acacia excelsa* (ironwood)
- *Acacia nilotica* (prickly acacia)
- *Acacia shirleyi* (lancewood)

- *Archidendropsis basaltica* (red lancewood)
- *Corymbia similis* (Queensland yellowjacket)
- *Eremophila mitchellii* (sandalbox)
- *Eucalyptus populnea* (bimble box), and
- *Grevillea striata* (beefwood).

Less than 10 samples of the following western Queensland hardwood species were collected on an opportunistic basis:

- *Corymbia setosa* (rough-leaved bloodwood)
- *Eucalyptus coolabah* (coolibah)
- *Grevillea parallela* (Japanese beefwood)
- *Persoonia falcata* (geebung), and
- *Ventilago viminalis* (vine tree).

Field collection took place on 11 geographically dispersed properties throughout western Queensland, to encompass a range of site qualities (*e.g.* soils, rainfall and altitude). Selected trees were considered, by the landholder, to be representative specimens for that species in their region, and had to be able to provide a minimum diameter of about 15 cm and billet length of 0.5 m. The exception was sandalbox, where minimum diameters of 10 cm to 15 cm were accepted, because few met the 15 cm target size. Each selected tree had its respective diameter at breast height and total tree height recorded. As illustrated in Figure 3.1, a chainsaw was used to fell each selected tree, and a test billet measuring approximately 500 mm in length, was removed from a position about waist high above the ground. Both ends were painted upon cutting to restrict any drying degrade. Figure 3.2 shows end-sealed test billets awaiting road or rail freight to Brisbane.

A botanical specimen of leaves, and available flowers and fruits were collected from each selected tree. Botanical specimens from each species were submitted to the Queensland Herbarium to authenticate field identification of species (Figure 3.3). This has ensured that reported wood properties have been attributed to the correct species.

3.2.2 Laboratory testing of wood samples

At QFRI's Salisbury Research Centre, appropriately sized laboratory test pieces were cut from the outer heartwood (truewood), thus eliminating problems in wood property testing that can arise from sapwood or the heart (*i.e.* juvenile core). Test pieces that predominantly consisted of sapwood were reserved for lyctid susceptibility testing. Depending upon the requirements of each test, some test pieces were machined and tested immediately after they were cut, while others were seasoned to 12% moisture content before final machining and testing. Laboratory testing was performed in accordance with QFRI procedures and relevant Australian Standards. The density, shrinkage, and the lyctid borer (powder post beetle) susceptibility tests were conducted at QFRI's Indooroopilly laboratories. The gluing and hardness tests were conducted at QFRI's mechanical testing laboratory at Salisbury, which is a National Association of Testing Authorities (NATA) registered facility.

Figure 3.1 *Cutting a billet from a tree for wood property testing*

Figure 3.2 *Billets were end-painted after cutting to limit drying degrade prior to testing*

Figure 3.3 *Example of the botanical specimens submitted to the Queensland Herbarium*

Green moisture content testing of western Queensland hardwoods

At the time of harvesting, timber is said to be 'green', due to its high moisture content. Knowledge of green moisture content is beneficial for determination of the timber's green density, to estimate drying times and suggest appropriate seasoning techniques.

The green moisture content of test pieces was determined in accordance with *AS/NZS 1080.1 1997, Timber - Methods of Test - Moisture Content*. This involved docking and weighing small sections from all green sample billets, followed by oven-drying of the test pieces at 103°C ± 2°C to remove all water from the sample. Oven-dried samples were then re-weighed and the original moisture content of each sample piece was determined. Green moisture content is expressed as a percentage of oven-dry weight. The green moisture contents for each test piece were then employed in the shrinkage tests (see below).

Basic density testing of western Queensland hardwoods

Basic density is a measurement of the actual wood mass (with all moisture removed) and is calculated as the oven-dry mass of a timber specimen divided by its green (saturated) volume. This property is related to the timber's hardness, strength, workability and seasoning properties. Basic density reflects the fibre wall thickness and the number of fibres per unit mass and is, therefore, a useful indicator of the timber's paper and pulping properties. Basic density, when combined with moisture content information, can also be used to calculate the weight (and density) of green timber, for example, to determine freight load weights.

In this research, basic density has been determined by the gravimetric method, in accordance with the *American Standards for Test Methods (ASTM) Designation D: 2395-93 Standard Test Methods for Specific Gravity of Wood – Base Materials*. In this method, the green volume of a test piece is determined by water displacement before being oven-dried to remove all moisture. Basic density is calculated as the ratio of oven-dry weight (grams) to the weight (grams) of displaced water from the equation:

$$\text{Basic Density (kg/m}^3\text{)} = \text{(oven-dry weight/green volume)}*1000$$

Note that the weight of displaced water in grams is equal to the volume of displaced water in millilitres.

Air dry density testing of western Queensland hardwoods

Air dry density is the seasoned wood mass per unit of volume, usually calculated at 12% moisture content for the purpose of comparability between species. The lengths, widths, and thicknesses of seasoned test pieces were measured with a Mitutoyo linear gauge, and mass of each sample weighed on an electronic balance. Density (kg/m^3) was calculated and moisture content verified by the oven-dry method reported in *AS/NZS 1080.1 1997, Timber - Methods of Test - Moisture Content*.

Shrinkage testing of western Queensland hardwoods

As moisture is lost from wood, shrinkage will occur after the moisture content falls below a particular level, called the 'fibre saturation point'. At this point, the wood cell cavities are empty of water, but the cell walls are still saturated. As moisture is removed from the cell walls, the timber shrinks until it reaches a local equilibrium moisture content (EMC), where moisture content of the wood balances that of the surrounding air. The timber is then said to be 'seasoned'. A measurement of the shrinkage that will occur in timber as it is seasoned provides processors with an indication of the dimensions that must be sawn from green timber (necessary extent of over-cutting) to ensure that seasoned timber will be available in the required dimensions. All species have different rates of shrinkage.

The test method adopted was similar to that described by Kingston and Risdon (1961). Test pieces were cut to the standard size for shrinkage testing (100 mm x 25 mm x 25 mm) and had true *radial* and *tangential* faces with length parallel to the grain (Kelsey and Kingston, 1957). After the green moisture contents of the samples were determined (see above), the samples were weighed and had length, width and thickness measurements made with a Mitutoyo linear gauge at regular intervals, until approximately 12% moisture content (air dry) had been reached. The measured shrinkage of the test piece from green to air dry is presented as a percentage of the original size of the test piece.

Gluing testing of western Queensland hardwoods

Cleavage characteristics were assessed for eleven western Queensland hardwood species. Tests were conducted in accordance with the joint Australian and New Zealand Standard, *AS/NZS 1328.1 1998 Glue Laminated Structural Timber Part 1: Performance Requirements and Minimum Production Requirements*. Samples were seasoned to 12% moisture content and pieces of the same species were glued together with an AV Syntec product *AV203*. This adhesive was chosen on the basis of CSIRO research conducted on behalf of AV Syntec, which indicated that the adhesive has properties suitable for gluing high-density species. Once the glue had cured, force was applied at the glue join with a hammer and chisel until the sample pieces were broken apart at the glue join. In accordance with Clause 2.6.6 of *AS/NZS 1328.1 1998*, a species was deemed to have satisfactory gluing properties if the average wood failure for all glue lines was at least 60%, with the minimum wood failure for any test piece not less than 30%. Wood failure is indicated by the surface area of separated test pieces being occupied by failed wood fibre, whereas glue failure is indicated by glue on the surfaces of the separated test pieces.

Hardness testing of western Queensland hardwoods

The hardness of a timber indicates its ability to resist indentation and ease of working with hand tools. Hardness has traditionally been used as a means to compare species for suitability in applications typically subjected to indentation pressure, such as flooring. Hardness of a species is closely related to its capacity to resist abrasion (*i.e.* wearing), which is another important property to consider when selecting species for flooring, bench tops and other specialist components, where sound wearing properties are necessary.

Hardness was measured by the *Janka hardness* test (British Standard *BS373*), the most common hardness test, which requires a steel ball with a diameter of 11.28 mm to be pressed into a test piece until the ball has penetrated to a depth equal to half its diameter. The force necessary to press the ball is measured in kilo Newtons (kN) and is recorded as the hardness of the timber.

Lyctid susceptibility testing of western Queensland hardwoods

Lyctus brunneus (lyctid beetle or powder post beetle) is a pest that can seriously damage the sapwood of many hardwood timbers. Appendix 3A provides a brief overview of the beetle's lifecycle and the impact the beetle has on timber. Ten beetles chosen at random from a culture of lyctid beetles that is maintained by QFRI in an insect rearing facility, were placed into a jar with western Queensland hardwood test pieces in November and December 1998. These beetles were used to initiate egg-laying in the test specimens. The test pieces were inspected at irregular intervals until August 1999 when they were assessed for infestation and adult emergence. This was considered sufficient time for the beetles to have completed at least one generation.

Where emergence holes and live adults were clearly visible, the wood sample was deemed susceptible. Where this was not the case, a portion of the sample was dissected with a chisel and hammer and viewed under a microscope for evidence of beetle larvae or larval galleries filled with powder-like frass. Where larvae or larval galleries were evident, the wood was also deemed to be susceptible. Only a single sample had to be infested for the species to be deemed susceptible to lyctid attack. In cases where there was no internal or external test evidence of an infestation, the wood was labeled susceptibility unknown, and any existing published susceptibility classes would remain unchanged. At the time of testing, there was no standard protocol to positively determine species that are not susceptible to the lyctid beetle.

3.3 Results of wood property tests on western Queensland hardwoods

The mean results of wood property testing of western Queensland hardwoods are presented in Table 3.1. The number of samples tested for each species is presented and standard deviations around mean values are reported in parentheses. Appendix 3B presents the average and minimum wood failure percentage for each species from the gluing testing. The hardness values reported in Table 3.1 are the average of tangential and radial surface hardness.

3.4 Discussion

The information generated from this testing has provided valuable wood property information about this under-utilised western Queensland hardwood resource. Most of the results represent new scientific information about these species. Some of this information has been published recently in Fairbairn (1999). The hardness and density results are especially interesting, as a comparison with some commercial Australian and international timbers in Table 3.2 indicates that western Queensland hardwoods are comparatively extremely hard and dense.

3.4.1 Shrinkage of western Queensland hardwoods

Most of the western Queensland hardwoods tested can be considered 'low' shrinkage timbers. Table 3.2 provides shrinkage values for several Australian and international commercial timbers for comparison. Low shrinkage facilitates improved sawn timber recovery because there is a reduced need for sawing boards oversize to allow for shrinkage as the board is seasoned from the green condition. In contrast, some ‘high’ shrinkage timbers, including many southern Australian eucalypts, must be sawn up to 10% oversize. There is strong correlation for most species between shrinkage (green to air dry) and unit shrinkage (stability in service). If future testing confirms this correlation for western Queensland hardwoods, then this will provide empirical confirmation of the anecdotal evidence suggesting the high suitability of these timbers for applications such as furniture, parquetry flooring and musical instrument manufacture.

3.4.2 Gluing western Queensland hardwoods

Red lancewood, beefwood and prickly acacia failed to achieve a satisfactory rating in the gluing tests. In the case of red lancewood, both the average and minimum wood failure percentage requirements failed to meet the *AS/NZS 1328.1 1998* criteria. This indicates that red lancewood is not suitable for glued components with the adhesive used in this testing program. In constructing the glued samples with this species, it was observed that the gluing surfaces were smooth, which may have affected mechanical adhesion between the timber and the glue. It may be possible to ‘roughen’ the surface of the timber prior to gluing to improve adhesion. There may also have been problems with the wetting ability of the glue with this species, perhaps due to an extractive present in this species, or surface tension between the glue and the timber. Research could be conducted to test the adhesive properties of other glues with this timber. However, gluing technology research is expensive, and may not be warranted for a single species, particularly given that most other western hardwood species performed well with the adhesive used.

Beefwood did not attain the minimum wood failure percentage requirement of 30%. It had been noted that the glue line failure was in the outermost laminate of the sample. The next value of wood failure above the minimum (and not occurring in the outer laminate) was 65%. It is, therefore, asserted that the low minimum observed was related to insufficient clamping pressures being applied during curing, not any inadequacy of the adhesion process.

Prickly acacia also failed the minimum wood failure requirement. With this species, separation of test pieces occurred on an inner glue line meaning it is unlikely that the failure of adhesion was due to insufficient clamping pressure. Further testing is required to determine the gluability of this species.

These results have been achieved with one recommended glue type. Species that have performed poorly may benefit from additional testing.

Table 3.1 *Mean wood property test results for western Queensland hardwood species*

Species	Sample replicates	Green MC (%)	Green density (kg/m^3)	Green volume (m^3/tonne)	Air-dry density (kg/m^3)	Basic density (kg/m^3)	Shrinkage from green to 12% moisture content (% of original board size)[1] Radial	Tangential	Longitude.	Gluing [2]	Hardness (kN)	Lyctid suscep-tibility[3]
Acacia aneura	11	26.7	1,188	0.84	1,101	911	1.6	2.2	0.1	S	17.1	(s)
(mulga)		*(3)*	*(89)*		*(81)*	*(55)*	*(0.5)*	*(0.4)*	*(0.1)*			unchanged
A. cambagei	10	26.4	1,354	0.74	1,283	1,016	1.5	2.3	0.2	S	17.3	S
(gidgee)		*(5)*	*(24)*		*(34)*	*(30)*	*(0.3)*	*(0.3)*	*(0.2)*			unchanged
A. coriaceae	12	24.6	1,206	0.83	1,099	886	1.6	2.0	0.6	S	15.5	S
(desert oak)		*(4)*	*(86)*		*(74)*	*(39)*	*(0.3)*	*(0.5)*	*(0.3)*			new
A. excelsa	11	37.5	1,284	0.78	1,122	908	1.6	2.6	0.1	S	18.0	S
(ironwood)		*(7)*	*(52)*		*(84)*	*(62)*	*(0.5)*	*(0.9)*	*(0.2)*			new
A. nilotica	13	55.2	1,162	0.86	875	698	1.0	1.6	0.3	M	13.9	S
(prickly acacia)		*(14)*	*(34)*		*(68)*	*(30)*	*(0.6)*	*(0.5)*	*(0.2)*			new
A. shirleyi	10	25.0	1,103	0.9	1,020	833	1.0	1.8	0.2	S	17.3	S
(lancewood)		*(3)*	*(59)*		*(67)*	*(40)*	*(0.8)*	*(0.9)*	*(0.1)*			new
Archidendropsis basaltica	11	31.4	1,322	0.76	1,218	924	3.0	4.4	0.4	F	17.9	S
(red lancewood)		*(4)*	*(15)*		*(28)*	*(34)*	*(0.8)*	*(1.8)*	*(0.9)*			new
Eremophila mitchellii	13	20.4	1,110	0.97	1,051	845	1.3	2.7	0.6	S	14.6	NS
(sandalbox)		*(2)*	*(25)*		*(63)*	*(75)*	*(0.9)*	*(1.5)*	*(0.5)*			Unchanged
Eucalyptus populnea	10	37.2	1,260	0.79	1,145	873	2.8	4.0	0.1	S	15.1	S
(bimble box)		*(6)*	*(53)*		*(45)*	*(32)*	*(0.7)*	*(1.1)*	*(0.2)*			Unchanged
Corymbia similis	12	37.5	1,160	0.86	1,034	805	2.5	3.3	0.2	S	13.2	S
(Queensland yellowjacket)		*(7)*	*(60)*		*(62)*	*(36)*	*(0.1)*	*(0.7)*	*(0.3)*			New
Grevillea striata	9	42.3	1,198	0.79	990	824	1.5	3.5	0.2	M	14.5	S
(beefwood)		*(6)*	*(38)*		*(43)*	*(39)*	*(0.6)*	*(0.7)*	*(0.3)*			Unchanged
Corymbia setosa	4	-	-	-	-	-	-	-	-	-	14.9	(s)
(rough-leaved bloodwood)												Unchanged
E. coolabah	1	-	-	-	-	-	-	-	-	-	16.2	(s)
(coolibah)												Unchanged
G. parallela	1	-	-	-	-	-	-	-	-	-	15.3	(s)
(Japanese beefwood)												New
Persoonia falcata	1	-	-	-	-	-	-	-	-	-	-	(s)
(geebung)												Unchanged
Ventilago viminalis	1	-	-	-	-	-	-	-	-	-	-	(s)
(vine tree)												New

Notes: Results are presented as the average of the replicates tested. Standard deviations are in parentheses.

1. Shrinkage results refer to timber shrinkage from green to 12% moisture content.
2. Gluing test results are: S=satisfactory; M=marginal; and F=fail (refer to appendix 3B for further explanation).
3. Lyctid susceptibility test results are: S = susceptible and confirmed by laboratory tests; NS = not susceptible; and (s) = not conclusively confirmed by laboratory tests, but deemed legally susceptible by the *Timber Utilisation and Marketing Act 1987*. Test results provided 8 new classifications and left 8 unchanged.

Table 3.2 *Comparative air-dry density, hardness, and radial and tangential shrinkage of selected commercial timber species*

Species	Air-dry density (kg/m^3)	Hardness (kN)	Shrinkage from green to 12% moisture content (% of original board size)	
			Radial	Tangential
Araucaria cunninghamii (hoop pine)	560	3.4	2.5	3.5
Cinnamomum camphora (camphor laurel)	448	3.3	2.6	4.6
Corymbia citriodora (spotted gum)	1010	11.0	4.3	6.1
Elaeocarpus grandis (silver quandong)	495	2.8	1.4	4.3
Eucalyptus crebra (narrow-leaved red ironbark)	1090	14.0	3.5	5.0
Toona ciliata (red cedar)	420	2.3	2.2	4.4
Eucalyptus spp. (Tasmanian oak)	675-770	5.6	4.5-6.5	8-13
Callitris glaucophylla (white cypress)	680	6.5	2.5	3.0
Quercus spp. (European oak)	690	5.5	3.0	6.0
Acer saccharum (sugar maple)	740	7.3	3.0	6.0
Fraxinus excelsior (European ash)	700	6.1	3.0	4.5
Fagus sylvatica (European beech)	690	6.4	4.0	6.0
Diospyros spp. (ebony)	1100	14.0	2.5	5.0
Pterocarpus indicus (New Guinea rosewood)	615	4.7	1.0	2.0
Dalbergia spp. (Indian rosewood)	600	12	na	na
Tectona grandis (teak)	630	4.6	1.5	2.5

Source: Bootle (1985), Kynaston *et al*. (1994) and McGavin (2001)

3.4.3 Hardness of western Queensland hardwoods

In the hardness testing of the western Queensland hardwoods, it was noted that many of the samples split prior to the steel ball being embedded to half its diameter. This was not considered to be a problem for obtaining hardness values, as the loads at the point where samples split were already in excess of quoted hardness figures for most species. The splitting of the samples indicates that the *Janka* method of testing hardness is not entirely appropriate for the species tested. While the test method could be modified to reduce or eliminate splitting of the samples, this was not attempted in this sample set, as the objective of the testing was to obtain hardness values directly comparable with published figures for other species. Test results from any modified test method would not be comparable to published figures.

3.4.4 Lyctid susceptibility of western Queensland hardwoods

Laboratory testing in this study confirmed the following changes or additions (see also Table 3.1) to published lyctid susceptibility ratings for eight (8) species:

- *Acacia excelsa* is susceptible S to lyctid attack (listed in Cause *et al.* (1989) as non-susceptible)
- *Archidendropsis basaltica* is susceptible S to lyctid attack, (listed in Cause *et al.* (1989) as (s) ‘legally susceptible’)
- *Acacia coriaceae, A. shirleyii, A. nilotica and Corymbia similis* are susceptible S. These species are not listed in Cause *et al.* (1989), and
- *Grevillea parallela* and *Ventilago viminalis* are ‘legally susceptible’ (s). These species are not listed in Cause *et al.* (1989).

Tests for the remaining eight (8) species resulted in no change to published susceptibility ratings as listed in Cause et al. (1989).

- *Acacia cambagei* was susceptible, confirming the S rating in Cause *et al.* (1989).
- *Grevillea striata* and *Eucalyptus populnea* were not attacked, leaving the S rating in Cause *et al.* (1989).
- *Acacia aneura, Corymbia setosa, Persoonia falcata, and Eucalyptus coolabah* were not attacked, leaving the 'legally susceptible' (s) rating in Cause *et al.* (1989).
- *Eremophila mitchellii* was not attacked, leaving the not susceptible NS rating in Cause *et al.* (1989).

Note that where test samples were not attacked, this meant that (in the absence of a formal protocol) there was insufficient evidence to determine specific non-susceptibility, and so the existing published classifications were maintained without change. Any difference in test results from Cause *et al.* (1989) may exist for several reasons, including:

- insufficient sapwood in the test pieces
- insufficient starch in the sapwood present in the test pieces
- the inability of beetles to lay eggs in the wood due to an absence of one sex in the grab sample. This would be accentuated by the limited number of wood samples tested, and
- the beetles died before mating or before the females commenced egg-laying.

Note that lyctid susceptibility testing is a formal process, and proven non-susceptible species are nominated in a schedule in *The Timber Utilisation and Marketing Act 1987*. The *Act* places severe restrictions on the 'sale' and 'use' of susceptible timbers, which includes both those classified as susceptible S and 'legally susceptible' (s).

3.5 Conclusion

Wood property testing of several western Queensland hardwoods has provided some new information, and highlighted the uniqueness of this resource, particularly with regard to their high densities and hardness. Many species were found to have satisfactory gluing properties, which will enhance the range of applications for which western hardwoods can be considered suitable. Lyctid susceptibility testing has provided a number of new classification results, and indicated the potential value of further limited testing on the western hardwoods resource.

References

Balodis, V., Logan, A.F., James, I.R., Crawford, I.A. and Turner, C.H. (1976), *The sampling of species for pulpwood evaluation - Appita 30th Annual Conference*, Queenstown, N.Z.

Bootle, K.R. (1985), *Wood in Australia –Types, properties and uses*, McGraw Hill.

Budgen, B. (1981), *Shrinkage and density of some Australian and South-east Asian Timbers*. CSIRO Division of Building Research Technological Paper (Second Series) No. 38, Melbourne.

Cause, M.L., Rudder, E.J. and Kynaston, W.T. (1989), *Queensland Timbers: their Nomenclature, Density, and Lyctid Susceptibility*, Technical Pamphlet No 2, Queensland Department of Forestry, Brisbane.

Downes, G., Hudson, I., Raymond, C. A., Dean, G. H., Michell, A. J., Schimleck, L. and Muneri, A. (1997), *Sampling plantation eucalypts for wood and fibre properties*, CSIRO Publishing, Collingwood.

Fairbairn, E. (1999), *Australian Timbers Volume Two: Western Queensland Trees and Their Timbers*, Department of Natural Resources, Brisbane.

Hamza, K.F.S. and Lewark, S. (1994), ‘Sampling for wood properties in trial plots of 4 Eucalyptus species at Ruvu, Tanzania’, *Annales des Sciences Forestieres* **51**(3):233-240.

Kelsey, K.E. and Kingston, R.S.T. (1957), ‘The effect of specimen shape on the shrinkage of wood’, *Forest Products Journal*, **7**(7): 234-235.

Kingston R.S.T and Risdon C.J.E. (1961), *Shrinkage and the density of Australian and other woods.* CSIRO Aust. Division of Forest Products Technological Paper No. 13, Melbourne.

Kynaston, W.T., Eccles, D.B. and Hopewell, G.P. (1994), *Timber Species Notes*, Queensland Department of Primary Industries, Brisbane.

McGavin, R.L. (2001), *Wood Property Report on Camphor Laurel*, Queensland Department of Primary Industries, Brisbane.

Snedecor, G.W. and Cochran, W.G. (1967), *Statistical Methods*, Iowa State University Press, Ames (Iowa).

Tsehaye, A., A. H. Buchanan, et al. (1995), ‘A comparison of density and stiffness for predicting wood quality’, *Journal of the Institute of Wood Science* **13**(6): 539-543.

Appendix 3A. Lyctid Beetles (*Lyctus brunneus)* and their impact on hardwood timber

Powder-post beetles (*Lyctus brunneus*), illustrated in Figure 3A.1, are so named because their larvae can reduce susceptible sapwood timber to a fine flour-like powder. These beetles are pests of the sapwood of certain hardwood timber species. They will not infest softwoods (*i.e.* conifers) or the heartwood (truewood) of hardwoods.

After mating, the female beetle lays eggs in the pores of the sapwood. After approximately 14 days, the eggs hatch into small larvae (grubs), which feed on the starch in the sapwood until fully grown. Tunnels usually follow the grain of the wood and it is the larval stage that is primarily responsible for destruction of the timber. The development period for larvae can vary from two to twelve months depending on temperature, humidity and the supply of starch in the sapwood. Following pupation, mature beetles begin to emerge through the surface of infested timber, leaving a round hole (1-2 mm diameter) as each emerges. Small piles of frass (discarded and excreted material) associated with the emergence holes may collect on the surface of infested timber or fall nearby. The frass is smooth and floury (not gritty) when rubbed between the fingers.

Reinfestation of timber is common and may continue until the food resource is completely destroyed. Susceptible timber is generally attacked within 6-18 months of the timber going into service. Susceptibility and exposure are linked as the female beetles must be able to gain access to the timber to initiate egg-laying. Evidence of infestation may not become apparent until after the timber is in service and adults begin to emerge. The whole of the infested area may be reduced to powder leaving only a shell of wood on the outside, perforated by emergence holes.

Figure 3A.1 *Lyctid beetles*

Appendix 3B. Glue property testing of selected western Queensland hardwoods: Average and minimum wood failure percentages

The successful bonding of timber depends on the amount of adhesion occurring in the glue line. The process of adhesion depends on the secondary intermolecular forces between the glue and the timber, as well as the mechanical adhesion occurring in the glue line. Mechanical adhesion requires absorption of the adhesive into the surface layer of the timber. This absorption results in a mechanical ‘interlocking’ of the adhesive and the timber surface after curing. This interlocking requires that the timber surface is not planed smooth, because, at a microscopic level, some surface ‘unevenness’ will assist in the process of mechanical adhesion.

The adhesive used in gluing timber must be capable of fully wetting the timber surface and must cure to form a solid at readily achievable conditions in a manufacturing process. There should be no undue stress built up in the glue line during the curing process, and after curing is complete, the bond should be of adequate strength for its intended purpose.

Table 3A.1 presents the gluing results for selected western Queensland hardwoods. On the basis of the test requirement outlined in Section 3.2.2, all species tested, with the exception of red lancewood, passed the requirements for average wood failure. The requirement for minimum wood failure percentage of 30% was achieved by all species with the exception of red lancewood, beefwood and prickly acacia. The reader is cautioned against using the wood failure percentages to rank species within the ‘satisfactory’ range.

Table 3A.1 *Glue performance results for western Queensland hardwoods*

Standard trade name	Average % wood failure	Minimum % wood failure	QFRI rating with test glue
beefwood	80	20	marginal
bimble box	80	40	satisfactory
desert oak	90	55	satisfactory
gidgee	85	55	satisfactory
ironwood	80	50	satisfactory
lancewood	85	50	satisfactory
mulga	90	35	satisfactory
prickly acacia	70	25	marginal
red lancewood	35	0	fail
sandalbox	70	30	satisfactory
Qld yellowjacket	85	60	satisfactory

4. Portable sawmilling of mulga and gidgee in western Queensland: green-off-saw recovery, variable costs of production and comparisons with the east-coast hardwood industry

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*In association with local landholders, the Queensland Forestry Research Institute (QFRI) conducted portable sawmilling trials with mulga (*Acacia aneura*) and gidgee (*A. cambagei*) in western Queensland. The standing sawlog resource at the trial sites was found, on average, to be less than 1 m^3/ha. Harvested sawlogs were generally about 2 m in length and had centre diameters over bark of 20 cm. Defects in the logs were common, but reasonable green-off-saw (GOS) recoveries of 34.6% and 27.6% were achieved from mulga and gidgee sawlogs respectively. Time studies of the portable sawmilling trials facilitated the estimation of variable costs of milling mulga and gidgee on farms in western Queensland. Total variable costs were estimated at between \$730/m^3 GOS and \$980/m^3 GOS, and shown to be highly sensitive to imputed labour cost and GOS recovery. The land tenure from which logs are harvested is also demonstrated to have a large impact on total variable cost. Portable sawmilling costs for mulga and gidgee were found to greatly exceed typical costs of sawing east-coast Queensland hardwoods.*

4.1 Introduction

Literature suggests that people are, in general, risk averse and that uncertainty about future outcomes will drive people away from potential investments. Typical of many new industries, there is a scarcity of information relevant to people considering investing in the processing of western Queensland hardwoods. In particular, although several enterprises currently utilise these timbers, obtaining objective and meaningful information about product recoveries and processing costs is difficult. The Queensland Forestry Research Institute (QFRI) conducted two portable sawmilling studies as a first stage in the generation of information to assess the commercial viability of utilising western Queensland hardwoods.

Many western Queensland species have timber production potential; however, budget constraints necessitated that the study be restricted to two. Mulga (*Acacia aneura*) and gidgee (*A. cambagei*) were selected for the portable sawmilling trials on the basis of their wide distribution, potentially large sustainably harvestable volumes and promising timber properties.

The chapter begins with a description of the harvesting and milling methodology and is followed by a presentation and discussion of the outcomes from harvesting and milling. The variable costs of harvesting and portable sawmilling of mulga and gidgee are then estimated and discussed. Cost comparisons are made with the east-coast hardwood industry before some concluding comments.

4.2 Harvesting and milling methodology for mulga and gidgee

Over a six day period in 2000 and a five day period in 2001, harvesting and portable sawmilling operations were conducted by QFRI in the mulga stands of Maryvale Station (located south-west of Morven) and in the gidgee stands of Yankalilla Station (located south of Cunnamulla). These properties were chosen because they included patches of remnant bushland that were broadly representative of woodland types in the region and because supportive landholders were willing to provide unpaid assistance. The sites are likely to have been cut-over in the past for fence posts and other low-value products, which is common for these woodland types of western Queensland. Two portable sawmillers were contracted to undertake the harvesting and portable milling. The duration of all tree selection, felling, snigging, hauling and milling activities were recorded to facilitate an assessment of the labour costs of portable milling western hardwoods. Funding was not available to replicate the harvesting and milling studies elsewhere in western Queensland.

The procedures adopted during the harvesting and milling of mulga and gidgee are illustrated in Figure 4.1. A 20 ha site of mulga at Maryvale and two gidgee sites at Yankalilla of 4.5 ha and 5.5 ha each, were surveyed prior to harvesting. All trees capable of producing a sawlog[4] at each site were marked for removal and had their diameter measured at 30 cm above ground level. The portable sawmilling contractors felled each marked tree with a chainsaw and crosscut the tree bole to maximise log length. Figure 4.2 illustrates a typical docked log from a felled tree, which was then measured by QFRI personnel. In the mulga study, centre diameter over bark and log length was recorded. In the gidgee study, large-end diameter over bark, small-end diameter over bark and log length was recorded. Each harvested log was assigned a unique identifier, which would enable all sawn wood to be traced back to the log and tree from which it had been sawn.

QFRI was keen to undertake a preliminary examination of the financial implications of fixed-site portable milling versus multi-site portable milling in the context of western Queensland hardwoods. This accounts for the difference in procedures adopted at the two study sites. On Maryvale Station, a fixed-site sawmilling regime was employed for the mulga logs. A tractor snigged the logs to loading zones (Figure 4.3) where logs were lifted onto a truck for haulage to the mill, which was situated close to the homestead, about 6 km from the harvested mulga paddock. On Yankalilla Station, a multi-site sawmilling regime was adopted for the gidgee logs. A tractor snigged logs to the nearest of three predetermined sawmill sites in the forest.

All portable milling was performed with a Lucas 8'' portable sawmill, as illustrated in Figures 4.4 and 4.5. At each sawmilling site, logs were sorted into batches of similar sized logs and the contractors' experience was used to determine a sawing pattern suitable for each log size. Logs were processed into sawn boards (approximately 75% of sawn volume), bark to bark slabs (approximately 5% of sawn volume) and block sections (approximately 20% of sawn volume), with the aim of maximising recovery of green-off-saw (GOS) timber from each log. Boards of standard widths and thicknesses, ranging from 12 mm x 50 mm to 50 mm x 125 mm, were sawn oversize to allow for shrinkage. The thickness of bark to bark slabs ranged from 12 mm to 25 mm, and block sections of 75 mm x 75 mm and 100 mm x 100 mm were cut.

[4] Defined in section 4.2.1.

4.2.1 Sawlog specifications adopted for mulga and gidgee

Standard sawlog specifications in Queensland are based on eastern hardwood species that differ markedly in tree form from western Queensland hardwoods. This necessitated development of a new sawlog specification. For the purposes of this study, a sawlog was at least 1.2 m in length, had a minimum small end diameter under bark of 125 mm and had minimal sweep or bend (generally not exceeding 20 mm/m). If a tree had a large scar (*e.g.* from a fire or from physical damage) or showed other obvious signs of defective wood, it was immediately rejected as a sawlog tree.

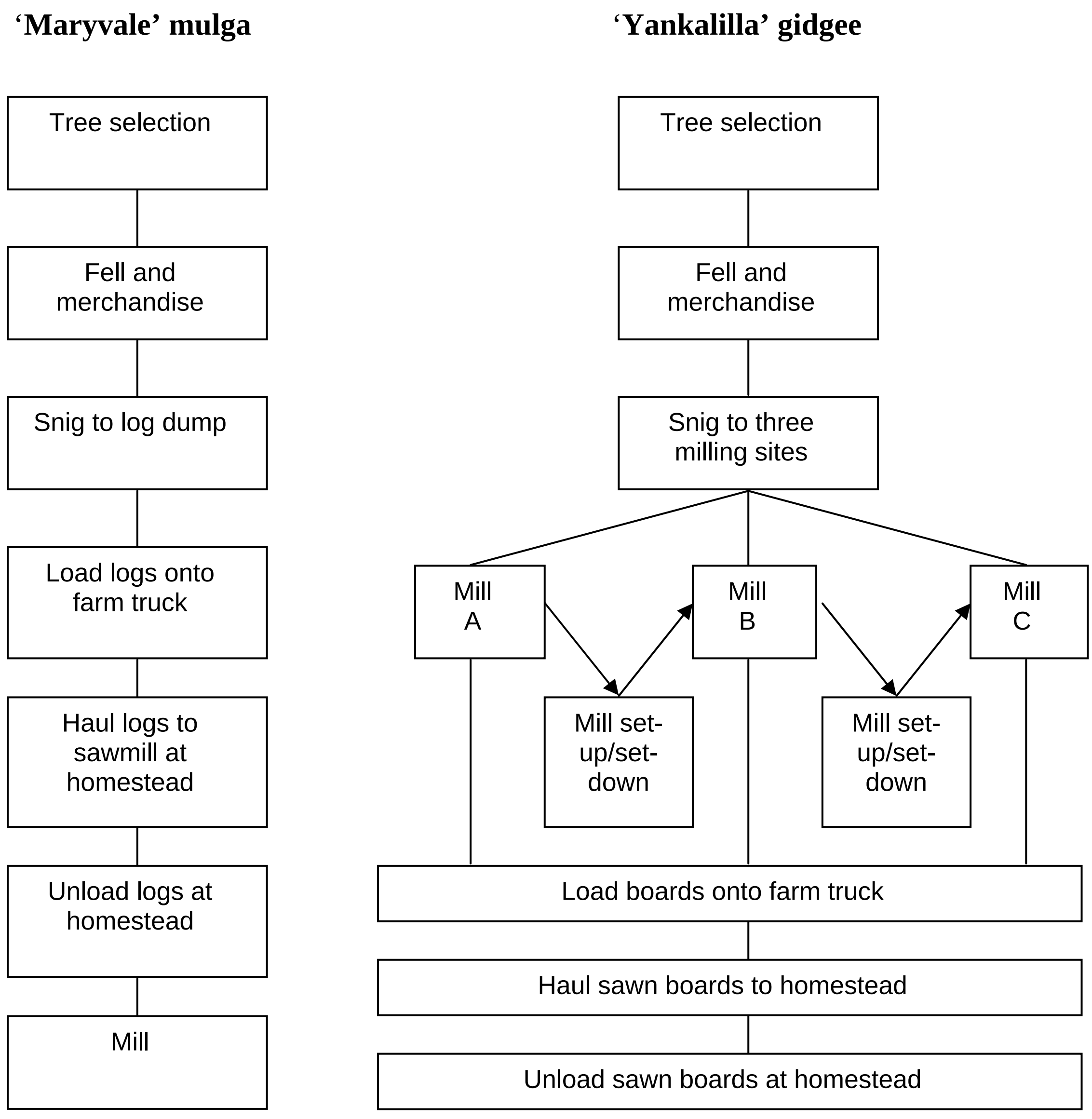


Figure 4.1 *Stages in the manufacture and delivery of green-off-saw boards to the station homestead during QFRI mulga and gidgee milling studies*

Figure 4.2 *A docked sawlog from a felled mulga tree*

Figure 4.3 *Snigging a mulga sawlog to a loading zone*

Figure 4.4 *The Lucas 8" portable sawmill in action at Maryvale Station*

Figure 4.5 *Sawing boards from a small mulga sawlog*

4.3 Outcomes of QFRI mulga and gidgee portable sawmilling studies

Table 4.1 summarises the outcomes of harvesting and milling at Maryvale and Yankalilla. The last row of the table indicates the scarcity of millable logs in stands on these stations, which has a direct effect on harvesting costs. Figures 4.6, 4.7 and 4.8 illustrate the distribution of diameters of felled trees, the centre diameters of sawlogs and sawlog lengths respectively, for mulga and gidgee harvested in the trials.

Table 4.1 *The mulga and gidgee timber resources at Maryvale and Yankalilla*

Summary statistic	Maryvale mulga	Yankalilla gidgee
Logged area (ha) site 1	20	4.5
site 2	na	5.5
Number of trees harvested	124	126
Average tree diameter [1] (cm)	21.9	26.4
Number of millable logs cut	128	117
Average log centre diameter (cm)	18.2	24.3 [2]
Average log length (m)	2.1	1.7
Gross log volume harvested (m^3)	7.24 [3]	9.86 [4]
Average log volume (m^3)	0.057	0.084
Gross log volume (m^3/ha)	0.36	0.99

Notes: 1. Tree diameters were measured at 30 cm above ground
2. Centre diameters of Yankalilla gidgee logs has been estimated as half the sum of the large-end and small-end diameters
3. Huber's formula used to estimate sawlog volume
4. Smalian's formula used to estimate sawlog volume

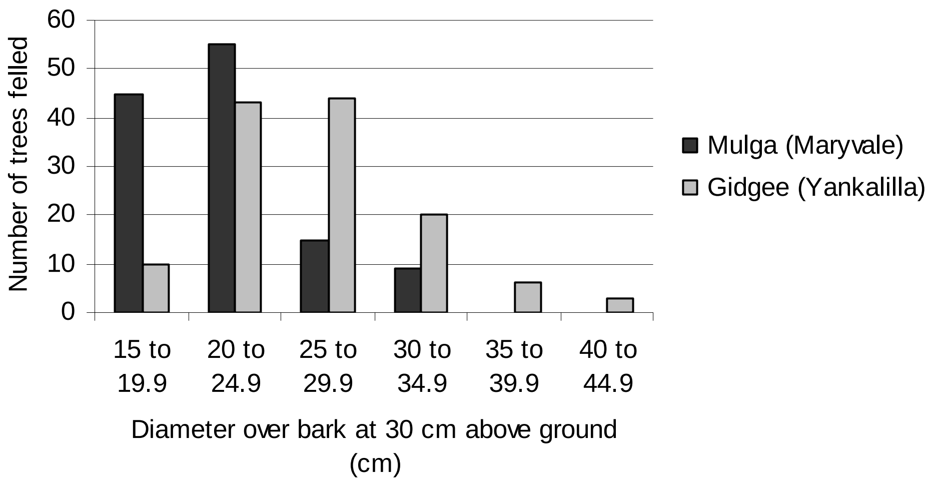
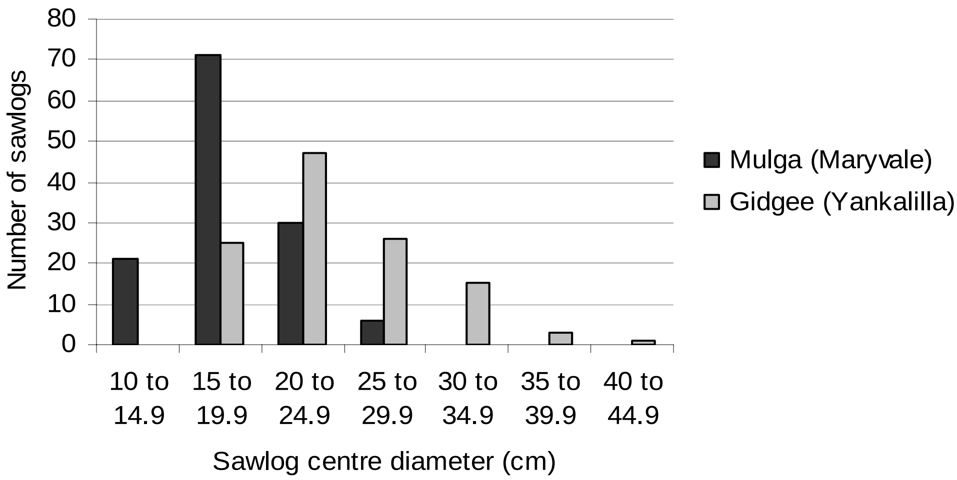


Figure 4.6 *Distribution of diameter over bark at 30 cm above ground of felled mulga and gidgee trees*



Note: Centre diameter in the Yankalilla gidgee has been estimated as half the sum of the large and small end diameters.

Figure 4.7 *Distribution of mulga and gidgee sawlog centre diameters*

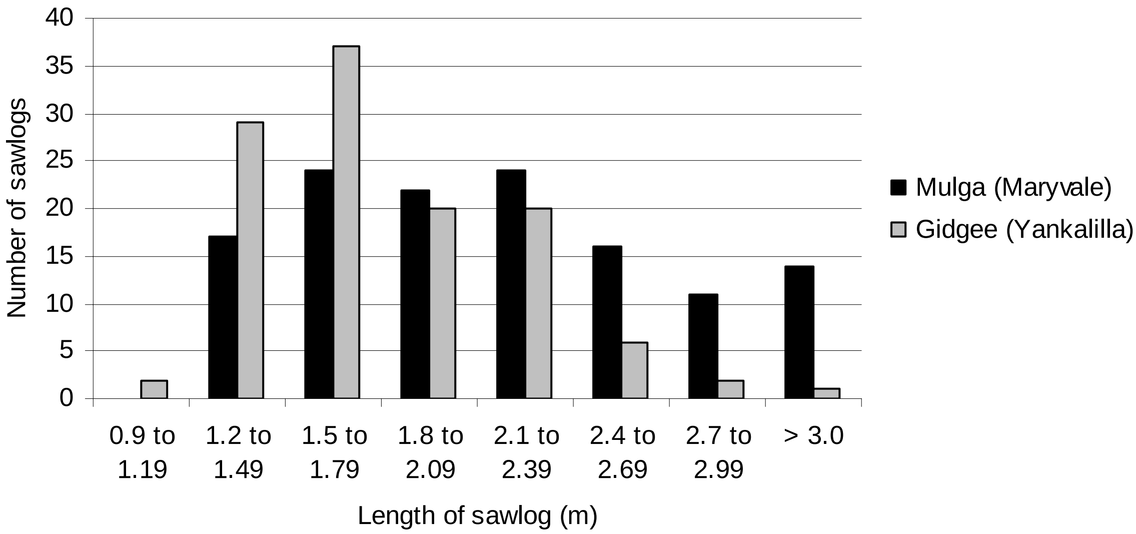


Figure 4.8 *Distribution of mulga and gidgee sawlog lengths*

4.3.1 Green-off-saw recovery of mulga and gidgee

The recovery of GOS mulga and gidgee boards is presented in Table 4.2. Figure 4.9 indicates that recovery from Maryvale mulga sawlogs increased sharply with sawlog centre diameter. Recovery of Yankalilla gidgee increased more gradually with sawlog centre diameter. Figure 4.10 illustrates the relationship between sawlog centre diameter and the number of sawn boards recovered per sawlog. In Figure 4.11, it is highlighted that, if maximisation of sawn board volume is desirable, production of a 100 mm wide mulga board requires a sawlog with a centre diameter of at least 15 cm to 20 cm. For gidgee, Figure 4.12 suggests that the minimum required sawlog centre diameter for a 100 mm wide board was 20 cm to 25 cm.

Table 4.2 *Green-off-saw recovery from mulga and gidgee sawlogs*

Summary statistic	Maryvale mulga	Yankalilla gidgee
Gross sawn log volume (m^3)	7.24[1]	8.69[2]
GOS volume (m^3)	2.51	2.40
Average GOS recovery (%)	34.6	27.6
Minimum GOS recovery (%)	14.0	7.6
Maximum GOS recovery (%)	57.9	41.2

Notes: 1. Huber's formula used to estimate sawlog volume
2. Smalian's formula used to estimate sawlog volume

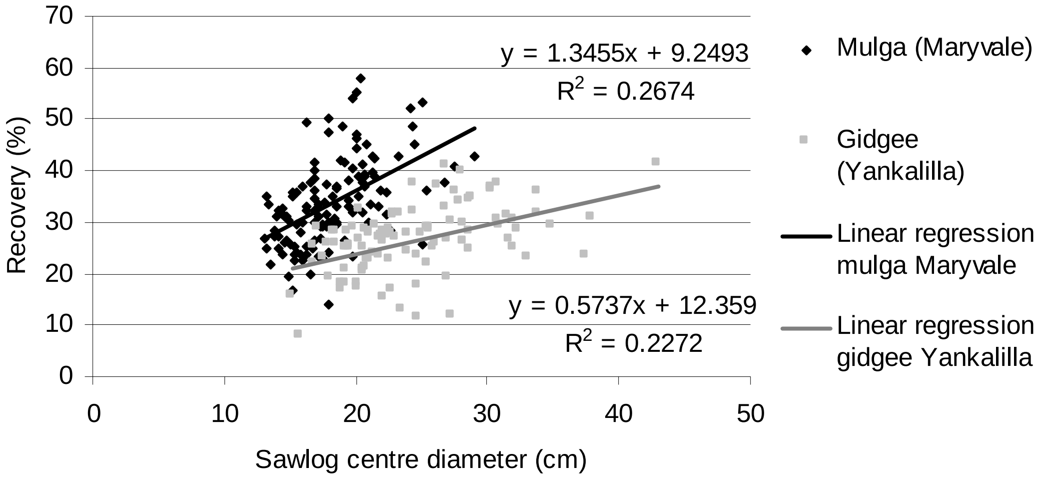


Figure 4.9 *Relationship between green-off-saw recovery and sawlog centre diameter for mulga and gidgee*

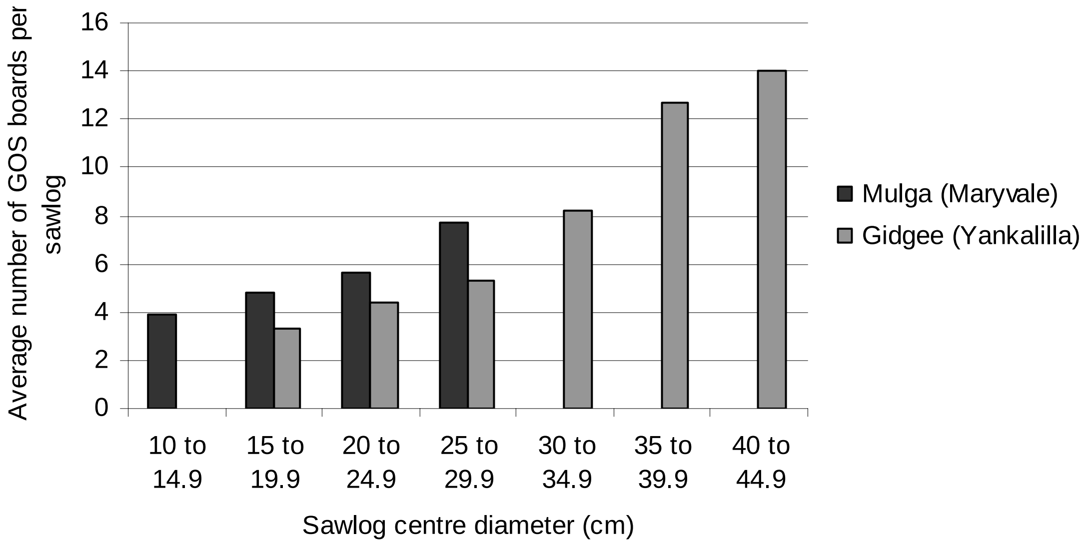


Figure 4.10 *Average number of boards sawn from mulga and gidgee sawlogs by sawlog centre diameter*

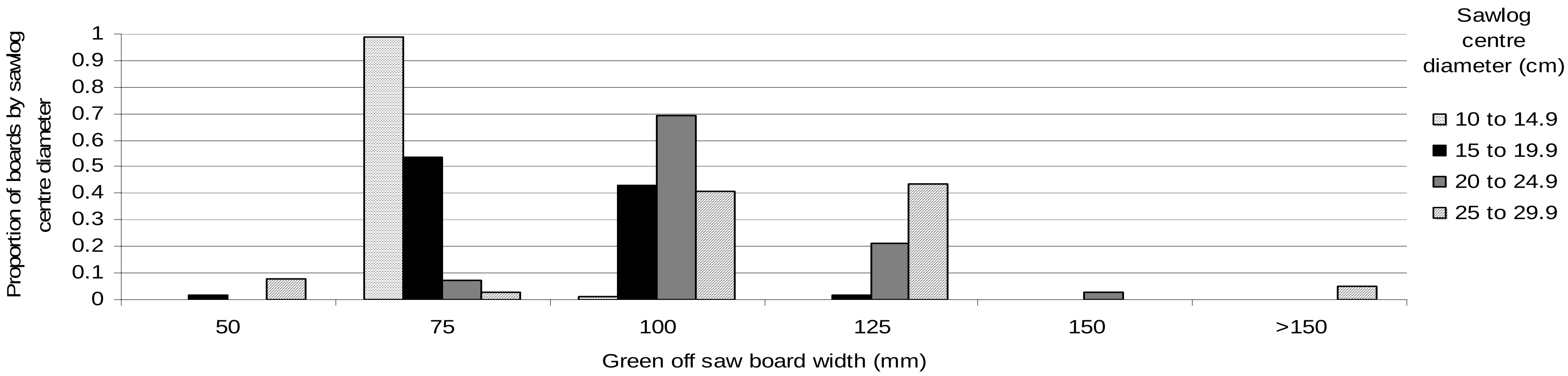


Figure 4.11 *Proportion of Maryvale mulga boards by board width sawn from sawlogs of specific centre diameters*

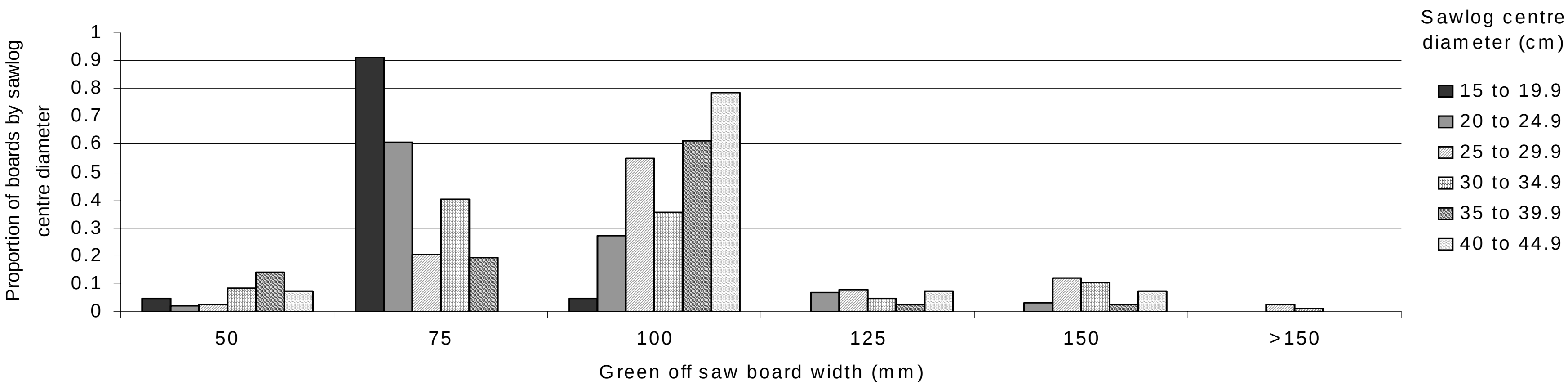


Figure 4.12 *Proportion of Yankalilla gidgee boards by board width sawn from sawlogs of specific centre diameters*

4.3.2 Time required to portable mill mulga and gidgee

Table 4.3 reports the labour time invested in processing mulga and gidgee during QFRI milling studies. Production of one cubic metre of GOS timber was found to require 37 person hours and 30 person hours for mulga and gidgee respectively. Lack of contractor experience milling western Queensland hardwoods resulted in unusually long periods of down-time due to difficulties clamping logs and the consequent damage to sawblades. These delays have been included under *extraordinary activities* in Table 4.3; however, they have been ignored in the assessment of variable cost, because they are considered avoidable for experienced western hardwood millers. Table 4.4 draws from the results presented in Tables 4.2 and 4.3 to report the productivity of persons utilising the Lucas portable mill to convert mulga and gidgee logs into GOS timber.

***Table 4.3** Utilisation of labour in QFRI milling trials*

Activity	Maryvale mulga			Yankalilla gidgee		
	Hours	No. persons	Total hours	Hours	No. persons	Total hours
Tree selection	5	2	10	3.75	2	7.5
Tree felling	5	2	10	8.75	1	8.75
Snigging	6.5	2	13	12.75	1	12.75
Hauling	2.5	2	5	0	0	0
Mill set-up/down	1	2	2	3	2	6
Milling	23.25	2	46.5	17.75	2	35.5
Mill sharpening and refuelling	2.75	2	5.5	0.75	2	1.5
Mill saw blade changing	0.5	2	1	0.5	2	1
Total hours			93			73
Total hours/m^3 GOS			37.1			30.4
Extraordinary activities						
Log holding mechanism modification	0.75	2	1.5	1.4	2	2.8
Sawblade change	0	0	0	2	2	4
Total extraordinary			1.5			6.8

***Table 4.4** Productivity of the Lucas 8" mill employed in QFRI mulga and gidgee trials at Maryvale and Yankalilla*

Item	Mulga	Gidgee
Volume of logs sawn (m^3)	7.24	8.69
GOS recovery (m^3)	2.51	2.40
Hours spent milling	26.5	19.0
Volume of logs sawn (m^3/hour)	0.27	0.46
GOS recovery (m^3/hour)	0.09	0.12

Note: Hours spent milling includes time spent refuelling the mill, sharpening and changing the sawblade, but does not include extraordinary activities.

4.4 Discussion of log volume and green-off-saw recoveries from portable sawmilling trials with mulga and gidgee

DPI Forestry records indicate that the average sawlog harvested from native forests in south-east Queensland during 2001-02 had a centre diameter of 46 cm and log length of 6.7 m. This contrasts markedly with the mulga and gidgee sawlog resources summarised in Table 4.1. The sawlogs of these western hardwoods are characterised by short lengths, small diameters and defects, such as fire scars, fungal infections, and termite and other insect damage. A discussion of the prevalence of defects in sawn timber can be found in Chapter 6.

Average mulga and gidgee sawlog volumes were found to be low - less than 1 m^3/ha. While the trials were conducted in stands deemed to be representative of the broader region, they constituted a limited sample. The sawlog volumes harvested may not be representative of mulga or gidgee stands in other regional ecosystems. Sawlog volumes were found to be substantially lower than the results of timber inventories conducted by Swift *et al*. (2002) and Rogers (2002), which have been summarised in Chapter 2. However, the aim of those inventories was to estimate total merchantable volumes, including roundwood and craftwood. Hence, less stringent log specifications[5] were adopted by Swift *et al*. (2002) and Rogers (2002), than were applied in the Maryvale and Yankalilla portable sawmilling trials.

GOS recovery has a large impact on the costs of timber production, since any improvement potentially increases volumes of saleable timber with little additional cost. A commonly asserted advantage of portable sawmills over fixed sawmills is that higher rates of GOS recovery are achievable (Smorfitt *et al.* 2001), thus lowering GOS production costs. However, western Queensland hardwood logs are difficult to mill, which resulted in GOS recoveries below those of east-coast fixed hardwood mills, which achieve GOS recoveries of about of 35.9% on average (Native Forest Sawlog Pricing Working Group 1997).

It is evident from Figure 4.9 that GOS recovery from mulga logs was consistently higher than from gidgee. Figures 4.10 and 4.11 illustrate that the number and width of boards that could be sawn from mulga logs generally exceeded what could be sawn from gidgee logs of the same centre diameter. While it is conceivable that this may be a reflection of the skill levels of the two portable sawmill contractors, it is more likely to be a direct result of sawlog quality. Defect in the gidgee logs was more prevalent than in the mulga logs.

Because of their economic implications, discussion of the results of the time studies arising from the harvesting and portable sawmilling mulga and gidgee, is postponed until the discussion of estimated variable costs of GOS production in Section 4.6.

[5] Minimum log length 0.6 m and minimum small end diameter over bark 10 cm. This inventory also included logs with more defect than was permitted in the portable sawmilling studies.

4.5 Estimation of the variable cost of producing green-off-saw mulga and gidgee with a portable sawmill

For project planning and assessment purposes, the most useful way to classify costs is by behaviour. Variable costs are costs that vary, in total, in direct proportion to changes in the level of activity. Fixed costs are those that remain constant in total, regardless of changes in the level of activity within a relevant range[6]. Examples of variable costs include fuel in the chainsaw and labour employed to mill timber. Examples of fixed costs include business loan repayments and sawmill depreciation. This Chapter focuses exclusively on the variable costs of GOS mulga and gidgee production on Maryvale and Yankalilla Stations. Chapter 10 incorporates fixed costs into financial assessments of several western hardwood production scenarios that are designed to be more widely applicable to western Queensland landholders.

The literature, private industry, Australian Tax Office, government agencies and academic institutions were consulted for estimates of variable costs associated with portable sawmilling. Little relevant portable sawmilling information has been published, which required most cost estimates to be gathered through formal and informal discussions with experts. The timber resources, sawn recovery and productivity of labour achieved in the Maryvale and Yankalilla studies have been incorporated into this financial assessment. The *extraordinary activities* in Table 4.3 have been ignored in this assessment of variable cost, because they are considered avoidable by experienced western hardwood millers. Appendix 4A details the derivation of variable cost estimates adopted in this financial analysis.

Table 4.5 presents an estimate of the variable costs incurred delivering GOS timber to the Station homestead on the Maryvale and Yankalilla Stations. Table 4.6 indicates the high proportion of labour expenses in total variable cost when the imputed cost of labour is $20/hour. Figures 4.13 and 4.14 illustrate the sensitivity of total variable cost of mulga and gidgee GOS production to imputed labour cost and GOS recovery respectively. A more detailed discussion of the sensitivity of assumptions employed in estimating costs (and returns) to western Queensland hardwood production is deferred until Chapter 10.

[6] The range over which assumptions about variable and fixed costs are valid.

Table 4.5 *Variable costs of manufacturing GOS mulga and gidgee in QFRI milling studies*

Activity	Costs ($/m³ log)						Explanatory notes
	Non-labour		Labour[1]		Total		
	Mulga	Gidgee	Mulga	Gidgee	Mulga	Gidgee	
Royalty on leasehold land[2]	20.20	70.61			20.20	70.61	
Tree selection[3]			27.62	15.21	27.62	15.21	
Fell and merchandise	5.03	5.03	27.62	17.75	32.65	22.78	Appendix 4A.2
Snig	1.13	1.13	35.91	25.86	37.04	27.00	Appendix 4A.2
Loading/unloading logs onto farm truck	0.5		4.76		5.26	0.00	Appendix 4A.3
Log haulage on farm truck[4]	1.21		4.07		5.28	0.00	Appendix 4A.4
Mill set-up/set-down[5]		0.14	5.52	13.81	5.52	13.95	
Portable sawmilling	36.02	32.26	146.41	87.46	182.43	119.71	Appendix 4A.5
Loading/unloading GOS boards onto a farm truck		0.07		0.66	0.00	0.73	Appendix 4A.3
GOS board haulage on-farm[6]		0.38		1.28	0.00	1.66	Appendix 4A.4
Total variable cost/m³ log on freehold land	43.90	39.01	251.92	162.03	295.82	201.04	
Total variable cost/m³ GOS on freehold land	126.87	141.34	728.10	587.06	854.98	728.40	
Total variable cost/m³ log on leasehold land	64.10	109.62	251.92	162.03	316.02	271.65	
Total variable cost/m³ GOS on leasehold land	185.26	397.17	728.10	587.06	913.36	984.23	

Notes: Where costs in Appendix 4A are reported in $/m³ GOS, but are presented here in $/m³ of log, they have been adjusted by the average GOS recovery percentage achieved in QFRI milling studies for mulga (34.6%) and gidgee (27.6%).

1. The imputed cost of labour is $20/hour, including on-costs, as discussed in Appendix 4A.1.
2. In 2002, royalties payable to DPI Forestry following commercial harvesting of mulga and gidgee on leasehold land were $17.00/tonne and $52.15/tonne respectively. These royalties have been converted to $/m³ by the green density of these species - 1,188 kg/m³ for mulga and 1,354 kg/m³ for gidgee.
3. Tree selection costs have been calculated by multiplying the hours spent selecting (Table 4.3) by the imputed labour cost ($20/hour, Appendix 4A.1), divided by the volume of logs harvested in cubic metres of each species. The small non-labour cost component for spray paint and flagging tape has been ignored.
4. On Maryvale Station, mulga logs were hauled 6 km to the homestead for milling. Cost estimates assume a return journey of 12 km.
5. Maryvale mulga was milled at a central location requiring a single set-up/set-down. Yankalilla gidgee was milled at three forest locations requiring two moves and three set-up/set-downs.
6. It has been assumed that sawn gidgee boards on Yankalilla Station were transported 6 km (12 km round trip) to the homestead from the portable milling sites.

Table 4.6 *Labour cost as a proportion of total variable costs in QFRI's western hardwood portable milling studies*

Land tenure	Labour costs as a percentage of total variable costs	
	Mulga	Gidgee
Freehold	85	81
Leasehold	80	60

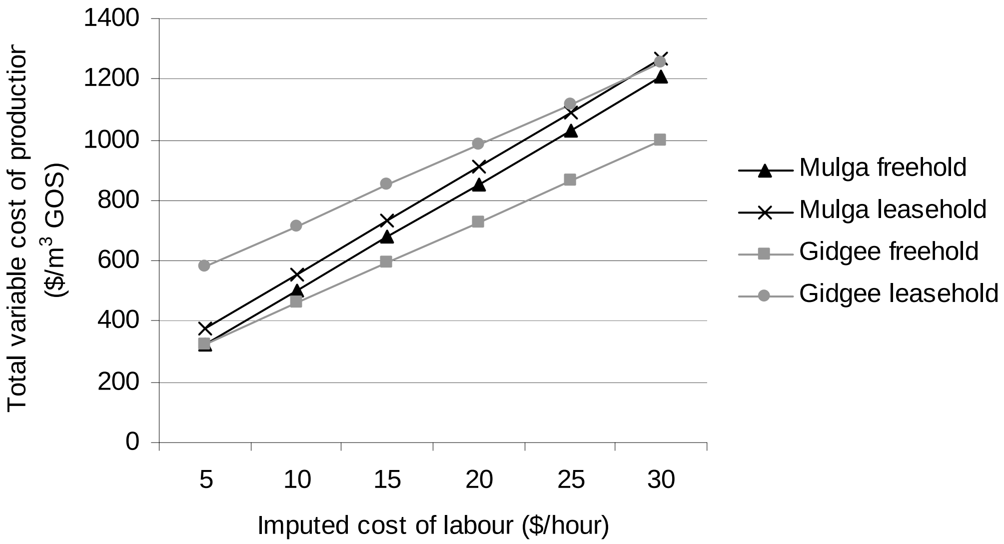


Figure 4.13 *Sensitivity of total variable cost of mulga and gidgee production to imputed labour cost in QFRI's portable milling studies*

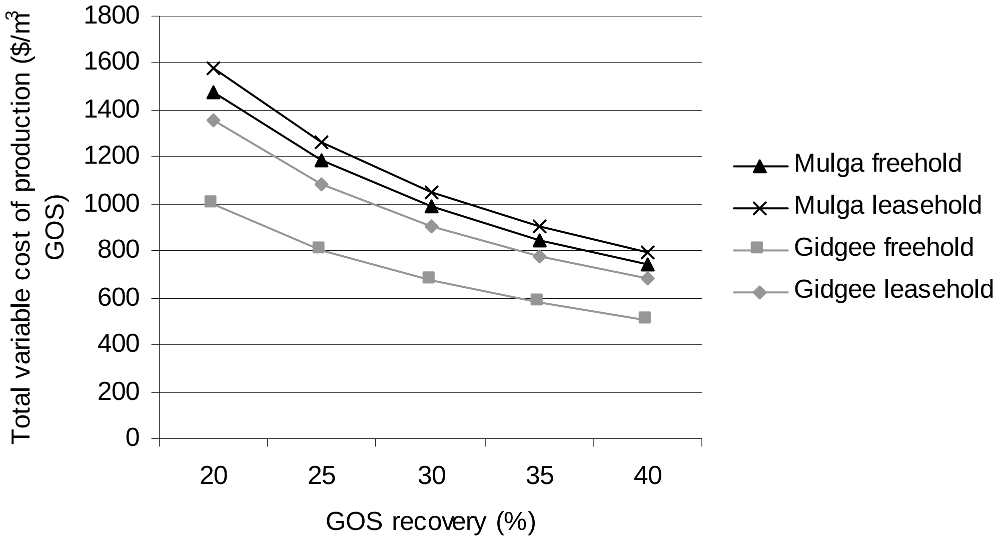


Figure 4.14 *Sensitivity of total variable cost of mulga and gidgee production to GOS recovery in QFRI's portable milling studies*

4.6 Discussion of harvesting and portable milling variable cost estimates for mulga and gidgee

In QFRI portable milling studies, the cost of producing mulga boards from logs harvested on freehold land was found to be higher than gidgee, with total variable costs estimated at $\$850/m^3$ and $\$730/m^3$ respectively. Most of this difference is attributable to the lower productivity of labour in the mulga milling study. Table 4.3 reported that each cubic metre of GOS mulga required an additional 6.7 person hours of labour than was required to saw gidgee. The untimely death of the portable sawmill operator employed for the mulga milling study, prior to commencement of the gidgee milling study, necessitated employment of different portable mill operators in the two milling studies. Although differing sawmilling practices between the two operators could have contributed to some of the divergence in labour costs, it is more likely that differences between the mulga and gidgee timber resources were the major contributing factor in this study.

Table 4.1 indicates that gidgee sawlog volumes per hectare exceeded mulga volumes by a factor of three at the study sites. This had the effect of increasing travel distance and time for the feller and snigger per cubic metre of mulga log harvested. Consequently, the total variable cost of felling, docking and snigging mulga exceeded gidgee by $\$22/m^3$ of log. Table 4.3 reports that mulga milling time exceeded gidgee milling time by 11 person hours, even though total mulga GOS production only exceeded gidgee by 0.1 m^3. Much of the difference is likely to be due to the (on average) smaller diameter of mulga logs compared to gidgee (Table 4.1), which made holding logs during sawing more time consuming. The operator milling mulga spent an additional 4 person hours sharpening the mill sawblade and refuelling, than the gidgee miller. It is probable that the difficulty in holding the smaller mulga logs during sawing led to greater wear and tear on the sawblade, necessitating additional blade sharpening. Log holding techniques and other skills acquired by QFRI staff overseeing the mulga study were applied during the milling of gidgee, which would have also contributed to reducing the blade sharpening time in the gidgee study.

Due to the requirement to pay royalties to DPI Forestry, the total variable cost of harvesting timber from leasehold land is substantially higher than timber from freehold land. In 2002, there was a large difference in royalty payable to DPI Forestry according to whether mulga or gidgee is harvested. This is a consequence of gidgee being classified as a ‘specialty timber’. At 2002 royalty rates, the variable cost of mulga and gidgee GOS production from leasehold land exceeds costs of timber milled from freehold land by 7% and 35% respectively. Consequently, while variable costs of production of gidgee are $\$130/m^3$ GOS less than mulga on freehold land, gidgee costs exceed mulga by $\$70/m^3$ GOS on leasehold land. Walls (2002) indicated that DPI Forestry is keen to encourage western Queensland forestry and that current royalty rates would be reconsidered if larger volumes of sawn wood were to be produced from western hardwoods. Royalties could be raised or lowered according to DPI Forestry’s assessment of the profitability of milling western Queensland hardwoods.

Table 4.6 indicates that labour costs generally accounted for at least 80% of total variable cost when an imputed labour cost of $20/hour is adopted. The exception is the case where gidgee logs are harvested from leasehold land, requiring a large royalty payment to DPI Forestry, which reduces the proportionate contribution of labour to total variable cost. The finding that labour is the major variable cost in portable sawmilling is consistent with other studies. For example, Smorfitt (2000) estimated that labour accounted for 91% of the total variable costs of a Portasaw bandsaw mill. Figure 4.13 illustrates the potential cost savings from reducing labour costs in these milling studies. For example, if the imputed cost of labour is assumed to be $10/hr, then the cost of sawing mulga and gidgee from freehold land are reduced by 42% and 37% respectively. At this lower imputed value of labour, the total variable cost of mulga and gidgee production would fall to $\$499/m^3$ GOS for mulga and $\$460/m^3$ GOS for gidgee.

Figure 4.14 illustrates that relatively small improvements in recovery can have a great impact on variable cost of production. For example, if the recovery of mulga could be improved from the study average of 34.6% to 40%, then production costs on freehold land can be lowered by $116/m^3 GOS. Likewise, if the recovery from gidgee logs can be raised from 27.6% to 35%, then this would lower costs by $152/m^3 GOS on freehold land. Figure 4.14 also highlights the potential for large cost increases if portable sawmillers cannot achieve the average recovery rates in these milling studies. This suggests that training portable millers in techniques to maximise recovery is likely to have a large pay-off in terms of lower production costs.

It has been indicated that the availability of sawlogs per hectare and the size of the logs harvested have a large impact upon variable costs. Stands with greater availability of sawlogs than those harvested in this study are likely to have lower variable costs of harvesting than reported here. Maryvale and Yankalilla stations were selected, in part, because the forest stands on the properties were believed to be broadly representative of the forests in the region; however, concerns have been raised about their representativeness in Section 4.4.

4.6.1 Costs of fixed-site portable sawmilling versus multi-site portable sawmilling

An insight into the cost of fixed-site portable sawmilling versus multi-site portable sawmilling can be gained from Table 4.5. Since only one of the two regimes was applied to each resource, only simple observations can be reported and no specific conclusions can be made about the relative merit of one strategy over the other. In variable cost estimation, the average snigging distance for both the fixed and multi-site strategies were assumed to be equal. The costs of employing the fixed-site portable milling strategy for mulga include loading and unloading logs, hauling logs to the mill site at the homestead, and the cost of setting up the mill at the beginning of the study and dismantling it at the study's conclusion. This amounted to $16.06/m^3 of mulga log in this study. The costs of adopting the multi-site milling strategy for gidgee include the labour costs of setting-up and setting-down the mill three times, transporting the mill between the milling sites, loading and unloading the GOS boards, and hauling the GOS boards to the homestead. These activities amounted to $16.34/m^3 of gidgee log. Consequently, in this study, there was found to be no cost saving attributable to the employment of either a fixed or multi-site milling strategy.

Some general comments can be made about the merits of fixed and multi-site portable milling under certain circumstances. Since, as presented in Table 4.5, the costs of transporting logs are far higher than for sawn boards, there will be a haulage distance beyond which the costs of fixed-site portable milling exceed multi-site milling. In the QFRI milling study, the return haulage distance was 12 km. Given that fixed and multi-site milling costs are similar at this haulage distance, it appears reasonable to suggest that the threshold haulage distance is about 12 km return for the timber resources harvested in this study. Equally, if return haulage distances are substantially shorter than 12 km, then this will confer cost savings over the multi-site regime. Multi-site milling becomes more attractive as the available timber resource at each milling site increases, thereby spreading the cost of each move of the mill over a larger volume of timber. The volume of sawlogs per hectare in the gidgee stand was three times greater than was available in the mulga stand. If the multi-site milling study had been conducted in a forest with sawlog volumes similar to those in the mulga stand, the costs of multi-site milling would be substantially higher than those reported.

Some potential costs of fixed and multi-site portable sawmilling have been omitted from this assessment. For example, if millers are not encamped close to the portable mill, there may also be transportation costs associated with getting workers to and from the mill-site each day. There are also likely to be other benefits of adopting a fixed-site milling strategy not captured by this assessment. For example, in the event of an accident or if the mill required uncommon repairs or maintenance, better access to medical assistance or specialized equipment is likely when milling at a central location, such as the homestead, rather than in the forest, as in a multi-site milling regime. On the other hand, disposal of off-cuts and sawdust may become a problem at a fixed, central location, while a multi-site operation can potentially leave waste in the woodland and move onto another location.

4.6.2 Additional costs of processing western Queensland hardwoods

The variable cost estimates of GOS timber production in Table 4.5 do not include several variable costs likely to be incurred making western Queensland hardwoods marketable. By law, mulga and gidgee boards containing sapwood and sold in Queensland must be chemically protected from lyctid beetle attack. The small size of mulga and gidgee logs means that most sawn timber is likely to have sapwood. Following treatment, the boards are likely to be air dried to 12% moisture content in a shed on-farm for about 16 weeks, graded and drymilled (dressed), and then transported to the nearest town for commercial freight to Brisbane (the nearest major market). Indicative costs for these activities have been collected from industry and are presented in Table 4.7. Grading will highlight timber too defective for sale. Drymilling will remove defective timber and dress the remainder for sale as a finished product, which is likely to reduce saleable volumes to levels between one-third and two-thirds of GOS volume (approximately 10 to 15% of original log volume). Therefore, the costs indicated in Table 4.7 will be much greater when calculated in terms of graded and dressed (saleable) volumes.

Table 4.7 *Indicative estimates of additional variable costs associated with getting western Queensland sawn timber to market*

Activity	Cost ($/m^3 ungraded)
Treatment[1]	35.00
Drying[2]	29.94
Grading and drymilling[3]	280.00
Load onto farm truck	2.63
Freight in farm truck to town[4]	22.20
Freight to Brisbane	87.40
Total	457.17

Notes:

1. Estimate provided by Norton (2002) assuming treatment is undertaken on farm with low technology methods.
2. Assumes air drying. Only stripping expenses are considered. Time cost of holding drying timber on-farm not included.
3. Leggate *et al.* (1998) reported drymilling expense for east-coast hardwoods at about $140/m^3 GOS. The higher density of western hardwoods means there will be greater wear and tear on equipment, and that machining will be slower and more labour intensive. The smaller piece sizes will also slow the process, making unit costs higher. In the authors' experienced judgement, doubling the estimate to $280/m^3 GOS is appropriate.
4. Assumes property is 75 km from town.

There may also be financial costs, such as repayments on business loans for sawmilling equipment, and non-cash expenses, such as depreciation on equipment and the cost of holding drying timber to consider. Therefore, the total cost of producing mulga and gidgee timber for market with a portable sawmill is substantially greater than the total variable cost estimated in Table 4.5. Chapter 10 provides a detailed and complete cost structure for several hypothetical western Queensland hardwood production scenarios.

4.7 The high cost of sawing mulga and gidgee: a comparison with the costs of sawing other hardwood species

When it is considered that the average total (fixed and variable) cost of producing GOS hardwood timber in coastal Queensland and New South Wales is reported by sawmillers to be in the order of $\$400/m^3$ to $\$500/m^3$ (Native Forest Sawlog Pricing Working Group 1997; Leggate 2000), western Queensland hardwood boards are comparatively highly expensive to produce. Costs of harvesting, transporting and milling timbers from the Western Australian goldfields, a resource with many similarities with the western Queensland hardwoods, were originally quoted by Desert Timber Products at about $\$1,200/m^3$ (Siemon and Kealley 1999). However, with experience and improved harvesting and processing methods, costs were reportedly lowered to between $\$600/m^3$ and $\$800/m^3$ by 1997 (Siemon and Kealley 1999) or approximately $\$660/m^3$ to $\$880/m^3$ adjusted to 2001-2002 dollars by the Consumer Price Index (CPI). There is no indication which costs were included, nor how they were calculated; however, the Western Australian estimates are comparable with the total variable cost estimates reported in Table 4.5. It is informative to examine the cost structures of forestry operations elsewhere in Queensland to gain some insights into why hardwood production in western Queensland is such a high cost operation.

Labour costs are incurred at all stages of timber production. The imputed labour cost adopted in this study is likely to be higher than many forestry enterprises pay for their labour. For example, one western Queensland sawmiller asserted that his labour costs were in the order of $18/hour, including one-third on-costs. The Queensland State Award for fellers, sniggers and sawmill workers was $17.40/hour in 2002, including one-third on-costs (Queensland Government 2002). Given the importance of labour costs in portable sawmilling, the imputed wage rate in this study will have accounted for some of the higher cost of western hardwood production. If the State Award were to be adopted by western Queensland hardwood portable sawmillers, then the total variable costs of producing mulga and gidgee on freehold land, presented in Table 4.5, would fall by $\$93/m^3$ GOS and $\$69/m^3$ GOS respectively.

In 2002, royalties for east-coast hardwoods in Queensland ranged from $\$10/m^3$ to $\$100/m^3$, with the average between $\$30/m^3$ and $\$40/m^3$. The equivalent GOS royalty[7] for a $\$40/m^3$ east-coast hardwood log is about $\$111/m^3$ of sawn timber. In contrast, the royalty for gidgee is $\$70.61/m^3$ of log. When converted to GOS boards, the royalty equivalent[8] for gidgee is $\$256/m^3$, which far exceeds that of east-coast hardwoods. Unlike gidgee, the relatively high cost of mulga production is not compounded by royalty payments, since the royalty rate is less than the average royalty for east-coast hardwoods.

There are no tree selection cost estimates in the literature with which to compare the figures in Table 4.5. In western Queensland, the labour cost of this activity is high because of the small log volumes and the travel time between trees with millable logs. For the purposes of this study, tree diameters were also measured and recorded, an activity that is unlikely to be performed in commercial operations. While tree selection was performed as a separate phase in the QFRI milling studies, landholders undertaking forestry operations are more likely to combine this activity with felling and log merchandising. These factors should facilitate avoidance of a large proportion of the tree selection costs reported in Table 4.5 by commercial operators.

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7 Assuming the average hardwood GOS recovery in Queensland of 35.9% (Native Forest Sawlog Pricing Working Group 1997).

8 Assuming a GOS recovery of 27.6%, as achieved in the QFRI milling study.

Felling, docking and snigging costs are in the order of \$69.69/m^3 and \$49.78/m^3 for mulga and gidgee respectively. These costs are high when compared to commercial forestry estimates for other Queensland timber resources, presented in Table 4.8. However, when felling, merchandising and snigging operations are undertaken on a part-time basis by landholders with little experience and without purpose-built equipment, these activities are likely to be carried out less efficiently than can be achieved by commercial operators. Another important factor raising the costs of harvesting in western Queensland is the scarcity and smaller size of mulga and gidgee sawlogs compared with other Queensland native forests. The Comprehensive Regional Assessment Unit of the then Queensland Department of Natural Resources (CRA 1999) asserted that 2 m^3/ha of log is generally considered the minimum for a commercially viable operation in Queensland. In the mulga study, log volume was only 18% of this level. The high felling, merchandising and snigging cost estimates derived in this assessment contribute much to the additional costs of mulga and gidgee timber production over east-coast Queensland hardwoods.

Table 4.8 *Reported felling and snigging costs from commercial forestry operations in Queensland*

Source	Year	Costs (\$/m^3 log)			Costs adjusted by CPI to 2001-02 (\$/m^3 log)		
		Cut	Snig	Cut & snig	Cut	Snig	Cut & snig
1. Wet Tropics N QLD[1]	1988	8.21	15.20	23.41	11.72	21.69	33.41
3. Native western QLD[2]	1997	9.00	11.70	20.70	10.01	13.02	23.03
4. Plantation eucalypt SE QLD[3]	1998	9.00	12.00	21.00	9.89	13.18	23.07
5. Plantation cabinet timbers SE QLD[4]	1999	8.10	10.80	18.90	8.90	11.86	20.76
6. Cypress pine W QLD[5]	2002	9.00	9.00	18.00	9.00	9.00	18.00

Sources:
1. Cameron McNamara Consultants (1988, cited in Smorfitt 2000).
2. Average of the South West, Central West and Burnett Central Hardwood Pricing Zones - the zones encompassing the South West and Desert Uplands Strategy Areas – for *Eucalyptus* and *Corymbia* species (Native Forest Sawlog Pricing Working Group 1997).
3. Leggate *et al.* (1998).
4. Capill (1999).
5. Schultz (2002).

Notes: Costs include equipment and labour. Costs adjusted for inflation by the CPI may not sum due to rounding error.

A major review of hardwood pricing in Queensland (Native Forest Sawlog Pricing Working Group 1997) estimated sawlog loading and unloading expenses at \$5.81/m^3, so the \$5.26/m^3 estimated in this study appears reasonable. The farm truck log haulage costs reported in Table 4.5 are based on rates of \$0.44/ m^3/km and \$0.49/ m^3/km for mulga and gidgee respectively (Appendix 4A.4). These correspond closely with an estimate of haulage costs on farm tracks in Victoria of \$0.46/m^3/km (inflated by the CPI to 2001-2002, cited in Stewart and Hanson 1998). Haulage costs on farm are greater per kilometer than the haulage costs of log trucks in coastal Queensland; however, distance to the portable sawmill on-farm is shorter than typical distances to a fixed mill in coastal Queensland. Consequently, log haulage to the mill is a phase of sawn timber production where portable milling of western hardwoods is more cost effective than east-coast Queensland hardwood production.

In a survey of managers of 20 sawmills in north Queensland, comprising four portable mobile mills, 10 portable fixed-site mills and six fixed-site sawmills, Smorfitt (2000) found that none were able to provide a definitive estimate of the cost of milling timber. Stewart and Hanson (1998) interviewed 25 portable sawmill operators in Victoria and found that meaningful cost information was difficult to collect. After removing the costs of purchasing sawlogs and equipment depreciation from Stewart and Hanson's (1998) estimate of the cost of milling southern Australian hardwoods, the variable cost of sawing with a single circular saw portable mill (similar to the Lucas 8'' mill in the QFRI milling studies) was $62.23/m^3 of log. This is 40% of the estimated variable cost of portable milling mulga. The costs of milling timbers of the Western Australian goldfields, a resource that is similar to western Queensland's hardwoods, has been estimated at about $120/m^3 of log (Siemon 2002). Smorfitt (2000) estimated the variable cost of milling cabinet timbers with a portable bandsaw mill in north Queensland at $140/m^3 of log. The latter two estimates suggest that the milling costs presented in Table 4.5 are realistic.

Difficulty in estimating and comparing variable costs of portable sawmilling arises from the lack of meaningful, independent performance figures for the majority of portable sawmills (FORTECH 1994, cited in Stewart and Hanson 1998; Smorfitt 2000). The related factors of speed at which logs can be converted to sawn wood and the proportion of the log recovered as sawn wood, have a large impact upon production costs. The productivity of the Lucas Mill in the QFRI mulga and gidgee milling trials (Table 4.4) is at the low end of the productivity scale reported by Stewart and Hanson (1998). They indicated that, under certain conditions, portable mill processing capacities range from 0.1 m^3 GOS/hr for chainsaw mills to 2.5m^3 GOS/hr for twin circular sawmills. In their financial analysis of a single circular saw portable mill (like the Lucas Mill) sawing southern Australian hardwoods and softwoods, Stewart and Hanson (1998) assumed that GOS recovery would be 65% and 0.84 m^3 of sawn wood could be produced per hour with two operators. These assumptions seem optimistic and, at least partly, explain why their estimate of variable cost (indicated above) is low. Such high rates of production and recovery of sawn wood is impossible with western Queensland hardwoods.

Fixed sawmills in eastern Queensland, sawing east-coast hardwoods, appear to have a major cost advantage over portable millers sawing western Queensland hardwoods. Total fixed and variable costs of hardwood sawmills in Queensland were reported to be approximately $240/m^3 GOS in 1997 or approximately $270/m^3 GOS in 2002 dollars (Native Forest Sawlog Pricing Working Group 1997)[9]. When the variable costs of portable sawmilling mulga and gidgee are converted to their GOS equivalent, they amount to $527/m^3 and $434/m^3 respectively. The high milling costs appear to explain much of the difference in timber production costs between east-coast and western Queensland hardwoods. The difference is largely attributable to three factors. Firstly, equipment in fixed sawmills generally facilitates more rapid conversion of logs to sawn timber. Most importantly, this lowers labour input per cubic metre of sawn output. Secondly, as discussed above, the cost of labour in established east-coast sawmilling operations is likely to be less than the imputed value adopted in this study. Finally, east-coast hardwoods are available in larger log sizes with less defect than western Queensland hardwoods.

[9] The fixed cost component of this estimate is likely to be small, because fixed costs are often not fully accounted for by managers and because of the age of antiquated (fully depreciated) equipment employed throughout much of the hardwood milling sector.

4.8 Conclusion

The portable sawmilling studies undertaken with mulga at Maryvale Station and gidgee at Yankalilla Station have highlighted that the sawlog resource in these woodland types may be less than 1 m^3/ha. The marked contrast with the results of resource inventories presented in Chapter 2 is probably explained by differences in sawlog specifications. GOS recoveries were about 30% for both species and showed a tendency to increase with sawlog centre diameter.

Estimated to be in the vicinity of $730/$m^3$ GOS and $980/$m^3$ GOS, variable costs of portable sawmilling mulga and gidgee on the Stations was found to be approximately twice the reported total cost of fixed sawmills processing east-coast Queensland hardwoods to the same stage. Virtually all production stages for mulga and gidgee were found to be more expensive than for the equivalent stage of production with east-coast hardwoods. Only in costs of log transportation could western Queensland portable millers better the costs of east-coast hardwood producers. Labour was identified as the major variable cost component in portable milling, and total variable cost of production was shown to be highly sensitive to the wage drawn by the portable millers. Land tenure was also found to have a substantial impact on the cost of GOS production, particularly for gidgee, due to the requirement of leaseholders to pay a royalty to DPI Forestry.

It had been noted that there are many additional costs associated with preparing timber for market that have not been accounted for in the portable sawmilling variable cost assessment. Chapter 10 presents a more complete financial analysis of several western Queensland hardwood production scenarios.

References

ABARE (2001), *Exploring ABARE's Farm Survey Data*, http://agsurf.abareconomics.com/cgi-bin/abare.pl?_PROGRAM=ags4Home&wh=ter&pr=agsurf; accessed 13 March 2002.

Burns, D. (2002), personal communication, Portable Sawmill Trainer, Blackbutt.

Capill, L. (1999), 'Cabinet timbers fetch high prices at auction', *Queensland Forestry Network News*, Issue 3, March, pp. 16-17.

Cathcart, A. (2002), personal communication, Economist, Agency for Food and Fibre Sciences - Sheep and Wool, Department of Primary Industries, Charleville.

CRA (1999), 'An inventory of private forests', in Comprehensive Regional Assessment (CRA) (ed.), *South-East Queensland Comprehensive Regional Assessment*, Commonwealth and Queensland Regional Forest Agreement Steering Committee, Brisbane, pp. 105-08.

Eastley, D. (2002), personal communication, Senior Teacher, Hollybank Forestry Centre, Tasmania.

Leggate, W., Palmer, G. and Walduck, B. (1998), 'Economic aspects of eucalypt hardwood plantation forestry: a case study on *E. cloeziana* plantations in S.E. Qld', Plantation and Regrowth Forestry: A Diversity of Opportunity, Australian Forest Growers Biennial Conference Proceedings, 6-9 July, Lismore, NSW.

Leggate, W. (2000), '25-year-old plantation-grown spotted gum: productivity, sawn recovery and potential rates of return', unpublished report to FORESTECH, Queensland Forestry Research Institute, Brisbane.

Lucas, R. (2002), personal communication, Manager, Lucas Mill Pty Ltd.

Native Forest Sawlog Pricing Working Group (1997), *Hardwood Pricing Review*, Hardwood Working Group Report for submission to the Native Sawlog Pricing Tribunal, Brisbane.

Norton, J. (2002), personal communication, Leader, Forest Products Biodeterioration, Queensland Forestry Research Institute, Indooroopilly.

Queensland Beef Industry Institute (2000), *Queensland Beef On Farm Situation Analysis: An On Farm Profile*, Queensland Government, Brisbane.

Queensland Government (2002), *Forest Resources Industry Award - State (Southern Division Western District)*, http://www.wageline.qld.gov.au/sumsheets/sdwd.htm, accessed 2 April 2002.

Resource Consulting Services (1995), 'Report on Investigation into the Potential Impact of Changes in Tree Clearing Guidelines on Profitability of Grazing Properties', unpublished report, Resource Consulting Services Pty Ltd, Yeppoon.

Rogers, H.M. (2002), personal communication, Project Officer, Forest Science Arid Woodlands Management, Barcaldine.

Schultz, J. (2002), personal communication, Regional Sales Officer, DPI Forestry, Dalby.

Siemon, G. (2002), personal communication, Timber Scientist, Forest Products Commission, Western Australia.

Siemon, G.R. and Kealley, I.G. (1999), *Goldfields Timber Research Project: Report by the Research Project Steering Committee*, Department of Commerce and Trade, Goldfields Esperance Development Commission, Department of Conservation and Land Management, Goldfields Specialty Timber Industry Group Inc., Curtin University, Perth.

Smorfitt, D.B. (2000), A commercial evaluation of the sawmilling industry in north Queensland with special reference to the current and potential role of portable sawmills, Master of Commerce by research thesis, School of Business, James Cook University, Townsville.

Smorfitt, D.B., Herbohn, J.L. and Harrison, S.R. (2001), 'The role of portable sawmills in tropical small-scale forestry', in S.R. Harrison and J.L. Herbohn (eds), *Sustainable Farm Forestry in the Tropics: Social and Economic Analysis and Policy*, Edward Elgar, Cheltenham, pp. 77-88.

Stewart, M. and Hanson, I. (1998), *On-site Processing for Farm Forestry*, RIRDC Publication No 98/79, Rural Industries Research and Development Corporation, Canberra.

Swift, S., Taylor, D., Cotter, D. and Fairbairn, E. (2002), 'Utilisation of Western Hardwoods as Specialty Timbers: Preliminary Resource Survey Report', Queensland Forestry Research Institute, Gympie.

Walls, J. (2002), personal communication, Principle Marketing Officer, Native Forests, DPI Forestry.

Appendix 4A. Cost assumptions for the estimation of variable costs

4A.1 Imputed value of farm labour

Landholders rarely cost their own labour (Stewart and Hanson 1998); however, an assessment of forestry opportunities in western Queensland should account for landholder time. Stewart and Hanson (1998) adopted a rate of $20.30 per person hour in their assessment of farm forestry opportunities in Victoria. This was derived by dividing average broad-acre and dairy farm incomes in Victoria ($66,370 from Wilson *et al.* (1995), cited in Stewart and Hanson (1998)) by an assumed number of work hours per year (3,276) to arrive at $20.30 per person hour. A similar approach has been attempted with grazing incomes in western Queensland. The AgSurf website (ABARE 2001) contains a large database that can be queried to report agricultural, financial and socioeconomic information about an average farm enterprise in any region of Australia. ABARE's West and South West, Charleville to Longreach, and Darling Downs and Central Highlands regions incorporate the South West Strategy and Desert Uplands areas of interest in this analysis. Over the period 1989-90 to 1999-2000, farms in these regions averaged a total farm cash income of $60,296 per annum (in 1999-2000 dollars). This had been earned from labour inputs averaging 129 hours per week, suggesting that labour productivity in these regions averages about $11.03/hour[10]. Family owned and operated farms in these regions averaged an ownership share of farm income of $22,500 (in 1999-2000 dollars) over the period 1989-1990 to 1999-2000. During this period, owner managers generally worked between 50 and 65 hours per week and their spouses between 20 and 40 hours per week on farm (ABARE 2001). Assuming a low labour input of 70 hours per week, the annual farm ownership share of income is equivalent to a wage rate of $6.70/hour[10].

ABARE adopted the Federal Pastoral Industry Award Rate to estimate the imputed value of farm labour on grazing properties in western Queensland. For operator managers, the relevant award in 2002 was $475 per 40 hour week ($24,700 per annum) or $11.88/hour. Over the period 1989-90 to 1999-2000, total imputed value of family labour on farm averaged $41,500 (1999-2000 dollars) across the ABARE regions encompassing the South West and Desert Uplands Strategy Areas (ABARE 2001). Resource Consulting Services (1995) adopted $30,000 per annum as an imputed cost of unpaid farm labour, while the Queensland Beef Industry Institute (2000) assumed $40,000 per annum to account for unpaid family labour. In both of the latter papers, labour hours contributed by the family were not indicated.

During discussions with several grazing industry experts, it was found that imputing an hourly rate for family labour on farm was a sensitive issue. A rate of $20/hour, plus on-costs (workers compensation and superannuation) had been commonly suggested by these experts. In this study, the 'middle ground' between industry statistics and expert opinion has been adopted. Farm labour has been valued at $15/hour plus one-third on-costs ($5), for a total labour value of $20/hour. This is equivalent to a gross income of $28,800 per annum[10], plus on-costs, which is a realistic rate according to Cathcart (2002).

[10] Assuming a 48 week work year

4A.2 Felling, docking and snigging expenses

Non-labour felling and docking expenses

It would have been convenient for chainsaw operating costs to be estimated per cubic metre of log felled; however, such estimates are unavailable for western Queensland hardwoods. Professional chainsaw operators are generally more comfortable discussing chainsaw operating costs per day. Discussions were held with chainsaw manufacturer technical help personnel and professional chainsaw users to ascertain daily operating costs. These discussions highlighted that there is little consensus on the useful life of chainsaw components, such as bars, chains, air filters and spark plugs. For example, the expected life of a Chainsaw bar varied from between two weeks (Burns 2002) and three to four months (Eastley 2002) of continuous use. A large part of this variation is probably due to the different timbers and environments with which each expert was familiar. Table 4.A1 reports the non-labour chainsaw operating costs per hour adopted for this study, which are based on an eight-hour working day. Burns (2002) asserted that the replacement of air filters and spark plugs would probably be unnecessary, provided they are looked after and cleaned regularly, as modern air filters are re-usable. Non-labour chainsaw felling and docking expense per cubic metre of log has been estimated in Table 4.A2.

Table 4.A1 *Chainsaw operating expenses per hour*

Chainsaw operating expense	Component expected life (hours)[1]	Replacement cost ($)	Chainsaw operating cost ($/hour)
Chainsaw bar	480	95	0.20
Chainsaw chain	24	45	1.88
Fuel[2]	na	na	0.86
Bar oil[3]	na	na	1.51
Contingency[4]	na	na	0.22
Total			4.67

Notes: Bar, chain, two-stoke oil and bar oil costs were provided by Stihl dealers

1. Expected life of bars and chains is based on an eight-hour work day. Bar life from Eastley (2002). Chain life from Burns (2002).
2. The chainsaw fuel mixing ratio is 50 parts fuel ($0.80/l) to one part Stihl two-stroke oil ($10/l). Chainsaw consumes 2-stroke fuel at the rate of 7 litres per 8 hour work day (Burns 2002)
3. Bar oil ($5/l) is consumed at the rate of 1 tank of bar oil per tank of fuel. The chainsaw fuel tank is 940 ml and the bar oil tank 325 ml.
4. A contingency for unexpected costs of 5% of the daily operating cost.

Table 4.A2 *Chainsaw operating expenses per cubic metre*

Chainsaw operating cost ($/hr)[1]	4.67
Logs felled and docked (m^3/hr)[2]	0.93
Chainsaw cost ($/$m^3$)	5.02

Notes:

1. Chainsaw operating costs from Table 4.A1.
2. Average volume of logs felled per hour across QFRI mulga and gidgee milling studies. This is equivalent to about 13 logs per hour.

Non-labour snigging expenses

Non-labour snigging expenses per cubic metre have been estimated in Table 4.A3.

Table 4.A3 *Non-labour snigging expenses*

Tractor operating cost (\$/km)[1]	0.595
Average return snig distance (km)[2]	0.4
Number of logs carried per load[2]	3
Average log volume per load (m^3)[3]	0.21
Non-labour snig cost (\$/m^3)	\$1.13

Notes:

1. The Australian Tax Office's expense claim rate for vehicles >2,600 cc has been adopted as the operating cost per kilometre for a tractor. This rate includes fuel, maintenance and depreciation. No farm equipment rates per kilometre were available from the tax office.
2. In the experience of QFRI personnel, these figures are reasonable for the resource in western Queensland.
3. Average log volume per load is the average log volume across QFRI's mulga and gidgee milling studies (0.07 m3), multiplied by the number of logs per load.

Felling, docking and snigging labour expenses

Labour costs adopted have been based on the time spent felling, docking and snigging in QFRI sawmilling studies, which are summarised in Table 4.A4.

Table 4.A4 *Labour costs for felling, docking and snigging in mulga and gidgee forests*

Activity	Maryvale mulga				Yankalilla gidgee			
	Total hours[1]	Total labour cost (\$)[2]	Sawlog volume[3]	Cost (\$/m^3)	Total hours[1]	Total labour cost (\$)[2]	Sawlog volume[3]	Cost (\$/m^3)
Fell and dock	10	200	7.24	27.62	8.75	175	9.86	17.75
Snig	13	260	7.24	35.91	12.75	255	9.86	25.86
Total	23	460		63.53	21.5	430		43.61

Notes:

1. Total hours is the total number of person hours spent undertaking the activity
2. Total labour cost is the imputed value of farm labour (\$20) multiplied by the 'total hours'
3. Sawlog volume is the sawlog volume removed during the 'total hours'.

4A.3 Loading and unloading expenses

Loading and unloading logs

Where log haulage by truck is required, it is assumed that a tractor with a fork is available for loading sawlogs. Loading costs have been estimated in Table 4.A5.

Table 4.A5 *Costs of log loading*

Loading rate by tractor (logs/minute)[1]	4
Average volume loaded (m^3/hr)[2]	16.8
Operating cost of tractor (\$/m^3)[3]	0.50
Labour cost (\$/m^3)[4]	4.76
Total loading and unloading cost (\$/m^3)	5.26

Notes:

1. An average loading rate of 4 logs per minute with a tractor has been assumed.
2. Average volume loaded is average mulga and gidgee log volume (0.07 m^3) x 4 logs/minute x 60 minutes/hour.
3. Loading cost with the tractor is a nominal estimate. Unloading of logs is by tipping or dropping them off the back of the truck.
4. Labour cost assumes 2 persons at the imputed labour cost of \$20/hr. Unloading time is assumed to be equal to loading time. Labour cost per cubic metre per hour is 2 persons x \$20/hour / 16.8 m^3 x 2 (to account for unloading time).

Loading and unloading sawn boards

It is assumed that sawn boards can be loaded onto a truck at half the cost of loading logs or \$2.63/m^3 of boards. This is similar to the loading rate charged by some road freight companies in western Queensland, for example one road freight company quoted \$40 to load a 22 tonne freight truck or approximately \$2.20/m^3 of sawn western hardwood timber.

4A.4 Log and board transportation expenses

Expenses of log haulage by farm truck

Log haulage costs by farm truck have been estimated in Table 4.A6

Table 4.A6 *On-farm log haulage costs in a farm truck*

Item	Mulga	Gidgee
Farm truck capacity (tonnes)	7	7
Farm truck capacity of log (m^3)[1]	5.9	5.2
Travel speed (km/hr)[2]	20	20
Truck cost (\$/m^3/km)[3]	0.10	0.11
Labour cost (\$/m^3/km)[4]	0.34	0.38
Total farm truck haulage expenses (\$/m^3/km)	0.44	0.49

Notes:

1. Log capacity estimated by dividing truck capacity by the green density of mulga (1,188 kg/m^3) and gidgee (1,354 kg/m^3).
2. The average speed at which mulga logs were hauled on farm during QFRI milling studies.
3. The Australian Tax Office's expense claim rate of \$0.595/km for vehicles >2,600 cc has been adopted as the operating cost for a farm truck. This rate includes fuel, maintenance and depreciation. No farm equipment rates per kilometer were available from the tax office. Truck cost is \$0.595/km / log capacity (m3).
4. Labour cost is 2 persons x \$20/hour / log capacity (m^3) / 20 km/hr.

Freight expenses for sawn timber

The costs of transporting green and dried sawn timber on and off farm in a farm truck have been estimated in Table 4.A7.

Table 4.A7 *Cost of freight for GOS and dried sawn timber*

Item	Mulga		Gidgee	
	GOS	Dry	GOS	Dry
Farm truck capacity (tonnes)	7	7	7	7
Farm truck capacity of log (m^3)[1]	5.9	6.4	5.2	5.5
<u>Freight sawn timber to town</u>				
Travel speed (km/hr)[2]	70	70	70	70
Truck cost (\$/m^3/km)[3]	0.10	0.09	0.11	0.11
Labour cost (\$/m^3/km)[4]	0.048	0.044	0.055	0.052
Total farm truck haulage expenses (\$/m^3/km)	0.148	0.134	0.165	0.162
<u>Freight sawn timber on-farm</u>				
Travel speed (km/hr)[2]	20	20	20	20
Truck cost ($/m3/km)[3]	0.10	0.09	0.11	0.11
Labour cost ($/m3/km)[4]	0.34	0.31	0.38	0.36
Total farm truck haulage expenses ($/m3/km)	0.44	0.40	0.49	0.47

Notes:

1. Log capacity estimated by dividing truck capacity by green or air dry density of mulga and gidgee.
2. The assumed average speed at which sawn timber would be hauled.
3. The Australian Tax Office's expense claim rate of $0.595/km for vehicles >2,600 cc has been adopted as the operating cost for a farm truck. This rate includes fuel, maintenance and depreciation. No farm equipment rates per kilometre were available from the Tax Office. Truck cost is $0.595/km / log capacity (m3).
4. Labour cost is travel time for one person for freight to town and two people for freight on-farm ($20 or $40/hour / timber capacity (m^3) / travel speed km/hr).

4A.5 Portable sawmilling expenses

Little objective information has been published on the operating costs of portable sawmills. Operating costs for a Lucas 8'' portable sawmill milling mulga and gidgee have been estimated in Table 4.A8. Apart from the blades, costs have been calculated on a per hour basis and converted to costs per cubic metre. This is because portable millers and sawmill manufacturers are more comfortable providing hourly cost rates.

The cost of retipping and tensioning blades adopted in this study is far higher than has been reported in other portable sawmilling literature. This is due to the high densities of western Queensland hardwoods and difficulties effectively holding small logs during sawing, which resulted in shorter blade life. Stewart and Hanson (1998) reported that a circular blade portable sawmiller indicated that about 60 m^3 to 80 m^3 of hardwood timber (blue gum and white stringybark) could be sawn before retipping is required. Another operator surveyed by Stewart and Hanson (1998) suggested that 50 m^3 of yellow box and red gum can be sawn before retipping is necessary. During the mulga and gidgee portable sawmilling trials, the average life of a sawblade was found to be 3.75 m^3 of log volume.

Table 4.A8 *Operating costs of a Lucas 8" portable sawmill milling mulga and gidgee*

Item	Consumption / hour	Unit cost ($)	$/hour	Cost ($/m³ log) [7] Mulga	Gidgee	Average
Blades[1]	na	100[2]	na	26.67	26.67	26.67
Fuel[3]	2.25 l	0.80	1.80	6.59	3.94	5.26
Fuel filter[4]	1/320	13.20	0.04	0.15	0.09	0.12
Oil[5]	1.5 l/120	10.17	0.13	0.47	0.28	0.37
Oil filters[4]	1/320	19.80	0.06	0.23	0.14	0.18
Air filter cartridges[4]	1/160	22.00	0.14	0.50	0.30	0.40
Spark plugs[4]	1/800	12.10	0.02	0.06	0.03	0.04
Pre-cleaner[4]	1/480	6.60	0.01	0.05	0.03	0.04
Drive belts[4]	1/480	21.00	0.04	0.16	0.10	0.13
Trolley rollers[4]	1/800	52.80	0.07	0.24	0.14	0.19
Contingency[6]	na	na	0.25	0.92	0.55	0.73
Total non-labour milling expense				36.02	32.26	34.14
Labour - milling				128.55	81.75	105.15
Labour - sharpening and refuelling				15.19	3.04	9.12
Labour - saw blade changing				2.67	2.67	2.67
Total labour milling expense				146.41	87.46	116.93
Total milling expense				182.43	119.71	151.07

Notes: Consumption per hour is per 8 hour day spent milling, not per hour of engine time. An 8 hour day spent milling would typically include about 5 hours of engine time (Lucas 2002).

1. In the QFRI gidgee milling study, blades required changing after milling approximately 3.75 m^3 of log. This rate has been adopted for mulga and gidgee, although greater blade life could be possible milling mulga. With experience and better milling techniques, blade costs may decrease.
2. Approximate average cost of retipping and tensioning a blade gathered from blade doctors in Brisbane is $80, including GST. Freight from western Queensland about $10 each way.
3. Fuel consumption is based on 18 litres per 8 hour day of milling (Burns 2002).
4. These cost estimates were based on information supplied by Lucas Mill Pty Ltd (Lucas 2002).
5. An oil change was recommended once every 100 engine hours by Lucas (2002) and every 50 engine hours by Burns (2002). The average 75 engine hours (120 milling hours) has been adopted.
6. Contingency for batteries, throttle cables and other parts (Lucas 2002).
7. Cost/m^3 is based on an average log throughput of 0.27 m^3/hr for mulga, 0.46 m^3/hr for gidgee and an overal average of 0.37 m^3/hour (5.4 logs/hour) achieved in the QFRI mulga and gidgee milling studies.

Mill set-up/set-down expenses

In the QFRI mulga and gidgee milling studies, it was found that mill set-up and set-down required two person hours of labour. At the imputed farm labour cost $20/hr, this comes to $40 per move. A 1 km distance between portable mill sites has been assumed. Vehicle costs of mill relocation are estimated at the Australian Tax Office's expense claim rate of $0.595/km for vehicles greater than 2,600 cc.

5. Drying time and costs associated with seasoning mulga and gidgee timber in western Queensland

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Information about the seasoning of western Queensland hardwoods is scarce. The Queensland Forestry Research Institute (QFRI) has undertaken an assessment of the suitability of five seasoning methods for western Queensland hardwoods – unprotected air drying, protected air drying, solar kiln, dehumidifier kiln and conventional kiln drying. The first four methods are considered appropriate for landholders producing small timber volumes. Recorded drying times indicate that kilns reduce drying time appreciably over air drying. However, a financial analysis identified air drying as the most economically efficient seasoning technique for mulga and gidgee in western Queensland. Where a kiln is required, for example, because product specifications require it, a solar kiln is likely to be the best investment option for a landholder.

5.1 Introduction

Timber shrinks as it dries, which makes green (freshly cut) timber unsuitable for many applications. Seasoning (drying) timber prior to use can reduce or eliminate this problem. Many seasoning methods are available; however, there is no published information on the suitability and cost-effectiveness of specific techniques for landholders wishing to dry western Queensland hardwoods. The Queensland Forestry Research Institute (QFRI) has begun to address this lack of information through seasoning studies with mulga (*Acacia aneura*) and gidgee (*A. cambagei*). This has focused on air, solar kiln and dehumidifier kiln drying, which are low capital cost techniques suitable for adoption by landholders processing western Queensland hardwoods. Limited research has also been undertaken by QFRI with these species utilising conventional kiln technology. This chapter details drying times and costs for mulga and gidgee. Chapter 6 has been devoted to a discussion of timber quality, including a comparison of drying degrade between seasoning methods.

This chapter begins with a description of the seasoning methodologies employed by QFRI with mulga and gidgee. The outcomes of the seasoning trials are then presented. Drawing upon the results of these drying studies, the limited literature base and expert opinion, seasoning costs are estimated for air, solar kiln and dehumidifier kiln drying of western Queensland hardwoods. Implications of this financial assessment on the selection of seasoning technique are discussed, followed by some concluding remarks.

5.2 Methodology for air, solar kiln and dehumidifier kiln drying of mulga and gidgee

The sawn boards produced from the portable sawmilling trials of mulga and gidgee reported in Chapter 4, were end-sealed and randomly allocated to one of the following four drying methods: unprotected air drying; protected air drying; solar kiln; and dehumidifier kiln. Roughly 0.6 m^3 of boards of each species were seasoned under each regime.

The simplest seasoning method trialled was unprotected air drying, which involved leaving stripped-out stacks of mulga and gidgee timber in paddocks on the property from which the timber was harvested, as illustrated in Figure 5.1. The stacked sawn boards were exposed to the weather, except for a makeshift roof consisting of a piece of corrugated iron. In the protected air drying regime, stacked sawn boards were seasoned in sheds on each property. This limited the exposure of boards to rain, dew, direct sunshine and dry winds. Mulga and gidgee boards were also seasoned in solar and dehumidifier kilns at QFRI's Salisbury Research Centre, Brisbane.

Figure 5.1 *Unprotected air-drying of mulga on Maryvale Station*

The same board stacking procedure had been adopted for all seasoning trials and was in accordance with the *Australian Timber Seasoning Manual* (Waterson 1997). Bearers (gluts) were placed at 300 mm intervals to raise the stack off the ground, limit distortion and facilitate air flow. Each layer in the stack consisted of boards of similar dimensions to produce a relatively even stack. Stickers (strips), approximately 19 mm thick by 25 mm wide, were placed at 300 mm intervals in line with the bearers to separate each board layer. Table 5.1 reports the periods over which mulga and gidgee boards were seasoned by each drying method.

Table 5.1 *Duration of mulga and gidgee seasoning trials*

Species	Seasoning periods by drying method					
	Unprotected and protected air dry			Solar and dehumidifier kiln		
	Start	Finish	Days	Start	Finish	Days
Mulga	1/8/2000	15/3/2001	225	11/8/2000	29/9/2000	49
Gidgee	3/4/2001	2/1/2002	274	30/4/2001	1/8/2001	95

Four to six moisture content sample boards were prepared in accordance with the *Australian Timber Seasoning Manual* (Waterson 1997) and placed within each trial stack - one each of 12 mm, 19 mm, 25 mm, 50 mm 75 mm and 100 mm thickness. Sample boards were defect free and docked to about 300 mm in length. Air dried sample boards were weighed on approximately a monthly basis by the landholders to monitor the rate of moisture content loss. Kiln dried sample boards were weighed approximately twice monthly by QFRI staff. Records of all sample boards, including dates of weighing, current weight, estimated moisture content and oven dry weight, were entered into QFRI's *sample board moisture content monitoring system*. When sample boards had been dried to approximately 12% moisture content, sections were removed from the sample board to accurately determine the *actual* moisture content using the oven dry method in accordance with *AS/NZS 1080.1-1997-Timber Methods of Test-Moisture Content*.

5.3 Conventional kiln drying methodology

Although the focus of western Queensland hardwood research has been on methodologies to facilitate landholders entering the timber industry with minimal capital expenditure, a series of small seasoning trials with a conventional kiln were conducted to gain an insight into the potential of this drying method for these species. While it is unlikely that a landholder or landholder cooperative would invest in a conventional kiln during the development stages of a western Queensland hardwood industry, it is conceivable that landholders could send timber to a professional kiln drier for seasoning.

Table 5.2 details the conventional kiln seasoning schedules trialled for mulga and gidgee. Campbell (1980) reported a drying schedule that had been developed for 25 mm thick mulga boards, which was adopted as a control schedule for both the mulga and gidgee conventional kiln trials. Following these control trials, a second schedule for mulga was developed with the aim of reducing drying degrade, and a second gidgee schedule was developed with the aim of reducing drying time. Consequently, mulga trial 2 adopted a higher temperature schedule and less severe humidity conditions (smaller difference between dry bulb temperature (DBT) and wet bulb temperature (WBT)), than in trial 1. On the other hand, gidgee trial 2 employed milder initial humidity conditions followed by more severe humidity conditions during the later stages of drying to accelerate the overall drying rate.

The conventional kiln seasoning trials were conducted with end-sealed sections of mulga and gidgee that were 900 mm length and of varying thickness and width. This length chosen is the maximum sample length able to fit in the smallest of QFRI's experimental conventional kilns. Each mulga trial consisted of three 12 mm and 19 mm thick boards, four 25 mm thick boards and two 50 mm thick boards. Both gidgee trials consisted of three 12 mm thick boards, three 25 mm thick boards and two 50 mm thick boards. Boards used in the trial were representative of the resource and included defects such as flute, want and heart checking. These defects were marked so they would not be mistaken for drying defects during post-seasoning assessments. Each kiln charge utilised 19 mm stickers to separate board layers. For each trial, pre-seasoned 'dummy' boards were used to surround the sample boards to limit unrepresentative drying, which is common in the outer shell of a kiln charge.

Table 5.2 *Conventional kiln schedules for mulga and gidgee*

Trial	Moisture content change points (%)	DBT (8C)	WBT (8C)	RH (%)	EMC (%)	Duration (days)
Mulga trial 1 (Campbell 1980)	25mm at 26.5 -20	50	42	61	9.5	2
	25mm at 20- 16.5	50	40	53	8.5	3
	25mm at 16.5-15	55	45	55	8.5	1
	25mm at 15-11	60	45	42	6.5	5
	Equalise (all sizes) -36hr	60	55	78	12	
		Total duration				11
Mulga trial 2	25mm at 24.4 -15	70	64	75	11	7
	25mm at 15-10.9	70	60	60	8.5	7
	Equalise (all sizes) -24hr	70	65	78	12	
		Total duration				14
Gidgee trial 1 (mulga schedule from Campbell (1980))	25mm at 22.4-18.1	50	42	60	9.8	1.5
	25mm at 18.1-15	55	45	55	8.8	3
	25mm at 15-10.3	60	45	45	6.5	10
	Equalise (all sizes) -36hr	60	55	78	12	
		Total duration				14.5
Gidgee trial 2	25mm at 21.6-20	50	45	75	12.5	0.5
	25mm at 20-18	50	42	60	9.8	1
	25mm at 18-15.2	55	45	55	8.7	2
	25mm at 15.2-10.2	62	42	30	4.8	4.5
	Equalise (all sizes) -36hr	60	55	78	12	
		Total duration				8

Notes: DBT is Dry bulb temperature.
WBT is West bulb temperature.
RH is Relative humidity.
EMC is Equilibrium moisture content of the kiln atmosphere

Each board was removed from the kiln periodically and weighed to monitor moisture content in accordance with the sample board method in the *Australian Timber Seasoning Manual* (Waterson 1997). When weighing indicated that the average moisture content of boards of the same thickness was approximately 10%, all boards of that thickness were removed from the kiln and wrapped in impermeable plastic to prevent further adsorption or desorption of water before the equalisation phase. Remaining boards were left in the kiln to continue drying. An exception to the requirement to season to 10% was made for the 50 mm boards, because of time restrictions and visual assessments indicating a high level of drying degrade.

The surfaces of a board are usually drier than the core after seasoning. A process known as *equalisation* is employed to eliminate moisture variation within and between boards and relieve residual drying stress. This is common practice for drying hardwoods, particularly for high value applications where there are more stringent requirements for acceptable levels of moisture gradient and residual drying stress. The Australian drying standard, *AS/NZS 4787:2001 – Timber - Assessment of Drying Quality*, outlines the dried quality requirements for various products.

The last entry of each seasoning schedule in Table 5.2 was implemented to equalise the timber to 12% moisture content. Moisture distribution between the case and core of the boards was determined before and after equalisation according to the ‘case-core-case rip’ method (Waterson 1997). Case moisture contents were calculated as the average of both sides of the board. Each board was given a class rating in accordance with *AS/NZS 4787:2001 – Timber - Assessment of Drying Quality*. These ratings are explained in Appendix 5A. The 12 mm, 19 mm and 25 mm thick boards were also grouped to give overall group class ratings. The group class rating is the class rating that at least 90% of the sample boards conformed to (as detailed in *AS/NZS 4787:2001 – Timber - Assessment of Drying Quality*). Once all boards had been seasoned and equalised, the final moisture content was determined by the oven dry method in accordance with *AS 1080:1-Timber-Methods of Test for Moisture Content*.

5.4 Seasoning time for mulga and gidgee

Tables 5.3 and 5.4 report drying times for mulga and gidgee sample boards to 12% moisture content by air, solar kiln, dehumidifier kiln and conventional kiln drying methods. Drying times for gidgee have been based largely on *actual*[11] moisture contents. However, with the exception of the conventional kiln trial, errors in actual moisture contents for mulga led to results from the *sample board moisture content monitoring system* being adopted[12]. Figures 5.2 to 5.5 illustrate the drying of 25 mm and 50 mm mulga and gidgee sample boards over time for air, solar kiln and dehumidifier kiln drying methods.

During conventional kiln drying, excessive drying defects became obvious on 50 mm mulga boards in trial 1 and on 50 mm gidgee boards in trial 2. The severity of drying defects that developed during these trials proved that these schedules were inappropriate for drying 50 mm material, and, therefore, these trials were terminated before the 50 mm boards had been seasoned to 12%. Some drying degrade was expected, as the mulga schedule adopted from Campbell (1980) was developed for 25mm thick material. The two schedules developed by QFRI had been derived from this schedule and, hence, were also better suited to 25 mm material. Figures 5.6 and 5.7 illustrate the drying time for 25 mm and 50 mm thick mulga and gidgee boards in the conventional kiln. Grouped class ratings for moisture content gradients pre and post-equalisation are presented in Table 5.5. The moisture content gradient class ratings assigned to all conventional kiln dried boards are described in Appendix 5A and tabulated in Appendix 5B.

[11] *i.e.* calculated from oven dried sample boards
[12] *i.e*. estimated from non-oven dried sample boards

Table 5.3 *Time for mulga to season to 12% moisture content by seasoning method and board thickness*

Board thickness (mm)	Approximate number of weeks for board to attain a moisture content of 12% by seasoning method					
	Maryvale unprotected	Maryvale protected	Solar kiln	Dehumid-ifier	Conventional kiln	
					Trial 1	Trial 2
12	7	5	3	3	<1	1
19	9	9	3	2	<1	1
25	9	5	4	4	2	2
50	13	9	>7 (14.0%)[1]	>5 (13.9%)[1]	>2 (16.5%)[1]	>4 (13.1%)[1]
75	27	17	na	5	na	na
100	27	27	>7 (15.0%)[1]	na	na	na

Notes: Drying times are based on calculated moisture contents from the sample board moisture content monitoring system. Reported length of time for boards of 12 mm and 25 mm thickness is the average over two different board widths.

1. Calculated moisture content at two, four, five or seven weeks in parentheses where sample boards were not dried to 12% moisture content.

Table 5.4 *Time for gidgee to season to 12% moisture content by seasoning method and board thickness*

Board thickness (mm)	Approximate number of weeks for board to attain a moisture content of 12% by seasoning method					
	Yankalilla unprotected	Yankalilla protected	Solar kiln	Dehumid-ifier	Conventional kiln	
					Trial 1	Trial 2
12	4	4	3	3	<1	<1
25	27	27	8	8	2	1
50	27	36	>14 (13.1%)[1]	12	5	>1 (19.3%)[1]
75	39	36	>14 (13.2%)[1]	na	na	na
100	>39 (12.8%)[1]	>39 (13.9%)[1]	na	12	na	na

Notes: Drying times are based on actual moisture contents, except for the dehumidifier regime for boards of 12 mm and 25 mm thickness. For the latter boards, moisture contents from the sample board moisture content monitoring system have been employed.

1. Calculated moisture content at 1, 14 or 39 weeks in parentheses where sample boards were not dried to 12% moisture content.

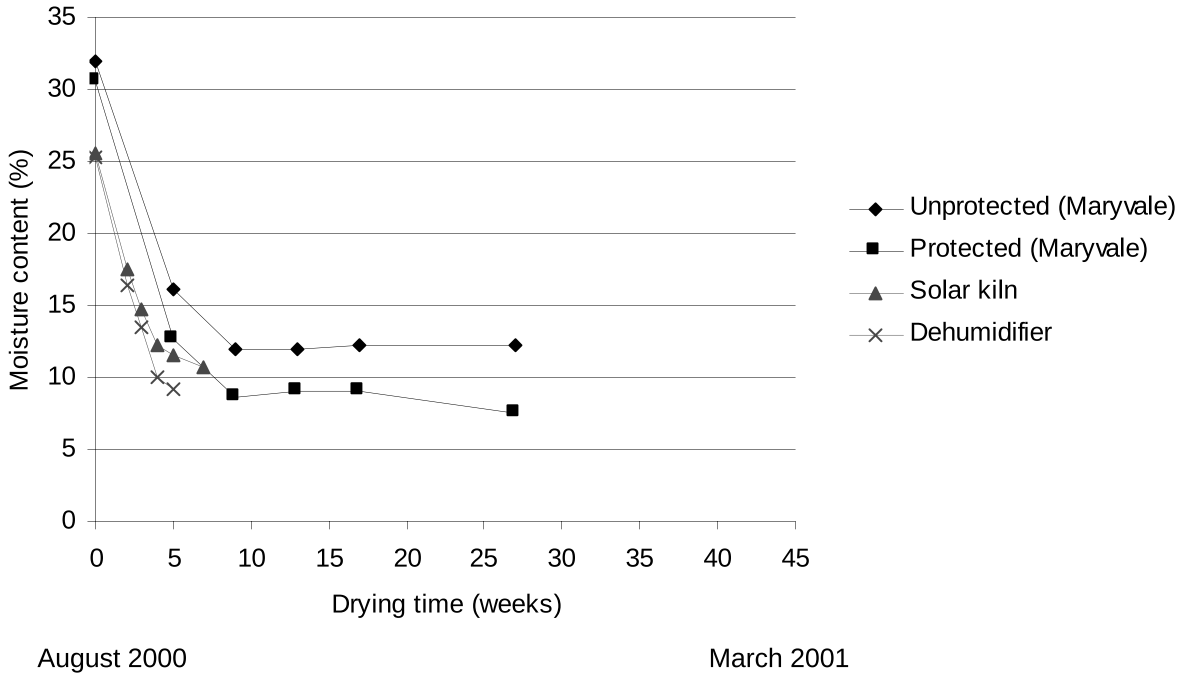

Figure 5.2 *Drying of 25 mm mulga boards under four seasoning regimes*

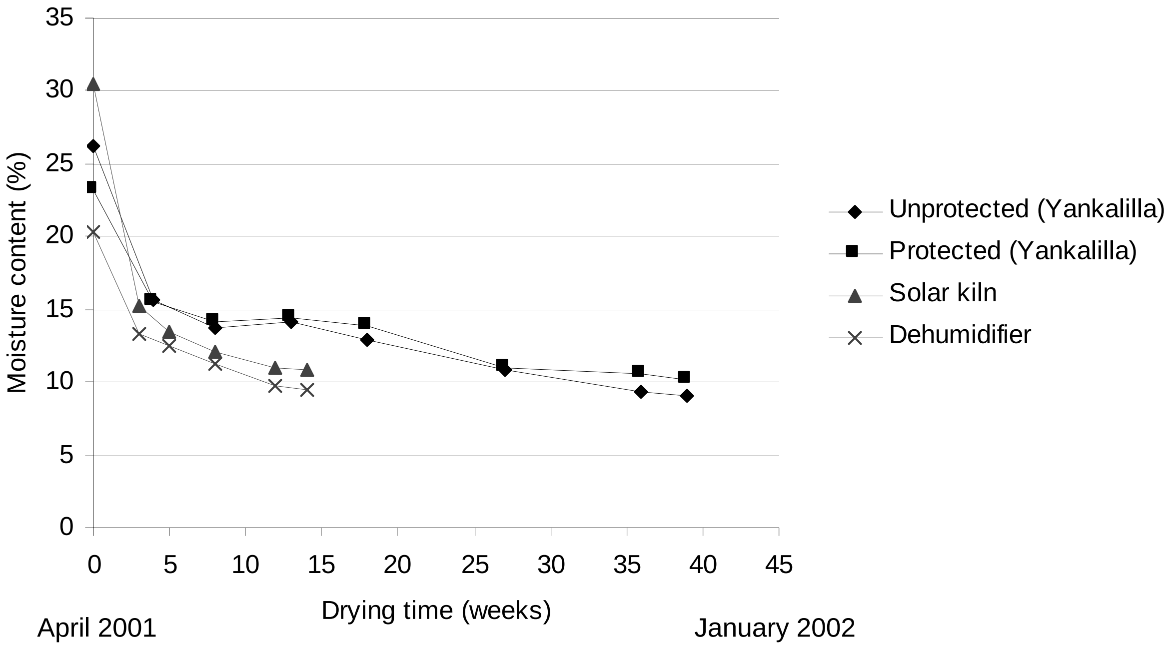

Figure 5.3 *Drying of 25 mm gidgee boards under four seasoning regimes*

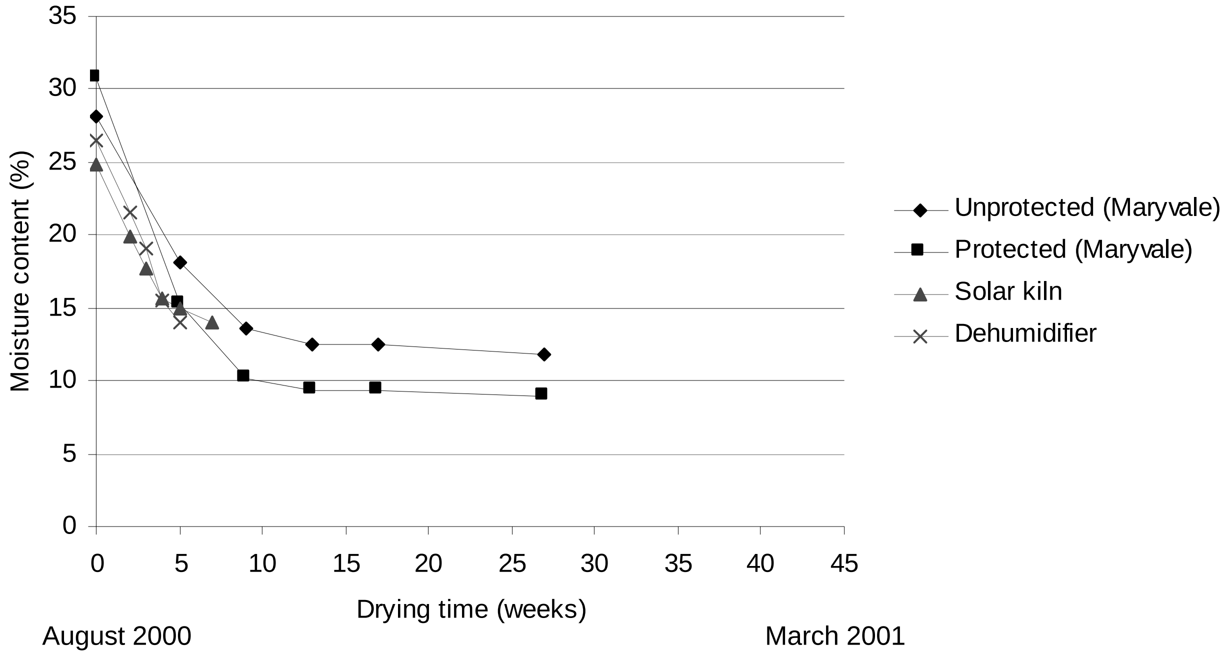

Figure 5.4 *Drying of 50 mm mulga boards under four seasoning regimes*

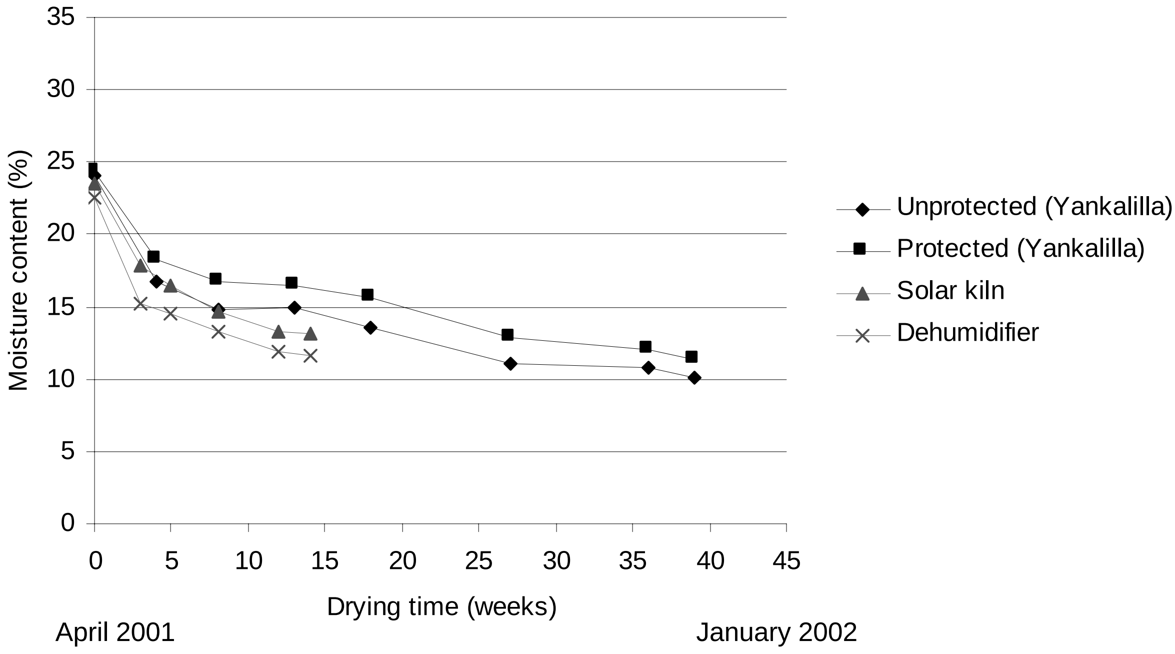

Figure 5.5 *Drying of 50 mm gidgee boards under four seasoning regimes*

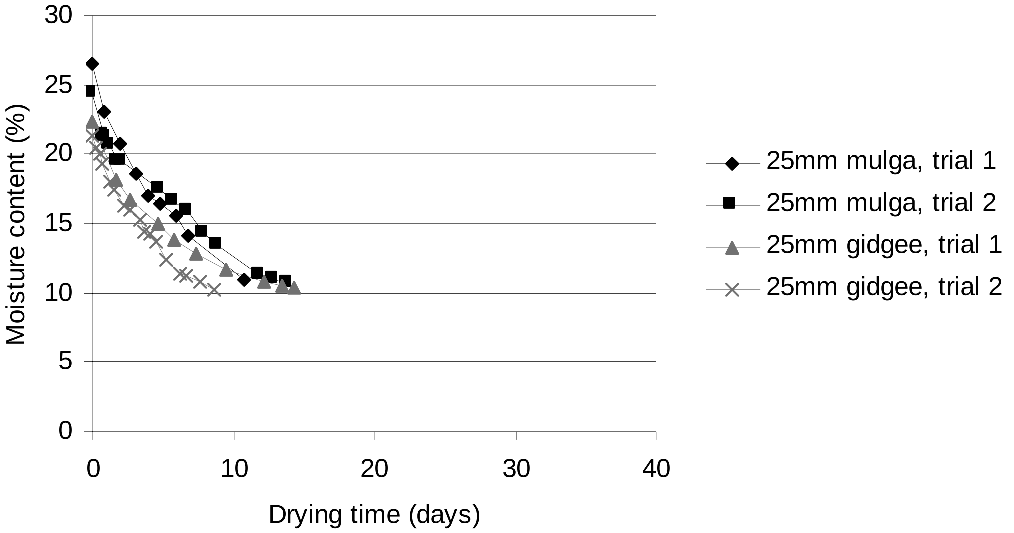

Figure 5.6 *Drying of 25 mm mulga and gidgee boards in the conventional kiln*

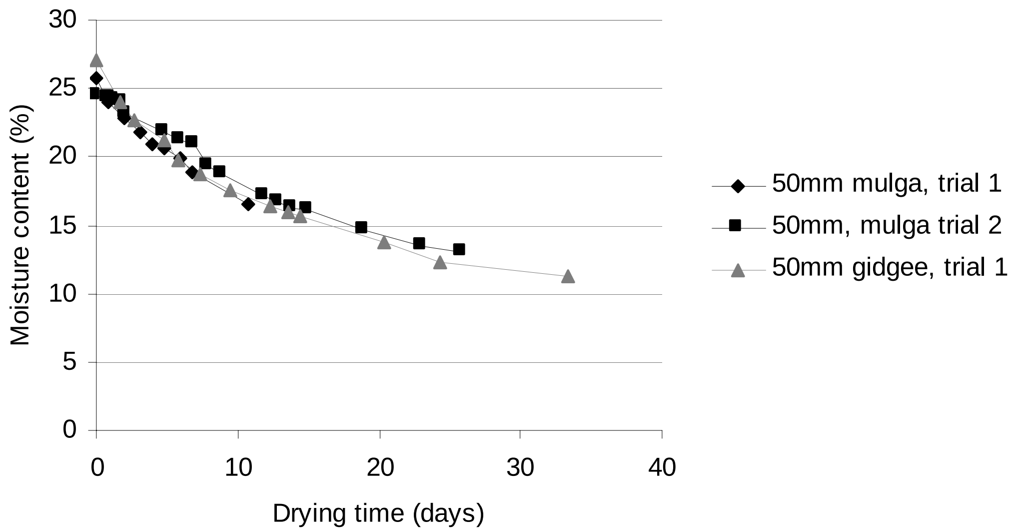

Figure 5.7 *Drying of 50 mm mulga and gidgee boards in the conventional kiln*

Table 5.5 *Grouped class rating for moisture content distribution in 12 mm, 19 mm and 25 mm mulga and gidgee boards pre and post-equalisation*

Species	Trial number	Pre-equalisation moisture content distribution grouped class rating	Post-equalisation moisture content distribution grouped class rating
mulga	1	E	B
	2	D	B
gidgee	1	B	A
	2	E	B

5.5 Discussion of seasoning trials with mulga and gidgee

A cursory examination of the air, solar kiln and dehumidifier kiln drying times might lead one to conclude that gidgee required longer to dry than mulga. However, the species were dried at different times of the year - mulga over spring and summer, and gidgee over autumn and winter. It should, therefore, be unsurprising to find that air and solar kiln dried mulga boards attained 12% moisture content more rapidly than gidgee boards. Less intuitive is why dehumidifier drying times for gidgee exceeded mulga. Examination of temperature and humidity readings from the dehumidifier during drying indicated that there were marked diurnal fluctuations, which suggests seasonal differences would have also affected drying times in the dehumidifier. In the carefully controlled environment of the conventional kiln, the same drying schedule had been adopted for both species in trial 1. The similarity of drying times in the conventional kiln indicates that neither species is inherently more difficult to dry than the other. This reinforces the argument that differences in drying times between the two species under the other seasoning methods is largely attributable to the prevailing weather conditions. The implication is that time of the year can have a major impact on timber drying times for these species.

Timbers dried most rapidly in the conventional kiln. The equalisation phases adopted in all schedules in the conventional kiln trials were found to be suitable, since Table 5.4 indicates that substantial improvements in moisture content gradient and residual drying stress was achieved post-equalisation. In the mulga trial, protected air-dried boards generally seasoned to 12% moisture content faster than unprotected boards. There was less difference in drying times between protected and unprotected air dried gidgee boards, although Figure 5.5 suggests that 50 mm gidgee boards air dried faster when unprotected. Solar and dehumidifier kilns were found to speed the drying process substantially over air drying. Boards up to 25 mm thick dried equally rapidly in solar and dehumidifier kilns; however thicker boards tended to dry more rapidly in the dehumidifier than in the solar kiln.

5.5.1 Comparison of seasoning times with other Australian hardwood species

The Goldfields timber resource of Western Australia is similar to the western Queensland hardwood resource, particularly with regards to the small merchantable piece-sizes and the high density of the timbers. The CALM Solar-assisted Kiln had been used to dry appearance grade boards from Goldfields timber species and was found by Siemon and Kealley (1999) to do so successfully when initial drying rates were set at 0.3% per day and increased to 0.5% per day later in the schedule. Siemon and Kealley (1999) reported a low temperature batch kiln drying schedule that had been developed for seasoning 25 mm thick appearance grade Goldfields eucalypts in Western Australia. This schedule was shown to dry Goldfields eucalypts with minimal drying degrade[13] to 10% moisture content over a period of 90 days (13 weeks). Given that mulga has been shown to air dry at a faster rate in western Queensland, this schedule is very conservative. Drying degrade arising from batch kiln drying of Goldfields eucalypts are reported in Chapter 6 to provide a comparison with results from air, solar kiln, dehumidifier kiln and conventional kiln drying trials with mulga and gidgee.

McNaught (1993) summarised drying times for heavy eucalypt species in Queensland, such as spotted gum (*Corymbia citriodora* subsp. *variegata*), forest red gum (*Eucalyptus tereticornis*) and ironbarks (*e.g. E. crebra*). In southern Queensland, within 300 km of the coast, but west of the Great Dividing Range, 25 mm boards on open sites with good air circulation were reported to air dry in about 20 to 25 weeks over summer and 25 to 35 weeks over winter. In northern Queensland, west of the Divide, air drying times of 15 to 20 weeks are typical throughout the year. These figures concur with the air drying time for 25 mm gidgee boards (27 weeks over

[13] Drying degrade arising from the seasoning of mulga and gidgee in this study is discussed in Chapter 6.

winter); however, mulga air dried in only five to nine weeks in late winter and early spring. In southern Australia, air drying time for hardwoods are typically in the order of 12 to 24 months (Stewart and Hanson 1998).

Dehydration Kilns Australia Pty Ltd asserted that the typical drying time for timbers in their dehumidifier kilns is in the order of two to five weeks (Olson 2002). McNaught (1993) reported actual dehumidifier kiln drying times of 20 days and 30 days respectively, for 25 mm brush box (*Lophostemon confertus*) from 30% moisture content to 12%, and 25 mm green spotted gum to 12% in Queensland. Stewart and Hanson (1998) reported drying time of two weeks for river red gum (*E. camaldulensis*) in a dehumidifier kiln, following 12 months air drying. Burke (2002) asserted that solar kilns manufactured by Solar Dryers Australia Pty Ltd (Rose Gum Timbers Pty Ltd), dry rose gum (*E. grandis*) from 20% moisture content to 10% in one to two weeks. Actual solar kiln drying time for Sydney blue gum *(E. saligna*) at Beaudesert, in south eastern Queensland, is eight weeks from 27% moisture content to 12% from August to September (McNaught 1993). Also at Beaudesert, 25 mm spotted gum required three weeks in a solar kiln to dry from 22% to 12% in summer, and five weeks in winter (McNaught 1993). Solar and dehumidifier kiln drying times for mulga are within the range presented for other hardwood species. Gidgee tended to dry more slowly than other hardwood species over the winter months; however, this is probably a product of the weather and inefficiencies in the particular kilns utilised in this study.

5.6 Financial assessment of seasoning methods for mulga and gidgee

The literature, private industry, government agencies and academic institutions were consulted for estimates of variable costs associated with seasoning timber. Little information has been published that is relevant to small solar and dehumidifier kilns appropriate for western Queensland landholders. Manufacturers of solar and dehumidifier kilns in Australia were consulted about variable costs of kiln operation; however, their estimates were low and generally did not include labour or repairs and maintenance costs. Therefore, an unpublished review of seasoning costs in Queensland (McNaught 1993), personal communication from experts, and the energy costs associated with the operation of QFRI’s own solar and dehumidifier kilns, constitute the basis of the financial assessment of seasoning methods for western Queensland hardwoods. Drying times adopted for this financial assessment are the average of the mulga and gidgee seasoning trials reported earlier. Derivations of several assumptions employed in this financial analysis are detailed in Appendix 5C.

The dearth of objective sources of drying cost estimates led to the adoption of seasoning cost structures developed by McNaught (1993) for the financial analysis of western hardwoods. McNaught’s estimates have been inflated by the consumer price index (CPI) to 2001-02 dollars. Since small-scale production by landholders is the focus of this assessment, costs such as supervision wages, insurance on kilns and stock, and waste disposal and cleaning, have been omitted from western Queensland drying cost structures.

Table 5.6 reports the estimated cost structures for unprotected air drying, protected air drying, solar kiln drying and dehumidifier kiln drying. McNaught (1993) recommended that timber be air dried to about 20% prior to kiln drying, to maximise annual throughput of the kiln, thereby lowering fixed costs per cubic metre of timber. Estimates of the cost structures of kiln drying regimes with prior air drying have been made for western Queensland timbers in Table 5.6; however, no such trials were actually performed. Conventional kilns are often multi-million dollar capital investments with high operating costs and were not considered appropriate for western Queensland landholders. Cost structures for this kiln type have not been considered in this financial analysis.

The cost structures in Table 5.6 do not account for any potential differences in board quality arising from the various seasoning techniques employed. However, the graded recovery of seasoned mulga and gidgee is reported in Chapter 6 and indicates little difference in board downgrade between seasoning methods. Calculation of kiln costs per cubic metre GOS assume the kiln is utilised to its full annual capacity. These capacities are presented in Table 5.6 and derived in Appendix 5C. If kilns are not used to their full annual capacity, then the financial costs will be higher than indicated. In the calculation of the results, it has been assumed that there are no structural or maintenance costs associated with protected air drying. It has also been assumed that there is no volume capacity limitation for unprotected and protected air drying. For most conceivable western Queensland hardwood processing opportunities, this assumption is likely to be reasonable. For example, if 60% of the floor space of a 12.5 m x 12.5 m shed could be stacked 2 m high with timber, 86 m^3 could potentially be dried at the one time[14]. The solar and dehumidfier kilns are assumed to have been purchased (with a bank loan) and erected for a total cost of $20,000 and $35,000 respectively.

Two types of *opportunity cost* have been factored into Table 5.6. These costs are informative for decision-making about alternative seasoning methods, but do not represent *real* cash costs. The first type is the opportunity cost of seasoning timber. That is, revenues foregone from not selling the timber green-off-saw (GOS). This cost is dependent upon the length of time the timber requires to season, which varies by seasoning method, as detailed in Appendix 5C. The second type of opportunity cost arises from delayed sale of seasoned timber. That is, revenues foregone from not selecting the fastest seasoning method (solar kiln with prior air drying) and, therefore, requiring a longer time period than absolutely necessary to generate cash flow from the sale of seasoned, ungraded, undressed boards. This opportunity cost is dependant upon the additional time required for a particular seasoning method, over the time required by the solar kiln with prior air drying method.

The final row of Table 5.6 indicates the net present values (NPV) of the seasoning costs per cubic metre GOS for each seasoning method. The investment period adopted is 15 years (the assumed life of a kiln) and the cost of capital 10% per annum. Since the tabulated figures are seasoning costs, the most economically efficient method of seasoning mulga and gidgee is the one that minimises NPV. Therefore, protected air drying is the most economically efficient drying method. This result does not change, even if it is assumed that a $10,000 shed must be built for air drying[15].

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[14] Assuming an 80% stack efficiency, as explained in Appendix 5C.2

[15] A 12.5 m x 12.5 m shed could be erected on-farm without a slab or walls for about $64/$m^2$ ($10,000). Such a shed would be capable of holding approximately 86 m^3 of timber at any one time, assuming stacks are 2 m high on 60% of the floor space, board thickness is 25 mm and 19 mm strippers are used, and an 80% stack efficiency is achieved (accounting for short board lengths). Average drying period is likely to be less than 6 months, meaning annual throughput could be about 172 m^3. The NPV of this scenario would be $765/$m^3$, which is still the most cost effective.

Table 5.6 *Estimated costs of seasoning western Queensland hardwoods*

Expense	Drying costs by drying method ($/m^3 GOS)					
	Air dry unprotected	Air dry protected	Solar kiln w air dry (not trialled)	Solar kiln w/o air dry	Dehumidifier kiln w air dry (not trialled)	Dehumidifier kiln w/o air dry
Max. annual kiln capacity	na	na	79	67	75	64
Stripping						
Labour (a)	24.67					
Stickers (b)	3.62					
Packaging (c)	0.15					
Mobile equipment (d)	0.50					
Repairs and maintenance (e)	1.00					
Total stripping cost	***29.94***	***29.94***	***29.94***	***29.94***	***29.94***	***29.94***
Air drying						
Opportunity cost of seasoning timber (f)	27.54	24.15	3.69	0	3.69	0
Kiln drying						
Labour (g)			12.67	12.67	12.67	12.67
Energy (h)			7.93	9.36	34.02	40.11
Mobile equipment (d)			0.50	0.50	0.50	0.50
Repairs and maintenance (i)			5.06	5.97	15.76	18.58
Opportunity cost of seasoning timber (f)			7.98	9.42	8.42	9.92
Total kiln costs			***34.14***	***37.92***	***71.37***	***81.79***
Financial						
Loan repayment expense (yrs 1 to 10) (j)			38.95	45.97	70.94	83.64
Depreciation tax shield (yrs 1 to 15) (k)			(5.06)	(5.97)	(9.33)	(11.01)
Total Financial costs (yrs 1 to 10) **(l)**			***33.89***	***40.00***	***61.61***	***72.63***
Total Financial costs (yrs 11 to 15) **(m)**			***(5.06)***	***(5.97)***	***(9.33)***	***(11.01)***
Opportunity cost of delayed sale of seasoned timber (n)	36.68	30.33	0.00	2.70	0.82	3.65
Total drying costs (years 1 to 10)	**94.16**	**84.43**	**101.67**	**110.57**	**167.42**	**188.02**
Total drying costs (years 11 to 15)	**94.16**	**84.43**	**62.72**	**64.59**	**96.49**	**104.38**
NPV ***(o)***	***788***	***706***	***788***	***851***	***1,287***	***1,439***

Notes:

(a) Stripping labour is used to stack the timber for drying. The rate presented is based on figures from McNaught (1993) - $13.82/m^3 + $6.22/m^3 on-costs (superannuation, workers compensation, annual leave), inflated by the CPI to 2001-02 dollars.

(b) Stickers are pieces of timber laid between layers of boards to facilitate air flow. The adopted rate is $2.94/m^3 from McNaught (1993), inflated by the CPI to 2001-02 dollars. This cost assumes 25% of stickers are replaced per annum.

(c) Packaging costs are steel straps wrapped around timber stacks. The rate is $0.12/m^3 adopted from McNaught (1993) inflated by the CPI to 2001-02 dollars.

(d) Mobile equipment costs accounts for the use of vehicles, such as forklifts and utilities, to move boards around the drying site. The rate adopted is a nominal figure recommended by McNaught (2002), and assumes that the vehicle is not used exclusively for this purpose on the farm.

(e) Repairs and maintenance expenses have been recommended by McNaught (2002) to account for stripping frames and mobile equipment.

(f) Opportunity cost of air drying and kiln drying assumes green sawn timber can be sold for $800/m^3 and the opportunity cost of capital is 10% p.a.

(g) McNaught (2002) recommended allowing five hours of labour per solar and dehumidifier kiln charge. This consists of one hour loading and unloading, and four hours moisture content monitoring. Labour is charged at $20/hr x 5 hrs / 7.89 m^3/charge = 12.67/m^3.

(h) The QFRI solar kiln has energy costs of $1.72/day. This equates to energy costs of $6.39/m^3 for the with air dry scenario (365 days x $1.72/day / 79 m^3/yr) and $9.36/m^3 for the without air dry scenario (365 days x $1.72/day / 67 m^3/yr). The QFRI dehumidifier kiln has energy costs of $6.99/day. This equates to energy costs of $34.02/m^3 for the with air dry scenario (365 days x $6.99/day / 75 m^3/yr) and $40.11/m^3 for the without air dry scenario (365 days x $6.99/day / 64 m^3/yr)

(i) Solar kiln repairs and maintenance expense is based on a nominal estimate of $400/yr to cover the kiln fan motor, electricals, air diverter, trolley and stacking system, and moisture content monitoring equipment. Dehumidifier repairs and maintenance expense is based on estimates from McNaught (1993), inflated to 2001-02 dollars by the CPI.

(j) Kilns are bought with a principal plus interest bank loan, fixed for 10 years at 8% p.a. Solar kiln purchased and erected with farm labour for $20,000. Dehumidifier kiln purchased and erected with farm labour for $35,000.

(k) Kilns are straight-line depreciated over 15-years and assumed to have no residual value. Depreciation lowers taxable income and taxes payable (shields the business from tax). It is listed in brackets because it is a negative expense; therefore a benefit. The tax shield has been calculated with the Australian company tax rate of 30%.

(l) In years 1 to 10, total financial expenses are loan repayments less the depreciation tax shield.

(m) In years 11 to 15, the loan has been paid off, but the depreciation tax shield is still benefiting the kiln owner. Financial expenses are negative, that is, net benefits are accruing to the kiln owner in the form of reduced taxable income.

(n) This opportunity cost differs from (f). This is the cost of using a seasoning technique that does not dry the timber as fast as the solar kiln with air drying method (the fastest seasoning method), thereby delaying cash flow from the sale of seasoned boards. Opportunity cost assumes seasoned, ungraded, undressed boards can be sold for $1,200/m^3 and the cost of capital is 10% p.a.

(o) Net present value (NPV) of drying expenses per cubic metre calculated over the life of a kiln (assumed to be 15 years) with a 10% discount rate. Since these figures are NPV of expenses, the most cost-effective seasoning method for mulga and gidgee is the one that minimises this figure.

5.7 Discussion of the financial analysis of seasoning mulga and gidgee

Total kiln drying costs have been asserted by professional sawmillers to be within the range from \$50/m^3 to \$180/m^3 GOS (McNaught 1993). The cost estimates presented for western Queensland timbers are within this *ballpark*. In view of the cost structures presented in Table 5.5, the claims made by one solar kiln manufacturer and one dehumidifier kiln manufacturer, that operating costs are in the vicinity of \$4/day, may be optimistic, particularly for dehumidifier kilns.

It is often asserted that air drying is *free*; however, this financial assessment has indicated that there is little difference between the costs of air and solar kiln drying for western Queensland hardwoods. This is because the long waiting period before air dried timber can be sold (opportunity cost) is almost as expensive for the landholder as purchasing and operating a solar kiln[16]. Nevertheless, protected air drying was found to be the most cost efficient seasoning technique in western Queensland for mulga and gidgee. From the seasoning methods trialled, protected air drying is also likely to minimise drying degrade, a crucial issue that is thoroughly discussed in Chapter 6. Although not tested, it is likely that this outcome is applicable to other western Queensland hardwoods seasoned in western Queensland.

Chapter 6 indicates that, with the exception of the conventional kiln[17], drying degrade in mulga and gidgee did not vary substantially between the seasoning methods trialled. Therefore, the purchase of a solar or dehumidifier kiln need only be considered by landholders if:

- product specifications demand drying below equilibrium moisture content
- future research or stricter grading standards than applied in Chapter 6, indicate that the quality of kiln dried boards is higher than air dried boards
- space for air drying becomes a limiting factor
- it is unsafe to leave drying stock for extended periods of time on-farm (*e.g.* fire hazard), or
- customers require a fast turn-around time.

If landholders do consider purchasing a kiln, then, according to this financial analysis, a solar kiln should be considered. McNaught (1993) also asserted that, where kilns are required, solar kilns are the most cost effective in Queensland, compared with dehumidifier and steam or oil heated conventional kilns. However, he suggested that for high throughput operations (about 3,500 m^3/ year and more), direct fired gas conventional kilns may become a competitive option.

5.8 Conclusion

Seasoning methods considered appropriate for small-scale western hardwood production have been trialled by QFRI. Conventional kiln seasoning trials with mulga and gidgee have also been conducted. Large differences in seasoning times between mulga and gidgee boards were observed; however, these appear to have been related to the prevailing weather conditions at the time of both trials. Solar and dehumidifier kiln drying times were, generally, found to be half the air drying time for the same species and board thickness.

[16] Recall, that opportunity costs are not true cash expenses

[17] Out of the seasoning techniques trialled, the conventional kiln resulted in the highest level of drying degrade in mulga and gidgee boards

Nevertheless, a financial assessment of seasoning methods, which incorporated the time cost of money, favoured protected air drying over unprotected air drying, and solar and dehumidifier kiln drying. If processing operations demand a kiln, then the financial assessment indicated that a solar kiln was likely to be more cost efficient than a dehumidifier kiln.

References

Burke, R. (2002), personal communication, Rose Gum Timbers Pty Ltd, Bellingen (New South Wales).

Campbell, G.S. (1980), ‘Index of kiln drying schedules for timbers dried in Australia’, unpublished report, Division of Building Research, CSIRO, Highett (Victoria).

McNaught, A. (1993), *Hardwood Drying Methods and their Economics in Queensland*, TRADAC Project 17-92, Queensland Department of Primary Industries Forest Service, Brisbane.

McNaught, A. (2002), personal communication, Principal Research Scientist, Queensland Forestry Research Institute, Brisbane.

Olson, R. (2002), personal communication, Manager, Dehydration Kilns Australia, Yackandandah (Victoria).

Siemon, G.R. and Kealley, I.G. (1999), *Goldfields Timber Research Project: Report by the Research Project Steering Committee*, Department of Commerce and Trade, Goldfields Esperance Development Commission, Department of Conservation and Land Management, Goldfields Specialty Timber Industry Group Inc., Curtin University, Perth.

Stewart, M. and Hanson, I. (1998), *On-site Processing for Farm Forestry*, RIRDC Publication No 98/79, Rural Industries Research and Development Corporation, Canberra.

Waterson, G.C. (ed.) (1997), *Australian Timber Seasoning Manual*, Australasian Furnishing Research and Development Institute Limited, Launceston.

Appendix 5A. Quality class ratings for moisture content gradients

Conventional kiln dried mulga and gidgee boards were assigned to the following drying quality class classifications extracted *from AS/NZS 4787:2001 –Timber–Assessment of Drying Quality*:

Class A	caters for specific end uses and very specific requirements for drying quality
Class B	applies where tight control over drying is required to limit 'in service' movement resulting from changes in equilibrium moisture content
Class C	applies where higher drying quality is required and the final use environment is clearly defined
Class D	applies when the final use environment is more clearly defined but again the drying quality requirements are not considered high, and
Class E	applies when the final use and drying quality requirements are not high.

Moisture content gradients were measured on three *ripped cross-sectional slices* - two *cases* and one *core*. Each slice was approximately one-third of the thickness of the original board. The oven dry method was employed to calculate moisture contents of the slices. Table 5A.1 presents the specifications for the moisture content gradient quality classes according to *AS/NZS 4787:2001 –Timber–Assessment of Drying Quality*. The Table lists the maximum allowable deviation in moisture content between the core slice and the case slice with the greatest deviation in moisture content from the core slice, by target moisture content and quality class. No information accompanies this standard regarding the suitability of the various quality classes for different applications.

Table 5A.1 *Allowable deviation of case moisture content from core moisture content by target moisture content for the various quality classes*

Quality class	Allowable deviation between core and case moisture content by target moisture content (%)				
	8%	10%	12%	14%	18%
Class A	1	1	2	3	3
Class B	1	2	3	4	5
Class C	2	3	4	5	5
Class D	3	4	5	6	7
Class E	4	5	6	7	9

Appendix 5B. Moisture content gradients from the conventional kiln trials

The 50 mm boards in trial 1 mulga and trial 2 gidgee were not given a class rating because of excessive degrade. Tables 5A.2 to 5A.5 indicate pre and post-equalisation moisture content gradients for mulga and gidgee in trials 1 and 2.

Table 5A.2 *Pre and post-equalisation moisture content gradient and drying quality class for mulga boards in trial 1*

Board thick-ness (mm)	Pre-equalisation moisture content gradient (%)				Post-equalisation moisture content gradient (%)			
	Case 1	Core	Case 2	Class	Case 1	Core	Case 2	Class
12	10.1	11.5	9.8	B	11.1	11.7	11.0	A
12	10.6	12.3	10.3	B	12.1	12.5	11.9	A
12	9.6	11.0	9.1	B	11.2	11.7	11.0	A
19	10.0	12.2	10.2	C	11.8	12.4	11.3	B
19	10.2	14.3	10.2	E	11.2	12.4	11.5	A
19	9.2	11.4	9.9	B	11.2	11.7	11.0	A
25	10.0	10.3	8.9	B	11.2	12.1	11.0	B
25	11.1	13.3	9.6	D	12.1	13.6	11.7	B
25	11.6	16.3	11.5	E	11.9	14.1	12.3	C
25	11.3	14.4	11.4	D	12.3	13.8	12.0	B
50	14.1	22.4	14.2	na	16.7	22.9	15.6	na
50	16.0	24.0	14.9	na	15.8	23.0	14.4	na

Table 5A.3 *Pre and post-equalisation moisture content gradient and drying quality class for mulga boards in trial 2*

Board thick-ness (mm)	Pre-equalisation moisture content gradient (%)				Post-equalisation moisture content gradient (%)			
	Case 1	Core	Case 2	Class	Case 1	Core	Case 2	Class
12	11.2	13.7	11.7	C	10.5	10.2	10.1	A
12	9.4	10.6	9.8	B	13.0	13.3	13.0	A
12	11.7	14.2	12.2	C	15.1	14.5	14.7	A
19	9.7	11.4	9.7	B	11.6	11.9	11.5	A
19	9.9	11.0	9.5	B	13.1	12.2	12.2	A
19	10.1	11.9	10.2	B	11.6	11.6	11.1	A
25	10.3	11.7	10.6	B	10.1	10.5	10.3	A
25	9.9	13.0	10.2	D	11.4	12.3	11.2	B
25	9.5	12.8	10.7	D	11.1	13.1	11.9	B
25	10.2	12.4	10.2	C	13.7	13.4	12.5	B
50	12.1	17.8	11.7	E	12.4	17.3	12.0	E
50	11.1	16.3	11.0	E	12.2	15.2	11.4	C

Table 5A.4 *Pre and post-equalisation moisture content gradient and drying quality class for gidgee boards in trial 1*

Board thickness (mm)	Pre-equalisation moisture content gradient (%)				Post-equalisation moisture content gradient (%)			
	Case 1	Core	Case 2	Class	Case 1	Core	Case 2	Class
12	12.3	14.2	12.9	B	12.9	13.1	12.2	A
12	11.7	13.4	12.1	B	11.9	12.3	11.9	A
12	11.0	12.4	11.2	B	12.4	12.4	12.0	A
25	11.0	13.6	11.3	C	10.5	11.3	10.7	A
25	10.9	13.7	11.1	C	10.8	11.5	10.7	A
25	10.5	14.0	12.5	D	10.7	11.1	10.9	A
50	10.5	13.5	10.7	C	10.6	11.9	9.2	C
50	9.2	11.6	9.2	C	10.5	10.3	10.5	A

Table 5A.5 *Pre and post-equalisation moisture content gradient and drying quality class for gidgee boards in trial 2*

Board thickness (mm)	Pre-equalisation moisture content gradient (%)				Post-equalisation moisture content gradient (%)			
	Case 1	Core	Case 2	Class	Case 1	Core	Case 2	Class
12	11.3	12.3	10.1	C	11.7	12.8	12.6	B
12	10.7	13.5	11.5	C	12.6	13.2	12.3	A
12	10.6	11.9	10.4	B	12.6	12.8	12.6	A
25	11.9	15.3	11.2	E	11.7	13.0	12.8	B
25	11.0	14.8	10.5	E	12.0	12.5	12.1	A
25	12.4	16.9	12.1	E	13.4	14.9	12.9	B
50	16.2	20.4	17.0	na	18.0	21.2	16.6	na
50	17.2	23.5	16.4	na	16.2	22.2	19.3	na

Appendix 5C. Assumptions employed in the financial analysis of seasoning methods

5C.1 Assumed dimensions of boards to be dried

Board thickness impacts upon drying time and the capacity of the kiln. Kiln capacity and drying times are discussed below. The QFRI mulga and gidgee sawing studies aimed to maximise green-off-saw recovery. Table 5A.6 presents the proportion of total green-off-saw volume by board thickness achieved in these studies. The final column of Table 5A.6 is believed to reflect a desirable sawing strategy for the western hardwoods resource and has been adopted for the financial analyses of seasoning. The sawing strategy is based on flooring, furniture and craftwood markets, where board thickness greater than 12 mm is desirable; however, small-scale producers are assumed to reduce their inventories of slow drying, 50 mm thick boards to less than could potentially be sawn.

Table 5A.6 *Proportion of sawn volume of mulga and gidgee by board thickness*

Board thickness (mm)	Proportion of total sawn volume (%)			
	Mulga	Gidgee	Average	Assumed sawing strategy
12	32	9	20.5	20
25	29	37	33	50
50 +	39	54	46.5	30

5C.2 Assumed kiln capacities

Kiln capacity will impact upon the total volume of timber that can be dried in any given period. In Australia, solar kilns up to 15 m^3 capacity and dehumidifier kilns up to 12 m^3 capacity for 50 mm boards are available for between $20,000 and $35,000, which appear to be suitable for small-scale producers of western Queensland timbers. To facilitate comparability of solar and dehumidifier kiln costs, a capacity of 12 m^3 of 50 mm boards has been adopted for both the solar and dehumidifier kiln. Table 5A.7 indicates the kiln capacity for different board thicknesses and the average capacity of the kiln given the sawing strategy from Table 5A.6. An 80% efficiency factor has been assumed to account for the kiln volume lost because of short and otherwise irregularly shaped boards that will be seasoned. McNaught (2002) asserted that this level is appropriate given that kilns drying softwoods operate on about a 90% efficiency factor.

5C.3 Assumed drying times for mulga and gidgee and annual solar and dehumidifier kiln capacities

Table 5A.8 presents the averages of mulga and gidgee unprotected and protected air drying times, which have been calculated from Tables 5.3 and 5.4. Based on the assumed sawing strategy in Table 5A.6, weighted average unprotected and protected air drying times of 17.9 weeks and 15.7 weeks respectively, have been estimated. These times have been adopted for the financial analyses to estimate the opportunity cost of air drying.

Table 5A.7 *Assumed solar and dehumidifier kiln capacities*

Board thickness (mm)	Assumed sawing strategy (%)	Kiln capacity (m^3)	Average kiln capacity for assumed sawing strategy (strategy % x capacity) (m^3)
12	20	7.0	1.4
25	50	9.6	4.8
50	30	12.0	3.6
Total			9.8
Assuming 80% efficiency factor			7.8

Table 5A.8 *Average air drying time for mulga and gidgee to 12% moisture content*

Board thickness (mm)	Air drying time (weeks)			
	Unprotected air dry		Protected air dry	
	Average mulga and gidgee	Weighted by sawing strategy	Average mulga and gidgee	Weighted by sawing strategy
12	5.5	1.1	4.5	0.9
25	18	9.0	16	8.0
50	26	7.8	22.5	6.8
Total		17.9		15.7

Table 5A.9 presents the average drying times for mulga and gidgee boards achieved in QFRI solar and dehumidifier kilns in Brisbane, as reported in Tables 5.3 and 5.4. To account for the lower relative humidity, higher day-time temperatures and greater number of sunny days in western Queensland, McNaught (2002) asserted that kiln drying on farm may be completed in about 85% of the time required in Brisbane. Utilising the assumed sawing strategy in Table 5A.6, the weighted average drying time per charge in the solar and dehumidifier kilns is 6.1 weeks and 6.45 weeks respectively. If kilns were operated at full capacity all year round, then annual output of dried timber would be approximately 67 m^3 (52 wks/yr / 6.1 wks/charge x 7.8 m^3) from the solar kiln and 64 m^3 (52 wks/yr / 6.45 wks/ charge x 7.8) from the dehumidifier kiln.

Solar and dehumidifier kiln manufacturers generally recommend that timber be air dried to between 20% and 25% prior to kiln drying, to limit degrade in the drying boards (McNaught 1993; Stewart and Hanson 1998; Burke 2002; Olson 2002). Figures 5.2 to 5.5 indicated that 25 mm and 50 mm boards can be air dried under cover to 20% moisture content within three weeks. McNaught (2002) asserted that 12 mm boards can be placed straight into kilns. For the purposes of estimating the opportunity cost of air drying of boards prior to placement in kilns, a weighted (according to the sawing strategy of Table 5A.6) average air drying time of 2.4 weeks has been adopted before kiln drying. This accounts for the fact that 12 mm boards are not air dried prior to kiln drying. It should be noted that, in the mulga and gidgee seasoning trials, boards were dried to a satisfactory quality when placed immediately into the solar and dehumidifier kilns without prior air drying.

Table 5A.9 *Solar and dehumidifier kiln drying times for mulga and gidgee to 12% moisture content (no prior air drying)*

Board thickness (mm)	Solar kiln drying time (weeks)			Dehumidifier kiln drying time (weeks)		
	Avge[1]	W QLD[2]	Weighted by sawing strategy	Avge[1]	W QLD[2]	Weighted by sawing strategy
12	3	2.6	0.5	3	3	0.6
25	6	5.1	2.6	6	6	3.0
50	12	10.2	3.1	9.5	9.5	2.9
Total			6.1			6.45

Notes: Columns do not sum due to rounding errors

1. Average of Brisbane drying times for mulga and gidgee taken from QFRI drying trials. Where test boards were only dried to 13% to 14% moisture content, two weeks have been added to account for additional drying to 12%.
2. For solar kiln drying in western Queensland, drying times are assumed to be 85% of Brisbane drying times to account for lower relative humidity, higher day-time temperatures and greater number of sunny days (McNaught 2002). Environmental conditions in western Queensland will have no impact on dehumidifier kiln drying times (McNaught 2002).

Following the advice of McNaught (2002), it has been assumed that air drying to 20% moisture content would reduce subsequent kiln drying times of 25 mm and 50 mm boards by the periods indicated in columns two and six of Table 5A.10 for solar and dehumidifier kilns respectively. Columns five and nine of Table 5A.10 report the weighted average (according to the sawing strategy of Table 5A.5) kiln drying times for kiln dried timber with prior air drying to 20% moisture content. The weighted average drying time per charge in the solar and dehumidifier kilns is 5.2 weeks and 5.5 weeks respectively. If kilns were operated at full capacity all year round, then annual output of dried timber would be approximately 79 m^3 (52 wks/yr / 5.2 wks/charge x 7.8 m^3) from the solar kiln and 75 m^3 (52 wks/yr / 5.5 wks/charge x 7.8 m^3) from the dehumidifier kiln.

Table 5A.10 *Time for combination air and kiln drying of mulga and gidgee on-farm to 12% moisture content*

Board thick-ness (mm)	Solar kiln drying time (weeks)				Dehumidifier kiln drying time (weeks)			
	Air dry time saving[1]	Avge less saving[2]	W QLD[3]	Wt by sawing strat.	Air dry time saving[1]	Avge less saving[2]	W QLD[3]	Wt by sawing strat.
12	0	3	2.6	0.5	0	3	3	0.6
25	1	5	4.3	2.2	1	5	5	2.5
50	2	10	8.5	2.6	1.6	7.9	7.9	2.4
Total				5.2				5.5

Notes:

1. Assumed solar and dehumidifier kiln drying time saved through prior air drying of boards to 20% moisture content (McNaught 2002).
2. Average solar and dehumidifier kiln drying times from Table 5A.9 less the saving in kiln drying time through prior air drying.
3. For solar kiln drying in western Queensland, drying times are assumed to be 85% of Brisbane drying times to account for lower relative humidity, higher day-time temperatures and greater number of sunny days (McNaught 2002). Environmental conditions in western Queensland will have no impact on dehumidifier kiln drying times (McNaught 2002).

6. Graded recovery of seasoned mulga and gidgee boards

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The economics of timber production are highly sensitive to graded recovery. Mulga and gidgee boards have been graded according to AS2796 – 1999 – Timber – Hardwood - Sawn and Milled Products, and a seasoning grading method developed by the Queensland Forestry Research Institute (QFRI) to ascertain drying degrade. High feature grade recovery of mulga and gidgee was found to be in the order of 10% of log volume. Only 60% of high feature grade board volume came from boards at least 0.9 m in length. Distortion and wane were primarily responsible for this low recovery. Seasoning grading[18] indicated that unprotected air drying resulted in higher levels of drying degrade than in protected air drying, or solar or dehumidifier kiln drying. However, grading mulga and gidgee boards in accordance with AS2796 – 1999 suggested that the level of drying degrade was independent of the seasoning method. Appearance grading of conventional kiln-dried material indicated that the drying schedules adopted could produce boards of sound appearance quality, when the thickness of those boards was not greater than 25 mm. However, high levels of drying degrade were common in boards exceeding 25 mm in thickness, indicating a need for new conventional kiln schedules to be developed for western Queensland hardwoods. These grading results, coupled with the seasoning times and financial analyses in Chapter 5, suggest that protected air drying is likely to be the most appropriate seasoning method for small-scale production of western Queensland hardwoods.

6.1 Introduction

Chapter 4 reported green-off-saw (GOS) recoveries from portable sawmilling trials with mulga (*Acacia aneura*) and gidgee (*A. cambagei*); however, this is unlikely to be the final saleable product. GOS boards, generally, include features that are undesirable for many product markets, such as wane, decay, insect damage and splits. Different wood product markets have particular specifications for timber inputs and require defects such as these to be docked from boards. For many applications, timber must also be seasoned and boards can be damaged during this process. Therefore, a proportion of the timber recovered GOS from log volume will not be saleable. The proportion of GOS volume that goes to waste has large implications upon the economics of timber processing. In order to adequately assess the financial viability of operations processing western Queensland hardwoods, it is necessary to estimate graded timber recovery. As with most other facets of western Queensland hardwood production, there is a scarcity of information about likely graded recoveries. Therefore, the Queensland Forestry Research Institute (QFRI) incorporated a timber grading component into its research of western Queensland hardwoods.

[18] A grading technique developed by QFRI to assess drying degrade, which facilitates assessment of the suitability of different drying techniques for particular timbers.

Grading has been conducted on the mulga and gidgee boards from the portable sawmilling trials and seasoning studies from Chapters 4 and 5. This enabled the graded recoveries of unprotected air drying, protected air drying, solar kiln, dehumidifier kiln and conventional kiln drying regimes to be compared. This chapter proceeds with a description of the grading methodologies, which is followed by a presentation of grading results, including reasons for mulga and gidgee boards not being suitable for appearance grade products. A discussion follows, wherein graded recoveries from mulga and gidgee sawlogs are compared with several other milled species in Australia. The implications of grading on the selection of an appropriate seasoning method for mulga and gidgee are also discussed. Concluding comments follow.

6.2 Grading methodology

In the absence of any grading standard for western Queensland hardwoods, the *Australian Standard (AS) 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products* has been adopted. A seasoning grading technique developed by QFRI to assess drying degrade, has also been applied to the mulga and gidgee boards. Grading methodologies for the air, solar kiln and dehumidifier kiln dried boards differed from the conventional kiln dried mulga and gidgee boards.

6.2.1 Seasoning and visual grading methodology for air, solar kiln and dehumidifier kiln dried mulga and gidgee boards

Following seasoning, all air, solar and dehumidifier kiln dried mulga and gidgee boards were *seasoning graded* according to a technique developed by QFRI. All sides of each board were examined and each board assigned scores from zero (no drying degrade) to six (100% of the board surface exhibited drying degrade), indicating the severity of surface checking, heart associated checking and end splitting. At this time, distortion of each board in the form of spring, twist and bow was also measured and recorded for the board's original GOS size. It should be noted that, in some cases, re-sawing or docking of boards could have reduced or eliminated distortion from the re-sawn boards. Hence, reported levels of distortion may overestimate what could be achieved with mulga and gidgee.

The solar and dehumidifier kiln dried mulga boards and all gidgee boards were then visually graded according to *Australian Standard (AS) 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products*. Except for seasoning related degrade, such as checking, end splitting and distortion, it is reasonable to assume that solar and dehumidifier kiln dried mulga is representative of the air dried material that was not visually graded to *AS 2796 – 1999*. The *AS 2796 – 1999* places timber into one of three grades, which in increasing order of board quality are: high feature grade; medium feature grade; and select grade. A hypothetical *clear* grade, not part of the *AS 2796 – 1999*, was also created to record the volume of timber that was completely clear of defects of any kind. Timber boards that failed to make the high feature grade of *AS 2796 – 1999* were rejected.

Visual grading to *AS 2796 – 1999* involved inspection of all sides of each sawn board for defects, such as wane, insect damage, tight knots, and decay, to determine the grade assigned to the board. Boards were visually docked in length and width to remove defects and maximise the recovery of grade quality timber. On the recommendation of timber product manufacturers, grading rules were modified to allow a minimum graded length of 200 mm. Lengths over 200 mm were incremented by 100 mm intervals.

The *AS 2796 – 1999* also specifies maximum levels of distortion (spring, twist and bow) for flooring and joinery applications. The distortion measurements recorded during seasoning grading have been utilised and boards were classified according to their suitability for flooring and joinery. Many mulga and gidgee boards had lengths less than the minimum length for which distortion specifications are detailed in the standard. In these cases, the specifications of *AS 2796 – 1999* were extrapolated to the length of the board. Therefore, distortion results should be applied cautiously.

6.2.2 Methodology for grading conventional kiln dried mulga and gidgee boards

Residual stresses can develop in dried timber, leading to distortion when machined after drying. This is undesirable in many dried wood products. In accordance with *AS/NZS 4787:2001 – Timber-Assessment of Drying Quality*, residual drying stresses were measured on each board before and after equalisation[19] using the *ripping test* (Waterson 1997). Class ratings were determined for each board and grouped class ratings were assigned for the 12 mm, 19 mm and 25 mm thick boards. The group class rating is the class rating that at least 90% of the sample boards conformed to (as detailed in *AS/NZS 4787:2001*). The class ratings are defined in Appendix 6A.

Surface checking, end checking and end splitting were measured in accordance with *AS/NZS 4787:2001*. Each board was assigned a class rating based on the side exhibiting the greatest level of defect. A 90% group class rating for the 12 mm, 19 mm, and 25mm boards was also derived. Distortion in the form of twist, spring, bow, cup and collapse was assessed according to *AS 2082 – 1979 – Visually Stress Graded Hardwood for Structural Purposes*. The boards were not given a class or grade as the board lengths were below the minimum required by the standard and extrapolations were not attempted.

6.3 Results of grading mulga and gidgee

Grading of timbers dried in the conventional kiln was conducted differently to the grading of the air, solar kiln and dehumidifier kiln dried boards; hence results are presented separately.

6.3.1 Outcomes of seasoning and visual grading of air, solar kiln and dehumidifier kiln dried mulga and gidgee

Tables 6.1 and 6.2 report the graded recovery of mulga and gidgee boards according to *AS 2796-1999- Timber–Hardwood-Sawn and Milled Products*, as a percentage of GOS volume and log volume respectively. The recovery of high feature grade mulga and gidgee, excluding distortion, expressed as a proportion of GOS volume and log volume, was found to be approximately 35% and 10% respectively across air drying and solar and dehumidifier kiln drying regimes. The recovery of clear mulga and gidgee timber was low.

Figures 6.1 and 6.2 illustrate the relationship between sawlog centre diameter and graded recovery for mulga and gidgee respectively. Few sawlogs in the largest diameter classes were milled, so these results should be applied cautiously; however they indicate increasing graded recoveries with sawlog centre diameter for mulga and stable recoveries for gidgee. Figure 6.3 presents the original distribution of GOS gidgee boards and the number of graded boards produced by length and grade. Similar results are not available for mulga, because only the total length of graded mulga boards was recorded, not the number of graded boards that an original mulga board was (hypothetically) re-sawn into. This Figure illustrates the large number of short graded board lengths recovered. Approximately 40% of total recovered high feature board volume was in pieces less than 0.9 m in length.

Appendix 6B details the severity of seasoning degrade for mulga and gidgee in terms of surface checking, surface heart checking and end splitting, as recorded during seasoning grading. The appendix highlights that drying degrade increases with board thickness for both mulga and gidgee under protected air drying, unprotected air drying, and solar and dehumidifier kiln drying methods. This is probably largely attributable to the difficulty in sawing thick boards free from heart, given the relatively small girth of western hardwood trees. The heart zone is often difficult to season successfully due to poor wood properties (*e.g.* spiral grain). Figures 6.4 to 6.6 summarise the results

[19] The equalisation procedure is described in Chapter 5.

from Appendix 6B, presenting the average proportion of 12 mm, 25 mm and 50 mm mulga and gidgee boards where surface checking, surface heart checking and end splitting accounted for at least 10% of the board surface area. The study had not been designed to test for differences in drying degrade between species and no conclusions on differences between species can be drawn from the results.

The reasons (excluding distortion) for approximately 65% of mulga and gidgee sawn volume or 90% of log volume failing to meet *AS 2796-1999* for high feature boards are outlined in Figures 6.7 to 6.9. These figures indicate that wane, insect damage and decay are among the most important reasons for downgrade from high feature grade in air and kiln dried mulga and gidgee boards. Figure 6.10 illustrates typical decay and heart associated defects in a gidgee board.

Figures 6.11 to 6.14 present the primary reasons for downgrade of solar and dehumidifier kiln dried mulga boards when distortion (spring, bow and twist) is included. Appendix 6C exhibits the same information for air and kiln dried gidgee boards. These figures indicate that distortion is the most common reason (70%) why mulga and gidgee boards did not meet specifications for high feature joinery applications, and generally the second most common reason (15% to 30%) for boards being unsuitable for high feature flooring. However, there is generally no substantial difference in distortion between seasoning methods for the same species and product category.

Table 6.1 *Graded recovery of mulga and gidgee boards expressed as a percentage of green-off-saw volumes*

Seasoning method	High feature grade			Medium feature grade			Select feature grade			Clear grade		
	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing
Mulga												
Solar kiln	31.1	7.4	23.4	23.0	6.6	18.3	21.4	6.1	17.0	5.7	1.9	5.3
Dehumidifier	40.3	9.7	32.2	30.7	8.5	26.5	27.7	8.4	23.7	8.2	3.0	7.7
Combined [1]	*35.9*	*8.6*	*28.0*	*27.0*	*7.6*	*22.6*	*24.7*	*7.3*	*20.5*	*7.0*	*2.5*	*6.5*
Gidgee												
Solar kiln	41.6	9.6	30.6	40.3	9.2	29.9	38.5	8.9	28.8	1.7	0.5	1.6
Dehumidifier	27.4	6.6	16.1	26.3	6.2	15.2	24.9	6.1	14.5	1.7	0.2	0.5
Combined [1]	*35.5*	*8.3*	*24.4*	*34.3*	*8.0*	*23.6*	*32.7*	*7.7*	*22.7*	*1.7*	*0.3*	*1.4*
Gidgee												
Unprotected air dry	33.9	9.0	23.5	33.4	8.9	23.2	31.0	8.6	21.4	1.5	0.5	0.8
Protected air dry	34.8	6.8	22.3	34.1	6.7	22.0	32.1	6.4	20.8	1.0	0.0	0.3
Combined [1]	*34.3*	*7.9*	*22.9*	*33.8*	*7.8*	*22.6*	*31.6*	*7.5*	*21.1*	*1.2*	*0.2*	*0.5*

Notes: All grades are reported independently of each other.

1. Combined is the average across solar and dehumidifier kiln dried boards and unprotected and protected air dried boards.

Table 6.2 *Graded recovery of mulga and gidgee boards expressed as a percentage of log volumes*

Seasoning method	High feature grade			Medium feature grade			Select feature grade			Clear grade		
	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing	Excl. distortion	Joinery	Floor -ing
mulga												
Solar kiln	10.8	2.6	8.1	8.0	2.3	6.3	7.4	2.1	5.9	2.0	0.7	1.8
Dehumidifier	13.8	3.3	11.1	10.7	3.0	9.2	9.6	2.9	8.2	2.8	1.1	2.7
Combined [1]	*12.4*	*3.0*	*9.7*	*9.4*	*2.6*	*7.8*	*8.5*	*2.5*	*7.1*	*2.4*	*0.9*	*2.3*
gidgee												
Solar kiln	11.5	2.7	8.5	11.1	2.6	8.2	10.6	2.4	7.9	0.5	0.1	0.5
Dehumidifier	7.6	1.8	4.4	7.2	1.7	4.2	6.9	1.7	4.0	0.5	0.1	0.1
Combined [1]	*9.8*	*2.3*	*6.7*	*9.5*	*2.2*	*6.5*	*9.0*	*2.1*	*6.2*	*0.5*	*0.1*	*0.4*
gidgee												
Unprotected air dry	9.3	2.5	6.5	9.2	2.5	6.4	8.6	2.4	5.9	0.4	0.1	0.2
Protected air dry	9.6	1.9	6.2	9.4	1.8	6.1	8.9	1.8	5.8	0.3	0.0	0.1
Combined [1]	*9.5*	*2.2*	*6.3*	*9.3*	*2.1*	*6.2*	*8.7*	*2.1*	*5.8*	*0.3*	*0.1*	*0.1*

Notes: All grades are reported independently of each other.

1. Combined is the average across solar and dehumidifier kiln dried boards and unprotected and protected air dried boards.

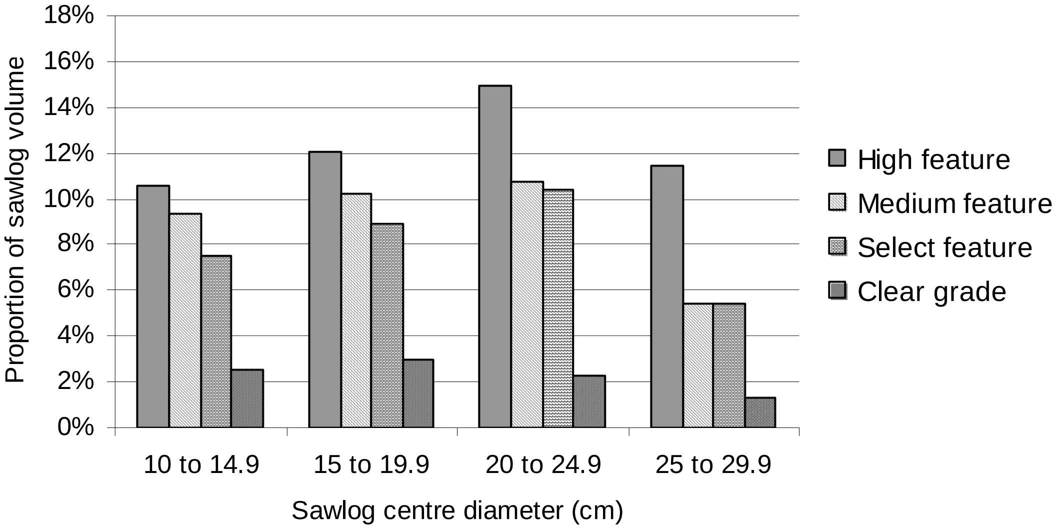

Figure 6.1 *Graded recovery of mulga boards from sawlog volume by sawlog centre diameter*

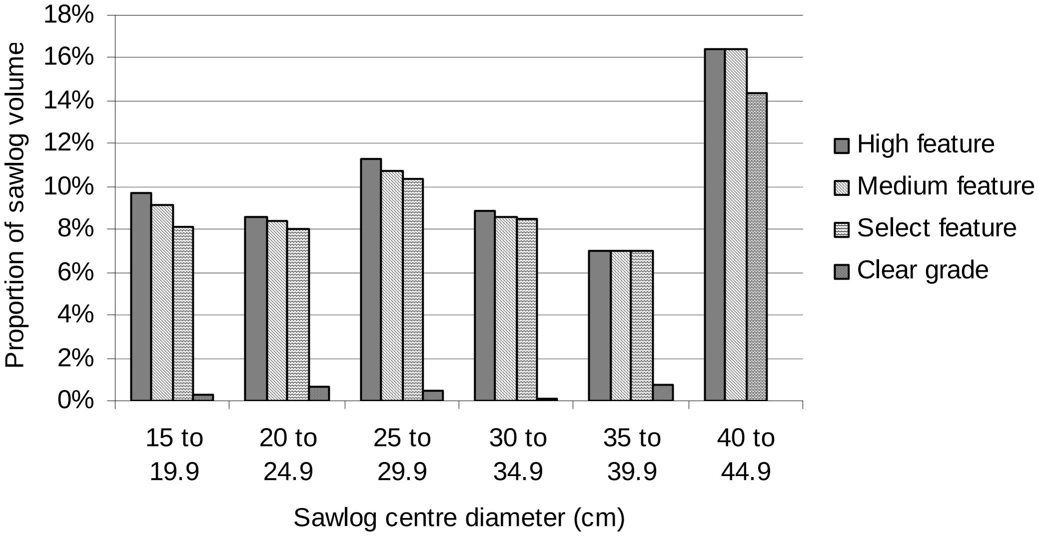

Figure 6.2 *Graded recovery of gidgee boards from sawlog volume by sawlog centre diameter*

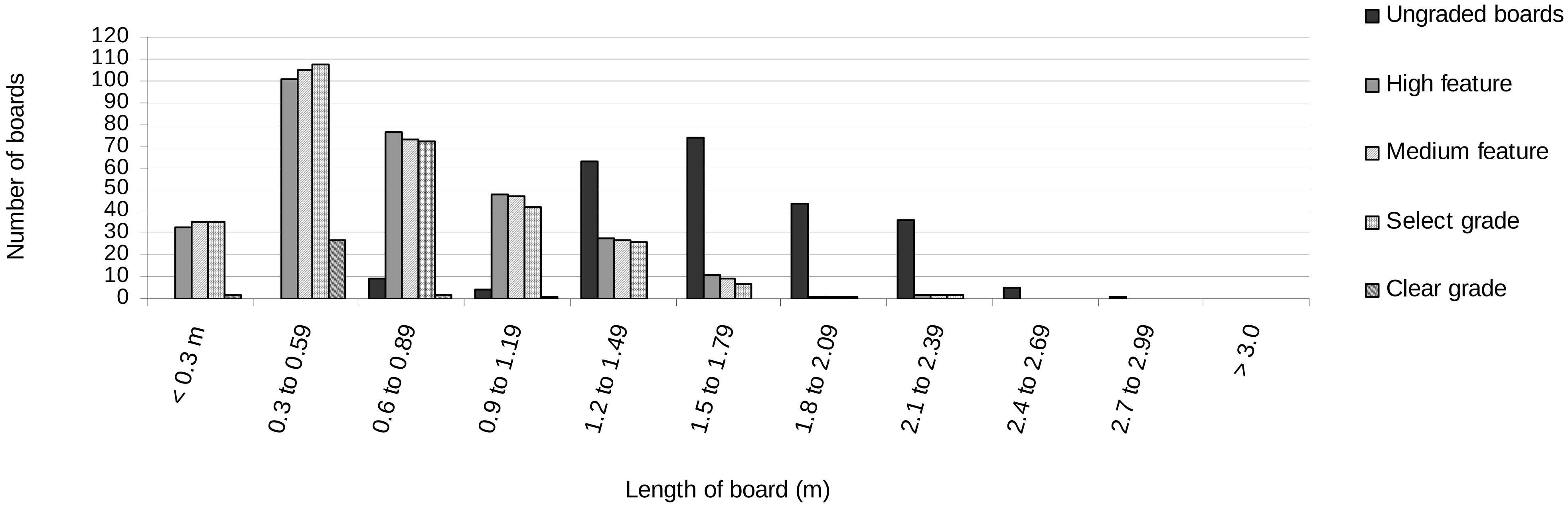

Figure 6.3 *Number of sawn gidgee boards recovered by board length and grade, excluding distortion*

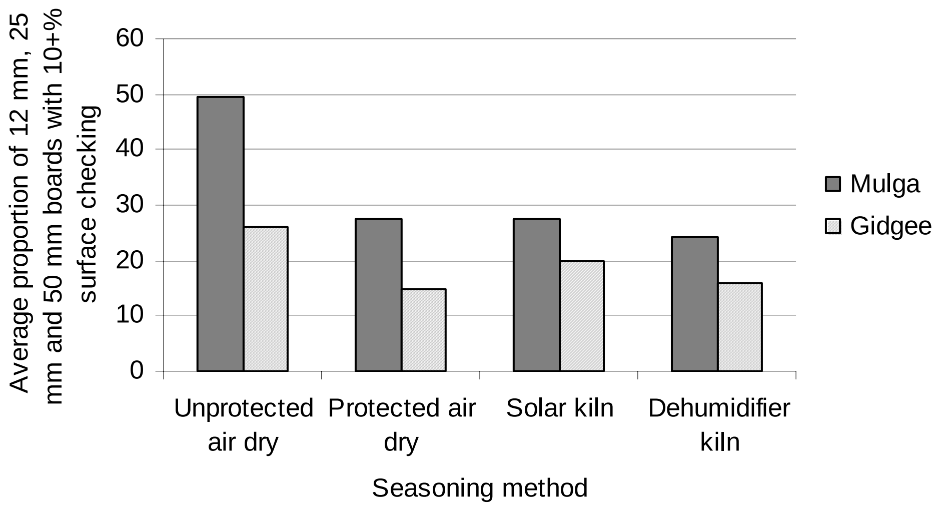

Figure 6.4 *Average proportion of 12 mm, 25 mm and 50 mm mulga and gidgee boards with at least 10% surface checking by seasoning method*

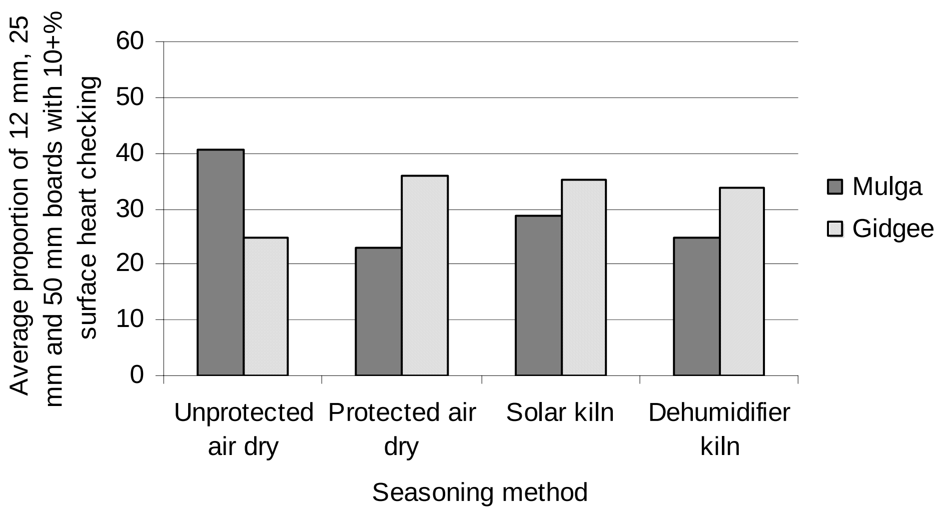

Figure 6.5 *Average proportion of 12 mm, 25 mm and 50 mm mulga and gidgee boards with at least 10% surface <u>heart</u> checking by seasoning method*

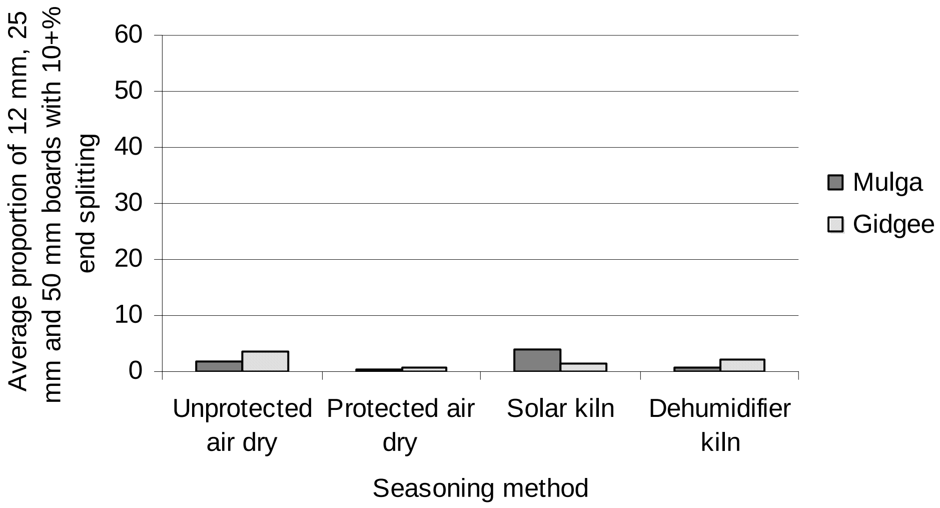

Figure 6.6 *Average proportions of 12 mm, 25 mm and 50 mm mulga and gidgee boards with at least 10% end splitting by seasoning method*

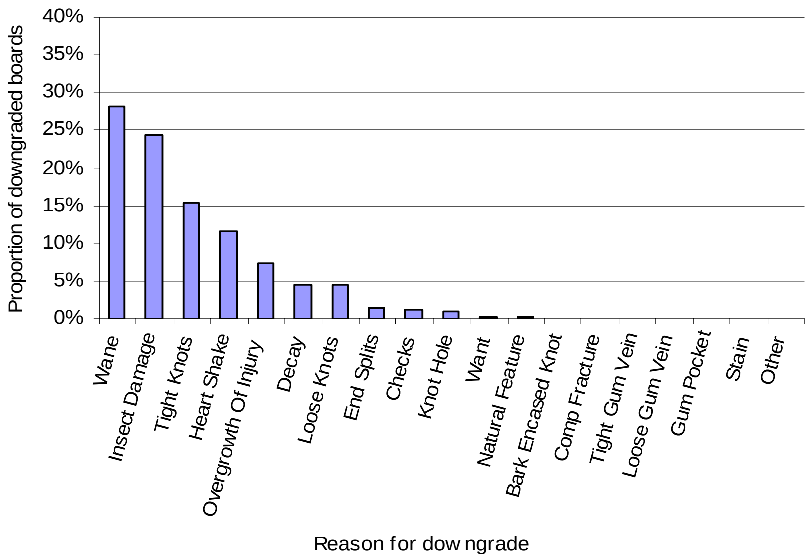

Figure 6.7 *Reasons for downgrade of dehumidifier and solar kiln dried mulga boards to high feature grade, excluding distortion*

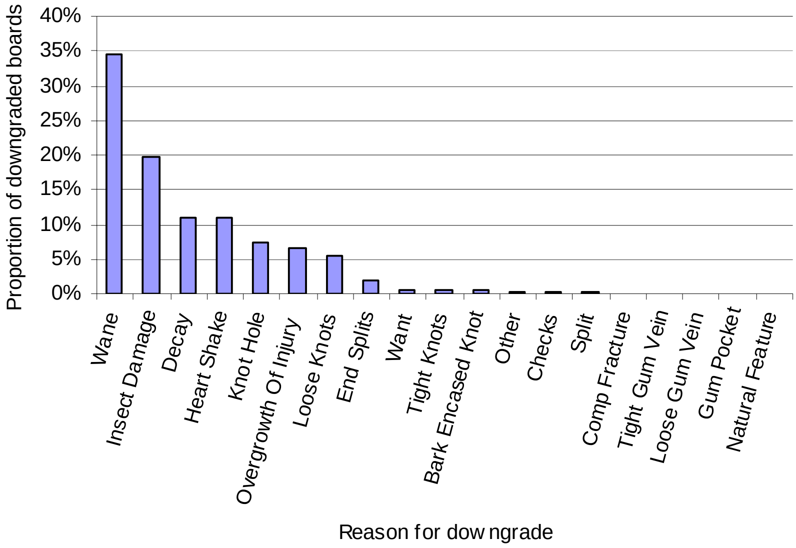

Figure 6.8 *Reasons for downgrade of dehumidifier and solar kiln dried gidgee boards to high feature grade, excluding distortion*

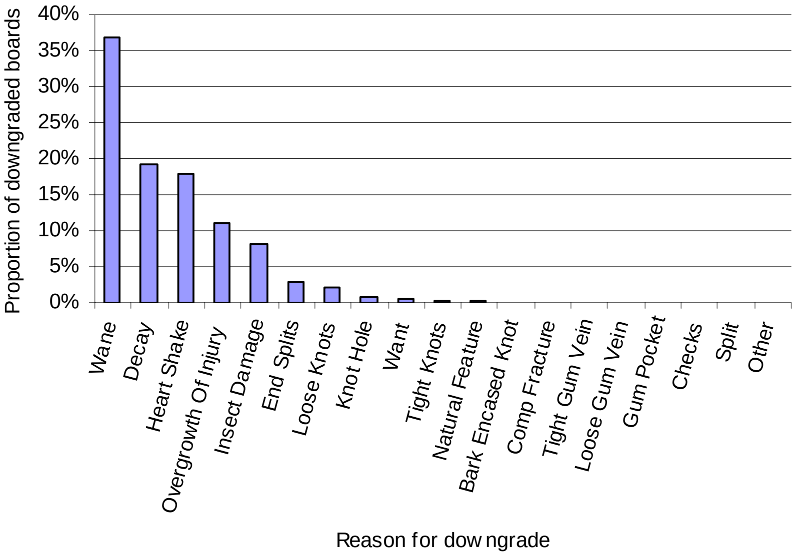

Figure 6.9 *Reasons for downgrade of unprotected and protected air dried gidgee boards to high feature grade, excluding distortion*

Figure 6.10 *Decay and heart associated defects in a gidgee board*

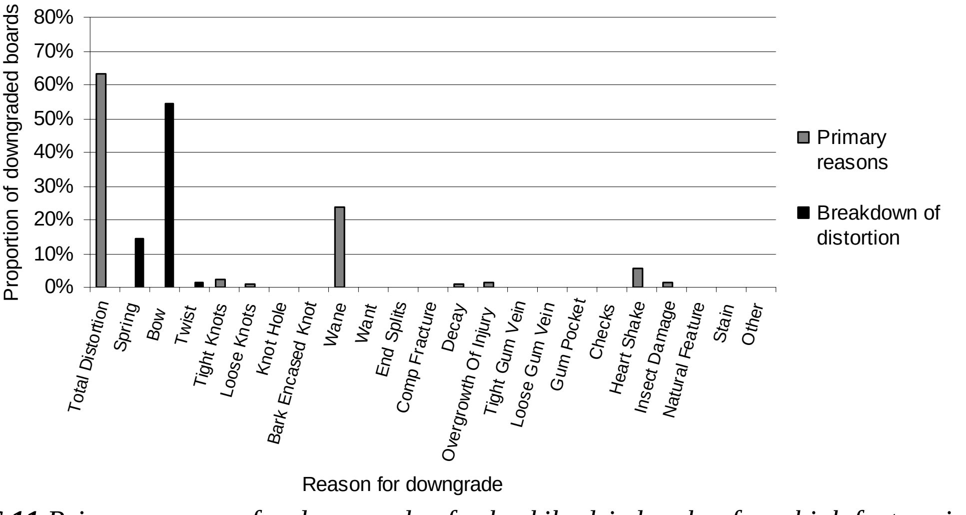

Figure 6.11 *Primary reasons for downgrade of solar kiln dried mulga from high feature joinery grade*

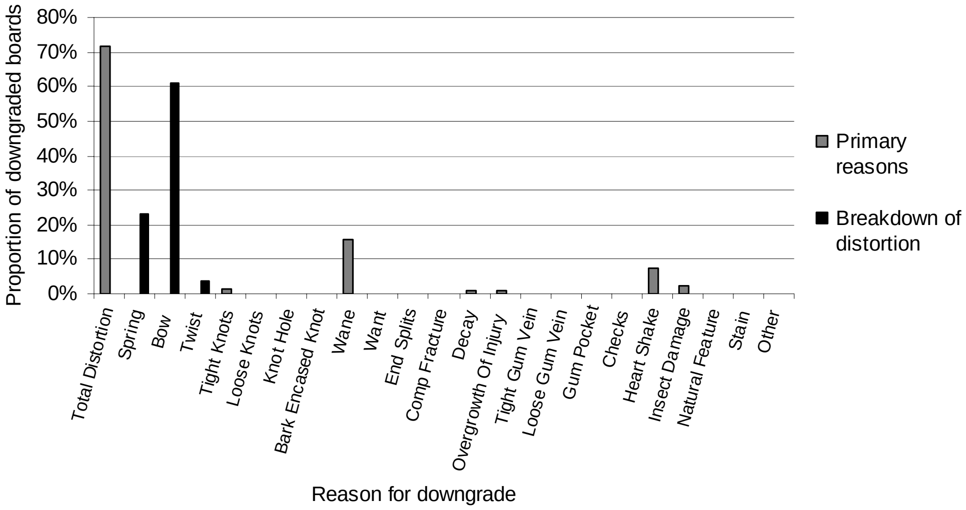

Figure 6.12 *Primary reasons for downgrade of dehumidifier kiln dried mulga from high feature joinery grade*

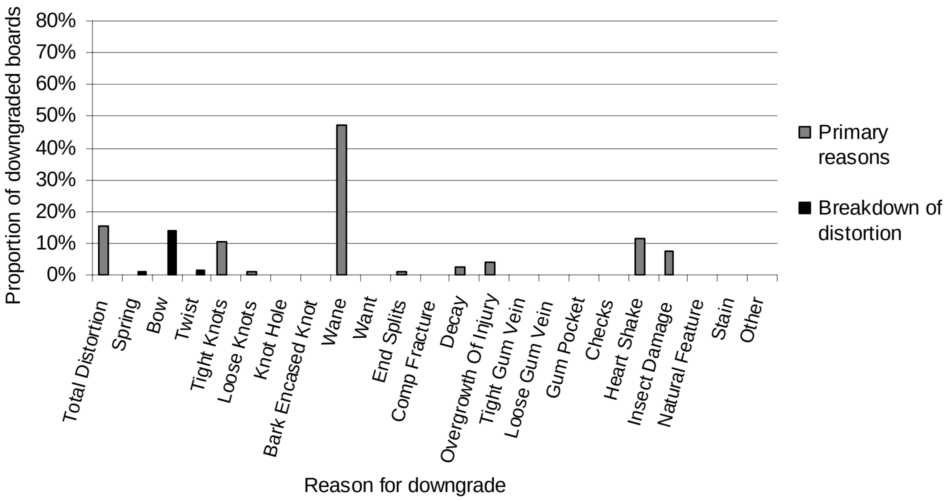

Figure 6.13 *Primary reasons for downgrade of solar kiln dried mulga from high feature flooring grade*

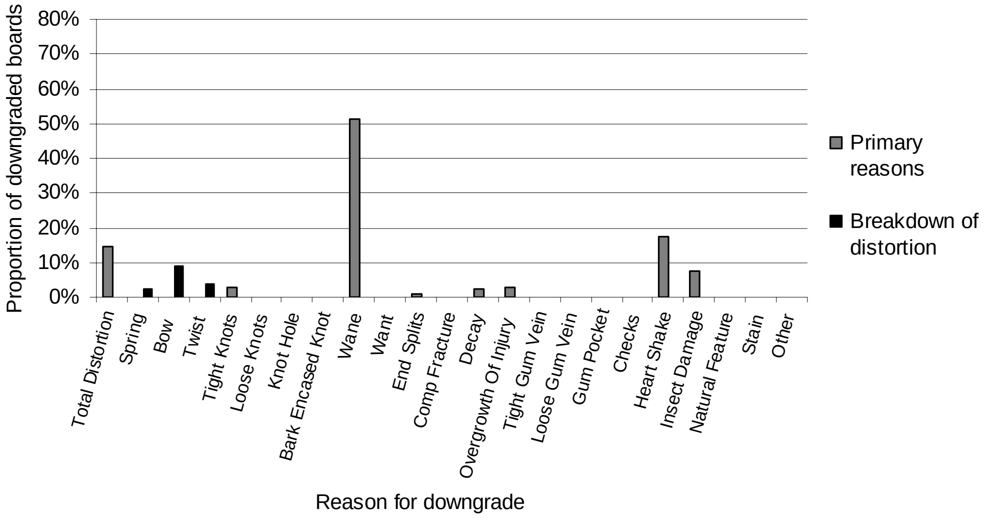

Figure 6.14 *Primary reasons for downgrade of dehumidifier kiln dried mulga from high feature flooring grade*

6.3.2 Outcomes of grading conventional kiln dried mulga and gidgee boards

Insufficient volumes of timber were dried in the conventional kiln to estimate graded recovery. Grouped class ratings for residual drying stress, and surface checking, end checking and end splitting are presented in Tables 6.3 and 6.4 respectively. The complete residual drying stress, checking and splitting results are detailed in Appendix 6D. The classes are defined in Appendix 6A.

Drawing conclusions from the distortion results from the conventional kiln drying trial was difficult due to the short board lengths available for the study, which are not represented in the standard *AS 2082 – 1979 – Visually Stress Graded Hardwood for Structural Purposes*. Nevertheless, Tables 6A.17 to 6A.20 in Appendix 6D present the distortion outcomes from conventional kiln drying of mulga and gidgee. Note that distortion may have been reduced if stack weights were employed throughout drying.

Table 6.3 *Grouped class rating for residual drying stress in 12 mm, 19 mm and 25 mm conventional kiln dried mulga and gidgee boards pre and post-equalisation*

Species	Trial number	Pre-equalisation residual drying stress grouped class rating	Post-equalisation residual drying stress grouped class rating
Mulga	1	A	A
	2	B	A
Gidgee	1	C	A
	2	B	B

Table 6.4 *Grouped class rating for surface checking, end checking and end splitting in 12 mm, 19 mm and 25 mm conventional kiln dried mulga and gidgee*

Species	Trial	Surface checking	End checking	End split
Mulga	1	E	B	B
	2	E	B	B
Gidgee	1	E	B	B
	2	E	A	C

6.4 Discussion

Conclusions cannot be drawn confidently from the results of the conventional kiln drying trial due to the small sample size. Given also that the board quality assessment methodologies adopted in this trial were different from the air, solar kiln and dehumidifier kiln trials, the conventional kiln drying trial is discussed separately in Section 6.4.2.

Graded recoveries from log volume in the air, solar kiln and dehumidifier kiln drying trials reported in Tables 6.1 and 6.2, are low compared with traditional sawlog resources. East-coast Queensland native hardwoods (cut to mixed structural and board products) typically have dried and graded recoveries of about 20% to 30% of log volume, and graded recoveries from slash and Caribbean pine thinnings (cut to structural products) are generally in the order of 30% to 35% of log volume (Hopewell *et al.* 2000). Evans (1999, cited in Leggate *et al.* 2000) asserted that hardwood sawmills in Queensland, sawing natural forest timbers, typically recover 85% to 90% of the GOS volume (in nominal dimensions) after drying, dressing and grading for flooring and other appearance grade board products. This is equivalent to approximately 30% of log volume being saleable as appearance grade board products, which is about three-times the high feature recovery from mulga and gidgee sawlogs. Recent research on eucalypt plantations in Queensland has indicated that dried and graded recoveries from eucalypt plantation sawlogs were in the vicinity of 8% to 19% (Leggate *et al.* 2000).

The Goldfields timber resource of Western Australia is similar to the western Queensland hardwoods resource, in that the timbers have high densities and are available only in short-lengths. Siemon and Kealley (1999) reported the results of low temperature batch kiln seasoning trials on 25 mm thick boards of several Goldfields species, including redwood (*Eucalyptus transcontinentalis*), Goldfields blackbutt (*E. lesouefii*), red morrell (*E. longicornis*) and black morrell (*E. melanoxylon*). A conservative schedule was adopted to dry the timbers over a period of 90 days to minimise drying degrade. To put this schedule in perspective, the kiln drying schedules adopted in this Queensland study seasoned 25 mm mulga and gidgee boards within 10 days. Employing the *Forest Industries Federation of Western Australia (1992) Industry Standard for Seasoned Sawn and Skip-Dressed W.A. Hardwoods*, appearance grade recoveries of between 14.5% and 22.5% were achieved. These recoveries are impressive; however the diameters of the original eucalypt logs were, on average, about twice the diameter of the mulga and gidgee logs in these trials. This is likely to be a major factor contributing to the comparatively high appearance grade recoveries. Siemon and Kealley (1999) did not report seasoning costs associated with their 90-day kiln schedule, although they are likely to be high relative to the seasoning scenarios presented in Chapter 5.

Between about 6% and 10% of mulga and gidgee log volume was found to have characteristics appropriate for flooring applications. The more stringent distortion requirements placed on joinery timber meant that only approximately 2% to 3% of mulga and gidgee log volume was suitable for these applications. Leggate *et al.* (2000) reported dried and graded recoveries of flooring and joinery boards from several plantation grown eucalypts in Queensland are about twice the level achieved by mulga and gidgee in this study.

Figures 6.7 to 6.9 indicate that wane dominates the reasons for downgrade of mulga and gidgee boards. The high incidence of wane is a direct result of the small diameter of mulga and gidgee sawlogs and the re-sawing limitations of the portable sawmill used. Termites were identified as the major insect problem. An interesting finding from the grading of mulga and gidgee has been the absence of gum veins and gum pockets as reasons for downgrading from high feature. This contrasts markedly with grading studies with eucalypts (*e.g.* Siemon and Kealley 1999; Leggate *et al.* 2000). These figures also illustrate that checking and end splitting, which are forms of degrade influenced by seasoning regime, accounted for only a small proportion of the reasons for mulga and gidgee boards failing to satisfy the high feature grade of *AS 2796-1999*. Differences in the level of importance of downgrade reasons such as decay, heartshake and overgrowth of injury, between kiln and air dried gidgee boards in Figures 6.8 and 6.9 are not likely to be a result of seasoning method, but rather random variation in boards.

6.4.1 Impact of seasoning method on mulga and gidgee board degrade

Tables 6.1 and 6.2 suggest that the seasoning method may have affected the recovery of graded timber. Higher graded recoveries have been reported for dehumidifier kiln dried mulga than for solar kiln dried mulga, while the opposite was found to be the case for gidgee. If the seasoning technique was affecting graded recovery, then this should be reflected in drying related degrade, such as checking, end splitting and the level of board distortion (spring, bow and twist).

Figures 6.4 and 6.5 indicate that, for both mulga and gidgee, there was little difference in surface checking and surface heart checking between protected air drying, solar and dehumidifier kiln drying methods. Surface checking was found to be most severe in unprotected air-dried boards. For mulga, surface heart checking was also found to be most severe in unprotected air-dried boards; however, Figure 6.5 highlights an anomaly, where surface heart checking in gidgee was least severe when boards were unprotected air dried. Because of the generally poorer quality of unprotected air dried boards, it is difficult to explain this result. This is likely to be a sampling error arising from the random allocation of sample boards and not a repeatable result. Figure 6.6 illustrates that end splitting was uncommon with the western hardwood timbers and not affected by seasoning method.

Figures 6.11 to 6.14 and Appendix 6C indicate that distortion was not affected by seasoning method. There is one possible exception illustrated in Appendix 6C, where there is a 15% difference in the incidence of distortion as a downgrade reason between dehumidifier and solar kiln dried gidgee for high feature flooring (Figures 6A.3 and 6A.4). Therefore, it appears likely that differences in high feature recoveries between seasoning regimes are the result of random board variation and not a relationship between drying degrade and seasoning methodology.

Implications of visual and seasoning grading results on the selection of a seasoning method
Seasoning grading indicated that in terms of drying degrade, protected air drying, solar kiln and dehumidifier kiln drying are preferable seasoning methods to unprotected air drying. This finding appears to be supported by standard practices in the Western Australian Goldfields timber industry, where woodturners and cabinet-makers have perfected protected air drying techniques over many years (Siemon and Kealley 1999). Goldfields woodturners recommended end-sealing timbers and wrapping boards in clingwrap or a combination of nylon and plastic sheets, to encourage condensation, resulting in a humid environment where drying stresses will be minimised. However, distortion results and the grade recoveries presented in Tables 6.1 and 6.2, suggest that, in terms of *AS 2796-1999*, there is no improvement in board quality to be gained from choosing protected air drying, or solar or dehumidifier kiln drying, over unprotected air drying. While this research with mulga and gidgee has not produced conclusive evidence to warrant the promotion of a seasoning method, the results of QFRI’s seasoning grading, together with the financial analysis of Chapter 5, indicate there are likely to be financial benefits arising from the adoption of protected air drying in preference to unprotected air drying, solar kiln and dehumidifier kiln drying.

6.4.2 Discussion of conventional kiln drying of mulga and gidgee

The first mulga schedule dried mulga boards more rapidly than the second mulga trial. Similar levels of checking and splitting degrade resulted from both drying schedules for this species. The grouped class ratings of pre-equalisation moisture content distributions indicate that trial 1 was superior for mulga. Despite the difficulties in assessing the level of distortion due to small board lengths and absence of stack weights, distortion also appeared to be less severe in trial 1 mulga boards.

The second gidgee trial, with its reduced humidity conditions, seasoned gidgee boards more rapidly than the first gidgee trial. However, the benefits from reduced drying time were outweighed by the severity of checking, which was substantially deeper and wider than on gidgee boards seasoned in trial 1. The *AS/NZS 4787:2001 – Timber-Assessment of Drying Quality* standard is not designed to highlight the depth and width of checking, only its presence or absence. Consequently, gidgee trial 2 boards are unsuitable for appearance products and the grouped class ratings presented in Table 6.4 are likely to overestimate the true quality of these boards in comparison with trial 1. Nevertheless, the grouped class ratings of pre-equalisation moisture content distributions indicate that gidgee trial 2 outperformed trial 1 in this drying quality indicator. Distortion also appeared to be less severe in trial 2 gidgee boards.

Trial 1 for both species had been developed for 25 mm timber and was found to be too severe for drying 50 mm thick mulga and gidgee boards, which developed high levels of surface checking. The poor surface checking group classifications for all trials of both species are likely to have been contributed to by the high proportion of heart material in the boards. In hardwoods, the heart is generally more prone to drying degrade and is often removed during sawing of timber products from traditional hardwood species.

The equalisation phases adopted in all conventional kiln schedules were found to be suitable, since substantial improvements in moisture content gradient and residual drying stress were achieved after equalisation.

Overall, trial 1 gave acceptable seasoning results for mulga boards up to 25 mm thick. Trial 1 was also considered successful for drying appearance grade gidgee boards 12mm and 25mm thick. It is believed that a hybrid of gidgee trials 1 and 2, incorporating the initial conditions of trial 2 and the later conditions of trial 1, could provide better seasoning outcomes for gidgee than either schedule did alone.

6.5 Conclusion

The graded recoveries of mulga and gidgee (according to *AS 2796 – 1999*) were found to be low in comparison with traditionally sawn timbers in Queensland and relative to graded recoveries from Goldfields eucalypt sawlogs. Distortion, wane, decay and insect damage were found to be the major reasons for mulga and gidgee boards being downgraded from *AS 2796-1999- Timber–Hardwood-Sawn and Milled Products* high feature grade. Analysis of the reasons for downgrade from *AS 2796* high feature grade indicated that, in the case of unprotected air dried, protected air dried, solar kiln dried and dehumidifier kiln dried boards, drying degrade (distortion, checking and splitting) was independent of seasoning method. However, seasoning grading highlighted greater levels of checking in unprotected air dried boards. On the basis of these grading results and the financial analysis of seasoning methods presented in Chapter 5, protected air drying appears to be the most cost-efficient seasoning method for small-scale producers of western Queensland hardwoods.

The suitability of two conventional kiln drying schedules for mulga and gidgee have been assessed in terms of drying time, moisture content distribution, residual drying stress, surface and end checking, end splitting, and distortion. The schedule for 25 mm mulga reported in Campbell (1980) was found to be sound for mulga and gidgee boards up to 25 mm thick, although researching new schedules could improve the quality of conventional kiln dried boards. Further research is necessary to develop optimal drying schedules for boards greater than 25 mm thick.

References

Campbell, G.S. (1980), Index of kiln drying schedules for timbers dried in Australia, unpublished report, Division of Building Research, CSIRO, Highett (Victoria).

Hopewell, G., Leggate, W., Spring, G. and Leet, M. (2000), 'An Evaluation of First Rotation, Australian-Grown Paulownia', unpublished report for Queensland Paulownia Forests Limited, Queensland Forestry Research Institute, Brisbane.

Leggate, W., Palmer, G., McGavin, R. and Muneri, A. (2000), 'Productivity, sawn recovery and potential rates of return from eucalypt plantations in Queensland', paper submitted to the IUFRO Conference, The Future of Eucalypts for Wood Products, Launceston, March 2000.

Siemon, G.R. and Kealley, I.G. (1999), *Goldfields Timber Research Project: Report by the Research Project Steering Committee*, Department of Commerce and Trade, Goldfields Esperance Development Commission, Department of Conservation and Land Management, Goldfields Specialty Timber Industry Group Inc., Curtin University, Perth.

Waterson, G.C. (ed.) (1997), *Australian Timber Seasoning Manual*, Australasian Furnishing Research and Development Institute Limited, Launceston.

Appendix 6A. Class ratings for residual drying stress, surface checking, end checking and end splitting

Conventional kiln dried mulga and gidgee boards were assigned to the following drying quality class classifications extracted *from AS/NZS 4787:2001 –Timber–Assessment of Drying Quality*:

Class A caters for specific end uses and very specific requirements for drying quality;
Class B applies where tight control over drying is required to limit 'in service' movement resulting from changes in equilibrium moisture content
Class C applies where higher drying quality is required and the final use environment is clearly defined
Class D applies when the final use environment is more clearly defined but again the drying quality requirements are not considered high, and
Class E applies when the final use and drying quality requirements are not high.

In accordance with *AS/NZS 4787:2001 –Timber–Assessment of Drying Quality*, to measure residual drying stress, a sample is 'ripped' down the centre (through thickness). Residual drying stresses are present if, when attempting to re-assemble the two halves, there is a gap between the concave faces. The degree of residual drying stress is measured by:

$$D_{stress} = (D_{gap} / W) \times 100$$

Where D_{stress} is degree of drying stress (%);
D_{gap} is gap between concave faces (mm); and
W is board width (mm).

Table 6A.1 presents the quality class specifications for residual drying stress.

Table 6A.1 *Maximum allowable residual drying stress by quality class*

Quality Class	Maximum allowable drying stress (D_{stress}, %)
Class A	0.5
Class B	1
Class C	2
Class D	3
Class E	4

The standard *AS/NZS 4787:2001*, requires that surface checking be estimated as a percentage of total board length. That is, if the length of board affected by surface checks is *a* and the total length of the board is *b*, then the percentage of the surface affected by checks is a / b × 100. Table 6A.2 presents the percentage of surface checking allowed by *AS/NZS 4787:2001* by quality class.

Table 6A.2 *Maximum allowable percentage of surface checking by quality class*

Quality Class	Maximum allowable surface checking (%)
Class A	0.5
Class B	5
Class C	10
Class D	15
Class E	20

For compliance with *AS/NZS 4787:2001* quality classifications, end checking and end splitting are calculated by measuring the longest end split or check on either end of the board. Table 6A.3 lists the maximum end split or check length permissible for each quality class.

Table 6A.3 *Maximum end split or check length by quality class*

Quality Class	Maximum end split or check length (mm)
Class A	0
Class B	50
Class C	100
Class D	200
Class E	300

Appendix 6B. Seasoning grading of mulga and gidgee

Tables 6A.5 to 6A.10 report the extent of surface checking, surface heart checking and end splitting in mulga and gidgee boards of different thicknesses for unprotected air drying, protected air drying, solar kiln drying and dehumidifier kiln drying. These tables highlight the increase in checking as board thickness increases. Table 6A.4 indicates the sample size by board thickness. Results from 75 mm and 100 mm thick boards should be applied with caution due to the small sample size.

Table 6A.4 *Number of boards of each species seasoned under the various seasoning methods*

Board thick-ness (mm)	Number of boards of each species by seasoning method									
	Unprotected		Protected		Solar kiln		Dehumidifier kiln		Conventional kiln	
	M	G	M	G	M	G	M	G	M	G
12	66	27	73	26	60	26	60	18	3	3
19	20	16	19	9	12	0	22	0	3	0
25	39	56	47	55	34	53	34	44	4	3
50	14	41	16	34	12	36	13	33	2	2
75	4	5	4	3	0	4	3	5	0	0
100	2	0	2	0	4	3	0	0	0	0
Total	145	145	161	127	122	122	132	100	12	8

Notes: M = mulga; G = gidgee.

1. Two conventional kiln drying schedules were trialled for mulga and gidgee. The numbers of boards indicated were placed in each charge.

Table 6A.5 *Proportion of mulga boards of various thicknesses exhibiting surface checking under several seasoning regimes*

% surface check	Percentage of boards by seasoning method and board thickness (mm)																							
	Maryvale unprotected						Maryvale protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	58	20	3	14	50	0	92	53	49	19	0	0	65	33	35	0	na	0	82	59	41	8	0	na
1-10	41	40	36	0	25	0	7	37	32	19	0	0	35	58	50	33	na	0	18	36	47	31	0	na
10-25	2	25	33	21	25	100	1	11	6	25	0	0	0	8	12	33	na	0	0	5	6	38	33	na
26-50	0	0	10	14	0	0	0	0	6	25	50	0	0	0	0	8	na	0	0	0	3	15	33	na
51-75	0	5	13	36	0	0	0	0	6	13	25	0	0	0	3	8	na	25	0	0	3	0	0	na
76-99	0	10	5	14	0	0	0	0	0	0	25	50	0	0	0	17	na	50	0	0	0	0	33	na
100	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	na	25	0	0	0	8	0	na

Note: columns may not sum to 100% due to rounding errors

Table 6A.6 *Proportion of mulga boards of various thicknesses exhibiting surface heart check under several seasoning regimes*

% heart check	Percentage of boards by seasoning method and board thickness (mm)																							
	Maryvale unprotected						Maryvale protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	73	65	44	21	0	0	86	58	62	38	0	0	85	92	71	33	na	0	90	73	79	38	33	na
1-10	18	15	15	7	0	0	11	5	21	13	50	0	5	0	12	8	na	0	8	9	3	8	0	na
10-25	6	5	15	7	0	0	1	16	6	19	0	0	5	0	9	8	na	0	0	9	9	23	0	na
26-50	2	5	18	21	0	0	1	11	4	19	50	0	3	0	6	17	na	25	2	5	0	8	67	na
51-75	2	10	8	29	0	0	0	11	4	0	0	0	2	8	0	8	na	0	0	0	6	15	0	na
76-99	0	0	0	14	25	50	0	0	2	6	0	50	0	0	3	17	na	25	0	5	0	8	0	na
100	0	0	0	0	75	50	0	0	0	6	0	50	0	0	0	8	na	50	0	0	3	0	0	na

Note: columns may not sum to 100% due to rounding errors

Table 6A.7 *Proportion of mulga boards of various thicknesses exhibiting end splitting under several seasoning regimes*

% end split	Percentage of boards by seasoning method and board thickness (mm)																							
	Maryvale unprotected						Maryvale protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	80	95	87	100	25	100	84	100	98	100	100	100	82	92	88	83	na	100	80	86	82	77	67	na
1-10	15	5	13	0	75	0	15	0	2	0	0	0	17	8	9	8	na	0	18	14	18	23	33	na
10-25	3	0	0	0	0	0	0	0	0	0	0	0	2	0	3	8	na	0	2	0	0	0	0	na
26-50	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	na	0	0	0	0	0	0	na
51-75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	0	0	0	0	0	0	na
76-99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	0	0	0	0	0	0	na
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	na	0	0	0	0	0	0	na

Note: columns may not sum to 100% due to rounding errors

Table 6A.8 *Proportion of gidgee boards of various thicknesses exhibiting surface checking under different seasoning regimes*

% surface check	Percentage of boards exhibiting surface checking by seasoning method and board thickness (mm)																							
	Yankalilla unprotected						Yankalilla protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	74	56	66	20	0	na	92	89	62	41	33	na	73	na	57	36	0	33	78	na	59	45	20	na
0.1-9.9	15	19	27	20	0	na	8	0	24	29	33	na	15	na	26	33	25	0	22	na	27	21	20	na
10-24.9	7	25	5	29	40	na	0	0	11	26	0	na	4	na	11	11	25	0	0	na	14	24	20	na
25-49.9	4	0	2	24	40	na	0	11	4	0	33	na	8	na	4	8	50	33	0	na	0	3	40	na
50-74.9	0	0	0	5	20	na	0	0	0	3	0	na	0	na	2	8	0	0	0	na	0	3	0	na
75-99.9	0	0	0	2	0	na	0	0	0	0	0	na	0	na	0	3	0	33	0	na	0	3	0	na
100	0	0	0	0	0	na	0	0	0	0	0	na	0	na	0	0	0	0	0	na	0	0	0	na

Note: columns may not sum to 100% due to rounding errors

Table 6A.9 *Proportion of gidgee boards of various thicknesses exhibiting surface heart checking under different seasoning regimes*

% heart check	Percentage of boards exhibiting surface heart checking by seasoning method and board thickness (mm)																							
	Yankalilla unprotected						Yankalilla protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	85	56	63	44	0	na	77	44	53	26	100	na	88	na	51	11	0	0	78	na	50	12	0	na
0.1-9.9	0	19	14	20	0	na	8	44	16	12	0	na	8	na	17	19	0	67	11	na	18	30	40	na
10-24.9	7	13	16	17	20	na	4	11	11	24	0	na	0	na	13	22	25	0	0	na	9	18	0	na
25-49.9	0	13	2	15	80	na	8	0	13	29	0	na	0	na	13	22	25	0	11	na	14	15	0	na
50-74.9	7	0	5	5	0	na	0	0	2	9	0	na	4	na	6	17	25	0	0	na	9	18	60	na
75-99.9	0	0	0	0	0	na	4	0	2	0	0	na	0	na	0	6	25	33	0	na	0	6	0	Na
100	0	0	0	0	0	na	0	0	4	0	0	na	0	na	0	3	0	0	0	na	0	0	0	na

Note: columns may not sum to 100% due to rounding errors

Table 6A.10 *Proportion of gidgee boards of various thicknesses exhibiting end splitting under different seasoning regimes*

% end split	Percentage of boards exhibiting end splitting by seasoning method and board thickness (mm)																							
	Yankalilla unprotected						Yankalilla protected						Solar kiln						Dehumidifier kiln					
	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100	12	19	25	50	75	100
0	93	88	96	98	100	na	96	89	87	94	100	na	85	na	91	92	100	100	78	na	93	100	100	na
0.1-9.9	0	13	2	0	0	na	4	11	11	6	0	na	12	na	8	8	0	0	17	na	5	0	0	na
10-24.9	4	0	2	2	0	na	0	0	2	0	0	na	4	na	0	0	0	0	6	na	0	0	0	na
25-49.9	0	0	0	0	0	na	0	0	0	0	0	na	0	na	2	0	0	0	0	na	2	0	0	na
50-74.9	4	0	0	0	0	na	0	0	0	0	0	na	0	na	0	0	0	0	0	na	0	0	0	na
75-99.9	0	0	0	0	0	na	0	0	0	0	0	na	0	na	0	0	0	0	0	na	0	0	0	na
100	0	0	0	0	0	na	0	0	0	0	0	na	0	na	0	0	0	0	0	na	0	0	0	na

Appendix 6C. Impact of distortion as a reason for downgrade of gidgee boards from high feature grade

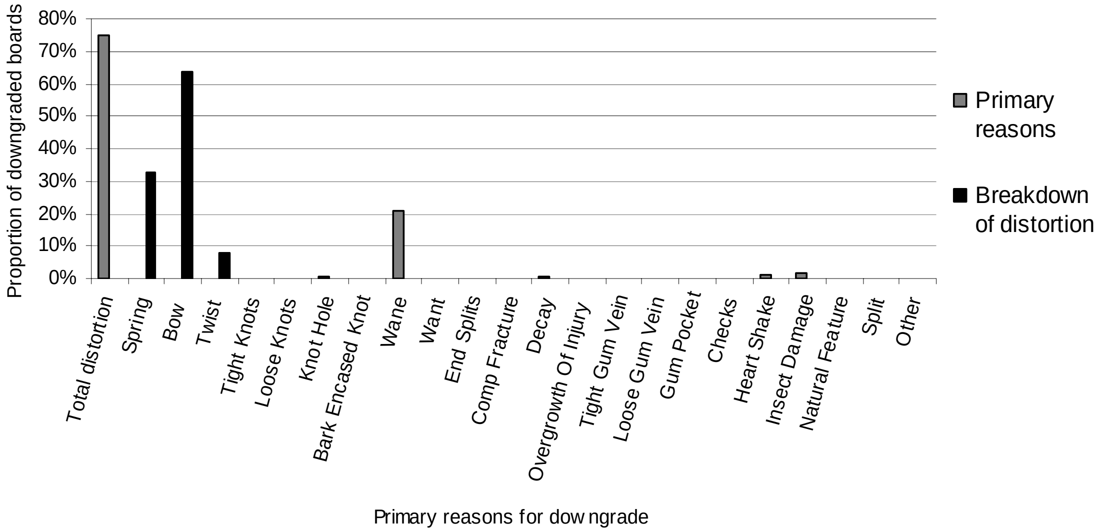

Figure 6A.1 *Primary reasons for downgrade of solar kiln dried gidgee from high feature joinery grade*

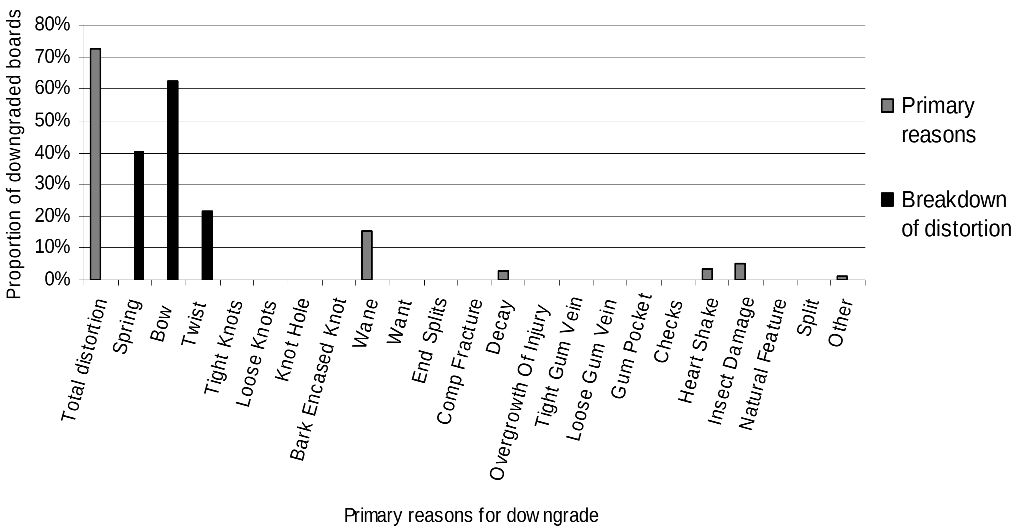

Figure 6A.2 *Primary reasons for downgrade of dehumidifier kiln dried gidgee from high feature joinery grade*

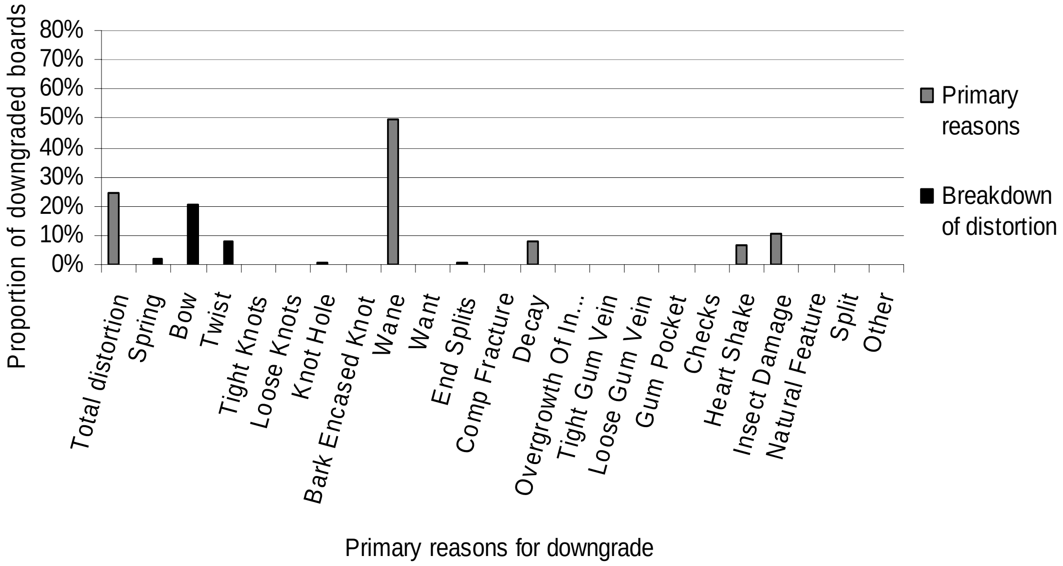

Figure 6A.3 *Primary reasons for downgrade of solar kiln dried gidgee from high feature flooring grade*

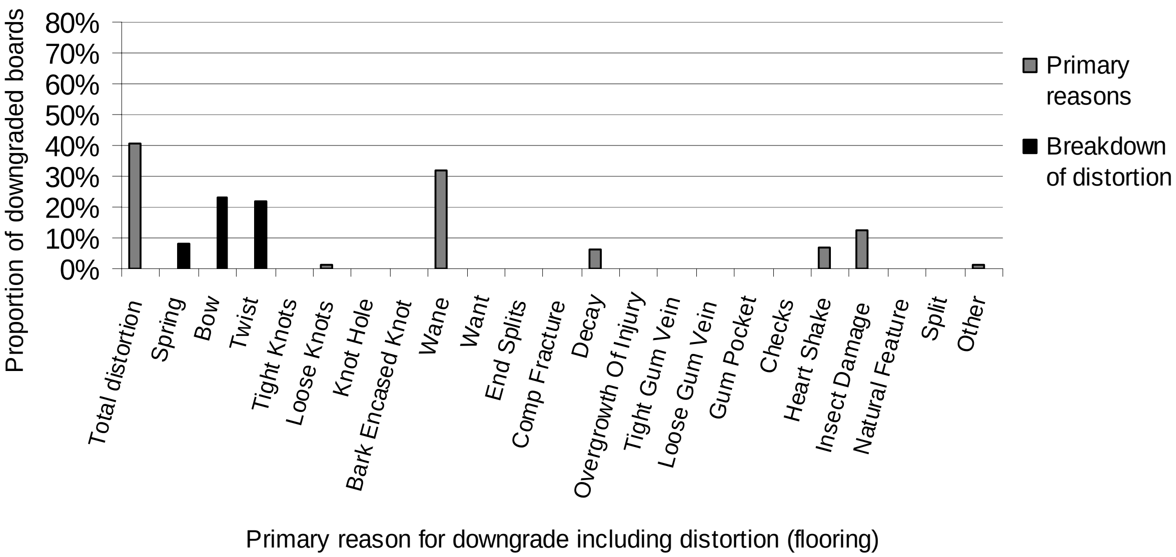

Figure 6A.4 *Primary reasons for downgrade of dehumidifier kiln dried gidgee from high feature flooring grade*

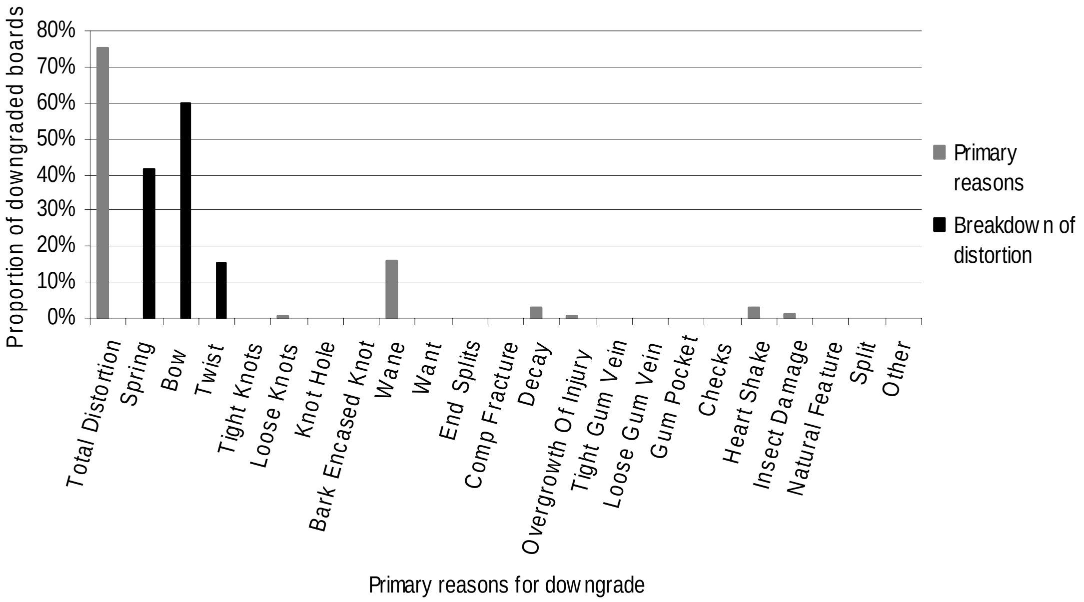

Figure 6A.5 *Primary reasons for downgrade of protected air dried gidgee from high feature joinery grade*

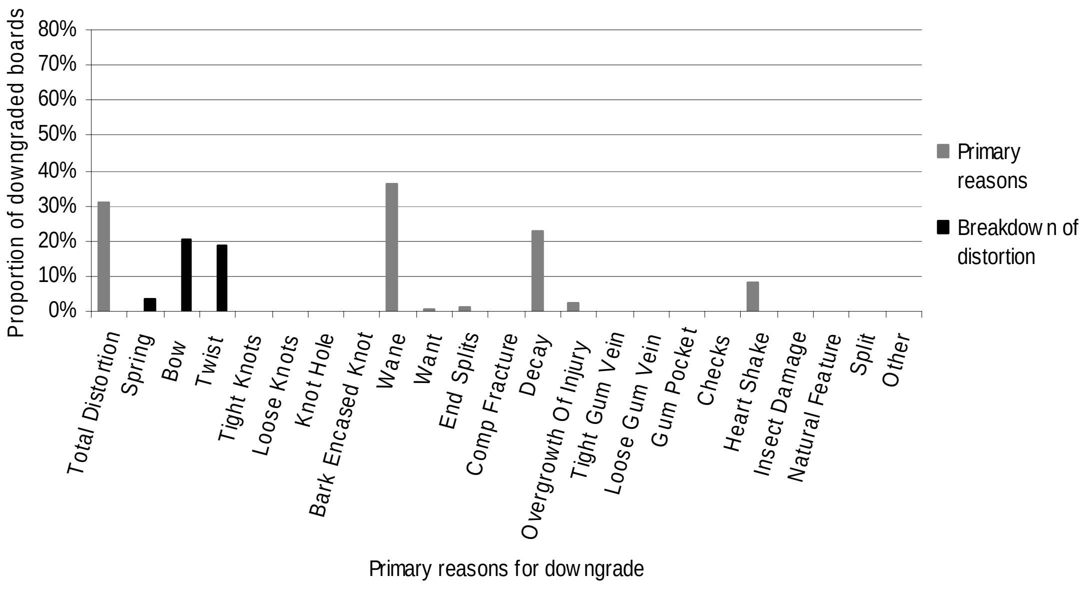

Figure 6A.6 *Primary reasons for downgrade of unprotected air dried gidgee from high feature joinery grade*

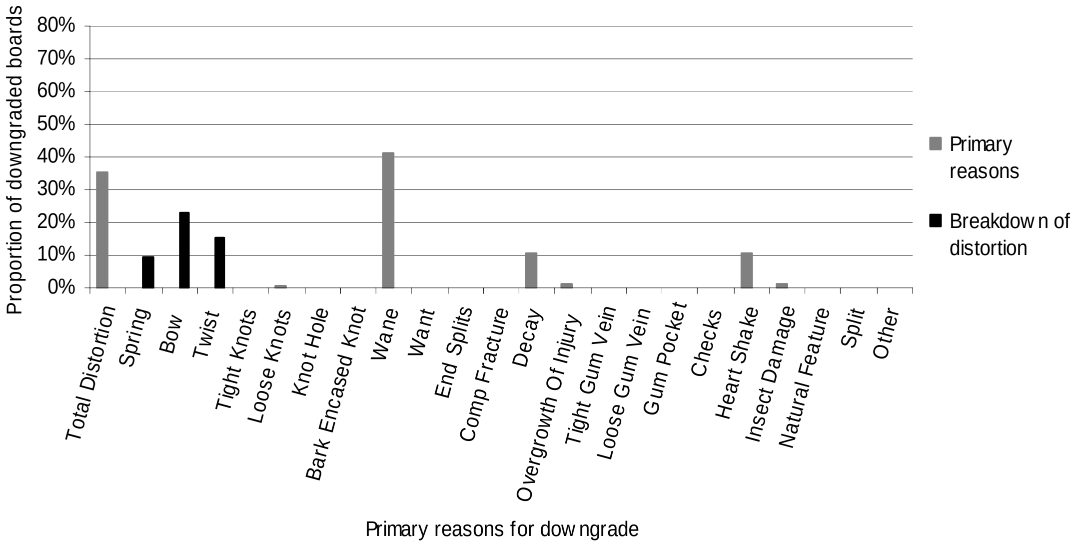

Figure 6A.7 *Primary reasons for downgrade of protected air dried gidgee from high feature flooring grade*

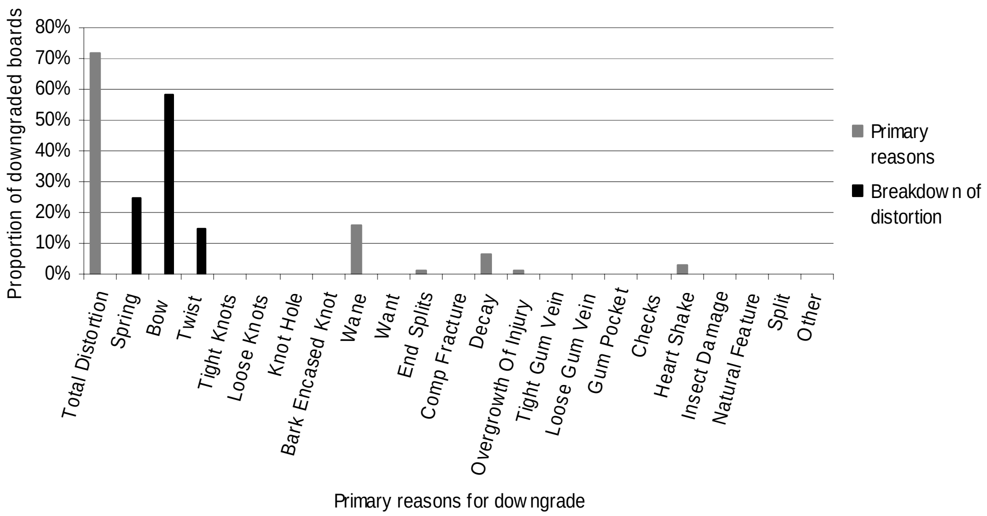

Figure 6A.8 *Primary reasons for downgrade of unprotected air dried gidgee from high feature flooring grade*

Appendix 6D. Residual drying stress, checking, splitting, and distortion results from conventional kiln dried mulga and gidgee

6D.1 Residual drying stress

Table 6A.11 *Pre and post-equalisation residual drying stress class for mulga boards in trials 1 and 2*

Board thickness (mm)	Trial 1		Trial 2	
	Pre-equalisation residual drying stress class	Post-equalisation residual drying stress class	Pre-equalisation residual drying stress class	Post-equalisation residual drying stress class
12	A	A	A	A
12	A	A	B	A
12	A	A	A	B
19	A	A	B	A
19	A	A	B	A
19	A	A	A	A
25	A	A	A	A
25	A	A	B	A
25	A	A	C	A
25	A	A	B	A
50	A	A	B	A
50	A	A	B	A

Table 6A.12 *Pre and post-equalisation residual drying stress class for gidgee boards in trials 1 and 2*

Board thickness (mm)	Trial 1		Trial 2	
	Pre-equalisation residual drying stress class	Post-equalisation residual drying stress class	Pre-equalisation residual drying stress class	Post-equalisation residual drying stress class
12	A	A	B	A
12	A	A	A	A
12	C	A	A	A
25	B	A	B	A
25	A	A	B	A
25	A	A	A	B
50	B	A	A	A
50	B	A	A	A

6D.2 Checking and end splitting

Table 6A.13 *Surface checking, end checking and end split on mulga boards from trial 1*

Board thickness (mm)	Surface checking (% board length)		Surf. Chk. Class	End split (mm)	End Split Class	End checking (mm)	End Chk. Class
	Side 1	Side 2					
12	0.0	0.0	A	0	A	0	A
12	73.4	0.0	E	0	A	0	A
12	0.0	0.0	A	35	B	12	B
19	22.4	0.0	E	0	A	6.7	B
19	0.0	0.0	A	10	B	0	A
19	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	0	A
50	95.5	96.4	E	0	A	40	B
50	90.7	0.0	E	100	C	0	A

Table 6A.14 *Surface checking, end checking and end split on mulga boards from trial 2*

Board thickness (mm)	Surface checking (% board length)		Surf. Chk. Class	End split (mm)	End Split Class	End checking (mm)	End Chk. Class
	Side 1	Side 2					
12	0.0	0.0	A	0	A	0	A
12	7.2	28.3	E	208	E	0	A
12	0.0	0.0	A	0	A	0	A
19	0.0	0.0	A	0	A	13	B
19	0.0	0.0	A	0	A	1	B
19	0.0	0.0	A	0	A	1.5	B
25	8.2	0.0	D	0	A	25	B
25	19.4	0.0	E	46.8	B	3.5	B
25	4.7	0.0	C	49.83	B	0	A
25	0.0	0.0	A	0	A	0	A
50	100.0	100.0	E	0	A	56.2	C
50	0.0	0.0	A	20.9	B	44.37	B

Table 6A.15 *Surface checking, end checking and end split on gidgee boards from trial 1*

Board thickness (mm)	Surface checking (% board length		Surf. Chk. Class	End split (mm)	End Split Class	End checking (mm)	End Chk. Class
	Side 1	Side 2					
12	0.0	0.0	A	0	A	0	A
12	0.0	0.0	A	0	A	0	A
12	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	25	B
25	31.7	15.0	E	50	B	0	A
25	16.0	32.0	E	5	B	0	A
50	100.0	0.0	E	80	C	50	B
50	10.0	100.0	E	0	A	0	A

Table 6A.16 *Surface checking, end checking and end split on gidgee boards from trial 2*

Board thickness (mm)	Surface checking (% board length		Surf. Chk. Class	End split (mm)	End Split Class	End checking (mm)	End Chk. Class
	Side 1	Side 2					
12	0.0	0.0	A	0	A	0	A
12	0.0	0.0	A	0	A	0	A
12	0.0	0.0	A	0	A	0	A
25	0.0	0.0	A	0	A	24	B
25	27.4	26.6	E	0	A	55	C
25	20.0	0.0	E	0	A	0	A
50	34.2	0.0	E	30	B	20	B
50	100.0	100.0	E	0	A	28	B

6D.3 Distortion

Table 6A.17 *Distortion of mulga boards in trial 1*

Board thickness (mm)	Board length (mm)	Twist (mm)	Spring (mm)	Bow (mm)	Cup (mm)	Collapse (mm)
12	520	0.00	0.00	2.72	0.00	0.00
12	545	2.09	0.00	0.00	0.00	0.00
12	540	0.00	0.79	0.69	0.00	0.00
19	580	0.00	0.98	2.15	0.00	0.00
19	555	0.00	1.36	2.19	0.00	0.00
19	505	1.39	0.00	0.96	0.00	0.00
25	570	0.00	1.06	1.58	0.00	0.00
25	550	0.67	0.60	0.95	0.00	0.00
25	550	0.00	0.00	2.12	0.00	0.00
25	555	0.00	0.00	0.00	0.00	0.00
50	550	0.00	0.00	1.50	0.00	0.00
50	590	0.00	0.00	0.00	0.00	0.00

Table 6A.18 *Distortion of mulga boards in trial 2*

Board thickness (mm)	Board length (mm)	Twist (mm)	Spring (mm)	Bow (mm)	Cup (mm)	Collapse (mm)
12	495	0.00	0.00	1.00	0.00	0.00
12	530	0.00	0.00	1.50	0.00	0.00
12	550	0.00	0.00	0.00	0.00	0.00
19	545	0.00	0.00	1.42	0.90	0.00
19	546	0.00	0.00	1.17	0.00	0.00
19	512	0.00	0.00	0.00	1.25	0.00
25	440	0.00	0.00	0.00	0.00	0.00
25	453	1.70	0.00	0.00	0.00	0.00
25	550	2.96	0.24	0.00	0.00	0.00
25	524	0.00	0.00	0.00	0.00	0.00
50	590	0.00	0.00	0.00	0.90	0.00
50	600	0.00	0.00	1.80	0.00	0.00

Table 6A.19 *Distortion of gidgee boards in trial 1*

Board thickness (mm)	Board length (mm)	Twist (mm)	Spring (mm)	Bow (mm)	Cup (mm)	Collapse (mm)
12	605	1.95	1.46	2.14	0.00	0.00
12	560	4.68	0.80	2.15	0.00	0.00
12	590	1.33	1.65	2.39	0.00	0.00
25	612	2.29	0.00	2.43	0.00	0.00
25	600	1.55	1.60	2.33	0.00	0.00
25	594	1.80	0.00	2.22	0.00	0.00
50	596	1.90	1.60	0.00	0.00	0.00
50	600	5.16	0.00	0.00	0.00	0.00

Table 6A.20 *Distortion of gidgee boards in trial 2*

Board thickness (mm)	Board length (mm)	Twist (mm)	Spring (mm)	Bow (mm)	Cup (mm)	Collapse (mm)
12	552	1.43	1.77	1.66	0.00	0.00
12	602	0.00	0.00	0.00	0.00	0.00
12	590	0.00	1.65	0.00	0.00	0.00
25	603	2.23	0.00	2.27	0.00	0.00
25	602	0.00	0.00	0.00	0.00	0.00
25	600	0.00	1.48	2.45	0.00	0.00
50	600	0.00	0.00	0.00	0.00	0.00
50	606	0.00	0.00	0.00	0.00	0.00

7. An investigation into the veneered product potential of mulga

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Veneer production has the potential benefit of maximising the value of a timber resource through higher recovery than is possible with solid wood products. Commercial veneer manufacturers have stringent billet quality specifications and preliminary investigations by the Queensland Forestry Research Institute (QFRI) have indicated that supplying western Queensland hardwood billets of such quality would be extremely difficult. A small-scale 'sliced' veneering trial was conducted with mulga, which resulted in the majority of veneer leaves containing unacceptable levels of defects (e.g. splits, grain tear, knots and decay) for standard board manufacture. Nevertheless, sections within the veneer leaves may be appropriate for special applications where small pieces of veneer can be utilised.

7.1 Introduction

Sliced veneering is a method of log processing that had been identified by the Queensland Forestry Research Institute (QFRI), and other project participants, as a potential opportunity to increase wood product recovery and maximise the value of the western Queensland hardwood resource. Given the funding restrictions of the project, it was decided to focus on the veneering potential of one western Queensland hardwood species. As the majority of the processing components of the project had focused on mulga and gidgee, it was decided that the veneering trial would be undertaken with one of these species. Mulga was selected as the trees were observed to contain less natural defect and have better tree form than gidgee. Therefore, it was anticipated that veneer production from mulga would be more successful than from gidgee.

Proveneer at Redbank Plains, Brisbane, agreed to participate in the trialling of mulga. Although they have a long history in processing a wide range of species, they had limited experience in processing western Queensland hardwoods.

This chapter proceeds with a brief outline of the standard commercial veneering process and markets. This is followed by the methodology of the trial conducted by QFRI and Proveneer. A discussion of the results and a concluding statement complete the chapter.

7.2 The veneering process and markets

Presently, commercial veneering operations require billets clear of defects, about 3.0 m in length and squared from logs of at least 50 cm in diameter. Billets produced from suitable quality trees of this size, are able to yield large volumes of veneer leaves free from sapwood and heart[20]. The normal process of sliced veneering involves producing thin veneer leaves

[20] Heart is defined in AS/NZS 4491:1997 Timber –Glossary of terms in timber-related Standards as timber within 50 mm of the centre of the pith.

(usually approximately 0.6 mm) from a large billet or block. Therefore, the potential recovery can be much higher than if the same resource is converted into solid timber products. Once seasoned and graded, the sliced veneers are glued onto a substrate such as plywood, particleboard or medium density fibreboard (MDF). These board products are mostly used for appearance applications. Those parts of the product that cannot be seen can, therefore, be a lower quality and lower cost material.

Veneer boards are generally sold to the timber manufacturing industry where they are further processed into articles such as door panels and tabletops. A small market also exists where individual veneer leaves are sold for 'one-off', high-value specialty applications.

7.3 Veneering trial methodology

Given that western Queensland hardwoods are characterised by short length, small diameter and often defected boles, trial billets of the 'traditional' specifications were expected to be scarce. Discussions with Proveneer resulted in an agreement to trial mulga using billets that were 1.2 m in length and as large in girth as possible. The billets were to be the full log, squared to produce a 'boxed heart[21]' billet. By using 1.2 m billets, it was hoped that half size panels could be produced.

Three mulga billets were selected and harvested from Maryvale Station, located south –west of Morven, Queensland, one of the two portable sawmilling study sites (Chapter 4). These billets were sourced from two trees (*i.e.* one tree yielded two billets), and were estimated to have centre diameters within the range of 30 cm to 35 cm. The need to traverse approximately 100 ha of mulga woodland to locate two high quality billet producing trees that met the size, straightness and defect requirements, indicates that billets of this quality are not common in mulga woodlands.

The three sample billets were end-sealed immediately after felling and transported to QFRI's Salisbury Research Centre in Brisbane. Sample billets had flat surfaces sawn to produce four faces, which removed the bark and majority of the sapwood. The billets were then forwarded to Proveneer for slicing appraisal.

The veneering process involved each billet being submerged into a hot water tank at a temperature thought appropriate for the species. This was estimated by Proveneer staff based on a combination of industry experience and the known wood properties of mulga. Soaking is required to soften the timber, which aids the slicing process. Soaking times and temperatures for specific species are often tightly held commercial secrets; however, Proveneer indicated that common commercially processed high density timbers, such as brush box and spotted gum, require soaking for approximately 14 days prior to slicing. As the softening behaviour of mulga was unknown, the billets were initially soaked for 14 days at 90 degrees Celsius.

After the 14-day soaking period, one sample billet was removed from the tanks and partially sliced on a vertical veneer slicer. In the machinery operator's opinion, considerable extra load was placed on the slicer, which was thought to be attributable to the extreme density and hardness of mulga. The extra load on the slicer caused movement of the machine 'head', resulting in veneer leaves that were uneven in thickness. This is an unacceptable fault in veneer. The sample billet was placed back in the tanks with the remaining billets, and continued to soak for a further seven days.

After 21 days of soaking, all billets were moved to the veneer slicer for evaluation. The additional soaking was found to have produced considerable improvements in both reduced

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[21] Boxed heart as defined in AS/NZS 4491:1997 Timber –Glossary of terms in timber-related Standards is where the heart is contained within four sawn surfaces of a piece of timber.

machinery load, and higher quality veneers (*e.g.* less grain tear). After slicing was completed, Proveneer staff visually graded the veneer leaves.

7.4 Results of the veneering trial with mulga

Proveneer personnel asserted that the recovery of full-length veneer leaves for half size board manufacture was in the range of 0% to 3%. Proveneer indicated they would usually expect at least 20% recovery when processing their standard commercial species. The large difference was found to be mainly due to the high incidence of defects, including splits, grain tear, knots and decay. Nevertheless, the majority of the veneer leaves did contain sections that would be of suitable quality for applications other than board manufacture. Furniture manufactures could cut small sections of high quality veneer from the full veneer leaf and glue the pieces onto a substrate themselves. This processing technique may be appropriate for high value specialty products or 'one-off' hobby applications; however, this is believed to be a small segment of the veneer industry.

7.5 Conclusion

Commercial volumes of western Queensland hardwoods are unlikely to be available in the dimensions of standard sized billets suitable for producing standard veneer board products (2400 mm x 1200 mm), nor half-size boards (1200 mm x 1200 mm). The high density of mulga was found to necessitate a far longer soaking period than is required for commercially produced species. Although high quality mulga billets were collected for this trial, defects were still prevalent in the sliced veneer leaves, including splits, grain tear, knots and decay, which significantly reduced the recovery of usable leaves for the production of board products. However, small sections of the veneer leaves could be suitable for high value specialty products.

8. Postal survey assessment of potential markets for western Queensland hardwoods

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A postal survey was sent to 225 Australian and international wood product manufacturers inquiring about the suitability of western Queensland hardwood timbers for specific products, including product specifications, and potential market volumes and prices. The overall response rate was 31%, but only 12% of international wood manufacturers responded. Currently traded volumes of sawn western Queensland hardwoods were found to be small and unlikely to be more than about 200 m^3 per annum. Respondents indicated several reasons for the lack of uptake of these species, particularly ignorance of the resource, the dearth of information about western hardwood timber properties and a poor supply chain. Nevertheless, the majority of respondents expressed great interest in stocking or experimenting with western Queensland hardwoods and believed the timbers have highly marketable qualities. Respondents indicated that flooring, small-scale furniture and musical instrument manufacturers, and timber merchants would likely be the major purchasers of western hardwoods. It was asserted by respondents that the Australian flooring industry could potentially consume thousands of cubic metres of timber per annum at standard hardwood flooring prices of about $1,500/$m^3$ dried roughsawn. Extrapolating from returned surveys, the future demand from Australian small-scale furniture manufacturers and timber merchants for high quality boards could potentially amount to several hundred cubic metres per annum at prices of about $1,500/$m^3$ to $3,000/$m^3$ dried roughsawn. There is also potential for small volumes (probably less than 20 m^3 per annum) of the highest quality western hardwood boards to be sold to domestic musical instrument manufacturers at about $20,000/$m^3$ to $30,000/$m^3$. Feedback from domestic and international respondents highlighted opportunities for exporting western Queensland hardwoods, especially to North America and Europe. Overseas, the potential demand for high-quality western Queensland hardwood boards is likely to greatly exceed the Australian market. However, it was suggested that a well-funded, well-directed marketing campaign would be necessary to establish such export markets.

8.1 Introduction

There is much uncertainty surrounding the profitability of operations supplying western Queensland hardwoods to market. Traditionally, these timbers have been viewed as fence post material and an impediment to land development, and consequently of little value. Today, the unique properties of these species are better appreciated and interest from the wood processing sector is growing. Landholders have heard about high prices being paid for western hardwoods; however, little is known about current and potential future markets for these timbers.

With the aim of reducing uncertainty about timber markets for western Queensland hardwoods, the Queensland Forestry Research Institute (QFRI) conducted a postal survey of 225 domestic and international wood suppliers and processors. The survey focussed on high-value product markets and was undertaken over the period January to April 1999. From the large diversity of western Queensland hardwoods, eleven species were selected for assessment of their market potential in the postal survey:

- *Acacia aneura* (mulga)
- *Acacia cambagei* (gidgee)
- *Acacia coriacea* (desert oak)
- *Acacia excelsa* (ironwood)
- *Acacia nilotica* (prickly acacia)
- *Acacia shirleyii* (lancewood)
- *Archidendropsis basaltica* (red lancewood)
- *Corymbia similis* (Queensland yellowjacket)
- *Eremophila mitchellii* (sandalbox)
- *Eucalyptus populnea* (bimble box)
- *Grevillea striata* (beefwood)

These timber species occur naturally in the Desert Uplands and South West Strategy regions of Queensland, the study area for the U*tilisation of Western Hardwoods as Specialty Timbers* project (see Chapter 1). Prickly acacia is an exotic weed that has become well-established in the study region. These species were believed to be those most likely to be harvested due to their abundance and promising timber properties.

This chapter presents the views of manufacturers of wood products and timber suppliers regarding the marketability of western Queensland hardwoods. Most responses are the expert opinions of people in the wood products industry and have not been substantiated by thorough testing of the suitability or marketability of western Queensland hardwoods for particular applications. This chapter proceeds with a statement of research objectives and survey methodology. The results of the survey are then presented in detail, which is followed by a discussion of the outcomes of the survey.

8.2 Objectives of the market survey

The objectives of the survey were to:

- establish whether the timber properties of western Queensland hardwoods make these species suitable for the manufacture of particular specialty products
- assess current and potential domestic and international markets for western Queensland hardwoods in terms of prices that manufacturers and retailers are willing to pay, and timber volumes that could be consumed, and
- determine timber condition and form required by particular product manufacturers to ascertain appropriate harvesting, processing and seasoning methods (*e.g.* green or dry; rough sawn, dressed or as billets; specifications, including length, width, thickness, sapwood free, and other special requirements).

8.3 Postal survey methodology

A seven-stage procedure was adopted for the postal survey:

- development of a list of potential products
- establishment of criteria for selection of manufacturers, retailers and merchants to be surveyed
- development of a list of potential respondents
- development of questionnaires for manufacturers of different product types
- distribution of questionnaires and accompanying information
- response collection, and
- response analysis.

8.3.1 Potential products list

Characteristics of western Queensland hardwoods, the size of the resource and knowledge of current and past applications, were utilised to develop a list of potential end-uses. The high density, durability and aesthetic appeal of these species, together with the irregularity of the resource and likely high processing costs, indicated that high value, niche and speciality markets would be most appropriate, including:

- billiard cues
- clocks
- fine furniture
- knife handles
- musical instruments
- parquetry flooring
- tool handles, and
- turned and carved objects.

Development of the survey was then based on communicating with manufacturers of these products and timber merchants supplying these manufacturers.

8.3.2 Criteria for selection of manufacturers, retailers and timber merchants

A number of criteria were developed to aid selection of companies to be surveyed, which are outlined for the different product groups below.

Billiard cue manufacturers
<u>Domestic</u>
- makers that could provide information regarding the suitability of these timbers for cue manufacturing

<u>International</u>
- high output cue manufacturers using specialty hardwood timbers that may provide information on the suitability of these timbers for billiard cues and could potentially use considerable volumes of these timbers

Flooring
<u>Domestic</u>
- local companies that specialise in hardwood flooring and parquetry

Furniture manufacturers and woodturners
<u>Domestic</u>
- enterprises that have had experience using these timbers and may have information on their suitability
- enterprises producing high volumes of hardwood furniture, and

- enterprises that manufacture high value, turned products from hardwood timbers and may be interested in utilising western Queensland timbers.

Knife manufacturers
<u>International</u>

- large, internationally renowned knife manufacturers who produce wood-handled knives and could potentially use considerable volumes of timber

Musical instrument makers
<u>Domestic</u>

- instrument makers who have previously used these or other Australian timbers, and may, therefore, be aware of the suitability of these timbers for musical instrument making, and
- the largest domestic instrument makers

<u>International</u>

- large, internationally renowned musical instrument manufacturing companies, who could potentially use large volumes of timber, and
- instrument makers who have had experience using these timbers

Timber merchants
<u>Domestic</u>

- currently or have previously stocked the timbers under consideration or other Australian desert timbers
- promote themselves as suppliers of specialty timbers for furniture, woodturning and craft markets, and
- exporters of Australian hardwoods

<u>International</u>

- large companies specialising in exotic timbers for specialty products.

8.3.3 Development of a mailing list of potential respondents

A list of timber manufacturers, retailers and merchants to be contacted was compiled from five principal sources.

1. Industry journals and magazines
Advertiser lists and classified sections in the publications *Australian Wood Review* and *Australian Woodworker* provided contact details for current and potential suppliers of specialty timbers in Australia. Feature articles also provided names of potential users of these timbers, in particular, furniture makers and wood turners.

2. The World Wide Web
The internet was used primarily to source the details of international respondents. This was particularly the case for billiard cue manufacturers, knife makers and musical instrument makers. This medium was also utilised to source contact details for timber, furniture and flooring associations or societies, to whom queries were made regarding possible industry contacts and general opinions on the markets for these timbers in their country.

3. The Australian yellow pages
The Yellow Pages was used to source details on local companies and individuals, particularly flooring and furniture manufacturers, and timber suppliers.

4. Referrals by respondents
Some questionnaire respondents provided details of other individuals or companies they believed could be interested in this research and who could provide valuable feedback.

5. Contact with the European and Japanese Secretariats, through the State Development sector of the Queensland Government
The Queensland Department of State Development was contacted to source general information about potential markets in Europe and Japan, and to obtain contact details for companies that may have an interest in utilising western Queensland hardwoods.

The enterprise selection criteria were applied to limit the list of companies and individuals to whom questionnaires would be distributed. A complete listing of the enterprises that were sent questionnaires is provided in Appendix 8A. Table 8.1 summarises the number of enterprises sent questionnaires by product type.

Table 8.1 *Distribution of questionnaires sent to potential users of western Queensland Timbers*

Product type	Location of potential respondent		Total
	Australia	International	
Associations	2	10	12
Cue makers	3	15	18
Flooring	13	0	13
Furniture manufacturers	34	0	34
Knife manufacturers	0	14	14
Musical instrument makers	36	11	47
Timber merchants	43	18	61
Veneer manufacturers	13	0	11
Woodturners and carvers	13	0	13
Total	157	68	225

8.3.4 The questionnaires and accompanying information

A package of information was sent to all enterprises listed in Appendix 8A, which included a covering letter, the questionnaire, images of some western Queensland hardwood timbers, and a table of timber properties. A description of each of these elements follows.

Cover letters
A two-page cover letter outlined the research being undertaken. It included a list of the species under consideration, a brief description of the resource and timbers, a list of potential products and an indication of the type of feedback sought. Slight modifications were made to the base letter to make it applicable to particular product manufacturers. Appendix 8B provides a sample of the letter distributed to timber merchants.

Questionnaires
Questionnaires were tailored to particular product manufacturers. Some variation was incorporated to account for the location of respondents, in particular domestic versus international respondents. A core set of questions were directed to all respondents. The questionnaires ranged in length from 15 to 20 questions on three to four A4 pages. The questions broadly covered the following issues:

- current use of western Queensland timbers
- reasons for not having used western Queensland timbers
- suitability of western Queensland timbers for given product types
- market potential for products manufactured from western Queensland timbers
- future use of western Queensland timbers:
    - species preference
    - reasons for use
    - important timber features
    - form required (*e.g.* green/dry, roughsawn/dressed, with/without sapwood, and dimensions), and
    - special requirements for harvesting, processing, seasoning
- potential volumes of western Queensland timber to be used
- prices willing to pay for western Queensland timbers, and
- further information required about western Queensland hardwoods.

Appendices 8C and 8D provide examples of the questionnaires distributed to veneer manufacturers and musical instrument makers respectively.

Table of timber properties
Selected results from research undertaken by QFRI on wood properties of western Queensland hardwood species were also distributed with the questionnaires. This data, tabulated in Appendix 8E, included average values for green moisture content, air dry density, and radial and tangential shrinkage. This information provided respondents with evidence of the relatively high densities and low shrinkage rates of these timbers and facilitated comparisons with other species.

Timber images
Scanned images of mulga, bimble box, sandalbox, gidgee, beefwood and red lancewood were produced from sample pieces and sent with the questionnaire. These six timbers were selected from the 11 to represent the range of colours and figures available, and because they are potentially available in large volumes. The scanned images are reproduced in Appendix 8F.

8.3.5 Response collection

Respondents were requested to return their questionnaire within approximately one month of receiving it. The first page of the questionnaire was headed with a fax template, such that respondents could easily return their questionnaires by facsimile. Postal, e-mail and telephone contact details were also provided to give respondents a variety of response options.

8.4 Results of the postal survey

The number of responses received by product group and location is presented in Table 8.2. An overall response rate of 31% was achieved; however, the international response rate was only 12%. Disappointingly, no knife handle manufacturers responded. Table 8.3 summarises the feedback from respondents by product category. Potential domestic market opportunities for western Queensland hardwoods highlighted in Table 8.3 have been extrapolated from the responses received. It appears that large volume timber consumers, such as flooring manufacturers, are willing to pay approximately $\$1,500/m^3$ for roughsawn, dried timber. However, frequently the comment was made that as western Queensland timbers become established in the market place, higher prices could be achieved. Niche markets, such as timber for woodturning and musical instrument manufacture, are likely to pay $\$20,000/m^3$ to $\$30,000/m^3$ for select boards, although volumes are small. For example, the second largest guitar manufacturer in Australia indicated that 1 m^3/yr to 2 m^3/yr would satisfy their demand for western Queensland hardwoods. An Australian timber merchant asserted that most Australian musical instrument manufacturers would only consume about 10 kg of western Queensland hardwoods annually. An Australian retailer of high quality timber products, who is supplied by more than 80 wood turners, attested that all of their suppliers use small volumes of timber. While insufficient response was received from international respondents to provide a direct indication of potential export opportunities for western Queensland hardwoods, the general view of Australian respondents was that western Queensland hardwoods have great potential in international markets. The following sections summarise questionnaire responses by product category.

Table 8.2 *Questionnaire response rate by product category*

Product category	Location of respondent				Total	
	Australia		International			
	No. of responses	Response rate (%)	No. of responses	Response rate (%)	No. of responses	Response rate (%)
Associations	2	100.0	1	10.0	3	30.0
Cue makers	1	33.3	1	6.7	2	11.1
Flooring	4	30.8	na	na	3	23.1
Furniture manufacturers	8	23.5	1	na	9	26.5
Knife manufacturers	na	na	0	0.0	0	0.0
Musical instrument makers	15	41.6	2	20.0	17	36.2
Timber merchants and suppliers	17	39.5	4	22.2	21	34.4
Veneer manufacturers	7	53.8	na	na	7	53.8
Woodturners and carvers	7	53.8	na	na	7	53.8
Total	61	38.6	9	11.8	70	31.2

Table 8.3 *Summary of information elicited from respondents regarding potential markets for western Queensland hardwoods*

Product manufacturer category	Domestic market		Preferred form of timber	Potential suitability for product category
	Potential demand (m^3/yr)	Potential Price (A$/$m^3$)		
Cue makers	Small (~2-10)	High	RS, dried, free from knots, splits and sapwood	High
Flooring manufacturers	Large (1,000s)	600 - 1,000 GOS 800 - 1,500 kiln dried	Short lengths okay. Sapwood free preferred, but chemical treatment sapwood is acceptable for some.	High
Furniture manufacturers	Small (~100)	1,500 - 3,000 RS, dried.	Highly variable. Some prefer absence of sapwood.	Moderate. Probably unsuitable for large-scale manufacturers.
Musical instrument manufacturers	Small (~5-20)	~30,000 instrument pieces 1,500 – 2,000 exported boards	Variable; however, RS, kiln dried, unblemished, free of sapwood is common. Quarter-sawn and back-sawn pieces.	High, excluding percussion instruments
Timber merchants and suppliers	Small (100) for specialty end-uses. Large (100s – 1,000s) for high volume end-uses.	600 – 3,500 log 3,000 – 8,000 dried, dressed 600 – 1,800 log delivered 600 – 1,200 GOS 1,500 – 3,500 dried.	Highly variable	High
Veneer manufacturers	Large (1,000s)	250/flitch	Billets. Consistent colour for high volume production.	Moderate – High
Woodturners and carvers	Small (100)	2,000 – 3,000 RS, dried (up to 8,000)	Highly variable.	High

Notes: GOS refers to green-off-saw. RS refers to roughsawn

8.4.1 Responses from cue makers

Only one response was received from manufacturers of billiard cues, making it difficult to assess the market; however, an indication of the suitability of these timbers and the required timber features and form has been obtained. It was suggested that the timber features of western Queensland hardwoods appeared to make them suitable for making the splice, which requires hard, dense and colourful timbers. The only way to assess the suitability of individual species would be to trial them. If utilised, preferred form of the timbers would be roughsawn, dried, and free from knots, splits and sapwood. Suggested dimensions required for making cues were:

- shafts – 1600 mm x 35 mm x 35 mm, and
- splice – 500 mm x 50 mm x 50 mm.

The volumes of timber that could potentially be used would be small on a domestic scale; however, if the timber properties were suitable, the prices paid could be high.

8.4.2 Responses from flooring manufacturers

Information was received from five companies involved in the manufacture or laying of timber flooring.

Current use of western Queensland hardwoods by flooring manufacturers
No western hardwood timbers had previously been used or trialled by the respondents, the principal reason cited being lack of availability. A general unawareness of western hardwoods and a lack of information regarding their properties were also indicated.

Potential future use of western Queensland hardwoods by flooring manufacturers
All respondents believed western Queensland hardwoods would be suitable for flooring and were interested in using them. It was recommended that further information and assessment would be required to determine the most suitable species. Knowledge of the colour, density, hardness and stability of these timbers was considered critical for determining suitability for flooring. Table 8.4 indicates the reasons stated for choosing to use western Queensland hardwoods in the future.

Table 8.4 *Reasons stated for using western hardwoods in flooring applications in the future*

Reasons for using western Queensland hardwoods	Number of responses
Timber features	4
Niche market opportunities	3
Environmental concern	2
Availability	2
Desire to use Australian timbers	1
Price	1

Notes: 4 respondents provided information.

Timber dimensions and other requirements for floor manufacture
Kiln dried timber would be required for flooring applications. The requirements for further dressing and moulding for flooring products will depend on each company's capacity to undertake these processes themselves. One respondent suggested that they might find it advantageous to obtain the timber in green off saw form, such that they could ensure quality control through drying, dressing and grading. Dimensions required are:

- length — variable for strip flooring (including short lengths). For floating panel floors 900mm.
- thickness — 12 mm, 19 mm and 25 mm, and
- width — 60 mm to 150 mm.

Sapwood free timber would be demanded by two of the respondents; however, two other respondents would be accepting of timber with sapwood present, if it were appropriately chemically treated.

Potential demand for western Queensland timbers from flooring manufacturers
Predictions of timber volumes that could be consumed were not made by respondents, who cited a requirement for more knowledge of the timbers to make this assessment. It was suggested that, given the likely niche markets, there is the potential for modest volumes to be exported. If the timbers could be utilised in new technology wood flooring (e.g. floating and composite floors), a '*great deal*' of timber could be used domestically and internationally.

It was suggested that consistent supply of timber would be the most important factor in generating market acceptance. Timber flooring is currently witnessing an upsurge in interest. New technology in this area, particularly in relation to the use of small timber pieces, will allow the use of previously unsuitable timbers. Therefore, it was suggested that there is strong potential for timbers such as western hardwoods. Narrow board strip flooring, parquetry and floating floor panels would be the most suitable use of relatively small and poor form logs. The overall assertion by respondents was that a market could exist for these timbers in niche areas, provided that the timbers are found to be suitable for flooring. It was indicated that further information regarding hygroscopic tendencies, drying degrade, gluing and response to finishes was required.

Prices flooring manufacturers are willing to pay for western Queensland hardwoods
Respondents were unclear on prices they would be willing to pay for these timbers, indicating that knowledge of properties, availability and market acceptance would be required. A figure of $\$800/m^3$ to $\$1,500/m^3$ for kiln dried timber was suggested by one respondent. It was suggested that prices would need to be comparable with hardwood timbers currently on the market. Brush box and Crow's ash were listed as comparative timbers with prices currently paid for GOS timber being quoted at $\$600/m^3$ and $\$900/m^3$ to $\$1000/m^3$ respectively. It was noted that the timbers would need to be moderately priced initially, but possibly increasing as western Queensland hardwoods become accepted in the market place.

8.4.3 Responses from furniture manufacturers

A response rate of 24% was achieved from furniture manufacturers.

Current use of western Queensland hardwoods by furniture manufacturers
The western Queensland hardwoods considered in this study had only been used by two of the respondents. Experience had been gained by these manufacturers with mulga, gidgee, beefwood and lancewood, which had been used because of their density, grain, colour and interesting features. Figure 8.1 illustrates a stool crafted from beefwood.

Figure 8.1 *A wind-up mulga stool*

Other respondents cited reasons for not having used western hardwoods:

- not available (three responses)
- unaware of timbers (one response)
- characteristics of timbers unknown (two responses), and
- customers request traditional timbers (one response).

Future use of western Queensland hardwoods by furniture manufacturers

Table 8.5 indicates the willingness of respondents to use western Queensland hardwood timbers in the future. The main reasons given for choosing to use western hardwoods timbers in the future are listed in Table 8.6.

Table 8.5 *Future use of western Queensland hardwood timbers by furniture manufacturers*

Future use western Queensland hardwoods?	Number of respondents
Yes	4
No	1
Maybe	3

Table 8.6 *Reasons given by furniture manufacturers for choosing to use western Queensland hardwood timbers in the future*

Reasons for choosing western Queensland timbers	Number of responses
Timber features	6
Desire to use Australian timbers	4
Environmental concern	2
Known markets	2
Availability	1
Price	1

Note: seven respondents provided this information

The western Queensland hardwood species preferred by respondents varied. Sandalbox and red lancewood were preferred by one respondent. Mulga and gidgee, due to their strong colours, were preferred by another. The principal response; however, was that preferred species would depend on customer demand and future trials undertaken by furniture manufacturers.

Desirable timber features for furniture manufacture

As indicated in Table 8.7, colour and ability to work the timbers were considered the most important features by furniture manufacturers when choosing western Queensland hardwoods.

Timber dimensions and requirements for furniture manufacture

The timber dimensions generally preferred by furniture manufacturers were:

- length — variable, with some indicating short lengths were fine, while others stressed the importance of minimum clear lengths of 2.4 m and some required 4.0 m clear lengths
- thickness — minimum of 20 mm, and
- width — minimum of 75 mm. Many manufacturers require 100 mm +.

The preferred form of timber was as roughsawn, dry boards. A preference for timber free from sapwood was also indicated by several respondents. Almost all respondents requested more information regarding the gluability of western Queeensland hardwoods.

Table 8.7 *Timber features considered important by furniture manufacturers*

Important timber features	Number of responses
Colour	6
Ability to work	4
Shrinkage/stability	2
Gluing capability	2
Density	1
Hardness	1
Moisture content	2

Note: seven respondents provided information

Potential demand for western Queensland hardwoods from furniture manufacturers

Most respondents indicated that they were unsure about potential volumes of timber that could be utilised. Market research and further evaluation of the suitability of the timbers for furniture manufacture would be required. It was suggested that the timbers are probably too hard and the resource too irregular and inconsistent for large-scale commercial manufacture of furniture. The timbers are, however, perhaps ideal for small-scale furniture manufacturers where size and consistency of timber inputs are not as important. Responses gave little insight to the international market for furniture manufacturing. Overall, the potential volumes utilised by the furniture industry in Australia would be quite small. Possible volumes suggested by three respondents were:

- 15 m^3 per year;
- 1 to 2 m^3 per month; and
- 4 to 5 m^3 per month.

Prices furniture manufacturers are willing to pay for western Queensland hardwoods

The findings from the survey suggest a possible average price of around $1,500/$m^3$. It was indicated that prices would depend on the size and quality of the timber pieces and customer demand. Suggestions were made that prices must be moderate and comparable with other Australian hardwood timbers, such as spotted gum and ironbark until a market is established. Once proven, western Queensland hardwoods would become more competitive and possibly command higher prices. The range of prices quoted for roughsawn dry timber included:

- $700 to $1,500/$m^3$
- $1,200/$m^3$
- $1,000 to $1,800/$m^3$
- $1,800 to $3,000/$m^3$, and
- <$3,000/$m^3$.

8.4.4 Responses from musical instrument manufacturers

A response rate of 36% was achieved for musical instrument makers. The majority of these were Australian and generally produced instruments on a small-scale. Table 8.8 presents the distribution of these responses by instrument type.

Table 8.8 *Responses by type of musical instrument manufactured*

Instrument	Number of responses
Guitars	5
Violins	5
Percussion	1
Woodwind	4
Other	2
Total	17

Current use of western Queensland hardwoods by musical instrument manufacturers

Six respondents were currently using or had trialled at least one of the western Queensland hardwoods considered in this study. In most instances, these timbers were only being used in experimental quantities. The suitability of western hardwoods varied according to the type of instrument produced. Trials by woodwind instrument makers, in particular for wooden flutes, have proven the suitability of many western Queensland hardwoods. The stability, and physical and aesthetic features of mulga, gidgee, red lancewood, sandalbox and beefwood indicate that they are all suitable for manufacturing wooden flutes or flute parts. Mulga, gidgee and ironwood have also been used successfully in the manufacture of guitars, principally due to their hardness and appearance. Trials by one respondent on mulga, gidgee and lancewood for percussion products (xylophones), suggested that their timber properties were unsuitable for this application.

Table 8.9 indicates that, among those instrument makers who have not previously used western Queensland hardwoods, the major reason these timbers had not been trialled was the perception that timber characteristics of western hardwoods were unsuitable. Problems relating to hardness, glueability and splitting were given as the major concerns.

Table 8.9 *Reasons why musical instrument makers have not previously used western Queensland hardwood timbers*

Reason offered	Number of responses
Timber unsuitable	5
Customer demand for traditional timbers	3
Traditional timbers easier to source in right sizes	1

Note: seven respondents provided information

Potential future use of western Queensland hardwoods by musical instrument manufacturers

Table 8.10 highlights that the majority of surveyed musical instrument manufacturers indicated they would consider using western Queensland hardwoods in the future. Table 8.11 reveals that the primary reasons why manufacturers considered utilising them in the future were a desire to use Australian timbers and to substitute for reducing supplies of traditional instrument making timbers. Environmental concerns were expressed by two respondents who referred to benefits from reducing the harvest of traditional timbers sourced from tropical rainforests and reducing clearing of remnant forests and woodlands in western Queensland.

Table 8.10 *Future use of western Queensland hardwood timbers indicated by musical instrument manufacturers*

Future use of western Queensland hardwoods?	Number of respondents
Yes	10
No	2
Possibly	3

Table 8.11 *Reasons offered by musical instrument manufacturers for considering utilising selected western Queensland hardwood species in the future*

Reasons for future utilisation of western Queensland hardwoods	Number of responses
Desire to use Australian timbers	8
Dwindling supplies of traditional species	6
Timber features	4
Expense of traditional species	3
Conservation concern	2
Known market for instruments	2
Provide variety for customers	1

Note: ten respondents provided information

Timber features desired by musical instrument manufacturers

Table 8.12 outlines the timber features considered most important to musical instrument manufacturers. The acoustic properties of the timber are most critical for musical instrument making. The importance of using very dry and stable timber, to ensure that pitch can be maintained over time, was emphasised. In most instances clear timber, totally free of blemishes, is required for instrument making.

Timber dimensions and other requirements of musical instrument manufacturers

The dimensions of timber required by musical instrument manufacturers varies according to the instrument, or part thereof, being manufactured. Table 8.13 details specific dimensions for several instruments. The form of timber required by respondents also varied. In most instances, roughsawn kiln dried timber was preferred, although some respondents required dressed timber. For the majority of instrument components, quartersawn timber would be desired due to its greater stability and resonance. For guitar manufacture, book-matched pairs are generally required for backs and sides. Clear, unblemished timber, free of sapwood is usually necessary for musical instrument manufacture. Some respondents were concerned with how the timber was processed and dried, stressing that it must be handled professionally in order to be suitable for instrument making.

Table 8.12 *Timber features important for musical instrument manufacturers*

Important timber features	Number of responses
Acoustic properties	9
Aesthetics	5
Ability to work	5
Hardness / density / strength	4
Shrinkage / stability	2
Gluing capability	1

Table 8.13 *Dimensions of clear, unblemished timber required by musical instrument manufacturers*

Instrument	Thickness (mm)	Width (mm)	Length (mm)
Flute	40	40	70 - 320
Guitar - side	50	135	900 - 1000
Guitar - face and back	50+	230	550
Guitar - neck	40 – 75	140+	400 - 600
Guitar - fingerboard	10	50	300 - 500
Violin	50	50	750
Xylophone	20 – 50	38 – 50	150 - 350

Potential demand for western Queensland hardwoods from musical instrument manufacturers

On a world scale, the Australian musical instrument manufacturing industry is small. Australian musical instrument makers are generally working with high labour to capital ratios. There are only one to two sizeable companies manufacturing instruments, with the remainder of the industry characterised by individuals with small output of fine instruments and limited timber consumption. From information received, it is not possible to make an assessment of the volumes that could potentially be used internationally.

The high value of musical instruments, and the traditions in manufacture and playing, have reportedly resulted in adherence to established materials and practices, and a reluctance of manufacturers to experiment. Dwindling supplies and the increasing expense of acquiring traditionally used musical instrument timbers had been noted by several respondents. Opposition to the use of non-traditional timbers is decreasing, as evidenced by the gradual acceptance of *Acacia koa*, a timber similar to blackwood (*A. melanoxylon*). It was suggested that the search for resources to replace traditional timbers is occupying the time of many instrument manufacturers. It was suggested that the marketing of western Queensland hardwoods timbers for use in the manufacture of musical instruments would benefit from a comparative study with timbers traditionally used in the manufacture of instruments. Timbers for comparison should include African blackwood, boxwood, cocobolo, cocuswood and ebony, traditionally used in woodwind instruments, and spruce, western red cedar, maple, mahogany and rosewood, traditionally used in stringed instruments.

Instruments manufactured from western hardwood timbers will sound different to those manufactured from traditional timbers, although this does not confer lower quality. One respondent has had success in marketing the different qualities of western Queensland timbers rather than marketing them as substitutes for traditional timbers. Western Queensland acacias, in particular, are viewed as having much potential, because they are unusually resonant.

Two Australian exporters of musical instrument timbers suggested that, if timely supply could be guaranteed, there would be international customers for these timbers in Europe and the USA. A number of manufacturers commented that they have had no trouble selling instruments made from Australian timbers overseas and often have customers demanding native Australian timbers. Americans, in particular, have shown keen interest in Australian timbers, viewing them as a novelty.

International and domestic markets could exist for western Queensland timbers in the manufacture of musical instruments, provided problems of supply are overcome and the suitability of timbers is ascertained. The timbers could be marketed either as substitutes for traditional timbers or based on their own qualities. However, the volume of timber utilised in musical instrument manufacture is likely to be small relative to the volume that could potentially be utilised in other applications, such as flooring.

Prices musical instrument manufacturers are willing to pay for western Queensland hardwoods

The manufacture of musical instruments is viewed as one of the best ways of adding value to timber. It was suggested that high prices would be paid for these timbers, provided high quality is assured and they are competitive with imported timbers. Examples of prices quoted by respondents include:

- \$10 for guitar fingerboards (approximately \$27,000/m^3)
- At least \$35 for sets of backs and sides for guitars, and more for fingerboards (approximately \$2,800/m^3+)
- \$30 to \$40 (approximately \$30,000/m^3) for 40 mm x 40 mm x 700 mm blanks for flute-making, and
- \$1,500/m^3 to \$2,000/m^3 for timber exported to international luthier suppliers.

8.4.5 Responses from timber merchants

A 34% response rate was achieved for timber merchants. Of the 21 respondents, four were international. The majority of respondents were in the business of selling craft, cabinet and decorative timbers to specialty product manufacturers.

Current stocking of western Queensland hardwoods by timber merchants

Eleven respondents presently stock at least one of the timbers under consideration. The total volume of western hardwood timbers sold by these company's totals about 35 m^3 to 45 m^3 per year. These timbers are principally sold to furniture makers, woodturners, craftspeople and musical instrument makers. Very small volumes of western Queensland hardwoods are also being exported to the United Kingdom, the USA and New Zealand. Prices currently paid by timber merchants for these timbers generally range from \$650/tonne to \$3,000/tonne for logs and from \$3,000/tonne to \$5,000/tonne for dressed timber. Merchants are willing to pay up to \$8,000/m^3 for milled and seasoned select grade timber of some species.

Potential future use of western Queensland hardwoods by timber merchants

Table 8.14 indicates that the majority of respondents would consider stocking western hardwood timbers in the future. Most merchants who indicated that they would potentially stock western Queensland timbers had no species preference. Most would initially prefer a mixture of species, until further knowledge about timber properties and marketability became available. When this knowledge had been acquired, some respondents suggested they would then prefer to deal in a few species only, while others were interested in retaining a mixture of species. Table 8.15 highlights that the timber features of western hardwoods were most commonly highlighted by merchants as a reason for stocking these timbers in the future.

Table 8.14 *Indication of future plans of timber merchants to stock western Queensland hardwoods*

Stock western Queensland timbers in the future?	Number of respondents
Yes	12
No	3
Maybe	4
na	2

Timber features desired by timber merchants and suppliers

Where the market demands aesthetically appealing timber, colour variation is an asset. For other product groups, such as musical instruments, consistency in colour is generally necessary. It was considered that for larger scale end-uses, such as flooring and furniture, uniformity of colour would be more important. It was suggested that the market generally prefers dark, red and brown colours. Given the specialty markets that timber merchants supply, clear and figured timbers would, generally, be more marketable.

Table 8.15 *Reasons given by timber merchants for stocking western hardwood timbers in the future*

Reason for stocking western Queensland hardwoods in the future	Number of responses
Timber features	12
Known markets	9
Environmental concern	7
Desire to stock Australian timbers.	6
Availability	1
Price	1

Note: 14 respondents provided information

Timber dimensions and other requirements sought by timber merchants

The form of timber demanded by timber merchants ranged from green logs to dried and dressed boards. This variation reflected the requirements of the merchant's customers and the capacity of merchants to undertake their own processing, drying and dressing activities. Most merchants undertake some form of value-adding and prefer to obtain boards or logs as long and as wide as possible. A number of merchants indicted a preference to select trees and undertake all processing activities themselves.

Potential demand for western Queensland hardwoods from timber merchants

Due to the limited knowledge about western Queensland hardwood timber properties, quality and markets, timber merchants generally expressed difficulties in predicting the volumes timber that they could potentially consume. Merchants asserted that there is presently no medium to large-scale manufacturing of western hardwoods, although most respondents believed that there is great potential for the development of an export oriented manufacturing industry utilising these timbers, and that this would be the means for achieving high volume sales. The most likely high volume products were believed to be flooring, furniture and veneer. Merchants involved principally in the sale of craft and decorative timbers reported that they would potentially stock only small volumes. They indicated that this sector largely consists of individuals who buy timbers to produce goods for their own enjoyment and use, and will probably always only account for small volumes. It was suggested by one respondent that many woodworkers and craftspeople avoid purchasing such timbers from merchants and retail outlets, instead preferring to obtain their supplies directly from landholders.

It was considered by most merchants that the domestic market is too small to support an industry based on western hardwood timbers. Some merchants were certain of demand for these timbers internationally, particularly in the United Kingdom, the USA, Japan and New Zealand. One international respondent suggested that while they were unaware of any other timber merchants selling these timbers, they knew of many whom could be potential future distributors. Several domestic respondents reported strong interest from international buyers for timbers with properties similar to western Queensland hardwoods.

Some respondents stated that it was unlikely a market would exist for these timbers. This view stemmed principally from the fact that only small log sizes would be available. Other merchants who believed that a market could exist, expressed concern regarding consistency of supply. Several merchants have previously encountered supply problems with western Queensland timbers and stated that this would need to be overcome before a market could develop. Finally, whilst a market may potentially exist, considerable education and marketing campaigns would be necessary to promote the timbers.

Prices timber merchants are willing to pay for western Queensland hardwoods

Generally, respondents were unclear on the prices that they would be prepared to pay for western hardwood timbers. There is presently no significant supply or demand of these timbers, and information about potential market values is limited. It was suggested by some respondents that, if the timbers are to be used in higher volume end-uses, prices would need to be similar to those paid for other hardwood species such as spotted gum, ironbark, brush box and Crow’s ash. The following prices were provided by merchants who typically deal in small volumes of timber sold into high value markets. Prices ranging from $\$600/m^3$ to $\$1,200/m^3$ were quoted for green, rough sawn timber, and $\$1,500/m^3$ to $\$3,500/m^3$ for seasoned timber. For delivered logs, merchants were prepared to pay prices ranging from $600/tonne to $1,600/tonne. A royalty of $50/tonne was quoted by one respondent, who would prefer to undertake all tree selection, harvesting and processing.

Necessity of ecolabelling western Queensland hardwoods

As indicated by Table 8.16, ecolabelling was seen as a necessity by most respondents, particularly if timbers are to be exported to the USA and Europe.

Table 8.16 *Perceived necessity of ecolabelling by timber merchants*

Ecolabelling necessary?	Number of responses
Yes	14
No	3
Unsure	1

8.4.6 Responses from veneer manufacturers and retailers

A response rate of 54% was achieved for veneer manufacturers and retailers. Of the seven respondents, four produce veneers and the remainder were suppliers of veneer.

Current use of western Queensland hardwoods by veneer manufacturers and retailers
No respondents are currently, or have previously, used or stocked western Queensland hardwoods for veneer. Reasons for not using the timbers were not explicitly stated; however, it was indicated that difficulties obtaining billets of a suitable size was the primary reason.

Potential future use of western Queensland hardwoods by veneer manufacturers and retailers
Table 8.17 indicates the willingness of respondents to manufacture or stock veneers of these timbers in the future. Respondents who indicated they would use or stock western Queensland hardwoods were unclear on preferred species, indicating that selection would be based on trial performance. Initially a mixture of species would be required to undertake trials.

Table 8.17 *Indicative future use of western hardwood timbers as veneers*

Future use or stocking of western Queensland timbers as veneers?	Number of respondents
Yes	4
No	2
Maybe	1

Note: seven respondents provided information

Timber features desired by veneer manufacturers and retailers
Colour is an important marketing feature for veneers. It was suggested by respondents that colour matching is not always necessary, as the veneer market is accepting of natural colour variations. However, in high volume manufacturing, consistency of colour may be necessary. Highly figured timbers were desired by some respondents.

Timber dimensions and other requirements for veneer manufacture and retailing
The manufacture of veneer requires timber in the form of billets. Plastic wrapping of billets may be necessary in some instances to prevent degrade. Minimum dimensions quoted by respondents were:

- length 2.5 m to 2.9 m
- width 150 mm to 250 mm, and
- thickness 100 mm to 250 mm.

Potential demand for western Queensland hardwoods from veneer manufacturers and retailers

The appearance of these timbers, in particular their colour and grain, were considered highly marketable, although respondents had difficulties predicting the volumes they could potentially consume within a given period, because:

- customer appeal determines demand
- some veneer manufacturers work closely with furniture manufacturers and would need to discuss the use of western Queensland hardwoods with them before making commitments, and
- of uncertainty surrounding the continuity of supply.

One domestic respondent suggested they could potentially use 6,000 m^3 to 9,000 m^3 of western Queensland hardwood billets annually, if these timbers are found to be suitable for veneering. Another respondent asserted that veneering is best the route to establish a broader market for these timbers, stating that if the marketing of western Queensland hardwood veneers is successful, then the sale of sawn timber will follow. However, opinions about potential markets for veneered western Queensland timbers varied notably among respondents. Some respondents suggested that the uniqueness of these timbers indicate the potential existence of niche export market opportunities, particularly for furniture manufacture in Asian, European and North American markets. On the other hand, doubts were expressed by three respondents as to whether international buyers would be interested in veneered panels of these timbers. A large marketing budget would be necessary to sell veneered western Queensland hardwoods internationally. Overall the survey results suggest there is an interest in manufacturing western hardwood veneers, provided concerns about high timber densities, poor log form, small log size and continuity of supply are overcome.

Prices veneer manufacturers and retailers are willing to pay for western Queensland hardwoods

The general opinion of respondents was that western Queensland hardwoods would need to be price competitive with other hardwood veneers, probably beginning with a 'middle-of-the-range' veneer log price. One respondent suggested a figure of $250/$m^3$ of veneer flitches (not the billets used to produce veneer). Other respondents suggested that pricing would be dependent on the recovery of billets from logs and the recovery of veneer from each billet. Price determination would require trials to assess recovery rates and suitability of western Queensland timbers for veneer.

Necessity of ecolabelling western Queensland hardwoods

Veneer manufacturers asserted that, for Australian markets, labelling western Queensland hardwoods as having been harvested from a sustainably managed resource, was unnecessary. Ecolabelling was considered advantageous if timbers were to be exported to Europe.

8.4.7 Responses from woodcarvers, turners and others

A response rate of 54% was achieved for wood turners, wood carvers and other potential end-users. Products manufactured by these respondents ranged from wooden boxes to golf tees and clocks. Figure 8.2 illustrates a beefwood vase.

Figure 8.2 *A spectacular beefwood vase*

Current use of western Queensland hardwoods by woodcarvers, turners and others
Five respondents have previously used the timbers under consideration; however, the volumes utilised are small. Prices reportedly paid for western Queensland hardwoods varied widely from $335/m^3 for green roughsawn boards to between $2,000/m^3 and $3,000/m^3 for roughsawn, dried timber.

Future use of western Queensland hardwoods by woodcarvers, turners and others
Four respondents suggested that they would use western Queensland hardwoods in the future. Generally no preference for species was indicated, although dark, rich and highly figured timbers are usually demanded by wood turners and carvers.

Timber features desired by woodcarvers, turners and others
Aside from aesthetics, the hardness and ability to work the timbers are most important to wood turners.

Timber dimensions and requirements for woodcarving and turning
A plethora of timber forms and dimensions were provided, commensurate with the variety of products manufactured; however, boards were ideally at least 50 mm x 100 mm x 500 mm.

Prices woodcarvers, turners and others are willing to pay for western Queensland hardwoods
Woodturners are generally prepared to pay relatively high prices for timber given the small volumes that are used. Prices suggested range from $2/kg to $8/kg (approximately $2,000/m^3 to $8,000/m^3).

Potential market demand from woodcarvers, turners and others
Respondents found predicting volumes they could potentially consume within a given period difficult. Domestically, the potential volumes consumed would be small, probably in the vicinity of tens of cubic metres per year. In Europe and North America, where woodworking is a popular pastime and the number of woodworkers extends into the millions, a large market could potentially exist. Woodworkers are keen to use new and unique timbers and will pay high prices for them. However, it was again indicated that a strong marketing campaign would be required to exploit overseas markets.

8.5 Discussion

Currently, total consumption of the western Queensland hardwoods considered in this survey is likely to be no more than a couple of hundred cubic metres of sawnwood per annum, little of which is exported. The small volume milled was found to be due to many factors, including ignorance about the resource, lack of information about timber properties, small log size, poor form and prevalence of defects, preference for 'traditional' timbers, and an unprofessional and inefficient supply chain. The latter point was frequently included in questionnaire responses, with many timber merchants and musical instrument manufacturers stating that they have had frustrating and costly dealings with so-called suppliers of western Queensland hardwoods. Nevertheless, most survey respondents believed western Queensland hardwoods have great market potential, many indicated a willingness to stock, trial or use the timbers and virtually all requested to receive further information about the timbers as it becomes available. This was true even of consumers who have had costly experiences in the past. A high proportion of respondents indicated that all 11 species targeted in the survey were marketable, but that they would limit their purchases to between two and three species after product suitability trials had been conducted and their customers had revealed their preferences.

Substantially increasing the domestic demand for western Queensland hardwoods is only likely to be possible through flooring and veneer markets. Domestic timber flooring manufacturers were particularly interested in these timbers, suggesting that the use of small board lengths would be possible in floating and parquet flooring. A reluctance to (initially) pay more than standard rough-sawn, dried hardwood timber prices ($1,500/m^3) was indicated by flooring manufacturers. Domestic veneer manufacturers and suppliers asserted that if western Queensland timbers could be veneered and marketed successfully, then a market for solid wood would follow. However, veneer manufacturers require logs at least 2.5 m long and with minimal defect, which are rare among many western Queensland timbers. This survey indicated that the domestic market could potentially absorb several thousand cubic metres of western hardwoods for flooring and veneer applications, provided product trials were successful.

Improving the supply chain and marketing of western Queensland hardwoods is likely to expand the domestic market for these timbers beyond current levels (~200 m^3/yr), although total demand is not likely to grow beyond a few thousand cubic metres per annum. In the high value category, small-scale furniture producers and timber merchants seeking small volumes of high quality boards are likely to account for most of the market (several hundred to one thousand cubic metres per annum), and are willing to pay about $3,000/m^3. Many musical instrument manufacturers are genuinely excited by western Queensland hardwoods and will pay approximately $20,000/m^3 to $30,000/m^3 for timber of the highest quality; however these manufacturers demand kilograms, not cubic metres of timber per annum. Musical instrument manufacturers have a reputation of being fussy about their timber and several hinted that they would not be interested in western Queensland hardwoods if they were going to be sawn by 'bushmillers who do not cut properly'. Catering for niche markets in Australia would necessarily involve distributing very small volumes of very high quality timber to many consumers. Nevertheless, the potential for value-adding in musical instrument manufacture warrants these markets being further investigated.

Although no international flooring manufacturers responded to the survey, domestic flooring manufacturers were confident in establishing flooring markets for western Queensland hardwoods in North America and Europe. One supplier of veneer in the USA showed great interest in western Queensland hardwoods and believes a large market would exist there, if these timbers can be veneered. There are reportedly millions of amateur and professional woodturners in the USA and Europe, so there potentially exists an export market for hundreds of cubic metres of high quality western hardwood boards. If the bias in favour of 'traditional' species can be overcome, there may also be high value musical instrument export markets. Respondents reported that timber and timber products must be presented well for international markets, particularly for sales into Europe, Japan and North America. Ecolabelling was found to be of relatively low importance for potential Australian consumers of western Queensland hardwoods; however, survey responses indicated that certification would be virtually a necessity for export to Europe and would be of benefit in the USA. Domestic and international respondents attested that a large, well directed marketing campaign would be necessary for western Queensland hardwoods to make an impact on foreign markets.

Chapter 9 presents QFRI's assessment of market potential based on information collected on the western Queensland hardwood resource since the postal survey was undertaken.

Appendix 8A. List of enterprises to whom western Queensland hardwoods questionnaires were sent

DOMESTIC

Timber Merchants/Suppliers

Acacia Craft Timbers
Adam's Timber
Advance Timbers
Allwood Antiques and Exotic Woods
Anagote Timbers
Austimber Resources, IntexPacific P/L
Australian Choice Timber Supplies
Australian Design Hardwoods
Australian Furniture Timbers
Baker Moon
Bankstown Timber and Hardware
Bill Philip's Specialised Timbers
Brads Burls and Craftwoods
Cockatoo Creek Timbers
Djarilmari Timber Products
Fiddleback Fine Australian Timbers
Fox Road Timbers
Gilet Guitars and Guitarwoods
Ironwood Antique Timbers
Lazarides Timber Agencies
Matthew's Timber
Moxon Timbers
Mullumbimby Woodworks
Otto and Co Pty Ltd
P.N.G. Quality Timbers
Peter's Timber Shack
Planter and Grace Pty Ltd
Rare Woods
Rings of Time Timbers
Rosebank Timber Traders
Southern Trade Supplies
Supreme Wood Pty Ltd
Teak & Fancy Timbers
The Marquetry Craft Company
The Woodage
Toona Australis
Toowoomba Recycled Timber and Furniture
Trend Timbers Pty Ltd
Wauchope Wood and Turning Supplies
Westralair Pty Ltd
Woodturning Supplies Pty Ltd
Wren Timbers
Xylo-Australis

Veneer Manufacturers/Retailers

Albart Trading Co. Pty Ltd
Briggs Veneers Pty Ltd
Brims Wood Panels Pty Ltd
Five Star Finishers
Mayze Corp. Pty Ltd
Morley Wood Products
Panel Veneer Pty Ltd
Peter Scott-Young
Proveneer Pty Ltd
Specialty Wood Veneer Panels Pty Ltd
Timberwood Trading
Veneer Craft and Marquetry Veneers Pty Ltd
Veneer Panels Pty Ltd

Musical Instrument Makers

Animato Violins
Arthur T. Robinson
Chris Brady and Craftsman
Dale E Stevens
David S Brown
Doug Eaton and Dale Jacobsen Stanley River Music
Duff Mandolins and Guitars
Fred Morgan
Gabriel Ochoteco
Gabriel's Guitar Workshop
Gary Rizzolo
George Paxevanos
Gerard Gilet, Gilet Guitars and Guitarwoods
Gilchrist Mandolins and Guitars
Grawert Violin Makers and Restorers
Howard Oberg
Jack Akerman
James Carrett
Jeff Kemp
Joe Gallacher
John D Ferwerda
John Simmers Violin Maker
Kinman Guitar Craft
Lance Scott Violins
Lawrence K. Smith
LKS Guitars & Mandolins
Maton Guitars Pty Ltd
Michael Grinter
Musica Bambusa
Pat Sephton
Peter Coombe
Queensland Percussion Products
Terry McGee
The Guitar Company
Thomas B. Livesey T.B. Livesey Guitars

Woodturners/Craftspeople

Cessnocks Joinery and Timber Detailing
Colonial Woodcraft Clocks
Coramba Timbers
Doug Boxall
Gary O'Neill
Lifestyle Timber and Joinery
Martin Jackson
Montville Woods
Naturally Australian Pty Ltd
Peter Stroud
Roger Gifkins
The Bush Walking Stick Co.
Working Wood

Furniture Manufacturers

Absolute Timber – James Crawford
Anton Gerner Furniture Pty Ltd
Australian Fine Furniture
Australian Hardwood furniture
Australian Wood Design Studio
Australian Woodart
Biltrite Furniture Co.
Bowen Mountain Furniture Co.
Calyptus Fine Furniture
Canalpie Custom Crafted Furniture
Designer Furniture by Bruce James
Eco, Handcrafted Furniture
Fine Design Furniture Pty Ltd
Goldcreek Australia
Griffith Furniture
Illing's Own Fine Furniture
Lothlorien Designs
Maunsell's Fine Furniture
Neil Erasmus Designs
Nick Hill Furniture Designer and Maker
Nik Wynne Designer Maker
On the Porch
Paragon /Queen Anne
Pegar Furniture
Peter Lowe
Podger Australis
Scott Brothers
Specialty furniture by Dale Symes
Tascraft Furniture
The Furniture Manufacturng Company of Australia Pty Ltd
Tim O'Rourke
Woodsense
Woodwinks Custom Woodworking

Timber Flooring

Aarrow Floors and Floor Sanding Pty Ltd
Ambassador Floor Coverings
Beautiful Hardwood Floors
Bretts Trade Timber and Hardware
C Tatters & Sons Pty Ltd
Natural Timber Flooring
Northern Suburbs Timber Flooring
Phoenix Wood Floors
Premium Cork and Timber Pty Ltd
QLD Natural Flooring
QLD Parquetry and Cork Floors Pty Ltd
Traditional Hardwood Flooring
Wood Flooring Pty Ltd

Billiard Cue Makers

Auscues
The Cue Specialists
Zak's Custom Cues

INTERNATIONAL

Associations

American Assoc. of Woodturners
American Furniture Manufacturers Association
Assoc. of Woodturners of Great Britain
British Furniture Manufacturers
British Woodturners Association
British Woodworking Federation
Canadian Council of Furniture Manufacturers
Malaysian Furniture Industry Council
The British Timber Merchants Association
The Chamber of Furniture Industries of the Philippines

Timber Suppliers/Merchants

A&M Wood Specialty Inc.
Alta Resource, Altalab Inc.
Anchor Hardwoods Inc.
Blackmountain Northwoods
Colorado Woodworkers Inc
Edensaw Woods Pty Ltd
Eisenbrand Inc.
Exotic Woods Co.
Frost Hardwood Lumber
Glimer Wood Co.
International Violin Co. Ltd
Luthiers Mercantile International, Inc.
Macbeth Hardwoods
Martin Guitar Company
North West Timber
Quality Woodwork & Supply, Inc.
Tech-wood, Inc.
Willard Brothers Woodcutters

Musical Instrument Makers

C. F. Martin & Co Inc.
Choroi
Folkcraft Instruments
Gibson Guitars
Glaesel Stringed Instrument Division, Selmer Company Inc
Ithaca Stringed Instruments
Paul Jacobs
Prof. Felix Skowronek
Taylor Guitars
Yamaha Corporation

Billiard Cue Manufacturers

Bludworth Custom Cue Company
Capone Cues
Cousins Custom Cues
Danny Hathcocks, Centrefire Cues
DP Custom Cues
Huebler Industries
Kikel Custom Cues
Lambros Cues
Meucci Originals Inc
Prather Cues
Richard Black Custom Cues
Schon Custom Cues
Stealth Cues and Fabrics
Tim Scruggs Custom Cues Inc.
Viking Cues Mfg Inc.

Knife Manufacturers

Benchmade Knife Co.
Benchmark Knives
Boker USA Inc.
Buck Knives Inc.
Coast Cutlery
Cold Steel Knives
Gerber
Great American Tool Company Inc.
J.A. Henckels
K & K Custom Knives
Katz Knives
Lamson & Goodnow MFG Co.
Schrade Cutlery
Smith & Wesson Knives

Appendix 8B. Example of the letter distributed to timber merchants/suppliers

(similar letters sent to all other potential respondents)

3rd February 1999

****
****
****
****

Dear Sir/Madam

The Queensland Forestry Research Institute (QFRI), in collaboration with individuals and community groups representing the graziers of central western and south western Queensland, are undertaking a project which is investigating the utilisation and market potential of western hardwoods as specialty timbers.

Timber harvested by the graziers of western Queensland is currently poorly utilised. The graziers are keen to investigate whether an opportunity exists to better utilise these timbers and create a new and diversified income. We are therefore concerned with assessing the potential for developing a viable industry based on sustainable and ecologically sensible harvesting of the timbers of this region.

Research is currently being undertaken into the harvesting and processing of these timbers and this research is being complemented by a review of the market potential of these specialty timbers.

The species being considered include:

Acacia aneura	mulga
Acacia cambagei	gidgee
Acacia coriacea	desert oak
Acacia excelsa	ironwood
Acacia nilotica	prickly acacia
Acacia shirleyii	lancewood
Archidendropsis basaltica	red lancewood
Corymbia similis	yellowjacket
Eremophila mitchellii	sandalbox
Eucalyptus populnea	bimble box
Grevillea striata	beefwood

Enclosed are some images of the timbers under consideration and some data sourced from the current work being undertaken by QFRI regarding the properties of these timbers.

A number of potential problems exist with the resource including small or irregular tree form, variable log quality, dispersed distribution, refractory drying behaviour and unknown processing costs. The utilisation of these timbers for specialty products, that will deliver adequate returns, will thus be necessary to recover costs associated with processing. It is hoped that the characteristic high density, high durability and aesthetic features of these timbers, which far exceeds that of northern hemisphere hardwoods, will provide the opportunity for niche markets to be exploited.

A list of products has been proposed as potential avenues for utilising these timbers. These include:

- fine furniture
- flooring – parquetry
- wooden sculpture and carvings
- writing implements –pens/pencils
- clocks
- billiard cues
- knife handles
- musical instruments
- tool handles.

One aspect of our market research therefore involves contacting people who may potentially supply or use these timbers to manufacture the above products in the future.

It is hoped we can gather information that will allow us to make an assessment of:
- the current and predicted trends in consumption and prices of these products
- the potential volumes of timber that could be utilised
- required timber specifications i.e. the size of timber pieces
- the required timber features (density, hardness, durability, visual appearance).

In order to source some of this information a brief questionnaire has been prepared and is enclosed. It is hoped that you may be able to spare a small amount of time to fill this in and return it either by fax ((07) 3896 9628) or by post (see address below). We will ensure that all information supplied is held in confidence. It would be appreciated if you could return this questionnaire by the end of February.

We are keen to obtain as much information as possible regarding the marketing of these timbers and would welcome any additional material (company information, catalogues, price lists etc.) which you believe may be of assistance to us in our research. Should you require any further information or if you would like to discuss any matters regarding this issue feel free to contact us.

Thanking you, in anticipation of your correspondence.

Yours sincerely

Katherine Whittaker
Wood Products Program (QFRI)

Appendix 8C. Questionnaire sent to veneer manufacturers/retailers

FACSIMILE TRANSMISSION

DATE: ____________

TO Katherine Whittaker
Wood Products Program QFRI

FACSIMILE NO: (07) 3896 9628

FROM: ________________________________

____

NO. OF PAGES: ______________
(INCLUDING COVER)

MESSAGE: Western Hardwoods Questionnaire

<u>Questionnaire for veneer manufacturers/retailers</u>

Company name ____

Company description

____
____
____
____

Do you currently stock or have you previously produced veneers from any of the timbers listed above? If yes:

What species?

____
____
____
____
____

What volumes would you use over a given time?

What size pieces?

Who do you principally supply to and what products are being manufactured from these timbers?

Are any of these timbers exported? If yes, where?

Approximately what prices are paid for these timbers?

Would you consider stocking these timbers in the future? ________
If yes:

The Timber

Would you have a preference for species? Would it matter if you were supplied a mixture of species?

What would be the minimum size billets needed to produce veneers?

How important would timber colour be to you? Would colour matching be a requirement?

How much of these timbers could you potentially consume if a large resource was available?

Are there any other special requirements for seasoning? (e.g. Would timber need to be dried to particular moisture contents for different products or locations? Would timber need to be plastic wrapped to preserve dried quality?)

Would you require more information regarding utilisation and processing properties (drying/gluing etc.) before you would stock these timbers?

What would be the reasons behind your choice to stock these timbers?

e.g
- the features of the timber (high density, high durability etc.)
- a conservation/environmental concern
- known market
- desire to stock inland timbers

Would it be an advantage if the timber was 'eco-labelled'?

Do you have any other comments/questions on the resource?

Prices

What prices would you be prepared to pay for these timbers?

Markets

Who would be your potential customers and what products are likely to be manufactured from these timbers?

Do you believe there would be an international market for these timbers? Would you be likely to export any of these timbers? To what countries and for what products would they be exported?

Further comments

Are you interested in obtaining further information about these timbers?

Thanks for your time

Katherine Whittaker
Wood Products Program QFRI

Beefwood
- very stable, not prone to warping
- suitable for furniture, mallet heads
- has been used in musical instruments - violins
- moderately hard
- deep pink colour

Desert Oak
- very hard
- attractive dark timber
- timber has a tendency to crack – needs to be treated properly
- trees not large
- used for musical instruments

Red lancewood
- pink wood
- hard and beautiful timber
- wind checks and cracks make it hard to get good timber
- needs to be treated with care

Lancewood
- Very straight tree
- straight grain
- has been used for walking sticks/bagpipes
- has a tendency to crack
- suitable for musical instruments

Ironwood
- hard
- attractive dark grain with yellow sapwood
- used for turning

Sandalbox
- attractive scent
- small trees
- heartwood attractive
- turns well.

Mulga
- suitable for musical instrument making
- heartwood dark brown, with contrasting markings of golden yellow
- very hard
- wood turns well and takes a high polish

Bimblebox

Gidgee
- has been used in musical instruments

Appendix 8D. Questionnaire sent to musical instrument makers

FACSIMILE TRANSMISSION

DATE: ____________

TO Katherine Whittaker
Wood Products Program QFRI

FACSIMILE NO: (07) 3896 9628

FROM: ______________________________

____

NO. OF PAGES: ______________
(INCLUDING COVER)

MESSAGE: Western Hardwoods Questionnaire

Questionnaire for musical instrument makers

Name ____

Instruments produced

____
____
____

Do you currently use or have you previously used any of the timbers listed above? _______

If yes: What species? What are your reasons for using them? What volumes of timber do you use? How much do you pay for these timbers?

____
____
____
____

Do you currently use or have you previously used any other Australian timbers in the production of your instruments? If yes: What species? What are your reasons for using them? What volumes of timber do you use? How much do you pay for these timbers?

Are you aware of other musical instrument makers who are using the timbers listed above or other Australian species?

If you have not previously used Australian timbers in the manufacture of your instruments what are the reasons? e.g. timber characteristics not suitable, timbers not available, opposition from your customers to the use of non-traditional timbers etc.

Do you believe that the potential exists for these timbers to be used in musical instrument making and be used as substitutes for other timbers currently being used?

What is your view on the opposition to the use of non-traditional timbers for instrument making? Is there currently a market for instruments made from Australian timbers domestically? Internationally? Do you believe trends in this area are changing or will change over time?

Would you consider using these timbers in the future? _______ If yes:

Would you have a preference for species?

___

___

___

What would be the reasons behind your choice to use these timbers?

e.g.
- the features of the timber (high density, high durability, etc.)
- desire to use Australian timbers
- a conservation/environmental concern
- known market

___

___

___

What timber features would be most important in your selection of these timbers? (e.g. density, hardness, acoustic properties, ability to work, etc.)

___

___

___

How much of these timbers could you potentially consume?

___

___

___

What timber dimensions (length, width, thickness) would you require?

___

___

___

In what form would you prefer the timber – roughsawn/dressed, green/dry, etc?

___

___

___

Would the timber need to be sapwood-free?

___

___

___

Are there any other special requirements you would have in regard to harvesting/processing/seasoning of the timbers?

___

___

___

Would you require more information regarding utilisation and processing properties (drying/gluing/ working, etc.) before you would consider using these timbers?

____
____
____

What prices would you be prepared to pay for these timbers?

____
____
____

Do you have any further comments?

____
____
____
____
____
____

Are you interested in obtaining further information about these timbers?

____
____
____
____

Thanks for your time

Katherine Whittaker
Wood Products Program QFRI

Appendix 8E. List of timber properties distributed to potential respondents

The following data is sourced from the current work being undertaken by the Wood Utilisation Group at the Queensland Forestry Research Institute which was sponsored by the Department of Natural Resources, The Desert Uplands Build-Up and Development Strategy Committee and the South West Strategy Group. Data is given for green moisture content, air dry density and, radial and tangential shrinkage.

Trade name	Species name	Green moisture content (%)	Air dry density (kg/m3)	Radial shrinkage (%)	Tangential shrinkage (%)
Mulga	*Acacia aneura*	26.7	1101	1.6	2.2
Gidgee	*Acacia cambagei*	26.4	1283	1.5	2.3
Desert oak	*Acacia coriacea*	24.6	1099	1.6	2
Ironwood	*Acacia excelsa*	37.5	1122	1.6	2.6
Prickly acacia	*Acacia nilitica*	55.2	875	1	1.6
Lancewood	*Acacia shirleyi*	25	1020	1	1.8
Red lancewood	*Archidendropsis basaltica*	31.4	1218	3	4.4
Sandalbox	*Eremophila mitchellii*	20.4	1051	1.3	2.7
Bimble box	*Eucalyptus populnea*	37.2	1145	2.8	4
Qld yellow jacket	*Corymbia similis*	37.5	1034	2.5	3.3
Beefwood	*Grevillea striata*	42.3	990	1.5	3.5

Appendix 8F. Timber images distributed to potential respondents

Western hardwood timbers under consideration
The following images of six of the western hardwood that are being studied indicate the range of colours and figures that are available. These images are reproduced in colour on the back cover of this report.

Gidgee

Mulga

Sandalbox

Beefwood

Red lancewood

Bimble box

9. Appraisal of market opportunities for western Queensland hardwoods

T. J. Venn [1,2] and R.L. McGavin[1]

1. Queensland Forestry Research Institute, Indooroopilly QLD 4068
2. On leave from School of Economics, The University of Queensland, St Lucia QLD 4072

As more information has become available about the timber properties of western Queensland hardwoods, it has been possible to critically review market opportunities. Western hardwoods have been found to be unsuitable for the supply of markets where long or wide boards clear of defect are a prerequisite, such as strip flooring. These timbers are also unsuited to commercial manufacturing of veneer. However, western hardwoods are suitable where small lengths can be utilised, as in parquetry flooring, some types of furniture manufacturing, musical instruments, knife handle blanks, woodturning blocks, indigenous tools and weapons (e.g. boomerangs) and plaques. Although furniture and parquetry flooring production could potentially consume large volumes of timber, high costs of production are likely to constrain sales to high-value niche markets where throughput volume is likely to be far lower. High-value products, such as musical instrument timbers and woodturning blocks are only likely to be demanded in small volumes in the short to medium-term. Ringed gidgee has high export potential.

9.1 Introduction

The 1998 postal survey reported in Chapter 8 was highly informative about potential market interest in western Queensland hardwoods. Respondents were provided with the best information then available about these timbers and asked to comment on their suitability for particular markets. However, the postal survey was conducted before the harvesting, portable milling, drying, grading and veneering studies were undertaken, the outcomes of which have been reported in earlier chapters. These trials highlighted the reality of processing western Queensland hardwoods: short logs yielding relatively small volumes of utilisable timber and about 2% of log volume as clear wood. Many respondents to the postal survey were enthusiastic about western Queensland hardwoods; however, it had been noted that none of the flooring and veneer manufacturers, and only two out of nine furniture manufacturer respondents, had any experience with these timbers. It is apparent that these timbers will not be suitable for all markets assessed by the postal survey and, with more information now available, a re-appraisal of the suitability of these timbers for various markets is warranted.

During the first six-months of 2002, independent discussions were held with several current and potential consumers of western Queensland hardwoods, consisting of two wood-turners, a plaque manufacturer, two timber merchants, three sawmillers (who undertake their own value-adding), a cabinet-maker, a flooring manufacturer, a veneer manufacturer and Maton Guitars (Australia’s largest guitar manufacturer). The aims of these discussions included confirming the suitability of western Queensland hardwoods for particular products and exploring potential prices. With the exception of one sawmiller, the flooring manufacturer and Maton Guitars, all interviewees had sound to expert knowledge of the western hardwood resource. The nature of the resource was explained to those lacking this knowledge.

This chapter proceeds by outlining the impact that short board lengths and high levels of defect have on potential product markets for western Queensland hardwoods. A summary of interviewee market recommendations is then presented, followed by an assessment of the likelihood of high prices being achieved with western timbers in new or expanded markets. A discussion concludes.

9.2 The impact of short board lengths and high levels of defect on potential markets for western Queensland hardwoods

Grading of portable milled mulga and gidgee, as reported in Chapter 6, indicated extremely low recoveries of clear timber greater than 0.6 m in length and none over 1.2 m. It is likely that most western Queensland hardwood species would be unsuitable for products requiring long or wide clear lengths of timber. Therefore, the western hardwood resource is unsuited to products such as hardwood strip flooring and coffin manufacture. Many furniture manufacturers continue to demand wide, long (>2.0 m) lengths of clear wood (Sewell 2001) and, therefore, western hardwoods will not be suitable for all furniture manufacturing operations. It is evident from the portable sawmilling trials that even milling wood clear of defect in the dimensions required by billiard cue manufacturers (*e.g.* 500 mm x 50 mm x 50 mm) could present challenges. While some manufacturers are successfully marketing timber defects as features of their products, the reality is that defects remain undesirable in many markets, particularly export markets.

Commercial veneer manufacturers prefer billets clear of defects, about 3.0 m long and squared off from logs of at least 50 cm diameter. No western Queensland hardwoods are available in these dimensions in large volumes. While the minimum specifications of some veneer manufacturers could be met with the highest quality western hardwood logs, Chapter 7 indicated that veneer recovery was likely to be low. It may indeed be possible to produce veneer in dimensions suitable for musical instruments and other small items; however, low recovery means higher cost of production relative to standard veneers. The manufacturer who undertook the mulga veneering trial reported in Chapter 7, commented that, in veneered form, the property largely responsible for making western hardwoods unique - their high density - is no longer a positive feature. Veneers sell according to their aesthetic value, and it was suggested that few consumers of veneer would pay double the price of jarrah or silky oak veneer to obtain western hardwood veneer. Demand for western hardwood veneer would be unlikely to extend beyond very small and highly specific markets.

The small size of western hardwood logs means that many sawn boards will include sapwood. As indicated in Chapter 3, many western Queensland hardwoods have lyctid susceptible sapwood. The *Timber Utilisation and Marketing Act 1987* (TUMA) requires that the sapwood of these species is either removed or chemically treated prior to sale[22]. If the former course is adopted, then saleable product is substantially reduced and waste increased. One timber merchant asserted that, with the exception of woodturning, the sapwood of western Queensland hardwoods is unattractive for most applications, implying that consumers may demand the removal of sapwood in certain markets. On the other hand, the interviewed cabinet-maker suggested that the sapwood of western Queensland hardwoods is attractive in furniture manufacture.

[22] Unless the purchaser orders lyctid susceptible timber.

9.3 Recommended markets for western Queensland hardwoods

The timber manufacturers and merchants interviewed were divided on appropriate markets for western Queensland hardwoods. Of the markets that could potentially consume hundreds to perhaps thousands of cubic metres of timber, only parquetry flooring was recommended. Three manufacturers believed that parquetry could be milled and sold successfully, while select boards are saved for high value markets. On the other hand, both the plaque manufacturer and cabinet-maker were concerned that development of any type of flooring market for western hardwoods would lead to rapid exhaustion of the timber resource. This concern is based on anecdotal evidence of the slow growth rates of these species (*e.g.* see Chapter 2; and Swift *et al*. 2002). Most interviewees believed that the most suitable and lucrative markets for western hardwoods are furniture manufacture, wood blocks for wood turners, knife handle blanks, musical instrument timbers, and the production of assorted 'knick-knacks' such as plaques and clock faces.

9.3.1 Parquetry flooring

Although parquetry utilises small pieces of timber (*e.g.* 75 mm x 25 mm x 260 mm), which is appropriate for western hardwoods, the prevalence of defects in the western Queensland resource would lead to production costs exceeding those of parquetry flooring currently available in the Australian market. Wholesale prices for Tasmanian oak and spotted gum parquetry are in the vicinity of $\$40/m^2$ ($\$1,600/m^3$) and the flooring manufacturer interviewed asserted that the top wholesale price paid for parquetry in Australia is about $\$60/m^2$ ($\$2,400/m^3$). A miller who has explored the potential of parquetry with western woods believed a wholesale price of $\$65/m^2$ ($\$2,600/m^3$) would be necessary to cover all production costs and make a small margin. Several manufacturers and timber merchants suggested that there is not a large market for such expensive timber flooring in Australia.

One sawmiller believed that promising export markets exist for western Queensland hardwood parquetry flooring. Potential overseas customers were reportedly excited by the high density of these timbers and their ability to withstand indentation, for example, from ladies high-heel shoes. Nevertheless, a timber merchant with exporting experience, asserted that hardness is only a consideration of importers of flooring timbers up to a certain extent. Beyond a certain acceptable level of hardness, this factor is, generally, no longer a marketable feature. Price is then the major determinant. Concerns were also raised by this interviewee of the higher potential for litigation in the flooring market compared with markets such as furniture. In his experience, the timber supplier is often blamed when problems arise during or following laying of the floor. In the furniture industry, complaints can often be appeased by the supply of replacement timber. However, in a market such as flooring, large expenses may be incurred repairing or replacing the floor.

9.3.2 Other markets

One timber merchant asserted that the most lucrative market for western hardwoods is likely to be the furniture market. In Australia, furniture manufacturers are now incorporating defective timber as features in their products, making western woods more marketable to manufacturers. However, it was indicated by one timber merchant that there is currently little overseas demand for 'rustic' furniture made from timber with defects ('features').

Supplying woodturning blocks were suggested by interviewees because they are low-cost products, facilitate utilisation of off-cuts and other small pieces of timber, and woodturners will pay high prices. However, the two woodturners interviewed were not enthusiastic about the potential in this market, because the majority of both recreational and professional wood turners harvest their own timber. High demand potentially exists overseas, although one timber merchant recalled sending high quality western Queensland hardwood wood turning blocks to the USA and receiving unfavourable reviews from woodturners who were unhappy with the level of defect.

Western Queensland hardwoods have proven their suitability for tourist and assorted ‘knick-knack’ markets, including boomerangs, clap-sticks, didgeridoos, clock faces and plaques. Anecdotal evidence suggests that sound margins can be made from these products and that these markets are presently under-supplied with western Queensland timbers.

Large knife handle markets exist in the USA, where ringed gidgee (a beautiful figuring that can occur in gidgee) is highly regarded. Figure 9.1 illustrates a ringed gidgee knife. It was suggested that, with an effective marketing campaign, other western Queensland timbers could become attractive to knife handle manufacturers. It was thought that the hardness of western Queensland hardwoods could also make them suitable for martial arts sticks. Although total volumes in both of these markets would be low, market prices can be high. Ringed gidgee is potentially worth in excess of $\$30,000/m^3$ to knife handle manufacturers and it was asserted that dressed and painted wooden martial-arts sticks (35 mm x 35 mm x 700 mm) retail for in excess of $50.

Maton Guitars expressed an interest in western Queensland hardwoods, particularly for mulga, which from their experience, given the right grade quality, is suitable for bridges, fret boards and fingerboards. Western hardwoods are also suitable in colour for guitar sides and backs, but are too heavy for this purpose. Maton Guitars require about 2.5 m^3 of timber annually for bridges, fret boards and fingerboards, and indicated they could consume immediately about 0.6 m^3 of mulga per year for these purposes. Western woods were thought to also be suitable for finger boards of fiddles, string tuning pegs, violin bows, drum sticks and rhythm sticks. A Savart trapezoid violin with ironwood pegs, fingerboard and chin rest is illustrated in Figure 9.2. Mulga and gidgee are reportedly also suitable for bagpipes, where ebony is currently used (see Figure 9.3). In musical instrument markets, ebony trades at between $\$70,000/m^3$ and $\$100,000/m^3$.

Figure 9.1 *Ringed gidgee knife*

Figure 9.2 *A Savart trapezoid violin with ironwood wattle (*Acacia excelsa*) pegs, fingerboard and chin rest. The belly (front face) is King William pine (*Athrotaxis selaginoides*), while the back and sides are blackwood (*Acacia melanoxylon*)*

Figure 9.3 *Scottish small pipes with mulga pipes and gidgee bellows*

9.4 The likelihood of high prices being paid for large volumes of western Queensland timbers

Western Queensland hardwoods are sold for high prices within Australia and in overseas markets. For example, one timber merchant reportedly sold approximately 2.6 m^3 of high quality, clear gidgee boards and wood turning blanks, both domestically and internationally, during the financial year 2001-02 at \$9,000/m^3. However, this volume consisted of over 30 individual sales. This is characteristic of the high-value trade in western Queensland hardwoods, where individual sales are generally much less than 1 m^3. Of great interest to potential suppliers of western Queensland hardwoods is whether there is excess demand for these timbers in high value markets and whether high prices could be maintained if production was increased.

According to the results of a postal survey sent to 70 wood-turners, artisans and furniture manufacturers local to the Sunshine Coast Hinterland of Queensland (Sewell 2001), western Queensland hardwoods rank low on the preferred species list of many wood users. Only one of 30 respondents indicated a preference for a western Queensland hardwood[23]. That survey also highlighted that many popular native cabinet timber species, including blackwood, silky oak, Queensland maple and silver ash, are bought by these manufacturers for between \$1,500/m^3 and \$2,700/m^3 dried roughsawn (Sewell 2001). The interviewed cabinet-maker, who is passionate about western Queensland timbers, indicated that he would be willing to pay about \$2,000/m^3 for roughsawn and dried mulga and gidgee. To encourage the wider adoption of western Queensland hardwoods among furniture manufacturers, prices similar to the first-rate cabinet timbers listed above are likely to be necessary, at least in the short to medium term. Highly sought after cabinet timbers command higher prices, which is perhaps achievable by

23 That species was brigalow (*A. harpophylla*), not one of the 11 species included in the postal survey reported in Chapter 8.

western hardwoods if cabinet-makers begin to appreciate their qualities. Red cedar, for example, currently trades at about \$4,000/m^3 roughsawn and dried (Sewell 2001).

One hardwood flooring manufacturer near Brisbane purchases 6.0 m lengths of clear, roughsawn spotted gum for \$600/m^3 and sells it as parquetry for \$36/m^2 (\$1,440/m^3). Against such competition, large volume sales of high-priced (>\$65/m^2) *outback* timber parquetry flooring appear unlikely in Australia. Nevertheless, it has been asserted that there are niche export market opportunities for western Queensland hardwood parquetry at prices greater than \$65/m^2 (\$2,600/m^3). One sawmiller who has recently planed *Acacia shirleyi* (lancewood) into internal wall panelling (VJs), had been offered about \$2,400/m^3 for the finished product.

As indicated in Chapter 8, musical instrument manufacturers are willing to pay high prices for western Queensland timbers. However, most musical instrument manufacturers in Australia are small-scale operators and many are only semi-commercial. A typical small-scale guitar manufacturer may produce 20 guitars per year and purchase 20 mulga fingerboards at \$27,000/m^3. However, that purchase is equivalent to only \$200. This appears to be the reality of much of the Australian musical instrument timber market. Commercial musical instrument manufacturers, who demand larger volumes of high quality timber, undertake all of their own timber processing and quality control beyond sawmilling. For example, Maton Guitars, purchases large, clear blackwood (*Acacia melanoxylon*) billets for about \$2,200/m^3 and indicated a willingness to pay about \$3,000/m^3 for mulga in dimensions suitable for fingerboards with minimal defect. This price is far below the high prices reported for musical instrument manufacturers in Chapter 8, but is likely to be indicative of prices paid for larger volumes of musical instrument quality timbers.

It is evident that there is excess demand for ringed gidgee in the market place. The North American market for knife handle blanks was reported by interviewees to be large enough to absorb volumes of ringed gidgee far in excess of the quantities currently supplied, indicating that the high prices (around \$30,000/m^3) are likely to be maintained. However, it should be noted that ringed gidgee is extremely scarce. Professional western hardwood timber cutters and woodturners attest that only one gidgee tree in many thousands is ringed, and it is difficult to identify ringed gidgee trees before felling them.

Exporting western hardwoods does not guarantee high prices. In Europe and North America, comparatively expensive western Queensland hardwoods must compete with comparatively less expensive timbers from South America and Africa that have similar properties. It is rational to expect that, except in niche markets, when several timbers are equally suitable for a task, the least expensive will be chosen. It was asserted that European and North American markets do not share the interest that many Australian consumers have developed in timber with defects. These markets demand defect-free timber, which is expensive to produce from western hardwoods.

9.5 Discussion

The prevalence of short board lengths and timber defects makes western Queensland hardwoods unsuitable for markets where long lengths of clear wood are a prerequisite. Opportunities exist where short lengths can be utilised; however, high production costs will necessitate strategic marketing to obtain high prices. A small proportion of consumers are likely to be willing to pay above average market prices for unique western Queensland hardwood parquetry flooring or furniture. If some interest can be generated overseas, then market demand could amount to several hundred cubic metres of western hardwoods annually for these purposes. This level of production is likely to be within the bounds of the regenerative capacity of the western hardwood resource.

There are opportunities to increase supply to existing high-value markets for western Queensland timbers, such as ringed gidgee for knife handles and clear wood for musical instrument manufacture. However, in the former market, supply is likely to remain a constraint, while in the latter domestic and international markets where high prices are paid for these timbers, the demand is likely to remain small, at least in the short to medium term. Overseas musical instrument manufacturers currently regard western Queensland hardwoods as novelty timbers for one-off instruments. For western hardwoods to be utilised on a commercial scale by international musical instrument manufacturers, they will either need to become price competitive with currently used species or have superior qualities for music production clearly demonstrated.

References

Sewell, A. (2001), 'Timber needs into the future on the Sunshine Coast and hinterland', unpublished report, Department of Natural Resources.

Swift, S., Taylor, D., Cotter, D. and Fairbairn, E. (2002), 'Utilisation of western hardwoods as specialty timbers: Preliminary resource survey report', Queensland Forestry Research Institute, Gympie.

10. Financial comparison of potential hardwood timber processing operations with grazing in western Queensland

T. J. Venn

Queensland Forestry Research Institute, Indooroopilly QLD 4068, on leave from School of Economics, The University of Queensland, St Lucia QLD 4072

Financial analyses of several small-scale western Queensland hardwood production scenarios have been undertaken. Comparisons with returns from grazing in western Queensland indicated that production of western hardwoods could generate competitive to superior returns, both on a total net present value (NPV) and NPV/ha basis. The two best performing western Queensland hardwood scenarios were found to be the processing of clear wood for high value niche markets and a landholder co-operative scenario producing parquetry flooring.

10.1 Introduction

Information has been presented in the earlier chapters of this volume on processing and marketing of western Queensland hardwoods. However, many landholders in the South West Strategy and Desert Upland regions of Queensland are unlikely to consider managing their remnant stands for timber production unless it can be shown that likely returns exceed the *status quo*, *i.e.* clearing woodlands for grazing. Although somewhat constrained by scarce information, this chapter provides a preliminary financial assessment of several small-scale timber production scenarios for western Queensland landholders and provides a comparison with grazing. No information was available to assess the potential of an agroforestry management regime.

The chapter proceeds with a review of returns to cattle grazing in western Queensland. Eight western Queensland hardwood production scenarios are then outlined, followed by the assumptions made in the base case financial analyses. The sensitivity analyses performed are described and the means by which alternative farm management options have been compared is defined. This is followed by the results of the financial analyses. A discussion and conclusion complete the chapter.

10.2 Returns to cattle grazing in western Queensland

Particularly since the process of drafting tree-clearing guidelines in Queensland began in the mid-1990s, the analysis of grazing enterprise profitability has become highly emotive and politically charged. This is largely because graziers assert that tree clearing restrictions will have large negative impacts on farm incomes and regional communities, while environmental organisations assert that the total economic value[24] of additional land clearing in Queensland is negative. The on-going debate has made the comparison of grazing with timber values in this chapter controversial.

The reported before tax profitability of grazing enterprises from four regions in Queensland is summarised in Table 10.1. Net profits and net present values (NPV) are net of operating costs, including the (imputed) cost of family labour. The Australian Bureau of Agricultural and Resource Economics (ABARE 2001) estimates are averages compiled from annual agricultural surveys. The figures presented for the Central West Mitchell Grass region are from a 'representative' farm. The Clermont and Middlemount information is from specific case study farms. The Charleville-Longreach ABARE agricultural region and the Central West Mitchell Grass region overlap each other and fall within the South West Strategy and Desert Uplands areas of interest to this study. The Clermont and Middlemount case studies lie to the east of the study region.

Table 10.1 *Profitability of grazing enterprises in western Queensland*

Region	Source	Land area (ha)	Net profit before tax ($)	Profit/ha before tax ($)	NPV before tax ($)[1]	NPV/ha before tax ($)[1]
Charleville - Longreach	(ABARE 2001)	20,000	-8,000	-0.40	-116,726	-5.84
Central West Mitchell Grass	(Queensland Beef Industry Institute 2000)	18,020	60,944	3.38	889,217	49.32
Clermont	(Resource Consulting Services 1995)	18,220	45,323[2]	2.49[2]	661,295[2]	36.33[2]
Middlemount	(Resource Consulting Services 1995)	30,800	124,032[2]	4.03[2]	1,809,716[2]	58.80[2]

Notes:
The ABARE (2001) farm profitability estimates are the average of reported farm profits in the ABARE Charleville-Longreach agricultural region.
1. NPVs have been calculated at a 6% discount rate over 30 years.
2. These values are also before interest payments on loans.

There is large variation in the profit estimates presented in Table 10.1. The ABARE (2001) estimate is the average profitability of an average landholding in the Charleville-Longreach ABARE agricultural region over the period 1989-90 to 1999-2000. During this period, the region's annual net farm profit before tax ranged between -$50,000 and +$30,000. No indication of the variability of returns to grazing was provided by the sources of the other profitability estimates in Table 10.1. The representative farm for the Central West Mitchell Grass region, which encompasses the Charleville-Longreach ABARE region, was assumed to have a carrying capacity of 7.4 ha/beast, although farm survey data from ABARE (2001) indicate that average stocking rates may be closer to 16 ha/beast in this region. Returns from the Clermont and Middlemount properties do not account for interest costs on loans.

[24] Total economic value includes use values (*e.g.* cattle grazing) and non-use values (*e.g.* biodiversity conservation, soil conservation, carbon storage and aesthetic values).

Rolfe *et al.* (1997) reported Australian Bureau of Statistics data which indicated that, on average, grazing properties in the Desert Uplands made losses over the period 1988 to 1995 and farm debt levels increased. The Queensland Beef Industry Institute (2000) reported that two-thirds of Queensland beef enterprises experienced zero or negative returns over the entire seven-year period prior to 2000. Rolfe (2002) estimated that the NPV of grazing on cleared mulga country is likely to be in the vicinity of $10/ha to $20/ha, while on cleared gidgee land, NPV might be in the order of $50/ha.

The returns presented in Table 10.1 are for land where the costs of clearing have already been incurred. A landholder deciding whether to pull remnant woodland to increase cattle production or retain some timbered land for other uses, such as timber production, must take into account the costs of land clearing and pasture development. Resource Consulting Services (1995) estimate the cost of clearing virgin gidgee at $50/ha and regrowth at $24/ha. Rolfe (2002) estimated the costs of clearing mulga and gidgee at $35/ha. The variety of soils, vegetation types and management practices on the Desert Uplands means that returns from tree clearing are mixed. The additional pasture production post-clearing is reported by ABARE (1995) to increase shortly after development by 2 to 7 times, but then generally decreases from competition with regrowth and reduction in soil fertility. ABARE (1995) asserted that, in some cases, pasture yields can return to pre-clearing levels within 10 to 20 years.

Some estimates of the returns to land clearing for cattle grazing within the study region are reported in Table 10.2. The NPV of clearing varies widely between $58/ha for Desert Upland gidgee to $11/ha for Desert Upland open eucalypt communities. For the purposes of comparing grazing with timber production, it has been decided to use middle of the range estimates and assume that the NPV of returns to land clearing is in the vicinity of $20/ha to $40/ha. Given the prevalence of negative returns to grazing in recent history, this range may be optimistic for the industry as a whole, although it is understood that some graziers in the South West Strategy and Desert Uplands regions could be obtaining higher returns.

10.3 Western Queensland hardwood timber processing scenarios

Several timber processing scenarios have been developed to cover the spectrum of opportunities potentially available to western Queensland landholders. These range from selling logs at the stump to the production of dried and dressed products. The focus of the scenarios is on operations that could be undertaken by two persons harvesting and processing the timber resource on-farm. One landholder co-operative scenario is also presented.

Table 10.2 Returns to land clearing for cattle production

Region / vegetation	Source	Increase in gross returns from clearing ($/ha/year)	Increase in net profit from clearing ($/ha/year)	NPV ($/ha)
Box country	Scanlon and Turner 1995[1]		2.00	27.15
Desert Uplands / open eucalypt	Rolfe 2000	6.24[2]	3.12[2,3]	10.52[3,4]
Desert Uplands / gidgee	Rolfe 2000	10.38[2]	5.19[2,3]	40.72[3,4]
Desert Uplands / ironbark and box	RCS 1999[1]			28.31
Desert Uplands / wattle and ironbark	RCS 1999[1]			12.34
Desert Uplands / gidgee	RCS 1999[1]			57.61

Notes: NPV calculated over 30 years at 6% discount rate.
1. Cited in Rolfe (2000).
2. Does not account for the cost of land clearing.
3. Assumes that operating costs, fixed costs and imputed value of farm labour amount to 50% of gross returns. This may be an optimistic assumption for many landholdings in the Desert Uplands region of Queensland.
4. Includes land clearing and pasture development costs of $35/ha.

10.3.1 Scenario 1: sell logs at the stump

Landholders invite professional timber cutters on to their property. The landholders do not incur any direct costs and are paid a royalty for logs harvested.

10.3.2 Scenario 2: supply sawlogs to sawmillers

Landholders harvest sawlogs and deliver them to a local sawmill.

10.3.3 Scenario 3: produce green-off-saw, ungraded boards

Landholders harvest and mill sawlogs into green-off-saw (GOS) boards for sale to timber merchants, furniture manufacturers and low-value end users. It is assumed that all GOS timber recovered is sold ungraded. The small size of western hardwood logs means that many sawn boards will include sapwood. As indicated in Chapter 3, many western Queensland hardwoods have lyctid susceptible sapwood. The *Timber Utilisation and Marketing Act 1987* (TUMA) requires that the sapwood of these species is either removed or chemically treated prior to sale. However, in accordance with TUMA, it is assumed in this scenario that the purchaser orders lyctid susceptible timber from the landholder.

10.3.4 Scenario 4: produce treated, dried, graded, undressed boards

In this scenario, landholders harvest, mill, chemically treat, air dry and grade western Queensland hardwoods for sale to furniture manufacturers, timber merchants and perhaps flooring manufacturers. A minimum high feature grade (Australian Standard *AS 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products*) board length of 0.9 m is assumed for these markets. Where a recoverable high feature grade board length is between 0.2 m and 0.9 m, and at least 0.2 m of the board meets QFRI clear grade specifications (completely free of defect), the board is sold into high-value niche markets, such as to musical instrument and knife handle manufacturers. Given that the current market for these types of products is small, a maximum saleable volume of 2 m^3 per annum has been assumed. Remaining short-length high feature boards are sold into low-value markets. It is assumed that annual demand from wood turners, timber merchants and furniture manufacturers is no more than 5 m^3 of the short, high feature boards.

10.3.5 Scenario 5: produce treated, dried, graded and dressed VJ boards

Landholders harvest, mill, chemically treat, air dry, grade and dress western Queensland hardwoods for sale into the VJ market for internal wall panelling. A minimum high feature grade (*AS 2796 – 1999*) board length of 0.9 m is assumed for this market. Where a recoverable high feature grade board length is available between 0.2 m and 0.9 m, and the board meets QFRI clear grade specifications, the board is sold into high-value niche markets, such as to musical instrument and knife handle manufacturers. Remaining short-length high feature boards are sold into low-value markets. Although the short length products in this scenario are dressed, it is assumed that the same market demand constraints that faced short-length products in scenario 4 apply.

10.3.6 Scenario 6: produce treated, dried, graded and dressed parquetry flooring

All stages of manufacture, from harvesting logs to the finished parquetry are assumed to be undertaken by two persons on-farm. All timber that meets the requirements for high feature grade (*AS 2796 – 1999*) is assumed to be dry milled into parquetry.

10.3.7 Scenario 7: landholder co-operative producing treated, dried, graded and dressed parquetry flooring

In contrast with all other scenarios, the landholder co-operative scenario is assumed to employ eight persons full-time and two part-time. Six full-time workers are employed in three two-person harvesting and milling operations identical to scenario 3. They each supply GOS boards to a central parquetry flooring plant, which is operated by two full-time workers dry milling the parquetry, one part-time labourer responsible for chemical treatment and monitoring the seasoning of GOS boards, and one part-time administration officer. For the purposes of financial assessment, the eight full-time workers are assumed to have an equal stake in business establishment costs and profits arising from the sale of parquetry.

The central parquetry plant purchases GOS boards at cost price from the three portable sawmilling teams, *i.e.*, just enough to cover the fixed and variable costs of board production, including payments to labour. The aim is to maximise profits from the sale of parquetry and distribute these profits among the eight full-time workers who established the co-operative. Efficiencies in parquetry production are assumed to be gained through having two full-time employees specialising in the dry milling of parquetry, resulting in greater high feature recovery and lower dry milling costs than assumed in scenario 6.

10.3.8 Scenario 8: produce treated, dried, graded and dressed timber for high-value niche domestic and export markets

In this scenario it is assumed that there are high-value domestic and export markets for clear (defect free) western Queensland timbers, including to knife handle and musical instrument manufacturers. Two landholders operate the business. Following treatment and drying, boards are graded and cut to maximise production of clear timber. Often this will result in relatively long high feature grade (*AS 2796 – 1999*) boards having clear timber docked from within them. For example, a 1.5 m high feature grade board may yield 0.4 m and 0.6 m high feature boards either side of a 0.5 m clear board.

The high feature boards and off-cuts will be sold to domestic merchants and furniture manufacturers at a lower average price, reflecting the high proportion of short length boards.

10.4 Assumptions made about the manufacture of products from western Queensland hardwoods

For each timber processing scenario, assumptions have been made about parameters that affect the financial viability of the operation. The assumptions made for the base case financial analyses are outlined in this section. Sensitivity analyses have been undertaken to determine what effect changing these base case assumptions have on the profitability of western Queensland timber production scenarios. These are described in Section 10.5.

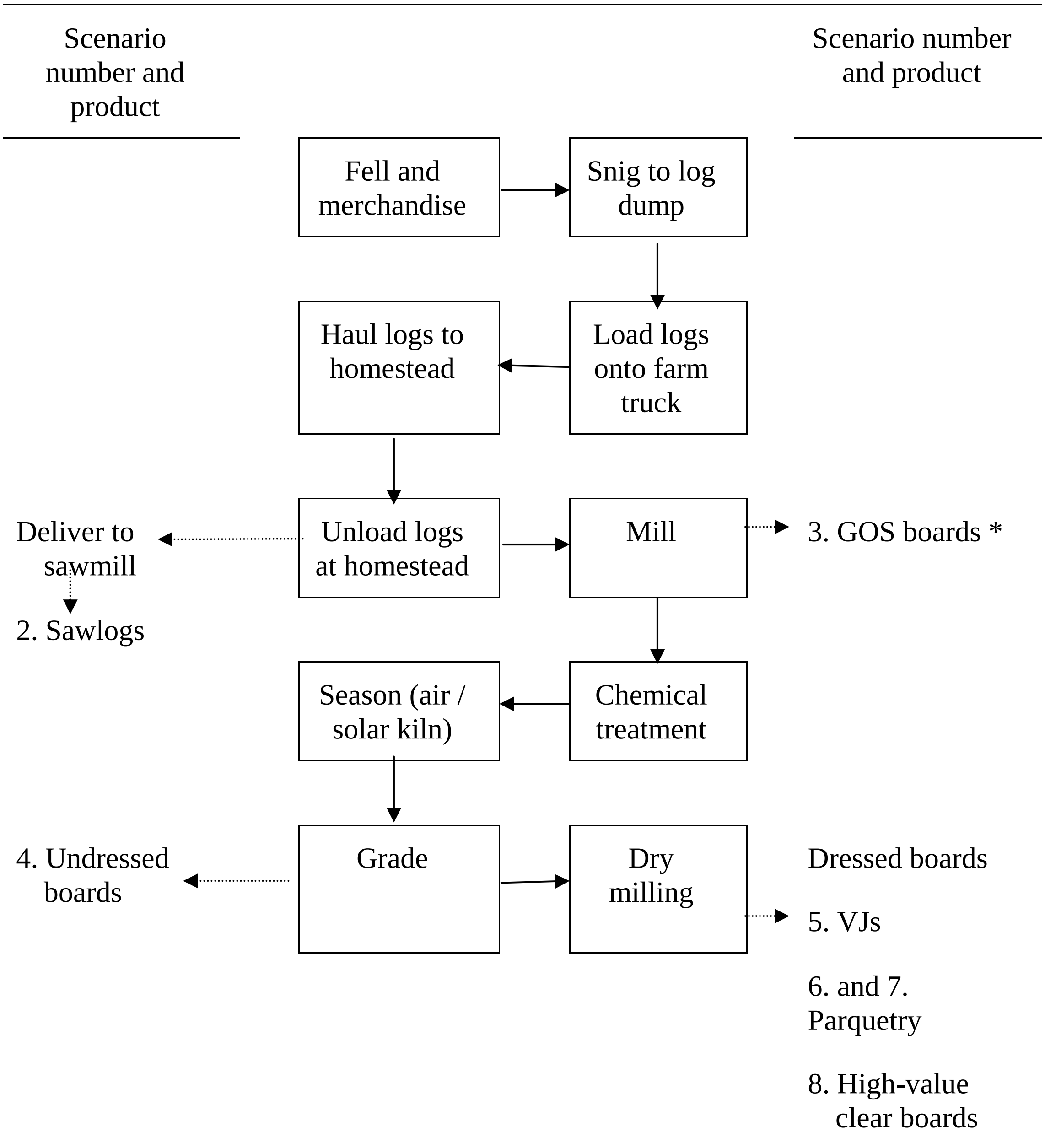
10.4.1 Production process for western Queensland hardwood scenarios

It is assumed that all scenarios follow the production process illustrated in Figure 10.1. Note that, unlike the harvesting and portable sawmilling trials described in Chapter 4, there is no separate tree selection phase. Scenario 1 is not represented in Figure 10.1, as it is assumed that the landholder does not undertake any activity in that scenario.

It is assumed that trees are felled and merchandised with a chainsaw before being snigged by a tractor with a chain to a log dump. At the log dump, the tractor loads the logs onto a farm truck with a fork attachment. The logs are then transported to the homestead in the farm truck where they are sawn by a portable sawmill or will be collected by a log truck for transport to a sawmill off-farm[25]. If logs are sawn on-farm, then boards are either sold green-off-saw (GOS) or further processing is undertaken.

If GOS boards are processed further on-farm, then it is assumed that boards will be chemically treated to prevent lyctid beetle attack. Most western Queensland hardwoods, including mulga and gidgee, have lyctid susceptible sapwood. The small size of western Queensland hardwood logs means that a high proportion of sawn timber is likely to include sapwood and will require treating. Norton (2002) advised that low-technology chemical treatment with a colourless boron dip could be undertaken on-farm. The method would involve placing the timber in a large tank and leaving to soak in the boron solution for approximately one week. Before the timber could be sold as treated timber without risk of lyctid attack, the seller would have to be registered with the Queensland Department of Primary Industries.

[25] Chapter 4 indicated that the costs of fixed-site and multiple-site portable sawmilling were likely to be similar in western Queensland.



Note: * There are restrictions governing the sale of seasoned timber in Queensland under the *Timber Utilisation and Marketing Act 1987* (TUMA). See section 10.3.3.

Figure 10.1 *Stages in the manufacture of western Queensland hardwood products*

The treated timber is then stacked for seasoning. Depending on the application, the timber is assumed to be either air or solar kiln dried. In Chapters 5 and 6 it was shown that air drying is likely to be the most cost-efficient seasoning method for landholders in western Queensland, even when the time value of money and drying degrade are accounted for. If landholders must construct a $10,000 shed, air-drying still remains the most cost-efficient. Solar kilns were found to be the most cost-efficient, low capital cost, kiln drying method.

The seasoned timber is then graded to the Australian Standard *AS 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products* high feature grade and QFRI's clear grade. The latter specifies that the board must be clear of any defect. Boards may be sold at this stage as treated, graded and undressed or be further processed. With additional specialised equipment, the dried and graded boards can be dry milled into various finished products.

10.4.2 Western Queensland hardwood sawlog resource

For the base case scenarios, the availability of sawlogs (minimum length 1.2 m and minimum small-end diameter over bark (sedob) 12.5 cm) has been set at a 1 m^3/ha. This is consistent with the recovery of sawlog in the mulga and gidgee portable sawmilling trials reported in Chapter 4. However, it is considerably less than estimates of total merchantable volumes (including sawlog, roundwood and craftwood) indicated in Chapter 2 and Swift *et al*. (2002). This is because the specifications for merchantable timber in these inventories included logs that would not be suitable for sawmilling. Logs down to 0.6 m in length, 10 cm minimum sedob, and with considerably more defect than considered permissible in a sawlog, were included in the volume estimates of Chapter 2.

The limited information available on regeneration of western Queensland hardwoods suggests that at least 50 to 70 years may be required between successive sawlog harvests (Swift *et al.* 2002). Each timber processing scenario is being considered over a 30-year investment period and, therefore, it is assumed that no stand will be harvested more than once in this time. In scenarios where landholders are harvesting over large areas, the available resource on their own properties could become exhausted before the end of the 30-year investment time frame. In reality, continuation of such enterprises would likely entail obtaining access to other woodlands off their own farm at an additional cost. This situation has not been incorporated into the financial analyses.

10.4.3 Royalty payable for timber harvested on leasehold land

In June 2002, royalties payable to DPI Forestry following commercial harvesting of mulga and gidgee on leasehold land were \$17.00/tonne and \$52.15/tonne respectively. Given the green density of these species, these rates are equivalent to \$20.20/m^3 log for mulga and \$70.61/m^3 log for gidgee. The large difference between species is due to gidgee being classified as a *specialty timber*. Walls (2002) indicated that DPI Forestry is keen to encourage western Queensland timber production and that current royalty rates would be revised if larger volumes of sawn wood were to be produced from western hardwoods. Royalties could be raised or lowered according to DPI Forestry's assessment of the profitability of milling western Queensland hardwoods. For the purposes of this financial assessment, a royalty rate of \$50/m^3 of log has been assumed.

10.4.4 Labour costs

For all scenarios, except scenario 7, only two owner-operators are involved in each scenario and these persons are employed full-time producing timber. A full-time work year for one person has been equated to 1,920 hours (40 hours/week, 48 weeks/year). All labour, including the hire of non-owner-operator labour in scenario 7, is paid at the rate of \$20/hour, which includes one-third on-costs, such as superannuation and workers compensation. The valuation of farm labour is an emotive issue and a discussion of the derivation of the adopted rate can be found in Appendix 4A.1. The labour costs associated with various stages of timber processing can be determined by multiplying the cost of labour for two-persons by the assumed *efficiency of production* (defined below).

Efficiency of western Queensland timber production

The time required in a two-person operation for various timber processing activities to be undertaken has been estimated from the harvesting, portable sawmilling, seasoning and grading trials reported in Chapters 4 to 6 and expert opinion. The base case efficiency of production estimates are presented in Table 10.3. Labour costs/m^3 can be determined by multiplying the inverse of the efficiency estimates in Table 10.3 by the value of labour. Incorporating efficiencies of production into the financial analyses has prevented unrealistic levels of output (and profit) being achieved in the scenarios by accounting for all time inputs.

Table 10.3 *Base case efficiency of production for western Queensland hardwood scenarios*

Activity	Volume of timber processed per hour in a two-person operation	
	(m^3 log/hour)	(m^3 boards/hr)
Felling and docking	1.14	
Snigging	0.78	
Loading/unloading farm truck	16.80	
Log transport on-farm	9.44	
Portable sawmilling	0.37	
Chemical treatment (place in and remove from dip)		3.0
Air drying (stack and unstuck)		0.81
Solar kiln drying (stack, unstuck and monitor)		0.53
Dry milling		
Short length high feature boards		0.25
VJs		0.25
Parquetry (co-operative scenario)		0.20 [0.22]
Clear boards		0.13

10.4.5 Capital costs of producing western Queensland hardwoods

Capital costs for each scenario are outlined in Table 10.4. It has been assumed that all buildings and equipment are financed with a principal plus interest repayment business bank loan fixed for 10 years at a rate of 8% per annum[26]. The chemical treatment tank has a capacity of 3 m3 GOS and the solar kiln has a capacity of 12 m3 of 50 mm thick boards. In the financial analyses, a nominal estimate of the cost of freighting purchased equipment to the landholder has been incorporated into the borrowed sum of money. The useful life of all equipment, except chainsaws, is assumed to be 15 years with no residual value. Chainsaws and safety equipment are estimated to have a useful life equivalent to the time it takes to cut 3,000 m3 log, with no residual value. This time will vary between scenarios, but is equivalent to about 2-years of full-time chainsaw cutting in western hardwood forests. All capital items are straight-line depreciated over their useful life. It is assumed that landholders have received appropriate, accredited training in the use of equipment relevant to each scenario; however, the costs associated with such training have not been included in the financial analyses.

Mobile equipment

A farm truck (7 tonne capacity) and tractor are assumed to be available for timber production (no capital outlay). The truck is used to transport logs on-farm, while the tractor is used to snig logs to log dumps and is fitted with a fork to facilitate truck loading and short distance transportation of timber at the milling site. Operating costs and depreciation allowances for these vehicles are detailed in Appendix 10A.

[26] Business loan available from ANZ bank as at 26 June 2002.

Table 10.4 *Cost of equipment required for each scenario*

Required equipment	Value of equipment ($) by scenario number							
	1	2	3	4	5	6	7	8
Chainsaw and safety equipment		2,169	2,169	2,169	2,169	2,169	6,507	2,169
Portable sawmill			13,500	13,500	13,500	13,500	40,500	13,500
Chemical treatment tank				3,500	3,500	3,500	10,500	3,500
Solar kiln						40,000	80,000	
Small thicknesser					3,500	3,500	3,500	3,500
Small bandsaw					5,000	5,000	5,000	5,000
Table saw					2,500	2,500	2,500	2,500
Docking saw				2,500	2,500	2,500	2,500	2,500
Linisher					750	750	750	750
Planer					40,000	85,000	85,000	
Total		***2,169***	***15,669***	***21,669***	***73,419***	***158,419***	***236,757***	***24,419***

Note:
Where a type of equipment is required, a single unit has been assumed, except in scenarios 6 and 7. In scenario 6, two solar kilns are required to ensure continuous production. In scenario 7, three units of the chainsaw and safety equipment, portable sawmill, and chemical treatment tank are required, and four solar kilns are necessary.

10.4.6 Non-labour variable costs of felling, docking, snigging, log haulage on-farm, portable sawmilling and chemical treatment

For the base case scenario, non-labour costs of felling, docking, snigging, log haulage on-farm and portable sawmilling have been set at the average of the levels achieved in the harvesting and portable sawmilling trials with mulga and gidgee. These costs are detailed in Appendix 10A.

Norton (2002) asserted that $35/m^3 GOS would cover the total cost of chemically treating western Queensland hardwoods with low-cost, low-technology methods. It is assumed that 60% of the cost is for the chemicals and 40% is for labour. Consequently, the non-labour variable cost of chemical treatment adopted for the financial analyses is $21/m^3 GOS.

10.4.7 Product recovery rates from western Queensland hardwoods

The following recovery figures have been adopted as the base case for all scenarios. They are the averages obtained from QFRI harvesting and portable milling trials with mulga and gidgee, as detailed in Chapter 6. In the absence of a timber standard specifically tailored to the western hardwood resource, the Australian Standards were adopted. The Australian Standards have been written for traditional, larger timber species, not for western Queensland hardwoods. It should be noted that a new industry based on western hardwoods is likely to develop its own standards, which may facilitate higher recoveries to be achieved than is indicated here.

- Green-off-saw recovery is 31.1%.
- Recovery from log volume of high feature grade (*AS 2796 – 1999*) timber is 10%. However, specialisation in the landholder co-operative scenario is assumed to raise high feature recovery to 15%.
- Recovery of high feature boards at least 0.9 m in length from high feature board volume is 60% of high feature board volume.
- Recovery from high feature boards of clear grade timber suitable for high-value niche markets is 20%.

10.4.8 Seasoning of western Queensland hardwoods

From the results of seasoning trials with mulga and gidgee, it was indicated in Chapter 5 that air drying western Queensland hardwoods is likely to be the most cost effective drying method for western Queensland landholders. In the base case, it has been assumed that a fully depreciated and disused shed is available for air drying.

For some products, such as flooring, kiln dried timber is essential. Out of the low-cost solar and dehumidifier kiln drying technologies examined in Chapter 5, solar kilns were shown to be the most cost-effective for mulga and gidgee and are assumed to be utilised in the parquetry flooring scenarios.

Drying costs and times adopted for this financial assessment have been taken from Chapter 5, less non-cash costs (*i.e*. opportunity costs) and the cost of financing the purchase of kilns, which is accounted for in the business loan repayment expense of each scenario. Therefore, excluding opportunity costs and loan repayment costs, air drying is assumed to cost \$29.94/m^3 GOS and solar kiln drying 58.45/m^3 GOS.

10.4.9 Dry milling costs for western Queensland hardwoods

Dry milling cost estimates from the timber industry are scarce. Following a thorough review of hardwood sawmills, Leggate (2000) reported that dry milling expenses for east-coast Queensland hardwoods were about \$140/m^3 GOS. Western Queensland hardwoods are likely to be much more expensive, although there is no published information and this research did not extend to dry milling. The dry milling costs adopted in the financial assessments are presented in Table 10.5 and have been estimated from the expert opinion of timber processors and QFRI personnel. In accordance with expert opinion, labour is assumed to account for 80% of dry milling processing costs, with materials and maintenance accounting for the remainder.

Table 10.5 *Adopted dry milling costs for each scenario*

Dressed Product	Drymilling costs (\$/m^3 board) by scenario number							
	1	2	3	4	5	6	7	8
VJs					200			
HF<0.9 m					200			
Parquetry						250	225	
Clear grade					400			400

Note: HF is short for *AS 2796* high feature grade.

10.4.10 Costs of off-farm freight to market for western Queensland hardwoods

For all products except sawlogs, the distance to market is assumed to be 1,200 km (the approximate road distance from Longreach to Brisbane). The commercial cost of freight from Longreach, Charleville and Emerald to Brisbane was found to be roughly \$0.08/m^3/km for boards, assuming a \$40 loading fee and that the timber is transported in 22 tonne (one semi-trailer) loads.

Sawlogs are assumed to be transported 200 km to a sawmill in the base case for scenario 2. Log haulage cost has been estimated with the log haulage cost equation developed by the Native Forest Sawlog Pricing Working Group (1997) for Queensland native forest sawlogs:

$$\text{Haulage cost } (\$/m^3 \text{ log}) = \$22.44 + (\text{Distance [km]} - 100) \times \$0.0997$$

10.4.11 Administration expenses for western Queensland hardwood scenarios

In the literature, Smorfitt (2000) assumed administration costs were $50/m^3 GOS for a portable sawmilling operation in north Queensland, while Stewart and Hanson (1998) adopted a rate of 15% of sawmilling costs for a Victorian portable mill. Two processors of western Queensland hardwoods indicated that they believed their administration expenses accounted for much less than 15% of their manufacturing costs. The base case adopted for the financial analyses assumes that administration expenses amount to 5% of total manufacturing costs.

10.4.12 Products manufactured from western Queensland hardwoods and assumed market prices

A listing of the products manufactured and the assumed market prices are presented for each scenario in Table 10.6. It is assumed that dressed and undressed boards must meet the Australian Standard *AS 2796 – 1999 – Timber – Hardwood - Sawn and Milled Products* high feature grade to be regarded as saleable timber. For high-value niche markets, such as for knife handles and musical instruments, it has been assumed that the timber must meet QFRI's clear grade classification, because of the stringent specifications of these manufacturers. Base case market prices reflect the values indicated in returns to the postal market survey and discussions with processors of western Queensland hardwoods, as reported in Chapters 8 and 9. The parquetry flooring price/m^3 is equivalent to $65/m^2.

Table 10.6 *Products manufactured and market price achieved by scenario*

Product	Market price ($/m3 of product) by scenario number							
	1	2	3	4	5	6	7	8
Stumpage	50							
Logs		100						
GOS boards			800					
Undressed boards								
>=0.9 m HF				2,000				
<0.9 m HF				1,200				
Clear grade				15,000				
Dressed boards								
VJs (HF>0.9 m)					2,400			
HF<0.9 m					1,600			1,600
Parquetry						2,600	2,600	
Clear grade					25,000			25,000

Notes: HF is short for *AS 2796 – 1999* high feature grade. VJs and parquetry are produced from high feature grade boards.

10.4.13 Tax on earnings

The taxation implications for each scenario have not been presented in this chapter, since comparable grazing figures are before tax. In Appendix 10B, full profit and loss statements are provided for each scenario and tax has been accounted for. For the calculation of tax, it has been assumed all scenarios that a limited company is established by the owner-operators or landholder co-operative. Owner operators draw their wage from the company and pay tax according to the Australian personal income tax schedule. Company profits (after all expenses, including wages to owner operators) are taxed at the company tax rate of 30%.

10.5 Sensitivity analysis on base case parameters for western Queensland hardwood production scenarios

A sensitivity analysis provides an indication of the extent to which returns to western Queensland hardwood production would change when the assumptions outlined in Section 10.4 are altered. A wide-ranging sensitivity analysis has been undertaken, because of the uncertainty surrounding base case scenario parameters. Generally, sensitivity has been assessed by incrementing and decrementing base values by 20% and 50%, and assessing the impact on profitability of the scenarios. For the business loan interest rate, freight or haulage distance to market and royalty payable for timber harvested on leasehold land, specific alternative parameter values appeared more appropriate than plus and minus 20% and 50%, and these specific values were used instead. The sensitivity of the following parameters have been assessed.

- royalty/m^3 log
- sawlog volume/ha
- value of labour
- cost of equipment
- business bank loan rate
- freight distance to market
- cost of freight ($/m3/km)
- administration expenses
- efficiency of felling, docking and snigging
- efficiency of portable sawmilling
- efficiency of portable sawmilling and dry milling
- efficiency of portable sawmillers (cost price of GOS boards in landholder co-operative scenario)
- size of high value markets (m3) (annual demand for clear grade products)
- GOS recovery (%)
- high feature grade recovery from log volume (%)
- recovery of boards >=0.9 m in length from high feature volume (%)
- clear grade recovery from high feature volume (%)
- market value of ‘main line’ products, and
- market value of ‘other’ products.

Initially, sensitivity analyses had been undertaken on a larger number of parameters, including chainsaw operating costs, snigging distance and life of a portable sawmill sawblade. However, the magnitude of parameters being assessed became difficult to manage. In many cases, the effect that any one of these parameters had on the profitability of the enterprise was found to be minute, which led to aggregation of parameters into ‘efficiency factors’. For example, efficiency of felling, docking and snigging includes volume of logs that can be felled and docked per hour, and volume of logs that can be snigged to a log dump per hour. These parameters affect labour and non-labour chainsaw operating costs and labour and non-labour tractor (snigger) operating costs. The sensitivity analyses on this efficiency parameter is effectively posing the question *what if the cost of landing sawlogs at the log dump were reduced (or increased) by 20% or 50%* from the base case level. The other efficiency parameters have been developed in the same manner.

A simple linear relationship between sawlog availability (m^3/ha) and felling, docking and snigging efficiency had been developed from information available from the mulga and gidgee portable sawmilling trials described in Chapter 4. This permitted a rough assessment of the impact that sawlog volumes per hectare could have on financial profitability. The cost of equipment parameter is the impact of changes in the total cost of all equipment required in each scenario. The discount rate adopted would usually be included in a sensitivity analysis; however, given the need to compare results with estimates for grazing, which were calculated at a discount rate of 6%, the sensitivity analysis of the discount rate is not reported.

10.6 Criterion adopted for comparing farm business development opportunities

The net present value (NPV) criterion has been adopted to compare farm business development opportunities. NPV is the difference between the present value of cash inflows and cash outflows throughout the life of an investment. A project with a positive NPV is economically feasible in the sense that it will generate returns in excess of all costs, including the opportunity cost of the capital involved. The opportunity cost of capital is also referred to as the discount rate. For consistency with recent studies on returns to grazing in western Queensland, a discount rate of 6% and an investment period of 30 years has been adopted to assess the western hardwood timber processing case studies. When comparing farm development opportunities, larger NPVs are preferred.

When calculating NPV, non-cash costs and returns should be excluded. In this financial analysis, the depreciation costs of equipment (which are subtracted with other fixed costs from operating profits) have been added back to net profit before the calculation of NPV.

There are two NPV estimates of interest for comparison of grazing and timber production opportunities: NPV/ha and NPV of the total enterprise. NPV/ha is NPV divided by the number of hectares harvested over the lifetime of the investment (30 years). Economically efficient utilisation of land is achieved by maximising NPV/ha. If western hardwood production scenarios cannot generate NPV/ha at least comparable with grazing, then they cannot provide a financially attractive alternative to grazing. However, even if the estimated NPV/ha is higher for western hardwood production than for grazing, if the activity takes place on only a small area, then total NPV may still be relatively small. On the other hand, a business like cattle grazing, that generates low NPV/ha over a much larger land area, may have a relatively high total NPV, making it more attractive to an individual landholder.

The following financial assessments of timber production opportunities are based on direct financial gains or losses only. The analyses do not account for the social or community benefits associated with grazing or timber production. Nor do they incorporate the environmental benefits that managing remnant woodlands for timber may have over clearing for grazing, such as increased carbon storage, biodiversity conservation and maintenance of ecosystem functioning (*e.g.* through salinity and land degradation control). These environmental benefits of timber production over grazing may be substantial (Rolfe *et al.* 2000).

10.7 Estimated returns to western Queensland hardwood production scenarios

Tables 10.7 and 10.8 present a summary of area harvested, total output of finished product and the annual profit and loss statement for scenarios 2 to 8 on freehold and leasehold land respectively. The NPV of each scenario is also indicated[27]. Since landholders in scenario 1 receive a stumpage payment per cubic metre of log harvested and undertake no production themselves, a profit and loss summary for this scenario is not presented. The annual profit for scenario 1 can be estimated as the stumpage price multiplied by the sawlog volume per hectare multiplied by the number of hectares harvested annually, less any royalty payments payable to DPI Forestry for timber harvested on leasehold land. All estimated profits and NPVs are before tax so that they are comparable with the grazing profitability estimates presented in Section 10.2. Detailed profit and loss statements are presented for each scenario in Appendix 10B.

[27] NPVs have been calculated for a 30-year investment period at a discount rate of 6% to facilitate comparisons with available grazing NPV estimates.

The level of fixed costs and net profits presented in Tables 10.7 and 10.8 are indicative of the first 10 years and years 16 to 25 of operation in each scenario. In years 11 to 15 and 26 to 30, all bank loans[28] are assumed to have been paid-off, meaning that fixed costs are lower and net profits higher for these years than indicated in the Tables[29]. The advantage of working with NPV is that such fluctuations in annual returns over the life of an investment are accounted for. Note that in scenario 3 on freehold land, a positive NPV resulted, even though annual profit was negative. This has occurred because large enough profits were made during years 11 to 15 and 26 to 30 (when fixed costs were low) to give the project a positive NPV overall.

Figure 10.2 illustrates NPV/ha for the various scenarios on freehold and leasehold land under base case assumptions. NPV/ha estimates for Western Queensland hardwood scenarios have been determined by dividing the estimate of NPV in Tables 10.7 and 10.8 by the number of hectares harvested over the 30-year investment period. In the base case net profit in scenario 1 is $50/ha on freehold land and $0/ha on leasehold land. If it is assumed that the same area of land is harvested annually over 30-years, but no area is harvested more than once during this period, then NPV/ha in scenario 1 is $24/ha and $0/ha on freehold and leasehold land respectively. It is notable that most scenarios are generating negative returns under the base case assumptions. Indicative ranges of NPV/ha for grazing in western Queensland ($20/ha to $40/ha) have been incorporated into Figure 10.2 and the remaining figures of this chapter.

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[28] Except for chainsaws and safety equipment, which are assumed to have a life of 3,000 m^3 of log, not necessarily 15 years.

[29] All equipment, except chainsaws, is assumed to be paid off over 10 years, and has an expected life of 15 years.

Table 10.7 *Summarised annual profit and loss statements for western Queensland hardwood production scenarios on freehold land*

Item	Scenarios on freehold land						
	2. Sawlogs	3. GOS	4. Treated, dried, graded, undressed boards	5. VJs	6. Parquetry	7. Parquetry (co-op)	8. Clear timber
Area of land harvested per annum (ha)[1]	1,324	458	411	324	308	1,374	240
Output (m^3) [2]							
Main line	1,324	143	25	19	31	206	5
Others			7	7			19
Sales ($) [3]	132,370	114,062	85,280	104,708	80,124	535,048	150,720
Cost of labour ($) [4]	*72,438*	*76,901*	*73,801*	*81,848*	*76,449*	*342,455*	*79,397*
Total operating expenses ($) [5]	127,709	111,918	99,277	108,537	103,239	521,807	104,714
Operating profit (loss) ($) [6]	4,660	2,144	(13,997)	(3,830)	(38,523)	13,241	46,006
Fixed costs ($) [7]	*2,041*	*3,764*	*5,048*	*16,622*	*35,380*	*43,163*	*7,873*
Net profit (loss) ($) [8]	2,619	(1,620)	(19,045)	(20,451)	(58,495)	(29,923)	38,133
NPV ($)	56,010	3,280	(242,391)	(185,548)	(610,817)	(144,201)	609,161

Notes:

1. Area over which harvesting must take place annually to sustain full-time production and the assumed output of saleable product in each scenario.
2. Output is split into ‘main line’ (the preferred product) and ‘others’ (fall-down product).
3. Sales are total value of sales of all saleable products.
4. Cost of labour is the total annual sum paid to labour (wages plus on-costs). In these analyses, this is paid to the participating landholders.
5. Total operating expenses is the sum of labour and all other operating costs, including chainsaw costs, farm truck expenses, portable sawmilling costs and dry milling expenses.
6. Operating profit is sales less total operating expenses.
7. Fixed costs comprise bank loan repayments and depreciation of equipment.
8. Net profit (loss) is operating profit less fixed costs and is before tax.

Table 10.8 *Summarised profit and loss statements for western Queensland hardwood production scenarios on leasehold land*

Item	Scenarios on leasehold land						
	2. Sawlogs	3. GOS	4. Treated, dried, graded, undressed boards	5. VJs	6. Parquetry	7. Parquetry (Co-op)	8. Clear timber
Area of land harvested per annum (ha) [1]	1,324	458	411	324	308	1,374	240
Output (m^3) [2]							
Main line	1,324	143	25	19	31	206	5
Others			7	7			19
Sales ($) [3]	132,370	114,062	85,280	104,708	80,124	535,048	150,720
Royalty	*66,185*	*22,922*	*20,533*	*16,218*	*15,408*	*68,766*	*12,000*
Cost of labour ($) [4]	*72,438*	*76,901*	*73,801*	*81,848*	*76,449*	*342,455*	*79,397*
Total operating expenses ($)[5]	193,874	134,840	119,811	124,756	118,648	590,074	116,714
Operating profit (loss) ($) [6]	(61,525)	(20,778)	(34,531)	(20,048	(23,115)	(55,026)	34,006
Fixed costs ($) [7]	*2,041*	*3,764*	*5,048*	*16,622*	*35,380*	*43,163*	*7,873*
Net profit (loss) ($) [8]	(63,566)	(24,542)	(39,579)	(36,669)	(73,903)	(98,190)	26,133
NPV ($)	(909,674)	(331,174)	(541,987)	(421,181)	(835,638)	(1,024,538)	453,918

Notes:

1. Area over which harvesting must take place annually to sustain full-time production in each scenario and the assumed output of saleable product.
2. Output is split into ‘main line’ (the preferred product) and ‘others’ (fall-down product).
3. Sales are total sales of all saleable products.
4. Cost of labour is the total annual sum paid to labour (wages plus on-costs). In these analyses, this is paid to the participating landholders.
5. Total operating expenses is the sum of labour and all other operating costs, including royalty payable to DPI Forestry, chainsaw costs, farm truck expenses, portable sawmilling costs and dry milling expenses.
6. Operating profit is sales less total operating expenses.
7. Fixed costs comprise bank loan repayments and depreciation of equipment.
8. Net profit (loss) is operating profit less fixed costs and is before tax.

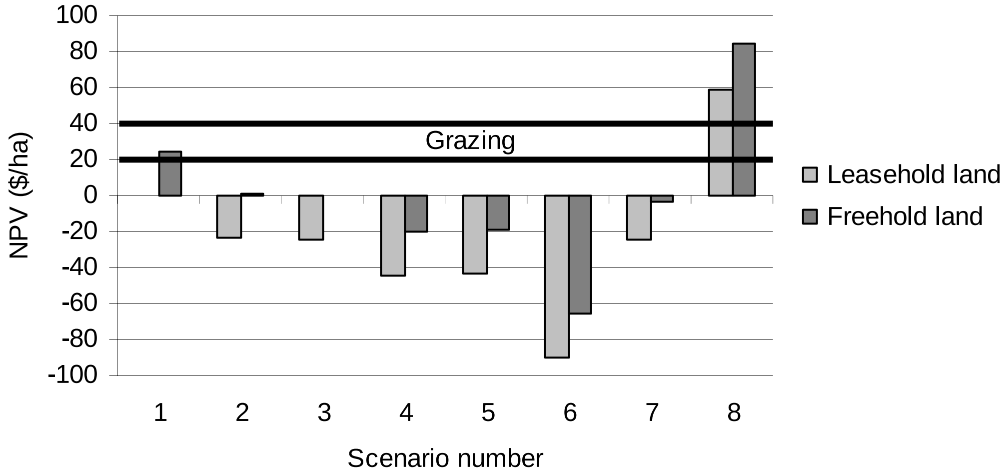

Figure 10.2 *NPV/ha for all scenarios under base case assumptions*

Figures 10.3 and 10.4 illustrate the market price required for 'main line' products to break-even (cover all variable and fixed costs for the duration of the 30-year investment) in each scenario, when all other base case assumptions are maintained. Enterprises with freehold timber supplies and specialising in undressed high feature boards at least 0.9 m in length (scenario 4) or VJs (scenario 5) are shown to require market prices of $2,700/m^3 and $3,000/m^3 to break-even respectively. Break-even prices for parquetry in scenario 6 are at least $4,000/m^3 (100/m^2), while in scenario 7 (the landholder co-operative) prices of about $2,750/m^3 and $3,000/m^3 ($75/m^2) are required for freehold and leasehold-based operations respectively. The high cost of producing clear grade timber in scenario 8 is indicated by the high break-even market prices. Prices of about $17,000/m^3 and $19,000/m^3 must be achieved to cover all costs of production for operations harvesting on freehold and leasehold land respectively.

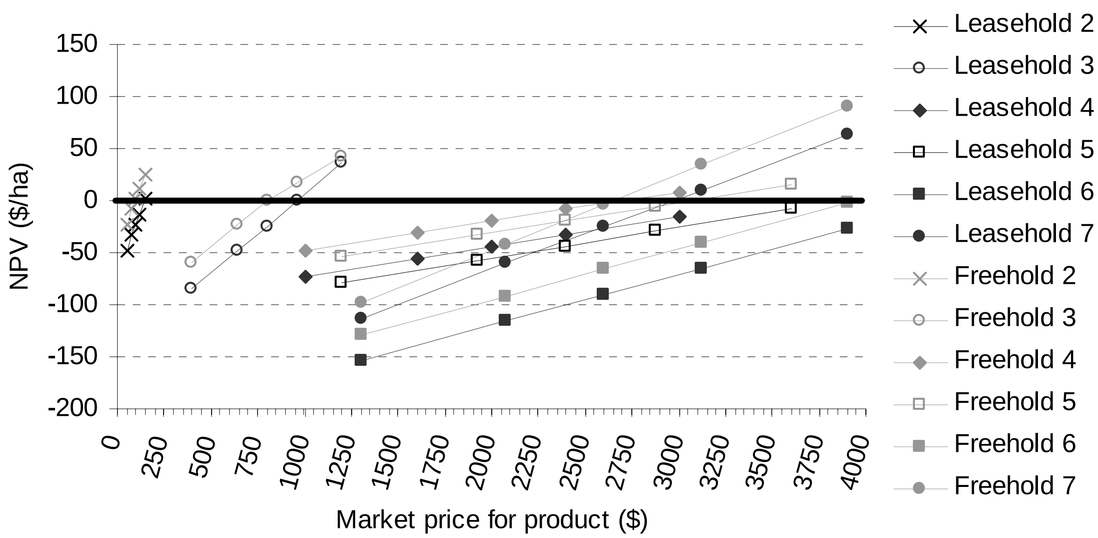

Figure 10.3 *Break-even 'main line' market prices for scenarios 2 to 7 under base case assumptions*

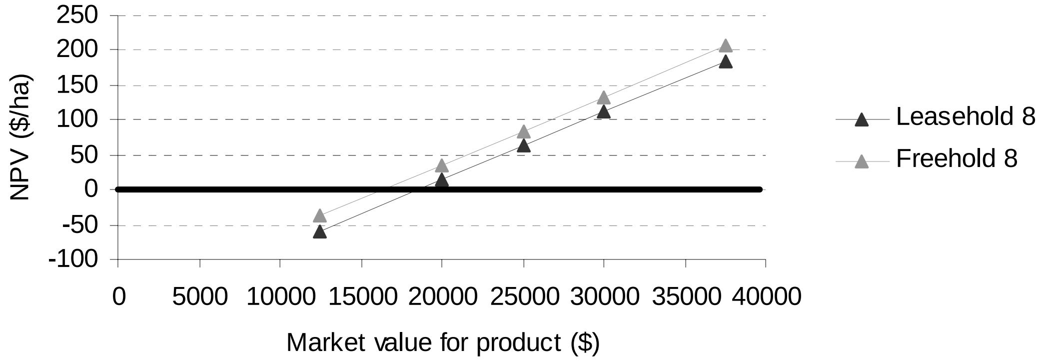

Figure 10.4 *Break-even 'main line' market price for scenario 8 under base case assumptions*

10.7.1 Results of the sensitivity analysis

Table 10.9 reports, in rank order, the five most sensitive parameters for each scenario. That is, the outcomes of the financial analyses for each scenario are most contingent upon the base case values adopted for these parameters. The results of sensitivity analyses on these parameters are presented in Appendix 10C. Scenario 1 has been omitted from the sensitivity analysis, because landholders do not undertake any activity. Equipment cost, business loan interest rates and administration expenses are conspicuously absent from these lists. The market price of 'main line' products and value of labour were found to be consistently high in the rankings. Figure 10.5 illustrates the effect of increasing 'main line' market prices by 20% in all scenarios, while keeping all other parameters fixed at base case levels. This may be considered a reflection of consumers willing to pay a premium for 'unique and rare' western timbers.

Returns in scenario 8 are impressive, even without the assumed 20% increase in market price for 'main line' product. However, a large volume of 'fall-down' product is produced in this scenario (see Table 10.7 or 10.8). Market value of other products was not among the top five most sensitive parameters for scenario 8, but it should be noted that if prices of 'fall-down' products were half the level assumed in the base case scenario, then NPV/ha would be reduced to $53 and $31 for freehold and leasehold land respectively. If no market at all existed for the 'fall-down' product, then NPV would be negative on leasehold land and $22/ha on freehold land.

In the short-term, while establishing western Queensland hardwoods in the market place, it may not be possible to obtain prices 20% above the base case. Cost cutting may be necessary to generate positive returns in scenarios 2 to 7. Figure 10.6 indicates the effect of lowering the value of labour to $15/hour. Figure 10.7 illustrates the returns that could be achieved through combinations of improved operational efficiency and product recovery, without reducing payments to labour. The parameters that were altered from their base case values, and the amount by which they were altered to produce Figure 10.7, are presented in Table 10.10. Figure 10.8 combines the effect of improved operational efficiency and product recovery in Figure 10.7 with a price increase for 'main line' products of 20%. Figure 10.8 may be indicative of the result of processing efficiencies and market acceptance that could be developed in the longer-term.

Table 10.9 *The five parameters that NPV/ha is most sensitive to for each scenario*

Rank	Top five most sensitive parameters by scenario number						
	2. Sawlogs	3. GOS	4. HF undressed	5. VJs	6. Parquetry	7. Parquetry Co-operative	8. Clear timber
1	Market price of sawlog	Market price of GOS boards	Value of labour	Value of labour	Efficiency of portable sawmilling and drymilling	Market value of parquetry	Market price of clear grade
2	Value of labour	GOS recovery	Market price of undressed HF boards >0.9m	Efficiency of portable sawmilling and drymilling	Market value of parquetry	High feature recovery from log volume	Clear grade recovery from high feature
3	Efficiency of felling, docking and snigging (Efficiency of felling, docking and snigging)	Value of labour	High feature recovery from log volume	Market price of clear grade off-cuts	High feature recovery from log volume	Efficiency of sawmillers in the co-op	GOS recovery
4	Sawlog volume per hectare (Royalty)	Efficiency of portable sawmilling	GOS recovery	High feature recovery from log volume	Value of labour	Value of labour	Sawlog volume per hectare
5	Sawlog haulage distance to sawmill (Sawlog volume per hectare)	Efficiency of felling, docking and snigging (Royalty)	Size of market for clear grade timber	Market price of VJs	GOS recovery	Efficiency of dry milling	Efficiency of dry milling

Notes: Parameters are listed in sensitivity rank order for western hardwood timber production scenarios on freehold land. Where rankings of parameters differ on leasehold land parameters are listed in parentheses.

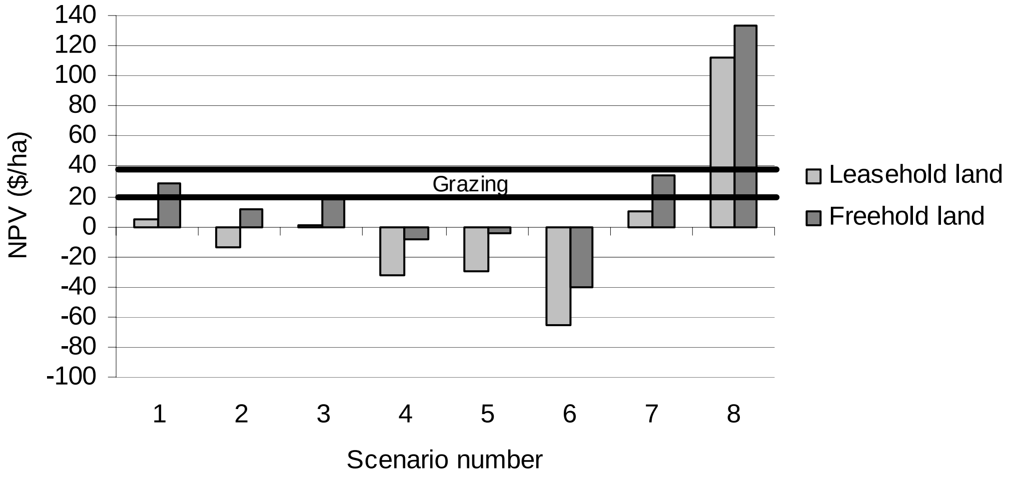

Figure 10.5 *NPV/ha for scenarios if all 'main line' products can be sold at market prices 20% above the base case*

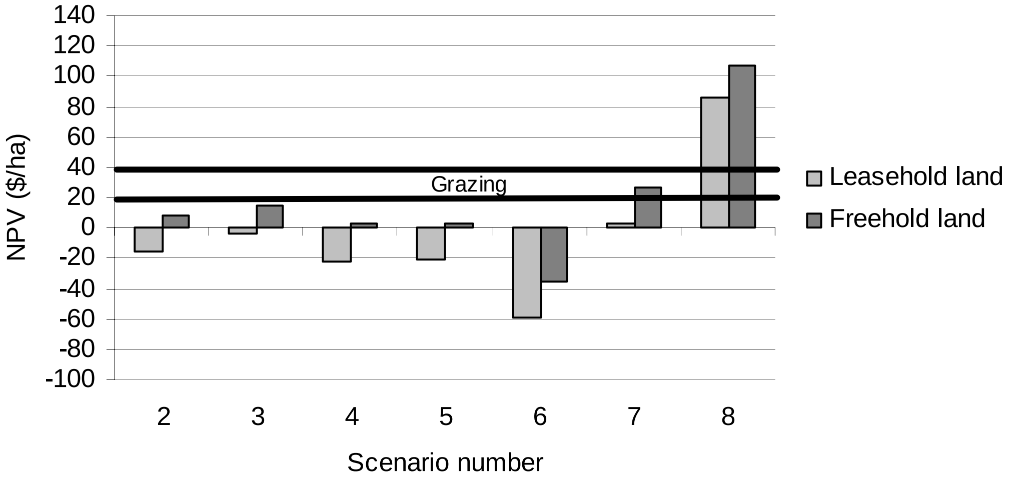

Figure 10.6 *NPV/ha for scenarios if value of labour reduced to $15/hour*

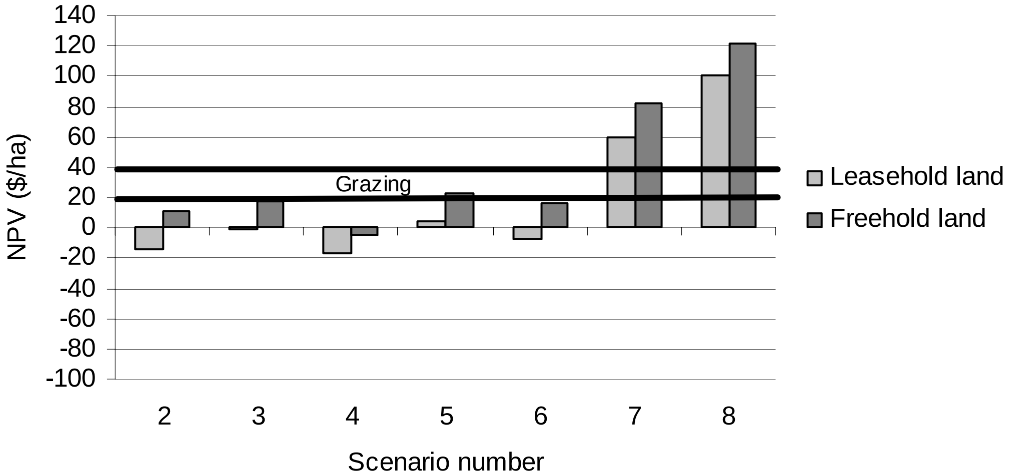

Figure 10.7 *NPV/ha for scenarios 2 to 8 when the two parameters in Table 10.10 are improved*

Table 10.10 *Assumed improvements in selected base case parameters for estimating NPV/ha in Figure 10.7 and 10.8*

Scenario	Improved parameters over base case					
	Parameter 1			Parameter 2		
	Item	Base case value	Improved value	Item	Base case value	Improved value
2	Efficiency of felling, docking and snigging	100%	120%	Sawlog haulage distance to sawmill	200 km	100 km
3	GOS recovery	31.1%	35%	Efficiency of portable sawmilling	100%	120%
4	High feature recovery from log volume	10%	15%	GOS recovery	31.1%	35%
5	High feature recovery from log volume	10%	15%	Efficiency of portable sawmilling and drymilling	100%	120%
6	High feature recovery from log volume	10%	15%	Efficiency of portable sawmilling and drymilling	100%	120%
7	High feature recovery from log volume	15%	20%	Efficiency of sawmillers in the co-operative	100%	120%
8	Clear grade recovery from high feature volume	20%	25%	GOS recovery	31.1%	35%

Note: 'Efficiency' parameters are 100% when operational efficiency is equal to the average achieved in the mulga and gidgee trials (base case) reported in Chapters 4 to 6. Efficiency of 120% is a 20% improvement in efficiency (20% reduction in costs per unit produced) over the base case.

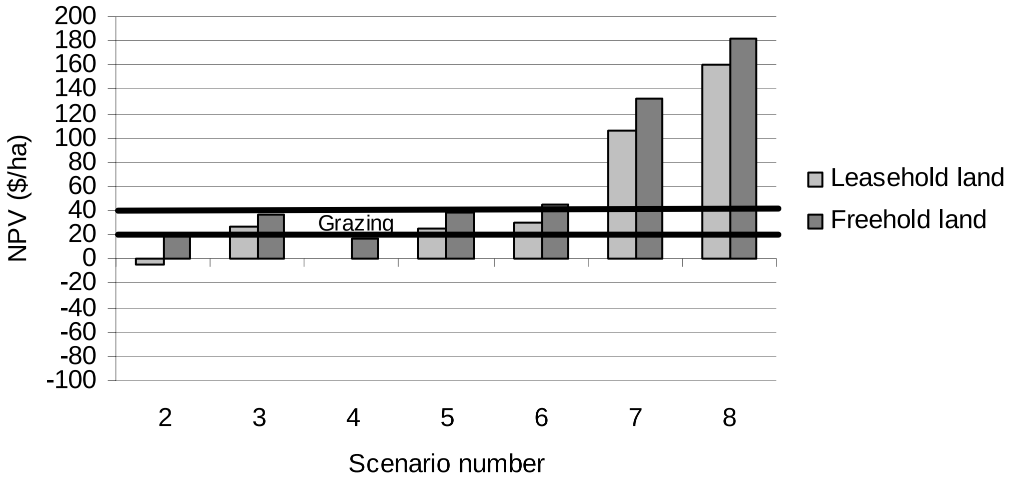

Figure 10.8 *NPV/ha for scenarios 2 to 8 when the two parameters in Table 10.10 are improved and market prices for 'main line' products are 20% higher than the base case scenario*

10.7.2 Opportunities for production of western Queensland hardwoods on a part-time basis

The base case scenario assumed full-time employment of landholders in the production of western Queensland hardwoods. Many landholders may be interested in farm income diversification, not a complete shift away from grazing into timber production. However, given that most scenarios were found to generate negative returns per hectare under base case assumptions, reducing the level of activity and output only compounds the negative result, as fixed costs (which remain fixed) must be met with declining revenue. Scenario 8 was the only enterprise modelled in which landholders were found to have the opportunity to enter the industry on a part-time basis. A minimum of three months of production per annum was necessary to cover all costs and generate profits sufficient to guarantee the enterprise had a NPV/ha greater than could be achieved by clearing remnant woodlands for grazing (*i.e.* >$40/ha) under base case assumptions.

10.8 Discussion of western Queensland hardwood processing opportunities

Using the best available information on processing costs, product recovery from log volume and market prices, costs were found to exceed returns for the majority of scenarios. Under base case assumptions, only scenarios 1 and 8 compared favourably with grazing. The NPV/ha estimated for scenario 1 should be applied with caution. Although professional timber cutters interested in western hardwoods have indicated a willingness to pay $\$50/m^3$, they can be highly selective (harvesting perhaps less than the available $1m^3/ha$) and, on current trends, demand only small volumes of timber annually. Professional timber cutters dealing in western woods are likely to demand no more than 20 m^3 of log of a given species per annum. Therefore, while NPV per hectare may be high relative to other scenarios, selling timber at the stump is unlikely to provide a substantial income stream to landholders.

In Chapters 8 and 9, the high prices potentially paid for clear cuts of western hardwood timber were discussed. Also discussed was the small current demand for these high value cuts of timber in Australia, the small volumes currently exported and the potential to expand the export market. In scenario 8, it is assumed that export markets have been expanded and landholders processing western hardwoods on a full-time basis sell 5 m^3 of clear grade timber per annum at $25,000/$m^3$. This scenario offers a highly profitable alternative to grazing in western Queensland, both in terms of NPV/ha and net profit. Net profit was estimated at $38,000 per annum on freehold land, earned from the harvest of only 240 ha of remnant woodlands per year. This annual profit compares favourably with annual profits earned from grazing enterprises over much larger areas.

The favourable outcome in scenario 8 is; however, dependent upon achieving high market prices for clear grade timber. In Figure 10.4, it can be seen that if prices fell below about $22,000/$m^3$ and $20,000/$m^3$ for clear grade timber harvested from leasehold and freehold land respectively, then NPV/ha for scenario 8 would fall below $40 and grazing may be more attractive in some areas. If prices fell below about $19,000/$m^3$ and $17,000/$m^3$ for clear grade timber harvested from leasehold and freehold land respectively, then NPV/ha would be negative.

When 'main line' prices were increased by 20% over the base case to reflect consumer willingness to pay higher prices for 'unique and rare' western timbers, the NPV/ha of all scenarios increased substantially (Figure 10.5). Nevertheless, many scenarios still generated negative returns and only the landholder co-operative and GOS production scenarios on freehold land joined scenarios 1 and 8 as activities competitive with grazing. Improved margins may also be gained from cost cutting. Figure 10.7 indicated that improved operational efficiency and product recovery alone could potentially make scenario 7 more commercially attractive than grazing on freehold and leasehold land.

An indication of the returns that might be achieved by efficient and experienced western Queensland hardwood producers, who strategically sell into niche product lines, is provided in Figure 10.8. In this case, all western hardwood scenarios are competitive with grazing on a NPV/ha basis, with the exception of selling sawlogs from leasehold land and manufacturing seasoned, treated, undressed boards from leasehold land. While Chapters 8 and 9 indicated a reluctance of potential purchasers of western hardwoods to pay more than the prices adopted in the base case for mainstream products, a 20% price premium is probably achievable in domestic and international niche markets. Estimates of costs of harvesting and portable sawmilling adopted for the base case were derived from the mulga and gidgee sawing trials discussed in Chapter 4. The persons involved in these trials believed that efficiency could be improved with experience. Dry milling costs were based on expert opinion; however, there may be avenues to reduce costs to levels below those assumed in the base case. While it is impossible to be certain about the magnitude of potential efficiency and product recovery gains that could be achieved by landholders, those assumed in Figure 10.8 do not appear to be unrealistically optimistic.

Supply of high-value, clear timber, is estimated to be more profitable than grazing in western Queensland. The landholder co-operative scenario is also likely to be highly profitable (in terms of total NPV and NPV/ha) when niche market prices 20% above mainstream markets are assumed and this is combined with production efficiency gains. Under the same niche market and efficiency gain assumptions, most other western hardwood scenarios were found to be competitive with grazing on a NPV/ha basis, but not in terms of total NPV. Therefore, under these circumstances, timber production may be a more efficient land-use than clearing for grazing; however, when labour inputs are limited, the comparatively extensive management of farmland for grazing may still facilitate higher total value of production.

10.8.1 Economic and ecological sustainability

The results of the financial analyses are dependant upon the sawlog resource not being exhausted within the 30-year life of the investment. Landholders wishing to undertake harvesting on their own properties may encounter resource constraints during this 30-year horizon, particularly if low-value products are being sold. For example, the base case sawlog production scenario indicates that one two-person operation would harvest 40,000 ha of western woodlands over 30 years.

The dearth of information about aerial extent and growth rates of the western hardwood resource (Chapter 2) does not allow meaningful comments to be made about the economic and ecological sustainability of various timber processing scenarios at this stage. However, scenarios requiring the annual harvesting of smaller areas will be more sustainable than scenarios requiring the harvesting of larger areas.

10.9 Conclusion

Contingent upon a large number of assumptions, which were necessary because of the scarcity of information, preliminary estimates of returns to landholders diversifying into western Queensland hardwood production have been made. Environmental and community costs and benefits of grazing versus timber production in remnant woodlands have not been incorporated into the analyses. In addition, it was not possible to consider agroforestry scenarios in this financial analysis.

Under base case assumptions, supplying high-value, clear cuts of timber was found to be a more profitable undertaking than grazing, although this result was shown to be highly sensitive to the assumed market price. From the perspective of an individual landholder with remnant woodlands, the net present value of future income streams from clearing the woodlands for grazing are likely to exceed the potential returns of the remaining timber production scenarios analysed under base case assumptions. However, the sensitivity analyses indicated that many western hardwood production opportunities have potential to provide returns competitive with or exceeding grazing. The landholder co-operative scenario, in particular, indicated that returns higher than grazing could be generated with small improvements in market price and production efficiency over the base case assumptions.

References

ABARE (1995), *Analysis of the Economic Impacts of the Draft State Guidelines on Tree Clearing in Queensland*, report to the Ministerial Consultative Committee and the Working Group on Tree Clearing, ABARE, Canberra.

ABARE (2001), *Exploring ABARE's Farm Survey Data*, http://agsurf.abareconomics.com/cgi-bin/abare.pl?_PROGRAM=ags4Home&wh =ter&pr=agsurf, accessed 13 March 2002.

Burns, D. (2002), personal communication, Portable Sawmill Trainer, Blackbutt.

Leggate, W. (2000), '25-year-old plantation-grown spotted gum: productivity, sawn recovery and potential rates of return', unpublished report to FORESTECH, Queensland Forestry Research Institute, Brisbane.

Lucas, R. (2002), personal communication, Manager, Lucas Mill Pty Ltd.

Native Forest Sawlog Pricing Working Group (1997), *Hardwood Pricing Review*, Hardwood Working Group Report for submission to the Native Sawlog Pricing Tribunal, Brisbane.

Norton, J. (2002), personal communication, Leader, Forest Products Biodeterioration, Queensland Forestry Research Institute, Indooroopilly.

Queensland Beef Industry Institute (2000), *Queensland Beef On Farm Situation Analysis: An On Farm Profile*, Queensland Government, Brisbane.

Resource Consulting Services (1995), ‘Report on Investigation into the Potential Impact of Changes in Tree Clearing Guidelines on Profitability of Grazing Properties’, unpublished report, Resource Consulting Services Pty Ltd, Yeppoon.
Rolfe, J.C., Blamey, R.K. and Bennett, J.W. (1997), *Remnant Vegetation and Broadscale Tree Clearing in the Desert Uplands Region of Queensland*, Choice Modelling Research Report No 3, University College, The University of New South Wales, Canberra.
Rolfe, J.C., Bennett, J.W. and Blamey, R.K. (2000), *An Economic Evaluation of Broadscale Tree Clearing in the Desert Uplands Region of Queensland*, Choice Modelling Research Report No. 12, University College, The University of New South Wales, Canberra.
Rolfe, J.C. (2002), personal communication, Associate Professor, Faculty of Business and Law, Central Queensland University, Emerald.
Smorfitt, D.B. (2000), A commercial evaluation of the sawmilling industry in north Queensland with special reference to the current and potential role of portable sawmills, Master of Commerce by research thesis, School of Business, James Cook University, Townsville.
Stewart, M. and Hanson, I. (1998), *On-site Processing for Farm Forestry*, RIRDC Publication No 98/79, Rural Industries Research and Development Corporation, Canberra.
Swift, S., Taylor, D., Cotter, D. and Fairbairn, E. (2002), ‘Utilisation of Western Hardwoods as Specialty Timbers: Preliminary Resource Survey Report’, Queensland Forestry Research Institute, Gympie.
Walls, J. (2002), personal communication, Principal Marketing Officer, Native Forests, DPI Forestry.

Appendix 10A. Base case scenario non-labour costs for felling, docking, snigging, log haulage on-farm and portable sawmilling

The tables in this appendix have been derived from those of Appendix 4A. Differences in the cost estimates between those adopted in the financial assessment of portable sawmilling in Chapter 4 and those adopted here are due to the averaging of cost estimates for mulga, and gidgee and differences in the rates of efficiency of production being assumed.

10A.1 Non-labour felling and docking expenses

Chainsaw hourly operating expenses per hour are assumed to be equivalent to those presented in Appendix 4A.2. The base case non-labour chainsaw felling and merchandising expense per cubic metre of log has been estimated in Table 10A.1.

Table 10A.1 *Chainsaw operating expenses per cubic metre under base case assumptions*

Chainsaw operating cost (\$/hr)[1]	4.67
Logs felled and merchandised (m^3/hr)[2]	1.14
Chainsaw cost (\$/m^3)	4.12

Notes:

1. Chainsaw operating costs from Appendix 4A.2.
2. Average volume of logs felled and merchandised per hour is the rate achieved in the gidgee milling study. This is equivalent to about 16 logs per hour. The gidgee felling rate was adopted, because, in the base case, 1 m^3/ha of sawlog resource has been assumed. This is equivalent to the sawlog volume per hectare in the gidgee study.

10A.2 Non-labour snigging expenses

The base case non-labour snigging expenses per cubic metre are equivalent to the rate adopted in Chapter 4, which are presented again in Table 10A.2.

Table 10A.2 *Non-labour snigging expenses*

Tractor operating cost (\$/km)[1]	0.595
Average return snig distance (km)[2]	0.4
Number of logs carried per load[2]	3
Average log volume per load (m^3)[3]	0.21
Non-labour snig cost (\$/m^3)	\$1.13

Notes:

1. The Australian Tax Office's expense claim rate for vehicles >2,600 cc has been adopted as the operating cost per kilometer for a tractor. This rate includes fuel, maintenance and depreciation. No farm equipment rates per kilometer were available from the tax office.
2. In McGavin's (2002) experience, these figures are reasonable for the resource in western Queensland.
3. Average log volume per load is the average log volume across QFRI's mulga and gidgee milling studies (0.07 m^3), multiplied by the number of logs per load.

10A.3 Non-labour loading and unloading expenses

Loading and unloading logs
It is assumed that a tractor with a fork is available for loading sawlogs. Tractor loading costs are assumed to be equivalent to $0.50/m^3 of log. Labour expenses are as detailed in Appendix 4A.3 and the efficiency rate of production has been presented in Section 10.4.5.

Loading and Unloading Sawn Boards
It is assumed that sawn boards can be loaded onto a truck at half the cost of loading logs or \$2.63/m^3 of boards. This is similar to the loading rate charged by some road freight companies in western Queensland, for example one road freight company quoted \$40 to load a 22 tonne freight truck or approximately \$2.20/m^3 of sawn western hardwood timber.

10A.4 Non-labour log haulage by farm truck

Non-labour log haulage costs by farm truck on-farm have been estimated in Table 10A.3. The rate adopted for the base case analyses was the average cost or \$0.11/m^3/km.

Table 10A.3 *On-farm log haulage costs in a farm truck*

Item	Mulga	Gidgee
Farm truck capacity (tonnes)	7	7
Farm truck capacity of log (m^3)[1]	5.9	5.2
Travel speed (km/hr)[2]	20	20
Truck cost (\$/m^3/km)[3]	0.10	0.12

Notes:

1. Log capacity estimated by dividing truck capacity divided by green density of mulga (1,188 kg/m^3) and gidgee (1,354 kg/m^3).
2. The average speed at which mulga logs were hauled on farm during QFRI milling studies.
3. The Australian Tax Office's expense claim rate of \$0.595/km for vehicles >2,600 cc has been adopted as the operating cost for a farm truck. This rate includes fuel, maintenance and depreciation. No farm equipment rates per kilometre were available from the tax office. Truck cost is \$0.595/km / log capacity (m^3).

10A.5 Portable sawmilling expenses

Assumed base case operating costs for a portable sawmill are detailed in Table 10A.4

Table 10A.4 *Operating costs of a Lucas 8" portable sawmill milling western Queeensland hardwoods*

Item	Consumption / hour	Unit cost ($)	$/hour	Cost ($/m^3 log)[7]
Blades[1]	na	100[2]	na	26.67
Fuel[3]	2.25 l	0.80	1.80	4.93
Fuel filter[4]	1/320	13.20	0.04	0.11
Oil[5]	1.5 l/120	10.17	0.13	0.35
Oil filters[4]	1/320	19.80	0.06	0.17
Air filter cartridges[4]	1/160	22.00	0.14	0.38
Spark plugs[4]	1/800	12.10	0.02	0.04
Pre-cleaner[4]	1/480	6.60	0.01	0.04
Drive belts[4]	1/480	21.00	0.04	0.12
Trolley rollers[4]	1/800	52.80	0.07	0.18
Contingency[6]	na	na	0.25	0.68
Total non-labour milling expense				33.66
Labour - milling				98.05
Labour - sharpening and refuelling				8.79
Labour - saw blade changing				2.67
Total labour milling expense				109.50
Total milling expense				$143.17

Notes: Consumption per hour is per 8 hour day spent milling, not per hour of engine time. An 8 hour day spent milling would typically include about 5 hours of engine time (Lucas 2002).

1. In the QFRI gidgee milling study, blades required changing after milling approximately 3.75 m^3 of log. This rate has been adopted for mulga and gidgee, although greater blade life could be possible milling mulga. With experience and better milling techniques, blade costs may decrease.
2. Approximate average cost of retipping and tensioning a blade gathered from blade doctors in Brisbane is $80, including GST. Freight from western Queensland about $10 each way.
3. Fuel consumption is based on 18 litres per 8 hour day of milling (Burns 2002).
4. These cost estimates were based on information supplied by Lucas Mill Pty Ltd (Lucas 2002).
5. An oil change was recommended once every 100 engine ours by Lucas (2002) and every 50 engine hours by Burns (2002). The average 75 engine hours (120 milling hours) has been adopted.
6. Contingency for batteries, throttle cables and other parts (Lucas 2002).
7. Cost/m^3 is based on an average log throughput of 0.365 m^3/hr for mulga and gidgee in the portable sawmilling trials.

Appendix 10B. Annual profit and loss statements for scenarios 2 to 8 on freehold and leasehold land under base case assumptions

Table 10A.5 *Annual profit and loss statement for scenario 2 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	*132,370*	*132,370*
Operating expenses		
Royalty on leasehold land		66,185
Fell and merchandise	28,758	28,758
Snig	35,520	35,520
Loading logs	6,965	6,965
Log haulage on-farm	7,484	7,484
Portable sawmilling		
Chemical treatment		
Drying		
Dry milling		
Freight off-farm	42,901	42,901
Administration and contingency	6,081	6,081
Total operating expenses[1]	*127,709*	*193,894*
Operating profit (loss)	**4,660**	**(61,525)**
Less financing expenses	1,084	1,084
Less depreciation	957	957
Net profit (loss) before tax	*2,619*	*(63,566)*
Less company income tax (30%)	786	0
Net profit (loss) after tax	**1,833**	**(63,566)**
Add back depreciation	957	957
Add back after tax wages[2]	45,270	45,270
Net annual cash flow after tax	***48,061***	***(17,339)***

Notes:

1. Total operating expenses includes $54,329 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.

2. After tax wages have been calculated by deducting the tax payable from the annual wage of $27,164/person (total of $54,329) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.6 *Annual profit and loss statement for scenario 3 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	***114,062***	***114,062***
Operating expenses		
Royalty on leasehold land		22,922
Fell and merchandise	9,960	9,960
Snig	12,302	12,302
Loading logs	2,412	2,412
Log haulage on-farm	2,592	2,592
Portable sawmilling	65,635	65,635
Chemical treatment		
Drying		
Dry milling		
Freight off-farm	13,687	13,687
Administration and contingency	5,329	5,329
Total operating expenses[1]	*111,918*	*134,840*
Operating profit (loss)	**2,144**	**(20,778)**
Less financing expenses	2,532	2,532
Less depreciation	1,231	1,231
Net profit (loss) before tax	*(1,620)*	*(24,542)*
Less company income tax (30%)	0	0
Net profit (loss) after tax	**(1,620)**	**(24,542)**
Add back depreciation	1,231	1,231
Add back after tax wages[2]	47,613	47,613
Net annual cash flow after tax	***47,224***	***24,302***

Notes:

1. Total operating expenses includes $57,676 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.

2. After tax wages have been calculated by deducting the tax payable from the annual wage of $28,839/person (total of $57,676) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.7 *Annual profit and loss statement for scenario 4 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	***85,280***	***85,280***
Operating expenses		
Royalty on leasehold land		20,535
Fell and merchandise	8,922	8,922
Snig	11,020	11,020
Loading logs	2,161	2,161
Log haulage on-farm	2,322	2,322
Portable sawmilling	58,794	58,794
Chemical treatment	4,470	4,470
Drying	3,824	3,824
Dry milling		
Freight off-farm	3,037	3,037
Administration and contingency	4,727	4,727
Total operating expenses[1]	*99,277*	*119,811*
Operating profit (loss)	**(13,997)**	**(34,531)**
Less financing expenses	3,451	3,451
Less depreciation	1,597	1,597
Net profit (loss) before tax	*(19,045)*	*(39,579)*
Less company income tax (30%)	0	0
Net profit (loss) after tax	**(19,045)**	**(39,579)**
Add back depreciation	1,597	1,597
Add back after tax wages[2]	45,986	45,986
Net annual cash flow after tax	***28,537***	***8,004***

Notes:

1. Total operating expenses includes $55,351 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.
2. After tax wages have been calculated by deducting the tax payable from the annual wage of $27,676/person (total of $55,351) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.8 *Annual profit and loss statement for scenario 5 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	***104,708***	***104,708***
Operating expenses		
Royalty on leasehold land		16,218
Fell and merchandise	7,047	7,047
Snig	8,704	8,704
Loading logs	1,707	1,707
Log haulage on-farm	1,834	1,834
Portable sawmilling	46,438	46,438
Chemical treatment	3,531	3,531
Drying	3,020	3,020
Dry milling	28,548	28,548
Freight off-farm	2,540	2,540
Administration and contingency	5,168	5,168
Total operating expenses[1]	*108,537*	*124,756*
Operating profit (loss)	**(3,830)**	**(20,048)**
Less financing expenses	11,637	11,637
Less depreciation	4,985	4,985
Net profit (loss) before tax	*(20,451)*	*(36,669)*
Less company income tax (30%)	0	0
Net profit (loss) after tax	**(20,451)**	**(36,669)**
Add back depreciation	4,985	4,985
Add back after tax wages[2]	50,210	50,210
Net annual cash flow after tax	***34,743***	***18,525***

Notes:

1. Total operating expenses includes $61,386 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.

2. After tax wages have been calculated by deducting the tax payable from the annual wage of $30,693/person (total of $61,386) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.9 *Annual profit and loss statement for scenario 6 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	***80,124***	***80,124***
Operating expenses		
Royalty on leasehold land		15,408
Fell and merchandise	6,695	6,695
Snig	8,269	8,269
Loading logs	1,622	1,622
Log haulage on-farm	1,742	1,742
Portable sawmilling	44,120	44,120
Chemical treatment	3,354	3,354
Drying	5,602	5,602
Dry milling	23,960	23,960
Freight off-farm	2,958	2,958
Administration and contingency	4,916	4,916
Total operating expenses[1]	*103,239*	*118,648*
Operating profit (loss)	**(23,115)**	**(38,523)**
Less financing expenses	24,740	24,740
Less depreciation	10,639	10,639
Net profit (loss) before tax	*(58,495)*	*(73,903)*
Less company income tax (30%)	0	0
Net profit (loss) after tax	**(58,495)**	**(73,903)**
Add back depreciation	10,639	10,639
Add back after tax wages[2]	47,376	47,376
Net annual cash flow after tax	***(479)***	***(15,888)***

Notes:

1. Total operating expenses includes $57,337 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.

2. After tax wages have been calculated by deducting the tax payable from the annual wage of $28,668/person (total of $57,337) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.10 *Annual profit and loss statement for scenario 7 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales		***535,048***
Operating expenses		
Royalty on leasehold land		68,766
Fell and merchandise	29,880	29,880
Snig	36,906	36,906
Loading logs	7,236	7,236
Log haulage on-farm	7,776	7,776
Portable sawmilling	196,905	196,905
Chemical treatment	14,933	14,933
Drying	24,937	24,937
Dry milling	96,000	96,000
Freight off-farm	60,817	60,817
Administration and contingency	41,334	45,918
Total operating expenses[1]	*521,807*	*590,074*
Operating profit (loss)	**13,241**	**(55,026)**
Less financing expenses	30,514	30,514
Less depreciation	12,650	12,650
Net profit (loss) before tax	*(29,923)*	*(98,190)*
Less company income tax (30%)	0	0
Net profit (loss) after tax	**(29,923)**	**(98,190)**
Add back depreciation	30,514	30,514
Add back after tax wages[2]	212,370	212,370
Net annual cash flow after tax	***212,961***	***144,694***

Notes:

1. Total operating expenses includes $256,842 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.

2. After tax wages have been calculated for the six portable sawmillers by deducting the tax payable from the annual wage of $28,839/person (total of $173,028) in accordance with the Australian personal income tax schedule of 2001-02. After tax wages have been calculated for the two parquetry manufacturers and two half-time employees by deducting the tax payable from the annual wage of $27,938/person (total of $83,814) in accordance with the Australian personal income tax schedule of 2001-02.

Table 10A.11 *Annual profit and loss statement for scenario 8 on freehold and leasehold land under base case assumptions*

Item	Amount ($)	
	Freehold	Leasehold
Total sales	***150,720***	***150,720***
Operating expenses		
Royalty on leasehold land		12,000
Fell and merchandise	5,214	5,214
Snig	6,440	6,440
Loading logs	1,263	1,263
Log haulage on-farm	1,357	1,357
Portable sawmilling	34,360	34,360
Chemical treatment	2,612	2,612
Drying	2,235	2,235
Dry milling	43,942	43,942
Freight off-farm	2,304	2,304
Administration and contingency	4,986	4,986
Total operating expenses[1]	*104,714*	*116,714*
Operating profit (loss)	**46,006**	**34,006**
Less financing expenses	5,616	5,616
Less depreciation	2,257	2,257
Net profit (loss) before tax	*38,133*	*26,133*
Less company income tax (30%)	11,440	7,840
Net profit (loss) after tax	**26,693**	**18,293**
Add back depreciation	2,257	2,257
Add back after tax wages[2]	48,923	48,923
Net annual cash flow after tax	***77,873***	***69,473***

Notes:

1. Total operating expenses includes $59,548 paid as taxable wages to labour, which has been distributed across all operating expenses in accordance with the assumptions detailed in Section 10.4. On-costs, such as superannuation and workers' compensation are also accounted for within total operating expenses, but are not included in the taxable wages.
2. After tax wages have been calculated by deducting the tax payable from the annual wage of $29,774/person (total of $59,548) in accordance with the Australian personal income tax schedule of 2001-02.

Appendix 10C. Results of sensitivity analyses

Table 10A.12 *Results of a sensitivity analysis on the five parameters to which scenario 2 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Market price of sawlog						Market price of sawlog					
	Base case	50	80	100	120	150	Base case	50	80	100	120	150
	1.4	-22.9	-8.3	1.4	11.1	25.7	-22.9	-47.2	-32.6	-22.9	-13,2	-1.4
2	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	1.4	14.8	8.1	1.4	-5.3	-12.0	-22.9	-9.5	-16.2	-22.9	-29.6	-36.3
3	Efficiency of felling, merchandising and snigging						Efficiency of felling, merchandising and snigging					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	1.4	-22.8	-4.7	1.4	5.5	9.5	-22.9	-47.1	-29.0	-22.9	-18.9	-14.8
4	Sawlog volume per hectare						Royalty					
	Base case	0.5	0.8	1.0	1.5	2.0	Base case	20	30	40	50	70
	1.4	-3.4	-1.0	1.4	9.4	19.0	-22.9	-8.3	-13.2	-18.0	-22.9	-32.6
5	Sawlog haulage distance to sawmill						Sawlog volume per hectare					
	Base case	50	100	200	400	800	Base case	0.5	0.8	1.0	1.5	2.0
	1.4	9.0	6.5	1.4	-8.8	-29.1	-22.9	-15.5	-20.5	-22.9	-27.1	-29.7

Table 10A.13 *Results of a sensitivity analysis on the five parameters to which scenario 3 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Market price of GOS boards						Market price of GOS boards					
	Base case	400	640	800	960	1200	Base case	400	640	800	960	1200
	0.2	-60.3	-24.0	0.2	17.7	43.1	-24.1	-84.6	-48.3	-24.1	0.1	36.4
2	GOS recovery						GOS recovery					
	Base case	20	25	31.1	35	40	Base case	20	25	31.1	35	40
	0.2	-27.5	-20.5	0.2	10.0	21.9	-24.1	-61.8	-44.8	-24.1	-10.8	6.2
3	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	0.2	29.7	15.2	0.2	-20.4	-41.1	-24.1	17.3	-3.4	-24.1	-44.8	-65.4
4	Efficiency of portable sawmilling						Efficiency of portable sawmilling					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	0.2	-60.4	-14.9	0.2	7.8	14.8	-24.1	-84.7	-39.2	-24.1	-14.0	-3.7
5	Efficiency of felling, merchandising and snigging						Royalty					
	Base case	50%	80%	100%	120%	150%	Base case	20	30	40	50	70
	0.2	-24.5	-6.0	0.2	3.6	6.5	-24.1	-9.5	-14.4	-19.2	-24.1	-33.8

Table 10A.14 *Results of a sensitivity analysis on the five parameters to which scenario 4 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	-19.7	18.2	2.5	-19.7	-41.9	-64.1	-44.0	0.4	-21.8	-44.0	-66.2	-88.4
2	Market price of undressed HF boards >0.9 m						Market price of undressed HF boards >0.9 m					
	Base case	1000	1600	2000	2400	3000	Base case	1000	1600	2000	2400	3000
	-19.7	-48.9	-31.3	-19.7	-12.6	-1.9	-44.0	-73.2	-55.7	-44.0	-32.3	-14.8
3	High feature recovery from log volume						High feature recovery from log volume					
	Base case	5%	8%	10%	12%	15%	Base case	5%	8%	10%	12%	15%
	-19.7	-53.7	-30.8	-19.7	-8.6	6.5	-44.0	-78.0	-55.1	-44.0	-32.9	-16.3
4	GOS recovery						GOS recovery					
	Base case	20%	25%	31.1%	35%	40%	Base case	20%	25%	31.1%	35%	40%
	-19.7	-35.8	-28.5	-19.7	-14.0	-6.8	-44.0	-60.1	-52.8	-44.0	-38.3	-31.1
5	Size of market for clear grade timber						Size of market for clear grade timber					
	Base case	1.0	1.6	2.0	2.4	3.0	Base case	1.0	1.6	2.0	2.4	3.0
	-19.7	-37.3	-26.7	-19.7	-12.6	-2.0	-44.0	-61.6	-51.1	-44.0	-36.9	-26.3

Table 10A.15 *Results of a sensitivity analysis on the five parameters to which scenario 5 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	-19.0	21.3	3.2	-19.0	-41.1	-63.4	-43.3	1.1	-21.1	-43.3	-65.5	-87.7
2	Efficiency of portable sawmilling and dry milling						Efficiency of portable sawmilling and dry milling					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	-19.0	-93.2	-36.2	-19.0	-6.3	7.8	-43.3	-117.6	-60.5	-43.3	-30.6	-16.5
3	Market price of clear grade off-cuts						Market price of clear grade off-cuts					
	Base case	12500	20000	25000	30000	37500	Base case	12500	20000	25000	30000	37500
	-19.0	-56.5	-34.0	-19.0	-4.0	-16.5	-43.3	-80.8	-58.3	-43.3	-28.3	-5.8
4	High feature recovery from log volume						High feature recovery from log volume					
	Base case	5%	8%	10%	12%	15%	Base case	5%	8%	10%	12%	15%
	-19.0	-76.3	-33.6	-19.0	-8.2	14.9	-43.3	-100.6	-57.9	-43.3	-29.0	-8.1
5	Market price of VJs						Market price of VJs					
	Base case	1200	1920	2400	2880	3600	Base case	1200	1920	2400	2880	3600
	-19.0	-54.0	-33.0	-19.0	-5.0	14.7	-43.3	-78.3	-57.3	-43.3	-29.3	-8.3

Table 10A.16 *Results of a sensitivity analysis on the five parameters to which scenario 6 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Efficiency of portable sawmilling and dry milling						Efficiency of portable sawmilling and dry milling					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	-66.1	-162.0	-93.6	-66.1	-44.6	-18.4	-90.4	-186.3	-117.9	-90.4	-68.9	-42.7
2	Market value of parquetry						Market value of parquetry					
	Base case	1300	2080	2600	3120	3900	Base case	1300	2080	2600	3120	3900
	-66.1	-129.3	-91.4	-66.1	-40.8	-2.8	-90.4	-153.6	-115.7	-90.4	-65.1	-27.2
3	High feature recovery from log volume						High feature recovery from log volume					
	Base case	5%	8%	10%	12%	15%	Base case	5%	8%	10%	12%	15%
	-66.1	-126.8	-90.4	-66.1	-41.8	-5.3	-90.4	-151.2	-114.7	-90.4	-66.1	-29.6
4	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	-66.1	4.76	-35.4	-66.1	-96.7	-127.4	-90.4	-29.1	-59.7	-90.4	-121.0	-151.7
5	GOS recovery						GOS recovery					
	Base case	20%	25%	31.1%	35%	40%	Base case	20%	25%	31.1%	35%	40%
	-66.1	-88.3	-78.3	-66.1	-48.2	-38.2	-90.4	-112.6	-102.6	-90.4	-82.6	-72.6

Table 10A.17 *Results of a sensitivity analysis on the five parameters to which scenario 7 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Market value of parquetry						Market value of parquetry					
	Base case	1300	2080	2600	3120	3900	Base case	1300	2080	2600	3120	3900
	-3.5	-98.2	-41.4	-3.5	34.4	91.2	-24.9	-112.8	-60.0	-24.9	10.3	63.1
2	High feature recovery from log volume						High feature recovery from log volume					
	Base case	7.5%	12%	15%	18%	22.5%	Base case	7.5%	12%	15%	18%	22.5%
	-3.5	-94.5	-39.9	-3.5	32.9	87.5	-24.9	-109.4	-58.7	-24.9	9.0	59.7
3												
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	-3.5	-66.9	-28.9	-3.5	21.9	59.9	-24.9	-92.2	-58.1	-24.9	2.1	42.5
4	Value of labour						Value of labour					
	Base case	10	15	20	25	30	Base case	10	15	20	25	30
	-3.5	57.5	27.0	-3.5	-34.0	-64.5	-24.9	31.5	3.3	-24.9	-53.0	-81.2
5	Efficiency of dry milling						Efficiency of dry milling					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	-3.5	-21.3	-10.6	-3.5	3.6	14.3	-24.9	-41.4	-31.4	-24.6	-18.2	-8.3

Table 10A.18 *Results of a sensitivity analysis on the five parameters to which scenario 8 is most sensitive on freehold and leasehold land (NPV/ha)*

Rank	Freehold						Leasehold					
1	Market price of clear grade						Market price of clear grade					
	Base case	12500	20000	25000	30000	37500	Base case	12500	20000	25000	30000	37500
	84.6	-37.0	36.0	84.6	133.2	206.2	59.2	-58.5	14.1	59.2	104.3	172.0
2	Clear grade recovery from high feature						Clear grade recovery from high feature					
	Base case	10%	16%	20%	24%	30%	Base case	10%	16%	20%	24%	30%
	84.6	1.7	51.4	84.6	117.8	167.5	59.2	-19.9	28.4	59.2	90.0	136.1
3	GOS recovery						GOS recovery					
	Base case	20%	25%	31.1%	35%	40%	Base case	20%	25%	31.1%	35%	40%
	84.6	20.2	50.0	84.6	105.7	131.5	59.2	-1.3	28.5	59.2	84.1	110.0
4	Sawlog volume per hectare						Sawlog volume per hectare					
	Base case	0.5	0.8	1.0	1.5	2.0	Base case	0.5	0.8	1.0	1.5	2.0
	84.6	38.2	65.5	84.6	134.2	185.4	59.2	25.8	45.3	59.2	95.5	133.4
5	Efficiency of dry milling						Efficiency of dry milling					
	Base case	50%	80%	100%	120%	150%	Base case	50%	80%	100%	120%	150%
	84.6	37.9	65.9	84.6	103.3	131.4	59.2	15.8	41.9	59.2	76.5	102.6

11. Portable sawmill recommendations for the production of western Queensland hardwoods

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Portable sawmills have been identified as an effective method for graziers or others with limited timber industry experience, to value add western Queensland timbers with minimal financial risk. Various types of portable sawmills exist, including chainsaw mills, circular mills and bandsaw mills. Knowledge and experience gained throughout this project indicates that, at present, circular portable sawmills are the most suitable. This style of mill is available in a wide range of models ranging in price from several thousand dollars to several hundred thousand dollars. A number of factors specific to individual enterprises, including required throughput volume, the nature of the resource being processed, product type and quality required, need to be carefully considered prior to purchasing of a portable mill..

11.1 Introduction

For many years, scattered operations have harvested small volumes of logs for purposes such as fence posts and firewood. More recently, some western Queensland sawmills have sawn experimental volumes of western Queensland hardwoods on a semi-commercial basis. Wood enthusiasts have also produced turned articles and 'one off' furniture items from these timbers; however, usually not on a commercial basis. Therefore, knowledge and experience regarding commercial processing of western Queensland hardwoods is scarce.

One anticipated outcome from the *Utilisation of Western Hardwoods as Specialty Timbers* project was to identify appropriate machinery and methods for the commercial processing of western Queensland hardwoods. As the project has focused on the potential for development of a new timber processing industry, with heavy emphasis on grazier income diversification, priority was given to equipment with relatively low capital cost (*e.g.* portable sawmills) to encourage entry into the timber industry with minimal risk. Financial restraints within the project necessitated that the investigation be limited to the evaluation of portable sawmills. An overview of portable sawmills is presented, followed by a listing of some examples of available models.

11.2 Portable sawmills

This description has been compiled from information gathered through two small-scale portable sawmill studies with mulga and gidgee in western Queensland, literature searches, discussion with current industry participants and manufacturers of portable sawmills. It has been found that portable sawmills potentially offer many benefits to landholders interested in processing western Queensland hardwoods, including:

- allowing value-adding of the local resource
- being relatively easy to operate
- being relatively cheap to maintain and operate
- requiring a small capital outlay
- eliminating the need for expensive, specialised log transportation equipment, and
- potentially being more economical than a fixed mill, given the dispersed nature of the resource.

Nevertheless, portable sawmills compare unfavourably with fixed sawmill technology on several fronts, including:

- being less flexible with sawing options
- being more labour intensive
- having lower productivity in terms of sawn output per day (with the possible exception of more expensive portable sawmill models), and
- often requiring other equipment for re-sawing (to remove defects, cut to desired length and possibly change sawn width and thickness).

11.3 Categories of portable sawmills

Three broad types of portable sawmills exist:

- chainsaw mills
- circular mills, and
- bandsaw mills.

Some mills are a combination of these types. For example some circular mills can also attach a dedicated chainsaw slabbing attachment.

11.3.1 Chainsaw mills

Chainsaw mills are relatively cheap, ranging from a few hundred to several thousand dollars. Many of these mills utilise a large chainsaw with a frame attached to the chainsaw bar. They are often noisy to operate, very labour intensive, wasteful (due to their wide cut or kerf) and are limited in their capacity to cut sawn timber. These types of mills are best suited to very small-scale 'hobby' operations that only wish to produce bark edged timber slabs from large trees.

11.3.2 Circular mills

Circular mills range in price from approximately $4,000 to $150,000. These mills feature a range of saw arrangements including a fixed single blade, movable 'swing blade' or movable multiple blades. Logs can be either fixed with the blade passing over the timber or have the log passing over the saw. They can be either manually or automatically fed.

Most circular portable mills, except for those at the top-end of the range, have a motor and blade setup on a framework that rests on tracks or rails. This framework is manoeuvered over the top of the log, which is fixed in place. This style of mill cuts timber parallel to the rails and not necessarily parallel to the log or timber. This can create problems with logs that move during sawing (either accidentally or due to growth stress release); however, this style of mill has the benefit of being light (easily moved), very robust (including sawblades) and relatively simple in design.

Circular portable mills at the cheaper end of the range (<$40,000) are produced by a large number of manufacturers, with each model having advantages and disadvantages depending on the application (*e.g.* species sawn and product produced). While many of these mills are robust, and easy to transport, set-up and operate, many share a common fault, highlighted when processing western Queensland hardwoods. That is, they have been designed for milling large logs, where the weight of the log is sufficient to hold itself in place during sawing. On average, western Queensland hardwood logs are relatively small in both diameter and length, and without a mechanism to hold small logs firmly in place, sawing can be very inefficient and expensive. If the logs wobble slightly during sawing, the blade feed speed must be reduced to minimise movement, therefore slowing production. Damage to tungsten blades through loss of tips is also dramatically increased with log movement. If the log moves, sawing reference can be lost, potentially resulting in the waste of much time and timber in an attempt to realign the log to the saw. Successful processing of western Queensland hardwoods with this type of mill demands the development of a simple custom-made log holding device.

In the two portable sawmill trials conducted, an 8” Lucas mill was used. This mill was chosen principally due to its availability for the project. This style of mill was effective, although log movement was highlighted as a major issue. During the second of the two sawing studies, a set of modified sash clamps were used to hold the logs in place, which greatly improved sawing efficiency and reduced saw damage. However, there is substantial scope for further development in this area.

A number of more expensive (>$40,000) circular portable mills exist. Many of these have been designed in Europe, with low to medium density timbers in mind. Despite this, many are sufficiently engineered to handle the high densities of the western Queensland hardwood resource. In general, these mills are not as easy to move and set-up as the cheaper, smaller models, often requiring several hours to several days to set-up. The main advantage of these mills over the smaller circular mills is their better timber sizing capabilities. Log movement during sawing usually is not an issue, as these mills have effective log holding devices. Timber distortion ‘off the saw’ is also less of problem, because these more expensive circular mills usually pass the timber over the saw using a sizing fence (i.e. timber is cut parallel to the saw), as apposed to the blade running parallel to support rails, as with the cheaper versions.

11.3.3 Bandsaw mills

Bandsaw portable mills range in price from approximately $3,000 to $200,000 and can be categorised as either wide band (blade greater than 75 mm) or narrow band (less than 75 mm blade).

Narrow band bandsaw mills are usually trailer mounted making them very easy to relocate and setup. Narrow bands usually mean thin bands, which result in less waste from the saw cut. Narrow bands also require minimal saw doctoring skills as the blades are more or less disposable. A major disadvantage of these mills is the instability of the blades when cutting high-density timbers, producing boards of uneven dimensions. Blade life can also be dramatically reduced when cutting high-density timbers.

Narrow band portable mills work very effectively with low to mid density timbers. In general, most narrow band portable mills are easily transported and have effective log holding capabilities during sawing. An advantage of this style of mill is the potential to increase sawn recovery due to the small saw kerf (thickness of cut). A limited sawing trial with mulga and gidgee was performed using a narrow band portable mill. The trial indicated that boards of an even thickness could not be produced due to the instability of the narrow blades with these dense timbers. Discussions with Australian and international saw blade manufacturers suggest further investigations into blade technology may improve the potential for narrow band portable mills to successfully mill western Queensland hardwoods; however, it was suggested that any improvement would not be sufficient for a commercial sawing operation.

Wide band bandsaw mills are usually very large machines best described as ‘relocatable’ rather than ‘portable’. When relocating, considerable effort is required to dismantle the mill and a crane is necessary to lift the equipment onto a large truck. A wider blade is often thicker, therefore, it is more stable than a narrow band and produces a wider cut. These blades require specialised saw doctoring skills and equipment.

Wide band portable mills, while not trialed in this project, could be expected to process the high density western Queensland timbers successfully, assuming that tungsten tipped bands (or similar) are used. These types of mills were not investigated as very few exist in a portable format. The majority of wide band mills are used in a fixed mill situation and most are currently processing softwoods. The servicing and saw doctoring skills required to maintain the bands on these mills are specialised and would be expected to be difficult to source in western Queensland. This would mean that bands would need to be regularly sent to a major town to be serviced, which is likely to be expensive.

11.4 Portable sawmills recommended for processing western Queensland hardwoods

The most suitable portable sawmill for a particular operation is likely to vary according to:

- required or expected volume throughput
- species to be sawn
- log sizes expected to be sawn (diameter and length)
- quality of logs expected to be sawn (straightness etc.)
- required sawn section sizes
- history of the mill in similar applications
- sawmill location and whether it is intended for the mill to be fixed or variable multiple sites. If variable sites are an option, how often the mill will be required to be moved will need to be considered
- available labour and skills
- available saw doctoring services and associated costs
- backup support from the manufacturer in terms of advice and spare parts
- expected service life
- cost of initial purchase, and
- operating and maintenance costs.

Under the prevailing conditions of scarce information about western Queensland hardwood processing, circular portable mills appear to be the best low-cost option for landholders. Five circular portable mill models have been described below. They are not the only mills that could be used, but cover the general price range and capabilities of circular portable mills.

1. Lucas Model 8 – powered by a 27HP V Twin electric start Kohler engine with a centrifugal clutch. A basic saw package includes 3 sawblades, 12V diamond grinder, track extensions and 2 jockey wheels. This set-up allows 6.1 m long logs up to approximately 1.35 m in diameter to be cut. Timber sections up to 215 mm x 215 mm can be easily cut with a possible option to cut up to 215 mm x 430 mm. This mill also has an option to attach a dedicated slabbing attachment so that wide bark edge slabs can also be produced using the same power head and assembly. Price for the standard mill is approximately $14,000 plus $1,100 for the optional slabbing attachment. A Lucas mill with a slightly different motor configuration was employed in the mulga and gidgee portable sawmilling trials at Maryvale and Yankalilla stations.

2. Ecosaw –powered by a 22HP Briggs & Stratton petrol engine. The basic package comes with a blower housing snorkel, glass bowl fuel filter, sealed 12-volt battery kit, 9.6 L water tank, blade sharpener, 3 spare blades, basic tools and spares. This setup will allow logs up to 6.7 m in length and 1.5 m in diameter to be sawn with cuts up to 400 mm x 200 mm possible. The price for this mill is approximately $16,500. A supplier of this mill specialises in supplying packages to remote areas (mainly PNG) and puts together an excellent package with the mill that includes a Tirfor winch, wire ropes, chains, cant hooks and comprehensive spares. This option costs approximately $21,000.

3. Peterson 8” All Terrain Sawmill (ATS) – powered by a 13HP Honda motor. The basic saw package includes 6.0 m heavy duty tracks, 2 saw blades, 12 volt diamond saw sharpener, tools, safety pack, spare teeth and one pair of log dogs. This mill has the benefit of being able to produce 400 mm cuts relatively easy. Price for the standard mill is approximately $13,000.

4. Mahoe –This mill is powered by a 80HP VM Detroit diesel engine and can cut up to 300 mm x 200 mm. The mill has a hydraulic dog dogging system, comes with three blades, gullet sharpener and tools. The price for this mill is approximately $77,000 and includes a 5-day training program.

5. Kara F2000 Portable Sawmill –This mill can be powered via an electric motor, diesel motor or tractor power take off (not provided), and this particular model is optioned with a hydraulic size adjuster, 7 m dropper table, sawdust extractor, saw sharpening machine, folding weather canopy, hydraulic log adjuster and log rotator, automatic block aligner, log fastener and chain conveyors. The price for this machine is approximately $86,000.

12. Future prospects for the western Queensland hardwood processing industry

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This chapter reviews key insights from earlier chapters to summarise the potential for a western Queensland hardwoods industry. Benefits arising from the western Queensland timber industry could be substantial; however, several challenges will need to be overcome. There is considerable scope for future research into the industry, including a resource assessment incorporating studies on woodland regeneration and the potential for sustainable management, processing techniques, markets, marketing and total economic valuation of the potential of the industry. It is concluded that the utilisation of western Queensland hardwoods offers promising opportunities for landholders.

12.1 Introduction

Chapter 1 noted the interest of western Queensland landholders in utilising the hardwood timbers in their region. The lack of information about potential opportunities offered by this resource had been identified as a barrier preventing many landholders from becoming involved in this emerging industry. This project has reduced or removed some of the uncertainties surrounding small-scale production of western hardwoods, particularly with regards to wood property information, portable sawmilling, seasoning, appearance grade recoveries and potential returns.

This concluding chapter proceeds with a review of the prospects for western Queensland hardwoods, as developed in the discussions of earlier chapters. It is followed by an outline of the limitations of the methodologies employed. The benefits brought by expanding the western Queensland hardwood industry are summarised and then factors that could limit its expansion are described. Suggestions for further research to facilitate the development of the western Queensland hardwood industry are then presented. This is followed with advice for inexperienced western wood producers offered by the timber industry and potential western hardwood consumers. Concluding comments about the project complete the chapter.

12.2 Prospects for western Queensland hardwood production: A review of the earlier chapters

The strong imperatives for reducing land clearing in Queensland would suggest governments will further restrict land clearing in the future and that, consequently, substantial areas of western Queensland woodlands are likely to be conserved outside the formal reserve system. This resource could supply substantial volumes of timber in perpetuity if ecologically sustainable management practices can be developed. Chapter 2 highlighted that relatively little is known about the distribution of timber resources in western Queensland at the stand or bioregion level, nor is there knowledge about ecologically sustainable management practices. It was suggested that merchantable volumes of sawlog, roundwood and craftwood, were high in some stands. It was estimated that the major gidgee (*Acacia cambagei*) regional ecosystem type, in the Desert Uplands region, could potentially contain a total standing volume of approximately 1.4 M m^3 of these product types (assuming 15 m^3/ha). However, the only spatial data available for vegetation cover in the region are from 1999, and considerable land clearing has occurred since that time. Chapter 2 also highlighted the lack of scientific information about the regeneration and growth of mulga (*A. aneura*) and gidgee, which indicates the need for ongoing research.

Chapter 3 demonstrated the uniqueness of the wood properties of western Queensland hardwoods. Specifically, the extreme density and hardness of many of these timbers were shown to far exceed most other commercially available timbers from both Australia and around the world. The western Queensland hardwoods were also found to have 'low' shrinkage from the green to air-dry state. The future prospects of the western Queensland hardwood industry are intimately linked to the success with which these properties are utilised and marketed to consumers.

Sawmilling technologies appropriate for small-scale production by western Queensland landholders were trialled in Chapter 4, and some recommendations regarding portable sawmill varieties and models were presented in Chapter 11. Although difficulties were encountered milling the small sawlogs, the trials indicated that western Queensland hardwoods could be sawn successfully with portable sawmills. A combination of low sawlog volumes per hectare, small size of suitable logs, low rates of production and low green-off-saw (GOS) recoveries, resulted in high production costs relative to east-coast hardwood producers. This finding emphasises that profitable western Queensland hardwood production will require premium prices in traditional hardwood markets (reflecting the unique properties of these species) or a focus on high-value, niche markets that cannot be readily supplied by other timbers.

The seasoning characteristics and graded recovery of mulga and gidgee were reported in Chapters 5 and 6 respectively, for air drying, solar kiln, dehumidifier kiln and (to a limited degree) conventional kiln drying. With the exception of boards greater than 25 mm thick in the conventional kiln, the timbers were successfully seasoned with minimal drying degrade. The exception was due to the adoption of an unsuitable drying schedule for material greater than 25 mm thick. Recovery of appearance grade material was found to be about 10% of log volume, excluding distortion (spring, twist and bow) when graded to the high feature grade criteria of *AS2796-1999-Timber-Hardwood-Sawn and Milled Products*. Wane, decay, heartshake and insect damage were largely responsible for the downgrading of mulga and gidgee boards. These chapters indicated that, both in terms of graded recovery and cost-efficiency (including the time value of money), protected air drying in western Queensland was the optimal seasoning method for landholders entering the western Queensland hardwood industry. The implication is that necessary capital outlay can be minimised, thereby reducing the risk faced by potential entrants to the industry.

The scope of this project to assess the suitability of western Queensland hardwoods for further processing was limited. Research results reported in Chapter 7 indicated that mulga was unsuitable for the commercial production of veneer, although the production of small pieces may be feasible for specialty applications. Assessment of the suitability of western woods was necessarily restricted to the expert opinions of people in the timber industry. Chapters 8 and 9 reported the findings of the market research. While the response from manufacturers of product types surveyed in Chapter 8 were generally favourable, these judgements were based on limited information and, in most cases, no experience with western Queensland hardwoods. Chapter 9 reviewed market opportunities in light of information that has been gathered during this research project, which indicated that it was not feasible to consider supplying markets that require long or wide defect-free boards. This confirmed the unsuitability of the resource for strip flooring, veneering and large-scale furniture manufacture.

There was found to be a reluctance of domestic timber consumers to pay more for western hardwoods than is currently paid for other timbers being used for the same purpose. Therefore, in the early stages of supplying western Queensland hardwoods to traditional markets, there are unlikely to be price premiums of the size necessary to make production of these timbers highly attractive to landholders. While high margins may be immediately possible in some established, specialised niche markets, including the supply of timbers to musical instrument manufacturers, the indications are that these markets are small in Australia, and that it is potentially difficult to enter these markets overseas. Therefore, as with many new industries, the first few years of western Queensland hardwood production are likely to be challenging. However, once western Queensland hardwoods become established in the market place, many timber product manufacturers asserted that western woods could attract price premiums if their unique properties become popular with consumers.

The financial viability of several western Queensland hardwood production scenarios were examined in Chapter 10, encompassing a wide spectrum of timber processing opportunities. The findings of harvesting, milling, seasoning, grading and market research of earlier chapters were employed in these financial analyses. If substantial high value markets (*e.g.* musical instrument timbers) exist, then management of remnant woodlands for timber production was shown to be a more economically efficient land use than clearing for grazing. However, clearing for grazing generated higher returns per hectare than was achieved by the other hardwood timber processing scenarios. Nevertheless, it was shown that, in the longer term, if experience improved production efficiency, and market prices increased as western Queensland hardwoods carved out niche markets, a range of processing opportunities could provide higher returns to landholders than would be possible with current grazing practices. This suggests western Queensland hardwood production does provide realistic opportunities for landholders to diversify farm incomes. Considering that substantial non-market benefits, such as habitat protection, carbon storage and soil erosion control, will also be generated by an expanding western Queensland hardwood sector, there is sound justification for further research into the industry.

12.3 Methodological limitations of the research

This study has been successfully conducted under conditions of extreme information scarcity. The relatively small budget precluded intensive investigations being undertaken in all areas necessary for a thorough and conclusive study of the utilisation potential of western Queensland hardwoods. Section 12.5 highlights the considerable scope for further research.

A number of factors contributed to some unfortunate, although often unavoidable, methodological inconsistencies. When the project began, relatively little was known about the western Queensland hardwood resource. The research team had little experience in assessing the utilisation potential of timbers with non-traditional characteristics (piece size, wood properties etc.), which resulted in an occasional need to alter research methodologies as new or different requirements for information were identified, and as the constraints of traditional timber research methodologies became apparent. The inconsistencies that arose included:

- differences in timber volumes reported in Chapters 2 and 4, which were due to the adoption of different merchantability specifications
- mulga sawlog diameters being measured differently from gidgee sawlog diameters

- total length of graded mulga boards recovered from GOS boards was recorded rather than the length of each individual graded board comprising this total length, and
- different board grading methodology being adopted for the conventional kiln dried mulga and gidgee compared to the other seasoning methods.

These inconsistencies have been described in relevant sections of the report and have had no impact upon the overall conclusions drawn from the research. One unavoidable inconsistency in the research methodology arose from the sudden and untimely death of the portable sawmiller contracted for the study, who passed away before the second portable sawmilling trial was conducted.

The absence of published information on functioning markets for western Queensland hardwoods necessitated a reliance on stated preference techniques for estimating market prices. Under these circumstances, respondents have incentives to understate their *true* willingness to pay for western Queensland hardwoods. The financial analyses presented in Chapter 10 are dependant upon these stated market prices, and sensitivity analyses indicated that all scenarios were highly sensitive to the assumed market price.

Each western Queensland hardwood scenario in Chapter 10 also assumed that sufficient volumes of timber would be available throughout the modelled 30-year life of each investment. While the volume of timber required by most scenarios is small, there is still little scientific data to confirm that sufficient timber volumes could be harvested in an ecologically sustainable manner. This issue is being partially addressed by a Queensland Department of Natural Resources and Mines study that is due for completion in 2003 (Rogers in prep.).

12.4 Benefits of the western Queensland hardwood processing industry and challenges facing its further development

There are two major benefits that may arise from a vibrant western Queensland hardwood industry.

Reduced land clearing
The rate of land clearing in Queensland has been highly topical in recent years, with some estimates placing the State among the top land clearing nations of the world. Over the period 1997 to 1999, Queensland’s natural vegetation was estimated to have been cleared at the rate of 446,000 ha per year (National Land and Water Resources Audit 2001). The development of an industry that utilises the timber resources of western Queensland is likely to increase the value that landholders attribute to their remnant woodlands, which may encourage landholders to revise their clearing objectives downwards. This would confer many benefits upon the wider Australian community in terms of reduced land degradation (*e.g.* salinity), reduced carbon emissions from clearing and burning woody debris, improved quality of inland waterways and maintenance of habitat for biodiversity conservation[30].

Greater stability and diversification of landholder income
There are many risks and uncertainties associated with primary production, including the weather, local and international competing producers, substitute products and consumer demand. The total risk burden carried by a primary producer can be reduced if farm income is earned from several sources, in the same way that stock brokers minimise the risk of poor

[30] However, many landholders argue that western Queensland woodlands provide habitat for native and introduced pests (*e.g.* dingos, kangaroos, foxes and rabbits), which impact upon livestock production and, therefore, the livelihoods of rural communities.

investment returns by diversifying their share portfolios. Western hardwood timber production also potentially offers a more stable income stream to traditional western Queensland rural enterprises, as one of the main risks associated with primary production – the weather – has comparatively little impact upon production of these timbers. The benefits of landholder income diversification and stability are likely to be transferred to the wider rural community and assist efforts to reverse the decline of western Queensland towns.

Nevertheless, a number of factors are likely to constrain the development of a western hardwoods industry.

Concerns about the ecological sustainability of timber harvesting

There is inadequate information about the remaining area and distribution of woodlands in western Queensland, the ecology of the woodlands, and growth rates of the timber species. This has precluded the formulation of sustainable woodland management practices, including the estimation of sustainable harvestable timber volumes.

Extremely high densities and small piece sizes

Many of the unique and attractive qualities of western Queensland hardwoods can make them unsuitable for many traditional timber markets and this will limit processing and market opportunities. However, these constraints could be largely overcome by directing production to niche markets where the unique properties of western Queensland hardwoods are desirable.

Uncertainty about potential markets

The research presented in this volume has contributed much information on costs of production and potential returns. However, the absence of any published information on markets for western Queensland hardwoods means that all estimates that have been presented are anecdotal. For as long as considerable uncertainty remains about markets, investment in western Queensland hardwood production will be stifled.

Lack of market power and influence of landholders wishing to sell western Queensland hardwoods

There are likely to be difficulties in gaining acceptance of western Queensland hardwoods in certain product markets. Many of these challenges could require resources beyond the means of single, isolated landholders. Establishment of a landholder co-operative may provide a solution to this problem.

Perverse economic incentives for landholders

Land clearing costs confer a tax deduction benefit upon the landholder; however, schemes that provide incentives for landholders to conserve their remnant woodlands are lacking. Even the potential future market for carbon offsets appears unlikely to extend to native vegetation, despite the fact that clearing native vegetation would be recorded as an emission in the national carbon budget (Rolfe 2002). There appears to be a need for government to recognise the positive, non-timber externalities of woodland conservation that could arise from the development of a western Queensland hardwood industry.

Insecurity of property rights

There has been a well-publicised episode of higher land clearing rates in Queensland over recent years, resulting partly from concerns that land development rights may be restricted in the future. If this trend continues, the economic and ecological sustainability of the small-scale production of western Queensland hardwoods from the remaining woodlands may be threatened. Addressing the uncertainty surrounding property rights may encourage landholders to consider alternative woodland management opportunities, including timber production.

12.5 Suggestions for further research

This project has highlighted a number of areas where further research could generate substantial benefits, particularly for western Queensland communities.

12.5.1 Quantification and qualification of the western Queensland hardwood resource

This report has summarised current scientific information on the distribution, ecology, standing timber volumes and growth rates of mulga and gidgee. The research has highlighted how little is known about the western Queensland hardwood resource and the necessity of on-going research by the Queensland Department of Natural Resources and Mines (Rogers in prep.). The economic and ecological sustainability of timber industries are dependant, in large part, upon the timber resource. Increasingly, developed countries are placing restrictions on the importation of timber products that are not labelled has having been sourced from sustainably managed resources. Hence, further field-based inventories, remote spatial analyses and research into ecologically sustainable management practices would be of substantial benefit to the development of the western Queensland hardwood industry, including the successful marketing of these hardwoods internationally.

12.5.2 Assessing the timber production potential of other western Queensland hardwoods

The wood properties of eleven species and the milling, seasoning and recovery characteristics of mulga and gidgee were addressed by this research. However, many other western Queensland hardwoods have timber production potential and their characteristics are likely to differ from those of species analysed in this study. For example, the preliminary results of a Queensland Department of Primary Industries-funded study milling *Acacia shirleyi* (lancewood), indicate that this species is likely to yield a greater proportion of appearance grade timber than did either mulga or gidgee in this research. Harvesting and sawmilling studies with other species would also be useful to verify the findings presented in this volume. Initially, the nine other species for which wood property research has begun (Chapter 3) should be targeted.

12.5.3 Assessing the potential for agroforestry in western Queensland woodlands

An assessment of agroforestry (grazing and timber production conducted together) in western Queensland woodlands would be highly informative. This would be facilitated by research into areas such as the:

- impact of slash from timber harvesting and subsequent regeneration on fodder production
- impact of grazing on woodland regeneration
- marginal product of labour in agricultural enterprises (*e.g.* the rate at which cattle production would decline across the property as the grazier became involved in forestry activities)
- required changes to property fire management plans, and
- cost of herd management in woodlands versus cleared pasture.

12.5.4 Developing appropriate processing techniques for western Queensland hardwoods

At the primary processing stage, further research into sawing techniques to maximise graded recovery, particularly of quarter-sawn timber for high-value markets, would be highly beneficial. Investigations into cheap and effective log clamping devices for portable milling western Queensland hardwoods are necessary. It would also be informative to undertake a more comprehensive study of the costs and benefits of fixed-site versus multi-site portable sawmilling. The type of set-up adopted could have a large impact on the financial viability of an operation and, to the authors' knowledge, no independent and objective study of these two portable sawmilling operating styles has been conducted in Australia.

Some landholders have expressed a desire for rapid turn-around of dried, graded sawn timber to maintain cash flow. This approach would require conventional kiln drying; however, substantial research into the development of kiln schedules suitable for drying appearance grade western Queensland hardwood boards will be necessary.

There is a lack of information about machining western hardwoods into finished products. Encouraging and facilitating value-adding of the resource through investigations into processes such as planing, machining, sanding and jointing, were outside the scope of this project, but would be of substantial benefit to the industry. Potentially, there would also be large returns to the western Queensland hardwood industry from investigations that developed effective methods of jointing, and appropriate mechanical fasteners and glue types.

There is considerable need to investigate plant and equipment technologies suitable for processing western Queensland logs, from the sawmill (portable and fixed) through to the finished product. Machinery and tooling must be able to handle the extreme hardness and short lengths of the timbers. For example, most panel planers require minimum lengths of 300 mm, while many moulders require lengths of least 500 mm to process boards safely and effectively. Given the nature of the western Queensland resource, recovered piece sizes for many potential final products may be less than these minimum lengths.

12.5.5 Timber market and marketing research

Adequate knowledge of potential market prices and quantities of product demanded are crucial to a new industry, particularly when costs of production are suspected to be high in comparison to substitute products already in the market place. Marketing research is critical for new products. Before producers embark upon the manufacture of western hardwood products, there are many questions that need to be answered. For example, who or what should be the target market? Ideally, specific markets should be identified where the properties of western Queensland hardwoods are required, thereby eliminating competition from less-expensive timbers. Why do consumers buy and what will make them buy the new product? In specific terms, what do these consumers need or want (*e.g.* styles, colours, shapes and sizes)? What are the most appropriate distribution, market positioning and promotional strategies?

Many domestic and some international respondents to the postal survey in Chapter 8 indicated great interest in further discussing market opportunities and working with samples to determine the potential of western Queensland hardwoods. However, lack of project resources prevented these exciting leads from timber manufacturers and merchants being pursued. There is great scope for future market and marketing research to commence by following-up on these expressions of interest.

12.5.6 Total economic valuation of a western Queensland hardwood industry

Under the base case assumptions adopted to analyse western Queensland hardwood production scenarios in Chapter 10, grazing, generally, provided superior returns. However, these analyses were financial only; no provision had been made for the non-market costs and benefits implied in each scenario. Several economic methodologies have been developed to facilitate total economic valuation of natural resource management options over the last few decades (*e.g*. see Garrod and Willis 1999). If non-market values, such as carbon storage, watershed protection and wildlife habitat, were accounted for, it is possible that management of remnant woodlands for timber production would be highlighted as more socio-economically efficient than clearing for grazing. That is, it may be possible to demonstrate that national welfare would increase more by establishment of a timber industry utilising western Queensland hardwoods than by expansion of the cattle industry into previously uncleared areas. Such information would provide highly useful information for policy-makers and planners, and could be a powerful tool to aid funding further research or assistance packages for the western Queensland hardwood industry.

An added benefit of this research could be the development of a schedule of socio-economically efficient *conservation payments* that could potentially be paid by government to landholders who choose not to clear remnant woodlands, and forego future grazing or crop production, in favour of more ecologically sustainable land uses, such as timber production from natural woodlands. Governments wishing to promote sustainable woodland management in western Queensland could consider making these payments to landholders (who fulfil certain land management requirements) as compensation for their *stewardship* of western woodlands. Such a scheme could potentially be managed similarly to the Indigenous Protected Areas programs on indigenous-owned lands of Australia and address the lack of conservation incentives highlighted in Section 12.4.

12.5.7 Collaboration with industry in commercial trials of processing opportunities

Perceived risks and uncertainties may restrict investment in western hardwood production to socio-economically inefficient levels. In view of the potentially high socio-economic benefits that could be generated from such an industry, there is an argument that research agencies, in collaboration with industry, could be involved in the design and production of high-value, niche market products for western hardwoods. This would follow a comprehensive market study that had identified key target markets. The research would extend to the delivery of finished products to the market place to gauge interest, including prices and quantities demanded. The product focus could be varied, including furniture and musical instruments, and the research should involve in-person meetings and demonstrations in selected domestic and international markets. If these comprehensive trials proved successful, barriers facing landholders wishing to enter the industry would be lowered, facilitating socio-economically efficient levels of investment in the western Queensland hardwoods industry.

12.6 Succeeding in western Queensland hardwood production: Some suggestions from the timber industry and potential consumers

Several experienced persons in the timber industry and potential consumers of western Queensland hardwoods were asked for their recommendations on how landholders should develop their timber industry ambitions. Opinions varied substantially and this section presents some of the views expressed.

Timber production

Overall, the impression gained from discussions with people in the timber industry and with potential consumers was that western Queensland hardwoods have tremendous potential in the *right* markets. It was frequently asserted that western Queensland hardwood sawmillers must adopt a routine of identifying and cutting the large clear pieces of timber on the rare occasions they present themselves and hoard these for sale into high-value markets. However, larger markets accepting of lower quality timber will be required to generate cash-flow. On the other hand, one western hardwood timber cutter suggested that landholders, in general, would be better-off staying out of timber processing. He asserted that the skills necessary to successfully harvest and mill western hardwoods are acquired over many years and that landholders should instead focus on inviting professional sawmillers onto their property and accept royalties for the timber harvested. Western Queensland hardwood markets were said to be too small to warrant numerous landholders investing in portable sawmills and associated equipment and infrastructure.

Skills, equipment and technology

A common theme that arose from the majority of discussions was the need for landholders to *get skilled*. People in the timber industry commented that it is not straight-forward to progress from grazing to milling western hardwood timbers; *being successful in the timber industry is not guaranteed by knowing how to start a chainsaw*. Skills must be developed gradually in all stages of timber production, from tree selection through to the finished product. One western hardwood sawmiller mentioned that he could not recall how many times landholders had brought a truck of logs to his mill only to be sent away, because the right trees had not been selected, the trees had been felled incorrectly or the logs had not been merchandised properly.

Anecdotal evidence and feedback from cabinet-makers and wood craftpersons, who have experimented with the western Queensland hardwoods, suggests that extra care must be taken with these timbers and high quality tools are mandatory for producing quality products. For example, tungsten insert planer blades are required to dress reasonable volumes of these timbers. It was advocated that keeping abreast of new technology to maximise processing efficiency should be an on-going concern of any serious western woods producer.

Markets and marketing

The general advice was to ensure intimate knowledge of target markets is gained. Some timber product manufacturers recommended supplying the domestic market and gaining experience there before expanding into export markets. One large furniture manufacturer indicated that the North American furniture market is difficult to get into; *they demand too much and if you can't supply the volumes they want, you will burn your bridges*.

Persons currently supplying or manufacturing western hardwoods stated that new entrants should either enter the industry seriously or not at all; *you can't set yourself up as a western hardwoods supplier and then do it between milking the cows*. It was asserted that western wood production is a small, emerging industry and if new-comers generate dissatisfied customers, this is likely to affect everyone else in the industry.

Finally, if more than hobby or *Mum and Dad* type businesses are desired, it was recommended that western hardwood manufacturers band together to sell their output under one name and have one central marketing point. Several timber industry persons believed that is what modern consumers have grown accustomed to and want. It was indicated that this would not preclude the development of several manufacturing enterprises supplying the market through a single, centralised marketer.

12.7 Concluding comments

The foregoing discussion indicates that there are promising opportunities for western Queensland hardwood producers and there is great scope for further contributions to maximise the benefits from sunk research expenditure. Management of western Queensland woodlands for timber production could potentially create a new rural industry with considerable financial and environmental benefits. While there are challenges to overcome and there remains some uncertainty about the optimal direction for further development of the industry, the enthusiasm and optimism displayed by many current and potential western Queensland hardwood producers is likely to guarantee a successful future for the industry.

References

Garrod, G. and Willis, K.G. (1999), Economic Valuation of the Environment: Methods and Case Studies, Edward Elgar, Cheltenham.

National Land and Water Resources Audit (2001), Australian Native Vegetation Assessment 2001, National Land and Water Resources Audit, Land and Water Australia, Canberra.

Rogers, H.M. (in preparation), 'Resource assessment of western hardwood species in the Desert Uplands bioregion for short length timber production', Department of Natural Resources and Mines, Barcaldine.

Rolfe, J.C. (2002), personal communication, Associate Professor, Faculty of Business and Law, Central Queensland University, Emerald.

Utilisation of western Queensland hardwoods as speciality timbers

While not traditionally viewed as commercial timber species, western Queensland hardwoods from managed remnant woodlands have recently found application in high-value, niche markets such as fine furniture and musical instrument manufacture. While availability, small piece size and high levels of defect will limit the potential size of the industry, the inherent beauty of the wood of several of these species will command a premium price in specialised markets.

This investigation focused on characterising the extent and distribution of the resource, harvesting costs, recoveries, seasoning methods and markets, and on defining the commercial viability of production as a component of rural industries in these regions.

The Joint Venture Agroforestry Program

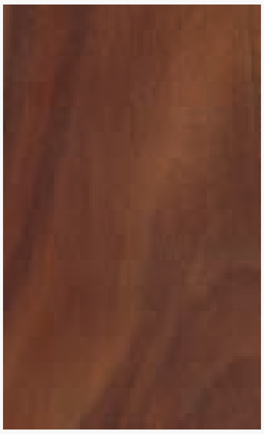
The Joint Venture Agroforestry Program (JVAP) aims to to integrate sustainable and productive agroforestry within Australian farming systems.

Agroforestry has the potential to improve agricultural productivity, diversify and increase farm income, conserve land, maintain biodiversity and contribute to the national timber supply.

The Joint Venture Agroforestry Program was established in 1993 and currently has four partners: RIRDC, Land & Water Australia (LWA), the Forest and Wood Products Research and Development Corporation (FWPRDC) and the Murray Darling Basin Commission (MDBC).

Funding is also provided for some activities by the Grains Research and Development Corporation (GRDC), the Australian Government Department of Agriculture, Fisheries and Forestry, and the Australian Greenhouse Office.

The JVAP recognises that future commercial agroforestry investments, particularly in the medium to low rainfall regions, are subject to considerably greater risk than other commercial land use enterprises with proven production systems and more transparent commodity markets. R&D intervention can help reduce this risk by quantifying land, water, biodiversity and social responses to agroforestry systems and developing new products from trees in low to medium rainfall areas.



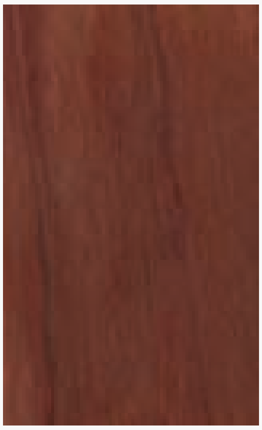
Gidgee

Mulga

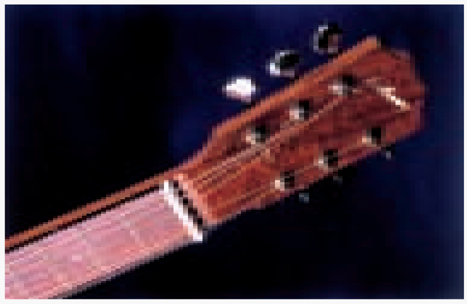
Sandalbox

Beefwood

Red lancewood



Bimble box



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