



# Commercial Prospects for Low Rainfall Agroforestry

by Amanda Zorzetto and Peter Chudleigh

**RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program**

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#### **Researcher Contact Details**

Name: Peter Chudleigh  
Address: Agtrans Research  
PO Box 385  
Toowong  
Brisbane Q 4066

Phone: 07 3870 9564  
Fax: 07 3371 3381  
Email: [agtrans@powerup.com.au](mailto:agtrans@powerup.com.au)  
Website: [www.powerup.com.au/~agtrans](http://www.powerup.com.au/~agtrans)

#### **RIRDC Contact Details**

Rural Industries Research and Development Corporation  
Level 1, AMA House  
42 Macquarie Street  
BARTON ACT 2600  
PO Box 4776  
KINGSTON ACT 2604

Phone: 02 6272 4539  
Fax: 02 6272 5877  
Email: [rirdc@rirdc.gov.au](mailto:rirdc@rirdc.gov.au)  
Website: <http://www.rirdc.gov.au>

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# FOREWORD

In 1998 the Joint Venture Agroforestry Program (JVAP) identified low rainfall agroforestry as a key priority area for R&D funding. Given the range of possibilities for low rainfall agroforestry, there was a need to assess the likely commercial viability of various options that might exist.

This study was commissioned to provide advice to the JVAP Management Committee in making assessments about the prospects for various agroforestry options in the low to medium rainfall zone. The project was to:

- assess the commercial opportunities for growing a range of tree species in the medium to low rainfall areas of Australia, and
- to establish priorities by commercial product and species type to assist resource allocation in R&D funding by the Committee.

The report is based on a literature review, interviews and consultation with experts and those with commercial experience. A range of commercial opportunities for agroforestry in the low to medium rainfall zone are identified.

While commercial agroforestry in the low to medium rainfall zones of Australia is unlikely to be as profitable as in the high rainfall zone due to lower growth rates, less established infrastructure and greater distances to markets, significant prospects do exist. These prospects may be enhanced with respect to environmental benefits in many areas if sustainability impacts of agroforestry are significant and capturable.

RIRDC's involvement in this project and in the Joint Venture Agroforestry Program, is part of the Corporation's Agroforestry and Farm Trees R&D Program which aims to foster integration of sustainable and productive agroforestry within Australian farming systems.

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**Peter Core**

Managing Director

Rural Industries Research and Development Corporation

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## List of Abbreviations

|           |                                                                   |
|-----------|-------------------------------------------------------------------|
| ABARE     | Australian Bureau of Agricultural and Resource Economics          |
| ABS       | Australian Bureau of Statistics                                   |
| AgWA      | Agriculture Western Australia                                     |
| AHHA      | Australian Home Heating Association                               |
| B/C Ratio | Benefit Cost Ratio                                                |
| BRS       | Bureau of Resource Sciences                                       |
| CALM      | Department of Conservation and Land Management, Western Australia |
| DSE       | Dry sheep equivalent                                              |
| ERDC      | Energy Research and Development Corporation                       |
| ETSA      | Electricity Trust of South Australia                              |
| FWPRDC    | Forest and Wood Products Research and Development Corporation     |
| GOS       | Green off saw recovery (unseasoned, undressed sawntimber)         |
| GWh       | Gigawatt hour                                                     |
| IRR       | Internal Rate of Return                                           |
| kW        | Kilowatt                                                          |
| kWh       | Kilowatt hour                                                     |
| LPG       | Liquified Petroleum Gas                                           |
| LWRRDC    | Land and Water Resources Research and Development Corporation     |
| MDF       | Medium Density Fibreboard                                         |
| MJ        | Megajoule                                                         |
| ML        | Megalitre                                                         |
| mm        | Millimetres                                                       |
| MRC       | Meat Research Corporation                                         |
| MSW       | Municipal Solid Waste                                             |
| MW        | Megawatt                                                          |
| NPV       | Net Present Value                                                 |
| OMA       | Oil Mallee Association of Western Australia                       |
| OMCA      | Oil Mallee Company of Australia Pty Ltd                           |
| OSB       | Oriented Strand Board                                             |
| p         | Preliminary data                                                  |
| R&D       | Research and Development                                          |
| RIRDC     | Rural Industries Research and Development Corporation             |
| T&G       | Tongue and groove                                                 |
| TPC       | Timber Promotion Council, Victoria                                |

## Executive Summary

The study has investigated market and economic prospects for agroforestry enterprises in the low rainfall zone, defined as 400-600 mm average rainfall per annum. A wide range of enterprises was investigated. While focus was on the commercial prospects of these enterprises, sustainability factors were also considered where they were thought to be important.

In general, commercial agroforestry in the low rainfall region of Australia is unlikely to be as profitable as agroforestry enterprises in the high rainfall zone, defined as greater than 600 mm average rainfall per annum. This is due to lower growth rates, less established forestry infrastructure, and, depending on the product form and its value, greater distances to markets.

While there may be some agroforestry enterprises in this rainfall zone that may be considered viable when grown under irrigation (e.g. olives), these were generally given less emphasis. This was because the study was, in the main, targeted at landscape scale change, which dictated dryland agroforestry.

Further, once commercial realities are known, some enterprises in future could be assisted by government/society where sustainability and conservation benefits are significant. Such assistance, if forthcoming and sufficient, could induce investors to pursue agroforestry enterprises that might be 'nearly' commercial. Again, government/society initiatives would likely favour activities where there was potential for 'landscape' or 'regional' change.

The focus in each prospective enterprise analysis was on markets and economics. This required assumptions to be made on the production process, product form and target markets for each enterprise. Information on many of the enterprises was difficult to obtain and for some variables best 'guesstimates' have been made. Hence, the end result in each assessment should be viewed as indicative rather than prescriptive. In particular, the economics will vary from one situation to another and care must be taken in interpreting results of analyses based on one set of assumptions or on one type of production system.

Enterprises which were considered included sawntimber, wood panel products, posts/poles, specialty timber, biomass for electricity and ethanol, firewood, charcoal and activated carbon, eucalyptus oil, fodder and a range of 'niche' markets (e.g. bushfood, olives, jojoba). Full investment analyses were conducted for four of these enterprises: sawntimber, firewood, biomass for electricity, and eucalyptus oil production. Other enterprises were handled in a descriptive manner. In addition, all of the major enterprises were ranked against a set of assessment criteria.

Three prospects that emerged reasonably favourably from the assessment were:

- fodder;
- eucalyptus oil; and
- electricity produced from by-products and residues.

The potential for Australian eucalyptus oil to increase its share of the world market for pharmaceutical use is limited by low production costs in China and, to some extent, in other producing countries. However, there is some limited scope to increase market share based on value adding products in Australia and high quality oil

production. However, the solvent market for eucalyptus oil could offer the greatest potential for expanding production from agroforestry, as synthetic products such as trichloroethane have recently been banned for their negative effects on the atmosphere. Estimates indicate that the world market is certainly large enough to support large scale production of eucalyptus oil in Australia. This potential, however, is subject to commercial cost of production being similar to competing products such as limonene and pinene which are by products of orange production and paper making respectively. There may also be potential in supplying to other niche solvent markets, such as hand cleaners, where world prices may be higher.

The economic analysis for eucalyptus oil production, based on planting designs and production systems being employed in Western Australia, was favourable with a benefit cost ratio of 1.14 : 1 and an internal rate of return of 6.9%. This result excluded any sustainability benefits and such benefits could be considerable. The analysis assumed the woody stem co-product would be returned to the field as mulch. If used in alternative uses this co-product could have a higher value. The scale of the eucalyptus oil operation could be significant depending on penetration into the industrial solvent market. The production scale analysed was for 22,900 ha of trees harvested each year and this would require a penetration of the world industrial solvent market of almost 1%.

Wood biomass for electricity also appeared promising if transferred at a low price from other agroforestry enterprises. It would be unlikely that growing biomass specifically for electricity production would prove economic. The economic analysis assumed gasification of wood residue with the resulting gas driving a combustion engine linked to a generator. The scale assumed was for a unit generating about 300kW capacity, sufficient for a small community in rural areas. This would require about 5,000 tonnes of biomass (green) per annum as feedstock. Cogeneration was also considered, with the main application by sawmills and factories already operating in the 400-600 mm zone

In terms of market potential, the Federal Government's mandatory goal of more green power being utilised to produce electricity, combined with the deregulation of the electricity generation and supply markets, should enable 'green power', such as that generated from wood biomass, to compete more favourably with fossil fuel sources of electricity. This is particularly so in rural areas where the cost of delivering electricity is high due to line infrastructure carrying small loads and transmission losses over long distances. The deregulation of the market should mean that supply authorities will attempt to source electricity from the lowest cost source.

Although no economic analysis was carried out for trees and shrubs planted for fodder production in low rainfall areas, this would appear to be an area of considerable promise. Benefits are already accruing from such species as Saltbush and Tagasaste plantings. Native saltbush species have a widespread distribution and survive well in dry, harsh and saline conditions. Commercial distribution of saltbush seedlings has already commenced in Western Australia for national distribution, with species such as *Atriplex amnicola* and *Atriplex nummularia*. Other native species also offer promise for fodder production. The exotic species Tagasaste perhaps offers the greatest economic potential for improved livestock grazing systems throughout much of the drier areas of Australia. Also, the concept of dual purpose fodder trees which

can be established and maintained in the normal course of farming, for example, through alley farming systems, offers potential.

Prospects for producing wood for timber are somewhat limited due to the slower growth rates and competition from forestry and agroforestry in the higher rainfall zone. The potential for hardwoods is based on the native species abundance in the lower rainfall zone and unique characteristics of density and appearance of many species. On the other hand while softwood species may have relatively limited opportunities for market differentiation away from *Pinus radiata*, they may still provide an important role in low rainfall agroforestry in some situations.

Production of quality hardwood timber from the lower rainfall areas of Australia would have to compete increasingly with hardwood plantations in high rainfall areas where growth rates would be higher. Low rainfall agroforestry based on hardwood timber production would need to be based on high value and unique type timbers to be the most competitive, such as might be used in the furniture, high value craft and specialty timber markets. In this respect many of the species suited to low rainfall regions are strong and of high density and many have a unique appearance.

An economic analysis based on growing *Eucalyptus maculata* for high quality furniture provided a negative NPV at a 5% discount rate but this assumed no value of the waste timber and sawdust which could amount to about 65% of the volume of total wood produced. This could be used in production of electricity or ethanol, as for the residue for eucalyptus oil. However, planting designs for timber production may need to be based on block designs which may not be as effective for capturing any sustainability benefits that might exist from agroforestry enterprises in a particular region.

Prospects for softwood production in lower rainfall areas are also mixed. There may be particular biophysical niches, particularly in the upper end of the 400-600 mm rainfall zone where certain species may be quite suitable (e.g. *Pinus pinaster*). In addition, there may be some opportunities for softwood species to differentiate themselves and so avoid direct price competition with *Pinus radiata*. Further, where softwood processing infrastructure already exists close to the 400-600 mm zone (e.g. South Australia), this would benefit enterprises focusing on softwood species in the lower rainfall zone. On the other hand, competition from *Pinus radiata* grown in higher rainfall areas (as well as imported material) is generally likely to place a price ceiling on sales of many softwood products. Residues and by products of softwoods, as with hardwoods, could provide feedstocks for conversion to energy products.

There are potential markets for hardwood panel products, particularly laminated flooring and MDF. However, issues of scale, costs of production and processing, and the potential market penetration are still uncertain and could be investigated further with respect to low rainfall areas. Further, agroforestry production for wood panel products is more likely to be commercially viable if alternative products (e.g. posts, firewood, biomass for electricity) are produced from the agroforestry planting, so as to spread the risk associated with singular markets and to utilise the majority of the wood not used, which can be up to 80% of the log.

The opportunities for gaining commercial value from the production of agroforestry biomass to charcoal initially, and then activated carbon are likely to be promising, and are worthy of further economic assessment. The technology is available and is being pilot tested. The economics of producing activated carbon will be even more promising if its production can be incorporated as part of another agroforestry industry, such as sawntimber or eucalyptus oil production.

Production of firewood, grown in the low rainfall areas of Australia as a sole dedicated product, is not likely to be generally economically viable. The greatest potential for firewood production from this zone could be as a byproduct from other agroforestry systems, such as thinnings from sawntimber production or residues from milling operations. Firewood sold from thinnings is likely to be more profitable than firewood production as a stand-alone operation, because the cost of production is largely recouped by the sawntimber production. In addition, due to potential increasing supply from waste products from high rainfall hardwood stands, the firewood market for low rainfall agroforestry may only be small and localised, centering around rural areas in proximity to large urban centres and where transport costs and competition with high rainfall zone forest waste are minimised. The city markets of Perth and Adelaide may offer potential to low rainfall production as they are located in close proximity to that zone.

There may also be an opportunity for low rainfall agroforestry to produce hardwood fence posts, depending on the extent of any future substitution for steel posts. It is more likely that fence posts would present an opportunity as a product from a multi-purpose agroforestry system, where the risk of the investment can be spread over a number of industries. These fence posts would still be competing against those from remnants and native forests. However, these latter resources may be more sustainably managed in the future, thereby reducing their availability to the fence post market in specific regions.

The market potential for hardwood poles for electricity transmission lines is limited due to competition from underground connections and steel/cement poles, as well as the limited species suitability and lower growth rates to meet the product requirements. Similarly, while the market for vineyard trellis posts could be penetrated by hardwood posts, the market is not large in terms of any landscape scale effects that might ensue. Also, vineyard expansion may have already peaked, and the potential would exist only in replacing existing posts.

The commercial potential for ethanol from biomass was found to be substantial, but subject to the proposed Commonwealth/State Forests of NSW pre-commercial demonstration project substantiating production costs as estimated by Gorton Timber's study. A considerable margin exists between that estimate and the higher current price of industrial grade ethanol, and this latter market may be where the most potential for ethanol from biomass exists. On the other hand fuel ethanol at 48 cents per litre is uncompetitive with petrol and diesel at 25-28 cents per litre.

By reference to the current untaxed wholesale price of conventional petroleum fuels, both diesel and petrol, the blending of ethanol in proportions of 15 and 10 percent respectively may, at the price estimated by Gorton Timber, impose a price premium of

the order of 10-15 percent, This may be acceptable to some consumers given the environmental and other benefits associated with replacement of fossil fuel use.

The large scale of operations for ethanol production may be a constraint on using feedstock from low rainfall areas. Electricity production using gasification technology is more suited to a smaller scale of production, and probably more compatible with agroforestry production in low rainfall areas.

Specialty markets for various wood products should be considered as opportunities, albeit somewhat limited. Timber for specialty markets such as musical instruments may be more efficiently sourced from native stands, for as long as this is permitted. This is because long rotation times are required to provide the density and appearance attributes of the timber, which are sought after in specialty timber products. It may not be economically feasible to produce timber over such long periods in an agroforestry situation, and as such, native stands may be the preferred source of timber. If the situation were to change, however, where native stands could not be harvested, opportunities may open up in this area. Specialty timbers for craft uses, such as wood turning and carvings could be supplied from low rainfall agroforestry. There is little doubt that the value of the market could be significant, but it is still likely to be a relatively small volume market compared with other wood markets. Tool handles, which require hardwood timbers with exceptional strength and durability, may provide another niche market for low rainfall agroforestry. While the tool handle market for wood is attractive in terms of the premium prices likely to be received, existing Australian tool handle manufacturers are experiencing intense competition from imported handles, and substitute materials.

The study also considered commercial products from a range of other enterprises. These included carob, cork, jojoba, olives, other essential oils, Guayule (resin/rubber), sandalwood, tannins, trees providing bush food, and trees providing flowers. While all of these markets, due to the market size and the relative scale of plantings required to meet the market, are considered "niche", the enterprises with the most potential include essential oils, olives, carob, jojoba and sandalwood.

Melaleuca species were considered for their contribution to produce essential oil and betaines. One of the more important prospects for Melaleucas in low rainfall areas of Australia could be in the production of betaines produced in *M. bracteata*. The betaines can be extracted and manufactured into crop chemicals. These betaine products, when used on crops, would alter the water efficiency of the plants, so that they become more tolerant of dry conditions.

It is likely that commercial olive production in the low rainfall zone would require irrigation. While there may be geographic niches in the low rainfall zone that are suitable for olive production and where irrigation water is available, it is not likely that olives will provide a significant area of trees unless an extensive olive/grazing system can be developed that integrates livestock grazing and is still able to use harvesting aids or mechanical harvesting.

Even if Australia were to meet 10% of the total world demand for carob bean gum, only 8,750 hectares would need to be planted. This scale of planting is likely to have minimal impact on the total landscape in the low rainfall areas of Australia.

The market opportunity for jojoba could be significant, if the potential world market is ever realised. Australia should have a 10% market share when present plantings peak in production after the year 2000. To reach 50% of current world production would require another 800 hectares or 1 million trees. If the world market for jojoba expanded significantly, it is likely that prices would also need to fall significantly.

The opportunity for plantation sandalwood in low to medium rainfall areas of Australia is typically "niche", due to species suitability, growth rates and limited potential for market expansion.

While there may be commercial opportunities to produce flowers in the low rainfall zone, the size of the market and the need for quality and consistency may drive such production to intensive operations. It is unlikely therefore, that any landscape scale impact would be apparent.

Domestic and export demand for bushfoods is still only small with the initial market developed being in the novelty restaurant sector within Australia. A few of the more promising species are suited to the lower rainfall areas. Most bushfoods are still supplied from native stands. If production of some of the bushfood species were proven to be commercially viable in the low rainfall zones, it is unlikely that large scale plantings could be developed due to the cost of production and the specialised niche markets from which demand currently emanates.

High establishment costs combined with poor rubber prices and low yields, mean that guayule production, under present circumstances, is unlikely to be economic. Significant changes in establishment costs, rubber prices, yields, or changes in a combination of these variables, would need to occur before guayule production became profitable.

Most of the world's tannin production generally occurs in higher rainfall areas. There may be limited potential for tannin as a commercial option for low rainfall agroforestry.

The long rotation and expensive harvesting and processing costs for cork, mean that cork production in Australia is not likely to be significant in the future.

The potential for producing and processing gum arabic in Australia is limited, due to high costs associated with stripping the bark from the trees, high capital costs for processing equipment, competition from other countries with lower labour costs, and competition from synthetic products, particularly synthetic glues.

Carbon credits could provide another market for low rainfall agroforestry. The additional source of income which might be provided from carbon credits could provide the extra return required to ensure commercial viability for any "almost commercial" low rainfall agroforestry products.

In addition, the study has provided an indicative list of suitable species for the low rainfall zone that might be suitable for agroforestry production.

A number of uncertainties exist for low rainfall zone agroforestry which could be the subject of further investigation. These include the threat of species dying after a series of poor seasons. The low rainfall zone is inherently risky in terms of climate. Existing biophysical predictive models mostly do not account for rainfall variability over a series of years and improvements in this regard could be made. Also, limited knowledge is known about how low rainfall species might adapt to a plantation situation. This adaptation could well be related to the planting design and could also be very important in the capturing of sustainability benefits that might be targeted from low rainfall agroforestry.

The study highlights the importance of utilising all of the resulting biomass from agroforestry and therefore targeting multiple products from an individual enterprise. In this regard, future prospects for electricity generation from biomass and production of activated carbon should be investigated further.

# 1. INTRODUCTION

---

## 1.1 Background

Sustainability benefits are being sought from widespread plantings of trees in many agroecological zones of Australia. In particular the impacts of dryland salinity may be alleviated by tree planting, as may other sustainability impacts such as wind and water erosion and habitat and biodiversity degradation. Many of these impacts are most severe in the medium to low rainfall areas of eastern, southern and western Australia.

The scale of planting is important. Small areas of land may be improved through small-scale strategic planting, but to achieve sustainability improvements on a large scale, large-scale plantings will be necessary. Whether plantings are contemplated for a large regional initiative or a small-scale, on-farm initiative, plantings for sustainability objectives alone may not be economic either for an individual land owner or society as a whole due to high initial costs of establishment and distant (temporally and spatially) future returns from the improved environment.

If tree species that provided commercial returns were identified, planted areas would most likely increase significantly with commensurate sustainability improvements. Indeed, the identification of species that may provide at least some commercial returns would be extremely valuable to the attainment of this objective. Under this scenario it is possible that government support in various forms may be available on a large enough scale to make a real impact.

The Joint Venture Agroforestry Committee will receive further applications for R&D funding over the next few years due to the allocation of Natural Heritage Trust resources to R&D. Relevant information on the prospective markets and economics for various tree species and product forms suitable to this zone would assist the Committee to allocate resources more efficiently. In addition, information on commercial prospects would enable greater proactivity on behalf of the Committee to pursue the more promising species and production concepts of promise.

## 1.2 Objectives

The aim of the study is to provide information that will be useful in assessing the relative priorities for R&D that may assist with the introduction of agroforestry activities to the medium to low rainfall zone of Australia. Specifically, the objectives of the study are:

- a) To assess the commercial opportunities for growing a range of tree species in the medium to low rainfall areas of Australia, and
- b) To establish priorities by commercial product and species type to assist resource allocation in R&D funding by the Joint Venture Agroforestry Committee.

## **2. SCOPE AND APPROACH**

---

### **2.1 Scope**

The study focuses on the 400 to 600 mm rainfall areas of Australia. Prospective markets for trees and tree products to be investigated included timber (sawn, poles), oil extraction, biomass for ethanol or electricity generation, and human and livestock food sources. The focus has been mainly on native species and for product opportunities where a future market of significant size may exist. Where niche markets may exist in future for only small areas of production, these have been identified but few have been addressed in any detail in this report.

The intended project was to complement the study proposed by Department of Conservation and Land Management (CALM WA) and Agriculture WA (AgWA) on 'selection and development of multiple purpose species for large scale revegetation'. In particular the economic and market components of the search and screening procedure to be adopted by the CALM project was to be supplemented by the Agtrans project on activity and preferred species within the eastern Australian regions. Integration of approach and search procedures with the CALM project was to be pursued. Because the CALM project has been delayed in commencing, the current study has now included activities and species relevant to Western Australia.

### **2.2 Approach**

The study has followed a framework of defining the various product forms, the market for such products and the economics of actually establishing trees to target the particular markets. Further dimensions addressed are those of a species list and assessment criteria.

Various researchers, Landcare Groups, Government Departments and commercial and industrial organisations have been approached for information. While there appears to be a significant amount of activity relevant to potential agroforestry in the medium to low rainfall zone, there was sparse activity that was considering any comparison between the options available, specific market information or commercial profitability, except perhaps for the Oil Mallee initiative in Western Australia.

Other sources of information utilised were the written literature available on the topic and information on the internet. Because of the wide range of products considered, there was sometimes difficulty ensuring a balance across the various product groups while maintaining a reasonable degree of detail within each product group.

Due to the wide scope of the study, a number of considerations have had to be addressed in broad terms only. For example, evaluation of the economics of production for specific products requires a significant number of assumptions to be made and there can be a need to include aspects of scale and location as well as the structure and logistics of operations. Time was not available to do this comprehensively for each product form. Further, the expected advent of new technology, especially in the wood technology, energy production, and oil distillation

areas made the assessment of the economics of production of various products quite difficult.

Information on the sustainability impacts of various agroforestry enterprises has not been given much attention in line with the prime objective of the project to assess commercial profitability. Sustainability aspects have been addressed where they were perceived to be particularly relevant. However, it should be noted that sustainability benefits will vary from region to region, production system to production system, and even by planting design. Hence the commercial profitability aspects can not be entirely separated from the sustainability benefits some of which will in fact influence profitability, especially in the longer term. Any assessment of the overall economics of producing different product forms for commercial gain can only be indicative unless the sustainability benefits and costs are considered.

## **2.3 Structure of Report**

The report is structured in the following manner. The next five chapters (Chapter 3, 4, 5, 6, and 7) provide information on each of five product groups: wood, energy, oil, fodder and 'miscellaneous' that includes a diverse product group that includes food and other products for human and industrial use. Chapter 8 provides a summary of the major species that are relevant to the various product groups. Chapter 9 provides an initial set of criteria that may be used in assessing priorities for future agroforestry R&D for the lower rainfall area, and a summary of those prospects that appear most promising.

## 3. WOOD PRODUCTS

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The following sections address four principal product groups of the timber market: sawn timber, wood panel products, posts and poles, and other wood products, including specialty timbers, such as for craft purposes.

### 3.1 Sawn Timber

#### 3.1.1 Market Overview

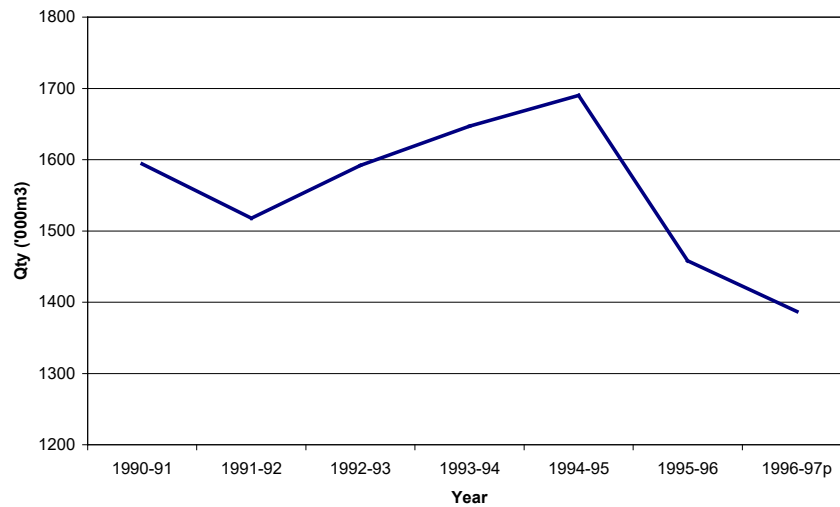
Sawn timber has a multitude of uses, ranging from structural timber (frames, trusses) and flooring to furniture.

The major use for sawntimber in Australia is for new residential buildings and renovations to existing buildings (70%). Another ten per cent of the sawntimber market is consumed by the non-residential building sector, and an additional 10% is consumed by furniture manufacturers.

The softwood and hardwood sectors of the sawn timber industry are very different, in terms of type and location of resources, infrastructure, markets, and opportunities. It is for this reason, that softwood and hardwood markets are usually examined separately.

Total consumption (based on production less exports plus imports) of sawntimber in Australia for 1996-97 was 4.1 million m<sup>3</sup>, of which 66% was for softwood sawntimber (2.7 million m<sup>3</sup>) and the remainder hardwood sawntimber (1.4 million m<sup>3</sup>) (ABARE, 1997). As an example of the distinction between softwood and hardwood sawntimber in the market place, two types of timber supply the furniture industry: high quality, appearance grade timber and lower quality timber. Generally, the appearance grade timber is supplied from hardwood species, while softwood species (e.g. *Pinus radiata*) generally cater for the lower end of the furniture market. Australian consumption of hardwood timber over the past few years is shown in Figure 3.1.

Figure 3.1. Australian Consumption of Hardwood Sawntimber, 1990/91 to 1996/97 ('000 m<sup>3</sup>)



Source: ABARE (1997)

NOTE: "p" is an ABARE notation meaning preliminary data.

It has been estimated that the consumption of hardwood sawntimber will decrease in the next few years (by 200,000 m<sup>3</sup>), while softwood sawntimber consumption will increase (by 400,000 m<sup>3</sup>) (Love *et al*, 1997). This predicted increase in consumption for softwood sawntimber could be due to the predicted availability of softwood sawntimber from plantations and the predicted reduction in availability of hardwood sawntimber as a result of pressure to conserve native forests (Love *et al*, 1997).

The substitution of softwood sawntimber for hardwood sawntimber might also be driven from the consumption side, such as changes in the building industry which allow the wider use of softwood sawntimber for construction. Substitution of softwood sawntimber for hardwood sawntimber might also be encouraged as processing and treatment technology for softwood sawntimber is further developed to manipulate wood characteristics, such as strength and durability.

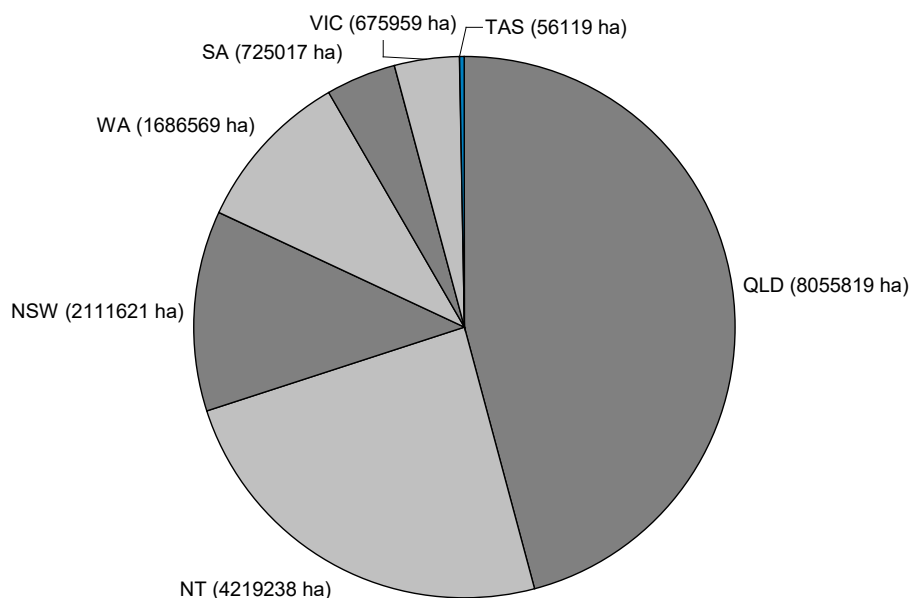
With regard to the furniture industry, however, it is more likely that growth in certain sectors will occur, rather than direct substitution. For example, the furniture market can be thought to consist of at least two major sectors: high value, high quality hardwood furniture, and less expensive, poorer quality softwood furniture. In general, substitution of hardwood for softwood, and vice versa, is less of an issue in these sectors, rather it is growth in one sector, at the possible expense of another sector.

While there are possibilities for technology to be developed to enhance the qualities of softwood sawntimber so that it may compete with hardwood sawntimber in other markets, development and marketing may also work in the opposite direction to create opportunities for hardwood timber to take market share from softwood timber. Product marketing is the essence of successful product growth, and this will apply to selling hardwood timber. The Timber Promotion Council of Victoria, which represents interests for both the hardwood and softwood timber industries, has successfully created a marketing "edge" for Australian native timbers. The hardwood timbers are promoted under the name "Natural Feature Hardwood", with applications including furniture and flooring. The "Natural Feature Hardwood" concept promotes

the distinctive features of Australian natives, which previously had attracted downgrading of the timber (TPC Victoria, Annual Report 1996/7). Promoting hardwood timber in this way is the mechanism which could drive market growth for hardwood sawntimber from the low rainfall area. Without it, there are restricted market opportunities for low-rainfall hardwood sawntimber because it is unlikely to be able to compete with softwood or hardwood produced in the higher rainfall areas.

The two main sawlog sources in Australia are native stands and plantation forests. There are almost 126 million hectares of native forests in Australia, which are predominantly hardwood species. Approximately 14% of native forest areas are in the 400-600 mm rainfall zone, and occur mostly in Queensland, NT and NSW. The distribution of native forest in the 400-600mm rainfall zone for each state and territory is graphed in Figure 3.2.

Figure 3.2. Hectares of Native Forests in 400-600mm Rainfall Zone, by State (June 1998)



Source: BRS, National Forest Inventory Extract, June 1998

While these figures are useful for comparing the size of native forests with plantations, they by no means indicate that the entire native forest area in low rainfall regions is logged. In fact, it has been suggested that very little of the total native forest area is harvested for sawntimber, with the exception of Cypress Pine (*Callitris glaucophylla*), a softwood species. The total native stand of this genera (the proportion of *C. glaucophylla* is not known) is summarised in Table 3.1, with other dominant genera found in native stands in the 400-600 mm rainfall zone.

Table 3.1. Genera in Native Forests, 400-600 mm Rainfall Zone

| Genera          | Hectares   |
|-----------------|------------|
| Acacia          | 3 454 102  |
| Allocasuarina   | 131 544    |
| Callitris       | 476 100    |
| Eucalyptus      | 11 501 103 |
| Excoecaria      | 396 839    |
| Macropteranthes | 803 701    |
| Melaleuca       | 174 506    |
| Other           | 592 447    |
| Total           | 17 530 342 |

Source: BRS, National Forest Inventory Extract, June 1998

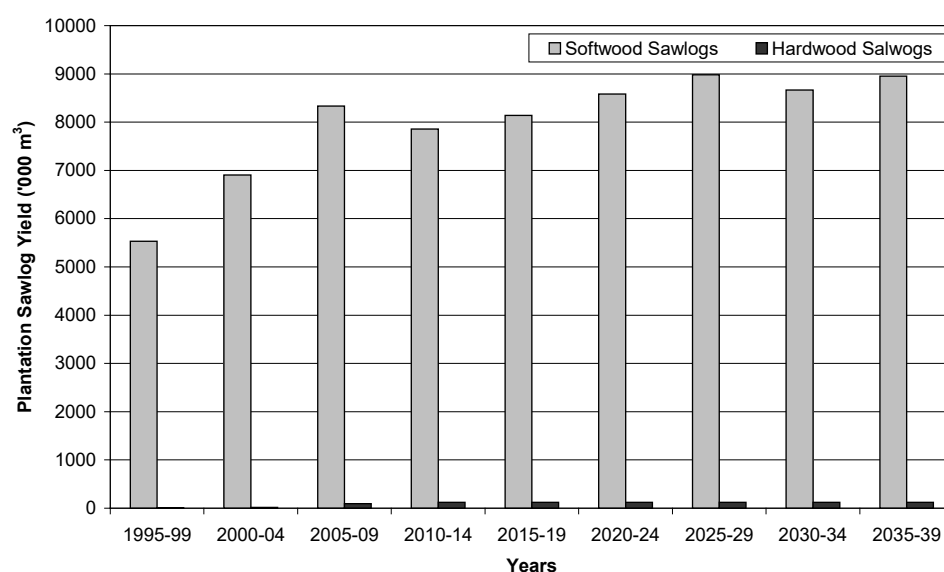
The second source for sawntimber supply is from plantations. In contrast to the type of timber sourced from native stands, the dominant types sourced from plantations are softwood timbers. In total, there are almost 884,000 hectares of softwood plantations in Australia, but less than 160,000 hectares of hardwood plantations. Most of the current production of plantation hardwood is not used for sawntimber, but for pulp. Hardwood sawntimber in Australia is either harvested from native stands or it is imported.

Softwood timber plantations are located predominantly in the Murray Valley in Victoria/NSW (18%), south east Queensland (17%), south east SA and south west Victoria (16%), south west WA (10%), Central Tablelands of NSW (8%), Tasmania (8%), and Central Gippsland in Victoria (7%). Most of these plantations are located in or near coastal areas of Australia. These production areas are favourable because softwood species, such as *Pinus radiata*, require reasonable quality soil and rainfall to achieve fast growth rates and need to be close to markets, thus enabling them to remain price-competitive. There are very few softwood plantations in the 400-600 mm rainfall zone.

Production of Australian sawntimber in the future will depend on plantation yields, product marketability, and harvesting permits for native forests. Love *et al* (1997) indicated that harvesting from native forests could decline up to 50% in the long term as it comes under increasing pressure from conservation groups.

The Bureau of Resource Sciences (1997) estimated that future potential yield of hardwood and softwood sawlogs from Australian plantations (Figure 3.3) would increase. These forecasts were based on estimates from growers and are considered conservative, since they do not include potential expansion through initiatives like the 2020 Vision for plantation expansion. The significant increase in hardwood sawlog yield illustrates that most hardwood plantations have only been planted in recent years. The growth in supply of hardwood sawlogs from plantations is supported elsewhere, with comments that the long-term trend will see a significant increase in production from hardwood plantations, as well as softwood plantations. This is further supported by the policy initiative (*Plantations for Australia: the 2020 Vision*) aimed at trebling Australia's plantation area by the year 2020.

Figure 3.3. Softwood versus Hardwood Sawlog Plantation Yield 1995-2039 ('000 m<sup>3</sup>)



Source: BRS (1996)

It is important to note in Figure 3.3 that, even though hardwood sawlog yield is increasing, it constitutes an average of only 1% of the total hardwood plantation, with most production destined for pulpwood.

Although a large proportion of Australian sawntimber demand is met through local production (3.4 million m<sup>3</sup>), Australia is a net importer of sawntimber (0.74 million m<sup>3</sup> of actual imports). That is, Australia imports more sawntimber than is exported. Table 3.2 shows the breakdown of Australian imports, as well as exports. Imports are 14 times more than exports, and most of imports (87%) are softwood timbers. Major source countries are the Pacific, including New Zealand (*Pinus radiata*), and North America (Douglas fir). These two regions combined constitute 88% of imports.

Table 3.2. Australian Imports & Exports of Sawntimber (hardwood and softwood) by Country, 1995-96 ('000 m<sup>3</sup>).

| Country     | Import from: | Export to: | Net Import |
|-------------|--------------|------------|------------|
| Asia        | 70           | 32.3       | 38         |
| Europe      | 16           | 12.7       | 3          |
| Nth America | 312          | 4.0        | 308        |
| Pacific     | 338          | 4.5        | 334        |
| Sth America | 3            |            | 3          |
| Other       | 2            | 0.3        | 2          |
| Total       | 741          | 54         | 687        |

Note: Imports exclude "sawn equivalent of log imports & boxboards" (ABARE, 1997)

Of total exports of sawntimber from Australia, 60% is exported to the Asian region. However, this 60% represents less than 1% of Australia's total sawntimber production, emphasising that sawntimber production in Australia is mainly for the domestic market.

The relationship between production, consumption and trade of softwood sawntimber is graphed in Figure 3.4A and in Figure 3.4B for hardwood sawntimber.

Figure 3.4A. Softwood Sawntimber Consumption, Production & Trade - 1996-97p

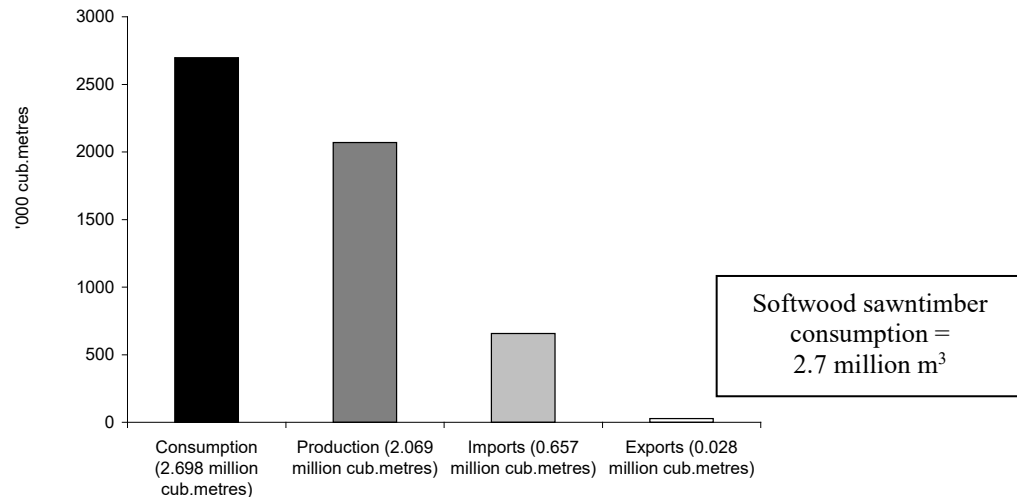


Figure 3.4A highlights the dominance of local production for Australian domestic softwood supply.

Figure 3.4B. Hardwood Sawntimber Consumption, Production & Trade - 1996-97p

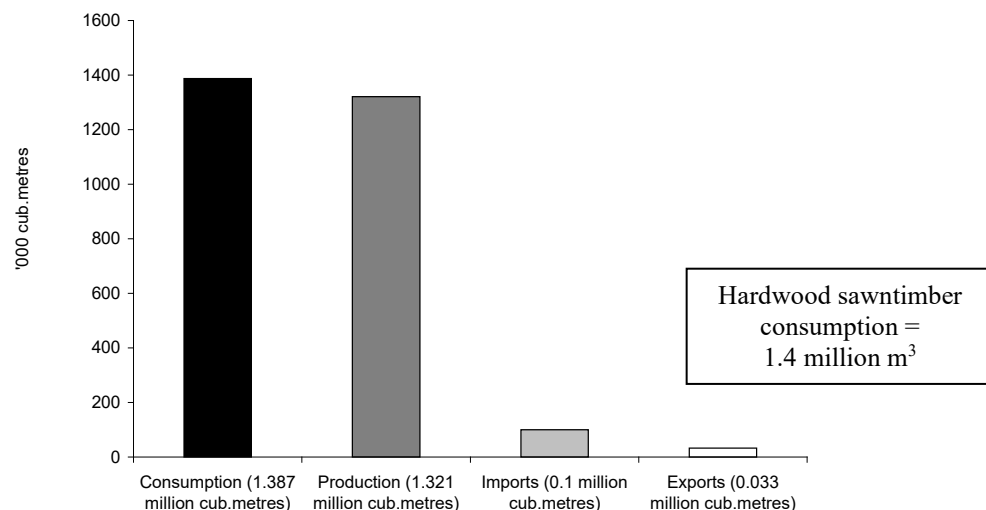


Figure 3.4B shows that most of Australia's consumption of hardwood sawntimber is met by local production, which in turn is sourced primarily from native stands. As mentioned earlier in this chapter, production from native stands is coming under increasing conservation pressure which may reduce the short term supply of hardwood sawntimber in Australia.

Similar to sawntimber demand projections for Australia, uncertainty exists in forecasts for international demand for sawntimber. Some reports suggest that future

demand will be strong, due to an increasing world population and developing countries' increasing standard of living. This outcome could arise, as living standards and demand for housing change in countries such as Korea, Taiwan, China, India and the Philippines. In other countries, existing consumption is being altered and enhanced through promotion and awareness. For example, markets for Australian hardwood sawn timber are presently being developed in Japan. Japan's level of new domestic housing has remained low. Despite this, imports of timber housing components into Japan are increasing (TPC Victoria, Annual Report 1996/7).

In terms of meeting international demand for sawntimber, forecasts have shown that there will be a decline in supply for sawntimber from some countries, and an expected increase in supply from other countries. For example, as the results of past excessive timber harvesting of old growth forests come to the fore, supply is likely to decline from North America, Malaysia and Indonesia. In addition, production from these types of native forests will become increasingly restricted due to conservation pressures, as they are in Australia. Conversely, supply to the world hardwood and softwood sawntimber market is scheduled to increase from other countries, including New Zealand, Chile and Brazil, who are increasing their forest product exports (Love *et al* 1997).

### 3.1.2 Economics

#### Prices

Market opportunity and stability for sawntimber (both softwood and hardwood) will depend on continued and planned supply, guaranteed volume, competitive pricing and competitive quality (RIRDC, 1996). Comments from the timber trading industry indicated that market development would be difficult if continuity of supply could not be guaranteed; continuity of supply is often the first issue raised by the international buyer. Long-term pricing of timber products will determine supply and the willingness of producers to maintain continuity of supply. Examples of current prices for sawntimber are summarised in Table 3.3.

Table 3.3. Average Prices for Sawntimber

| Product                                      | Price (\$/m <sup>3</sup> ) |               |         |
|----------------------------------------------|----------------------------|---------------|---------|
|                                              | Wholesale                  | Retail        | Average |
| <b>Hardwood Sawntimber</b>                   |                            |               |         |
| Decking (a)                                  | \$220-\$1400               | \$260-\$1650  | \$880   |
| Decking (b)                                  | n/a                        | n/a           | \$920   |
| Flooring (a)                                 | \$850-\$2350               | \$1000-\$2770 | \$1740  |
| Flooring (seasoned Brushbox & Blackbutt) (b) | n/a                        | n/a           | \$1170  |
| Kiln dried roughsawn (skip dressed) (a)      | \$1250-\$1950              | \$1475-\$2300 | \$1740  |
| Seasoned structural timber (b)               | n/a                        | n/a           | \$870   |
| Quality kiln dried furniture "blanks" (b)    | n/a                        | n/a           | \$2000  |
| <b>Softwood Sawntimber</b>                   |                            |               |         |
| Cypress pine – structural (b)                | n/a                        | n/a           | \$440   |
| Cypress pine – flooring (b)                  | n/a                        | n/a           | \$570   |
| Radiata pine – structural (b)                | n/a                        | n/a           | \$390   |

Notes:

- a) Prices sourced from B. Spillane, Moxon Timber (Brisbane), personal communication, August 1998, based on wholesale prices with 18% mark-up for retail prices.
- b) Prices were sourced from State Forests of NSW "Timber Market Survey – Pricing & Market Trends", April 1998, based on average prices for 1997.
- c) All prices have been rounded to the nearest \$10.

### **Cost of Production Estimate**

Although there may be niche supply opportunities for sawntimber production in the low rainfall zone, overall it is unlikely that production in low rainfall areas will be economically viable across large areas.

Large-scale plantings of softwood species in the low rainfall zone face significant constraints due to:

- Plantation softwood species grown in high rainfall areas grow faster.
- Plantations of this type (in high rainfall areas) are located relatively close to principal markets for sawntimber, thereby reducing the cost of transport of the product, and increasing its competitiveness.
- Softwood plantations are often vertically integrated with the processing/sawmilling chain, thus making entry for new suppliers difficult, unless they utilise existing infrastructure.

While there are many factors, such as those listed above, which may discourage investment in softwood timber production in the low rainfall areas, it should be noted that there are some existing and potentially emerging situations which may lend support to softwood timber production in this zone. For example, *Pinus pinaster* is particularly suited for growing on sandy ridges in the 500-600mm area of the low-rainfall zone of Western Australia. While *P. pinaster* might be able to compete directly with *Pinus radiata* in the market place, there is possibly some scope for *P. pinaster* to find niches in the softwood markets by differentiating with *P. radiata*. Such niches might exist in the furniture industry, where the appearance attributes of softwood timber, such as colour, are promoted. However, it is unclear as to the extent to which these trends may develop.

As well, softwood sawntimber may gain market share in areas where hardwood sawntimber has been the traditional supplier. This has already occurred to a limited degree in the building industry, where changes to building standards allowed the use of softwood timber in place of hardwood.

Large-scale plantings of hardwood species for sawntimber production also face significant constraints due to:

- Plantation hardwood species grown in high rainfall areas will grow faster
- Processing infrastructure is not common for hardwoods in low rainfall areas
- Many hardwood species with desirable market attributes have not been tested for their performance in a plantation situation for timber production in the low rainfall areas

However, there may be greater opportunities for low-rainfall agroforestry based on hardwoods than softwoods due to:

- Generally slower growth rates in low-rainfall areas lend themselves more to the production of harder and more durable native hardwood species.

- The range of colour, strength and density of hardwood timber produced in Australia may allow some product differentiation of low-rainfall species versus high-rainfall hardwoods in the hardwood sawntimber market.
- Appearance grade hardwood timber commands higher prices than low quality timber or softwoods, thus higher costs from longer growth times and distance to markets have more chance of being partially or fully covered.

Variations in the quality of hardwood timbers also exist based on the management regime practiced. For example, anything from slight to severe variations in management of the trees is likely to result in product with varying degrees of processing requirements and quality. Processing of faster growth, thinner, less dense timber, such as hardwood timber sourced from farm forestry, will have different milling requirements to those trees produced from a native stand of hardwoods, which are denser, and thicker and have experienced slower growth rates. Presently, most of the processing infrastructure has been designed to process the larger, denser, and more mature hardwood species. This is a key processing issue which must be addressed in considering market opportunities for low rainfall agroforestry. Further, the infrastructure in the 400-600 mm rainfall zone for hardwood timber from plantation agroforestry is not highly developed in many states and this could impose a higher cost structure on production in this zone.

Agroforestry production for the sawntimber market requires the adoption of management in the form of pruning and thinning regimes that may not be culturally in line with managers of cropping or grazing enterprises that dominate the 400-600 mm zone. Another major factor inhibiting the investment in production of sawn timber from this region is the time from planting to harvest which could be anything from 30 to 60 years, with possible cash flow from thinnings in the intervening period.

Efficient production of hardwoods for sawn timber in the low rainfall zone is likely to be associated with high density plantings to discourage branching and provide good tree form. Such planting designs may not be optimal from the point of view of the impact on sustainability. The two objectives may not necessarily be complementary in many situations (e.g. trees planted for windbreaks or salinity or watertable control over wide areas).

Further, there is limited knowledge of how Australian native hardwoods will survive and grow in a reasonably dense plantation situation that would most likely be required to produce high grade timber.

### **Investment Analysis**

An investment analysis was constructed for the production of sawntimber over 47 years, including a 45 year growth period, with harvesting and drying occurring in the 46<sup>th</sup> year and the sawntimber sold in the 47<sup>th</sup> year. The analysis was based on production and yield estimates from establishing one hectare of the species *Eucalyptus maculata*. Where required data were unavailable for this species, information relating to other low rainfall species was used. The analysis assumed that the sawntimber would be sold as a high value seasoned product to the furniture manufacture industry. It was also assumed that the agroforestry stand would be planted in a block formation, at a high initial but low final density, requiring zero to

minimal pruning to achieve straight form. Hence, maintenance costs were not included.

It was also assumed that the trees would be planted from seedlings, not dry seeded. The main reason for this is that correct densities are required for producing sawntimber, so that a straight form is achieved, and there are likely to be less "missed plantings" from seedling planted trees than from dry seeding processes.

To produce sawlogs in the shortest time possible, low final plantation densities would be required. It has been suggested by AgWA and CALM that final densities as low as 100-150 stems per hectare, as a general guide, would produce sawlogs more quickly than closer spacings where trees compete with each other for water and nutrients. It is assumed in the investment analysis that the final density is 150 stems per hectare. Thinning regimes will also vary, in accordance with species, growth rates, planting densities etc. To achieve a final density of 150 trees from 1000 planted trees, estimates from AgWA and CALM of 67% and 50% of trees to be thinned were rounded to 70% and 50%. These and other assumptions, with their relevant sources of information, are summarised in Table 3.4.

Table 3.4. Assumptions Used in the Sawntimber Investment Analysis.

| Variable                                                                | Base value                 |
|-------------------------------------------------------------------------|----------------------------|
| <i>General</i>                                                          |                            |
| Planting density (a)                                                    | 1000 stems/hectare         |
| % of trees harvested at 1 <sup>st</sup> thinning (b)                    | 70%                        |
| % of remaining trees harvested at 2 <sup>nd</sup> thinning (b)          | 50%                        |
| Timing of thinnings (c)                                                 | 15, 30 years               |
| Harvest rotation (growing time only) (c)                                | 45 years                   |
| Project life (d)                                                        | 47 years                   |
| Survival rate of trees (e)                                              | 80%                        |
| Discount rate                                                           | 5%                         |
| Opportunity cost of the land (f)                                        | \$100/ha                   |
| <i>Production Costs</i>                                                 |                            |
| Cost of establishing trees (g)                                          | \$0.48/tree                |
| Cost of fencing \$/ha (lasts 45 years) (h)                              | \$380/ha                   |
| Variable cost of watering trees (i)                                     | \$40/ha/establishment yr   |
| Contract thinning cost \$/m <sup>3</sup> of thinned material) (j)       | \$10/m <sup>3</sup>        |
| Contract harvest cost (k)                                               | \$21/m <sup>3</sup>        |
| Milling cost (\$/m <sup>3</sup> of milled product) (l)                  | \$108/m <sup>3</sup>       |
| Transport cost of logs (\$/m <sup>3</sup> /km) (m)                      | \$0.14/m <sup>3</sup> /km  |
| Transport distance for logs (m)                                         | 50km                       |
| Transport cost of sawntimber (\$/m <sup>3</sup> /km) (n)                | \$0.20/m <sup>3</sup> /km  |
| Transport distance for sawntimber (n)                                   | 200km                      |
| Cost of drying & dressing timber (o)                                    | \$260/m <sup>3</sup> (GOS) |
| <i>Prices &amp; Yield</i>                                               |                            |
| Wholesale price for seasoned & graded <i>E.maculata</i> (furniture) (p) | \$1,500/m <sup>3</sup>     |
| Yield per m <sup>3</sup> per hectare per year (q)                       | 5m <sup>3</sup> /ha/year   |
| Final yield achieved (cubic metres of sawlogs per ha)                   | 123.75                     |
| Green off saw recovery (% of log) (r)                                   | 35%                        |

|                                          |     |
|------------------------------------------|-----|
| Graded & dressed recovery (% of log) (s) | 15% |
|------------------------------------------|-----|

Notes:

- a) The initial planting density was based on average estimates from Agriculture Western Australia's Tree Notes (numbers 1 & 3).
- b) AgWA & CALM (Tree Note, Nos. 1 & 3) estimated the percent of trees harvested at the first thinning was between 50% and 67%, while the percent of remaining trees harvested at the second thinning was estimated at 50%. It was assumed in the investment analysis that the percent trees thinned at the first thinning was rounded up to 70% and 50% was used for the second thinning.
- c) The timing of the two thinnings was estimated to occur 15 & 30 years after planting. This was sourced from data for Spotted Gum in the 300-600mm rainfall zone in RIRDC's "Contribution of Farm Forestry to Australia – A Quantitative Assessment". The harvest rotation of 45 years was also sourced for Spotted Gum from the same publication.
- d) The project life is 47 years, which is made up of 45 years growing time/harvest rotation, harvesting, drying and dressing in the 46<sup>th</sup> year, and selling the timber in the 47<sup>th</sup> year.
- e) The survival rate of the trees, based on plantings from seedlings, was estimated by Agtrans to be 80%. It was assumed that changes in survival rate would affect the cost of replanting only, and not the final yield.
- f) The opportunity cost of the land was based on the gross margin per hectare of growing wheat.
- g) The cost of establishing trees was based on a seedling cost of \$0.23 cents per tree and the cost of planting of \$0.25 per tree, and were both taken from estimates of eucalyptus plantings for oil production in WA. It is recognised that planting costs could be higher if planting for timber because of the block formation and not being pre-ploughed, as for eucalyptus oil production in wheat. The cost of planting was not verified for its suitability to areas outside of WA. The cost figure used therefore could be an underestimate.
- h) The cost of fencing was based on a fencing cost of \$3000/km. The cost of fencing a 10 hectare block was based on a fence perimeter of 1.26km, with a hectare rate of approximately \$380/ha.
- i) The variable cost of watering the trees at establishment was based on watering taking 1 hour per hectare, and requiring two people at \$10/hour, with the cost of fuel equal to the cost of labour. It was also assumed that waterings would occur in the establishment year only, with two waterings occurring in that year. It was assumed that either farmers would already have the necessary capital equipment for watering, or it would be borrowed.
- j) The contract rate for thinning was sourced from RIRDC's "Contribution of Farm Forestry to Australia – A Quantitative Assessment" and based on a rate per m<sup>3</sup> of thinned material. Pruning costs were estimated to be minimal, as the trees are planted in a block formation. The yield at both thinnings was based on an annual yield of 5m<sup>3</sup>/ha/year, sourced from CSIRO. It was assumed that the thinnings were not sold, but left in the plantation.
- k) The assumed harvesting contract rate of \$21/m<sup>3</sup> is made up of \$9/m<sup>3</sup> for cutting and \$12/m<sup>3</sup> for snigging the trees to the truck loading point. These estimates were obtained from a higher rainfall plantation study by Leggate *et al* (1998) "Economic Aspects of Eucalypt Hardwood Plantation Forestry", paper presented at the Australia Forest Growers Conference, Lismore.
- l) The cost of milling sawlogs into sawntimber was sourced from ABARE's "Pricing & Allocation of Logs in Australia", 1991. Figures were in 1984/85 dollars and were adjusted, using CPI, to 1996/97 dollars.
- m) Transport costs from plantation to mill was taken from RIRDC's "Contribution of Farm Forestry to Australia – A Quantitative Assessment"; the distance transported was assumed to be 50km.
- n) Transport costs from mill to market were scaled up from RIRDC's "Contribution of Farm Forestry to Australia – A Quantitative Assessment", to \$0.20/m<sup>3</sup>/km and the distance was assumed to be 200km.
- o) The cost of drying and dressing sawntimber was sourced from the study by Leggate *et al*, and related to the cost per m<sup>3</sup> of "green-off-saw" timber. The cost was made up of \$120/m<sup>3</sup> for air and kiln drying, and \$140/m<sup>3</sup> for dressing.
- p) The wholesale price for seasoned & graded *E. maculata* was estimated in the State Forests of NSW's Timber Market Survey (1998) where it was reported by a survey respondent that there was growing interest in Spotted Gum (*E. maculata*) in the NSW & Victorian furniture markets, at a seasoned and graded wholesale price of between \$1,200 and \$1,800/m<sup>3</sup>.
- q) The yield per hectare per year was estimated by CSIRO for low rainfall areas (400-600mm) to be 5m<sup>3</sup>/ha/year.
- r) The GOS or green off saw recovery (% of log) was estimated by Norm Forbes, Hyne & Son, Maryborough, to be the current state average for hardwood timber in Queensland, that is, 35%.

- s) The % recovery of graded and dressed timber from the sawlog was estimated by Leggate *et al* (1998) to be approximately 15%.

Based on the assumptions from Table 3.4, the investment analysis produced the results shown in Table 3.5. Based on these assumptions, the net present value (NPV) was negative when establishment costs were either included or excluded, although the NPV and benefit cost ratio (B/C ratio) improved when establishment costs were excluded. Similarly, an improvement in the internal rate of return (IRR) occurred when establishment costs were excluded from the analysis.

Table 3.5. Results of Investment Analysis: Base Case

| <b>Investment Criteria</b> | <b>With establishment costs</b> | <b>Without establishment costs</b> |
|----------------------------|---------------------------------|------------------------------------|
| NPV (\$) @ 5%              | -16,710                         | -6,350                             |
| B/C Ratio                  | 0.69 : 1                        | 0.86 : 1                           |
| IRR                        | 2.7%                            | 3.8%                               |

In order to observe the circumstances under which the investment becomes positive, a sensitivity analysis of the major variables was conducted using the 'with establishment' scenario. Some of the variables from Table 3.4 were assessed for their impact on NPV (including establishment costs) when their base values were changed. The degree to which each selected variable was varied is summarised in Table 3.6 and the results of the sensitivity analysis are presented in Figure 3.5.

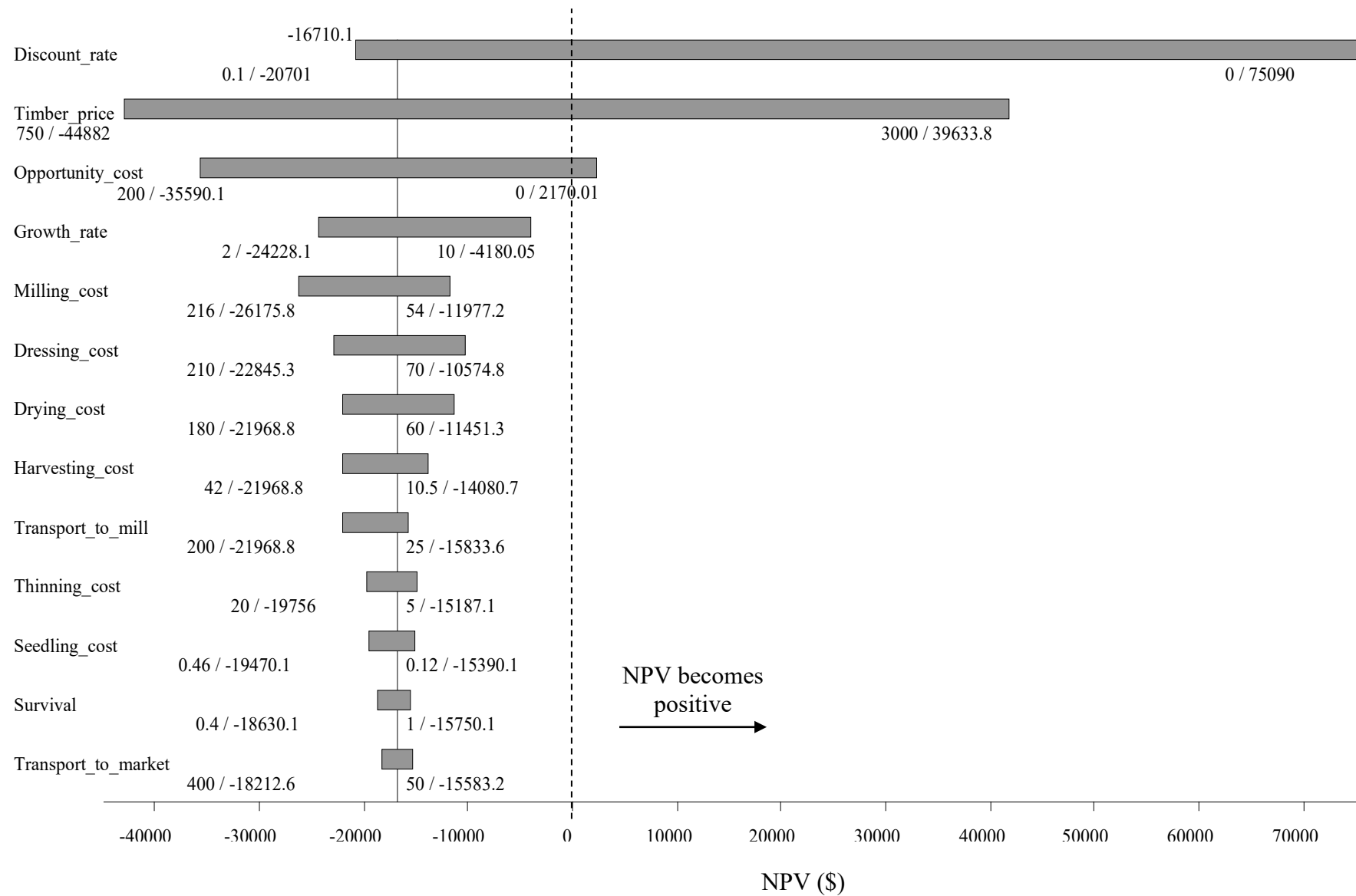
Table 3.6. Expected Minimum and Maximum Values for the Major Variables

| <b>Variables Subject to Sensitivity Analysis</b>                   | <b>Minimum</b>         | <b>Maximum</b>          |
|--------------------------------------------------------------------|------------------------|-------------------------|
| <i>Technical</i>                                                   |                        |                         |
| Growth rate (a)                                                    | 2m <sup>3</sup> /ha/yr | 10m <sup>3</sup> /ha/yr |
| Survival rate                                                      | 40%                    | 100%                    |
| <i>Economic</i>                                                    |                        |                         |
| Discount rate                                                      | 0%                     | 10%                     |
| Opportunity cost of land (b)                                       | \$0                    | \$200                   |
| <i>Costs (c)</i>                                                   |                        |                         |
| Seedling cost (\$/seedling)                                        | \$0.16                 | \$0.62                  |
| Thinning cost (\$/m <sup>3</sup> of thinned material)              | \$5/m <sup>3</sup>     | \$20/m <sup>3</sup>     |
| Harvesting cost (per m <sup>3</sup> of sawlog)                     | \$10.50/m <sup>3</sup> | \$42/m <sup>3</sup>     |
| Milling cost (per m <sup>3</sup> of sawntimber)                    | \$54/m <sup>3</sup>    | \$216/m <sup>3</sup>    |
| Drying cost (per m <sup>3</sup> of sawntimber)                     | \$60/m <sup>3</sup>    | \$180/m <sup>3</sup>    |
| Dressing cost (per m <sup>3</sup> of sawntimber)                   | \$70/m <sup>3</sup>    | \$210/m <sup>3</sup>    |
| <i>Transport distances (d)</i>                                     |                        |                         |
| Transport distance to mill (km)                                    | 25                     | 200                     |
| Transport distance to market (km)                                  | 50                     | 400                     |
| <i>Prices</i>                                                      |                        |                         |
| Timber price (wholesale price for graded & dressed sawntimber) (e) | \$750/m <sup>3</sup>   | \$3,000/m <sup>3</sup>  |

Notes:

- Growth rate was assumed to vary between 2m<sup>3</sup> and 10m<sup>3</sup>/ha/year, to represent the variation in yield which may occur within the low rainfall zone. For example, it more likely that higher growth rates would be achieved in the higher rainfall areas of the low rainfall zone (e.g. 500mm) than in the lower margin of that zone (e.g. 400mm).
- The opportunity cost was assumed to vary between \$0 and \$200, with \$0/ha representing zero value of the land for wheat production, and \$200/ha representing a 100% improvement in the gross margin for wheat.
- Costs of production and transport distances were varied by 50% to analyse their impact on the investment analysis.
- Transport distances were varied to reflect the distances for which sawntimber may need to be transported to both rural and city markets.
- The wholesale price received for dressed and graded sawntimber was varied by 50% to observe its impact on the investment criteria.

Figure 3.5. A Sensitivity Analysis of Changing Magnitudes of Variables on the NPV for Sawntimber Production.



Based on the sensitivity analysis (Figure 3.5) and the levels of variation (Table 3.6), the NPV of the investment (including establishment costs) becomes positive when the wholesale price of dressed and graded sawntimber is \$1,945/m<sup>3</sup> or when the discount rate is 2.7%. Reducing the discount rate has the greatest impact on improving the NPV, illustrating the long duration before returns are made on the investment. While improvements in each of these variables have the greatest singular impact on improving the NPV, other variables, when changed simultaneously, also have the potential of improving NPV to a positive state so that a rate of return of 5% is obtained. For example, improvements in the growth rate of trees in the low rainfall zone, combined with reduced milling, dressing and drying costs, would improve the overall investment outcome of sawntimber production, to the extent that the NPV would be positive. If the growth rate was varied on its own, it would need to increase from 5m<sup>3</sup>/ha/year to 11.7m<sup>3</sup>/ha/year to result in a positive NPV.

In comparison, transport distances, between the farm, mill and market, had little impact on NPV. Even when the transport distance between the mill and market was doubled (from 200km to 400km), the decrease in NPV was less than 9%. This shows the relative insensitivity of production of high value product in the low rainfall areas to transport costs.

Overall, the economic analysis suggests that the value of the timber produced in the low to medium rainfall zone would have to be very high in order for such a venture to be profitable. The risks associated with the long time period to harvest would also pose a constraint on investment. On the other hand, no value has been attributed in the analysis to by-products from the venture, and it is here that further economic potential may exist. It is suggested that further economic analyses incorporating potential by-product revenue should be conducted.

### 3.1.3 Summary of Prospects

Market opportunities vary for softwood and hardwood species, due to product end-use, price, quality and availability. While there are certain production and market niches for softwood sawntimber, such as species suitability to varying conditions (e.g. *Pinus pinaster* on sandy ridges), these factors are most likely outweighed by other production attributes. For example, the opportunity for softwood timber production in low-rainfall Australia is constrained most heavily by longer harvest rotations and distance from markets. Distance to markets can be critical in softwood sawntimber production, as the market price generally received may not be sufficient to cover costs associated with long transport distances. However, where processing infrastructure already exists close to the low rainfall zone, such transport cost disadvantages may be negated.

Longer rotation times are also a production factor which impacts on the profitability of hardwood sawntimber production in the low rainfall zone, although the higher prices paid for hardwood sawntimber can be substantial enough to absorb relatively large fluctuations in transport costs, as was illustrated in Figure 3.5. However, the prices received, and hence, the overall profitability of hardwood sawntimber production from low rainfall areas, is reliant on the effectiveness of these timbers being marketed as premium quality, value-added products. This is probably the

principal avenue available to agroforestry producers of timber products in this zone to recoup additional costs associated with longer rotations.

Finally, with regard to markets, domestic and international opportunities may exist for hardwood sawntimber in the future, if demand increases, as reported, or if supply from other countries declines. Supply from native stands may also decline in Australia due to increasing pressure to sustainably manage native timber resources. The majority of hardwood sawntimber in Australia has traditionally been sourced from native stands, although sawlog yield from hardwood plantations is expected to peak in 2010 at 24 times the present level.

However, production of quality hardwood timber from the lower rainfall areas of Australia would have to compete increasingly with hardwood plantations in high rainfall areas. A key factor is whether hardwood production in the low rainfall zone can differentiate its product sufficiently (e.g. appearance, density) from products that might be produced in the high rainfall zone from the same or similar species.

The economic analysis suggests that prospects for hardwood sawntimber production are not favourable, even at what might be considered a reasonably high price end product that enters the furniture market. In addition, it is unlikely that the market for such high priced products will be very large so that future production of hardwood sawntimber in this zone may be most realistically viewed as 'niche'.

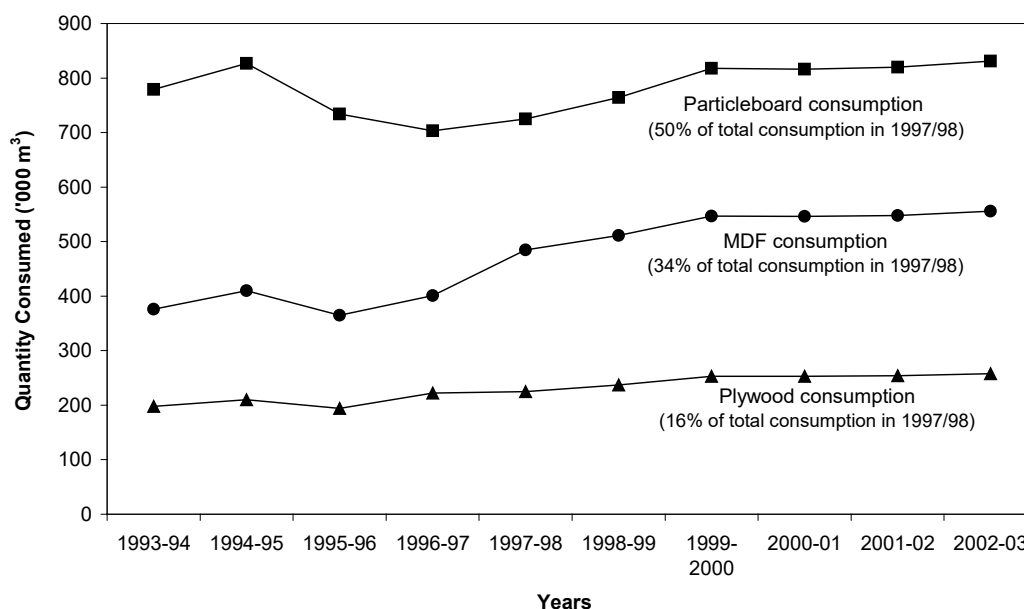
## **3.2 Wood Panel Products**

### **3.2.1 Market Overview**

Wood based panel products refer to those wood products which have been "layered, glued or reconstituted" (RIRDC, 1996). Products include veneers and plywood, particleboard, and MDF (Medium Density Fibreboard). Veneer is a thin section of timber, often used to cover lower quality wood, plywood is based on thin sections of timber layered together, and particleboard and MDF are reconstituted boards (RIRDC, 1996).

Australia currently consumes in the vicinity of 1.4 million m<sup>3</sup> of plywood, particleboard and MDF each year (Love *et al*, 1997). Of this, approximately 50% is particleboard, 34% is MDF and 16% is plywood. The past and expected future trend in consumption for these products is shown in Figure 3.6. While the trend in consumption for all three types of products is increasing (1.6 million m<sup>3</sup> by 1999/2000), the percent share each product has of the total market is increasing only for MDF. The share particleboard has of this market is declining, as is plywood. The decline in plywood, however, is only marginal. Veneer is also traded, although consumption figures are not available. As a guide, imports of veneer into Australia in 1994/5 were 20,690m<sup>3</sup>, up 13% from the previous year.

Figure 3.6. Australian Consumption of Selected Wood Panel Products  
1993/4 – 2002/3

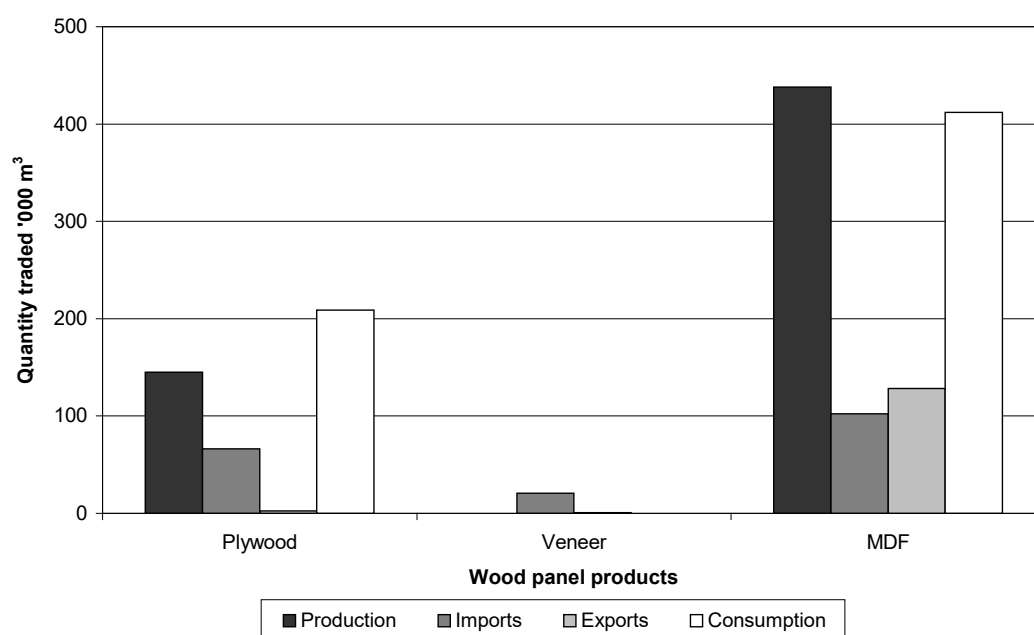


Source: Love *et al* (1997)

Plywood and veneers use both softwood and hardwood species, with the hardwood species utilised for their "feature" attributes in the veneer market where appearance is important, and the softwoods utilised in the plywood market where appearance is not as important. MDF manufacture uses both softwood and hardwood mill residues, whereas particleboard uses softwood residues only. Particleboard and other reconstituted boards (softboard and hardboard) are not covered in this section due principally to the perceived decline in growth in these markets. While oriented strand board (OSB), another type of reconstituted board, is a popular product in the USA, it is also not covered in this section, due to its low domestic consumption and value. The remainder of this section focuses on plywood and veneer, and MDF.

Australian production, trade and consumption for plywood, veneer and MDF are illustrated in Figure 3.7. Based on figures for 1994/95, Australia's consumption of MDF and plywood was met mostly by local production. Only import and export figures were available for veneer.

Figure 3.7. Production, Trade & Consumption of Plywood, Veneer & MDF, 1994/95



Source: ABARE (1995)

As illustrated in Figure 3.7, Australia imports more plywood and veneer than it exports. Australian MDF exports, however, outweigh imports. The main supplying nations for Australian imports of plywood and veneer are Indonesia and New Zealand (see Table 3.7). This is because both of these countries can efficiently source timber which is of large enough diameter and has a suitable grain for slicing and peeling into thin sections for veneer and plywood.

Table 3.7. Percentage of Plywood & Veneer Import Quantity by Country 1996/97<sup>p</sup>

| Country     | Plywood | Veneer |
|-------------|---------|--------|
| Indonesia   | 44%     | n/a    |
| New Zealand | 36%     | 5%     |
| Philippines | n/a     | 25%    |
| Other       | 20%     | 70%    |

Note: "p" is an ABARE notation used to indicate preliminary estimates.

Source: ABARE (1997)

Imports of veneer from New Zealand have fallen significantly since 1989/90. This has also occurred for other traditional supplier countries including Singapore, South Africa and Thailand. Imports from the Philippines and United States also declined, but are expected to rise again. The total veneer import market was forecast to increase in 1996/97 from the previous year's figures.

The years between 1989/90 and 1995/96 saw plywood imports steadily declining. However, this was expected to change with a forecast increase in imports for 1996/97 of over 74,000 m<sup>3</sup>, up 6% on 1989/90 imports.

Imports of MDF into Australia are dominated by New Zealand, although there has been a recent decline due to the increase in Australian production. For example, in

1994-95 Australia imported 100,000 tonnes of MDF from New Zealand, and this fell to 85,000 tonnes in 1996-97 (Love *et al* 1997). The forecasted increasing use of MDF in new constructions is expected to push overall consumption of MDF up significantly.

Traditionally, plywood and veneer have been sourced from mature, larger diameter trees, so that thin sections can be peeled and sliced from the log. However, new techniques which utilise smaller (diameter) logs have been recently developed, although not commercially proven. The idea of using juvenile timber was investigated by CALM in Western Australia, and led to the development of laminated flooring being produced from juvenile wood, and involved testing various veneer processing technologies. This particular development could have significant implications for low rainfall agroforestry if it can be proven at a commercial level. This is because it has the potential to significantly reduce harvest rotations, as it allows younger trees to enter the veneer market.

The commercial potential of this technology, however, is not only applicable to hardwood production in low-rainfall areas. For example, this technology also has applications with hardwood plantation thinnings in higher rainfall areas, thereby possibly eliminating the initial competitive advantage of the technology in the low rainfall zone. Laminated flooring produced from juvenile trees, however, is best suited to hardwoods with high density and durability, as is often exhibited in Eucalyptus species grown in the lower rainfall areas. In addition, while juvenile wood does not exhibit the same structural quality of more mature wood, it does have benefits in the 'knotting' quality of the timber. The branch knots of younger trees tend to be tighter than the knots of older trees where the branches have died. Although, it should be noted, that significant promotion of tight feature knots is likely to be needed to have the product accepted in traditional markets (Shedley, P. 1998, pers.comm.).

An export market opportunity for juvenile laminated flooring has been identified, although the market potential may not warrant harvesting for this product alone (Shedley, 1997). This type of product consists of core layers of softwood plywood and is covered in a layer of laminated hardwood veneer, such as from juvenile Eucalyptus species that could be sourced from the lower rainfall zone. The important attribute of the laminated flooring is its hardness and resistance to marking, characteristics often found in native hardwoods.

Other laminated veneer products from juvenile trees which are technically suitable are furniture, joinery squares, beams and slats for blinds, although the market potential for these products is not likely to be significant (Shedley, P. 1998, pers.comm.).

One of the most advantageous qualities of MDF is that it can have the visual characteristics of dressed timber which allow it to compete with sawn timber, but is less costly to produce than sawn timber, if produced from timber waste. It can be used in quality furniture manufacture and joinery. It is these 'quality' sensitive markets which are more likely to utilise hardwood MDF.

MDF technology is not limited to softwood timber species only. Hardwood species can also be used, and can give the product a marketing edge as a superior product to

softwood MDF. Research has shown that using wood material with different fibres produces MDF with different qualities. Also, the existing MDF market is based almost entirely on product manufactured from softwood, allowing any production of 'hardwood' MDF to be promoted in a different light (RIRDC, 1996).

### 3.2.2 Price & Cost of Production

As a guide to the prices that might be expected for wood panel products, estimates were taken from the State Forests of NSW Timber Market Survey (April, 1998). The average price for plywood in 1997 was approximately \$739-\$766/m<sup>3</sup>, based on plywood T&G (tongue and groove) and plywood bracing. The average price for MDF in the same year was estimated at almost \$452/m<sup>3</sup>. As a comparison, particleboard attracted a price per m<sup>3</sup> of around \$336. It is not known what prices would be received for hardwood MDF, although it is unlikely that hardwood MDF would command a higher price than, for example, hardwood plywood.

The variation in prices paid for wood panel products is the result of a combination of factors, including the cost of the resource and whether it is a waste product, the cost of processing and transport to processing facilities, and the demand for specific products in the market place.

The cost of producing wood for panel products is largely dependent on the rotation length. For example, growth rates for trees produced in higher rainfall zones are likely to be greater than those produced in lower rainfall areas. However, the ability for low-rainfall agroforestry species to compete with species growing in higher rainfall zones will depend on the type of wood panel product produced. For example, material for wood panel products which do not rely on appearance, strength or durability, are arguably best sourced from fast growing softwood species, produced in the higher rainfall zones. The types of wood panel products usually sourced from these types of timbers include reconstituted products like MDF, as well as plywood products. Fast growing, softwood species are suitable for these applications because they can be produced quickly and cost effectively, while still maintaining a quality standard suitable for such products as plywood. Timbers suitable for other higher value wood panel products, however, require a higher quality resource. For example, appearance grade veneers are generally sourced from hardwood timbers.

The rotation time required to produce the outer veneer layer for laminated flooring from juvenile species has been identified for *Eucalyptus globulus*. This species grows best in the 600-1500mm zone, and is suitable for harvesting for juvenile laminated flooring at approximately 9 to 18 years. As mentioned, there is little doubt that the rotation time for hardwood species produced in lower rainfall zones will be longer than in higher rainfall zones, although it is estimated that this time will not be significantly longer. For example, it has been suggested that production of *Eucalyptus* species in the 400-600mm rainfall zone for products such as juvenile laminated flooring may take up to 20 years.

The prospect of producing laminated flooring from juvenile species not only appears promising because of the reduced harvest rotation, but also due to the likely reduction in silvicultural practices. Juvenile trees used for laminated flooring are harvested when the branches are still green. Therefore, management input is at a minimum

because pruning is eliminated. As well, laminated flooring is manufactured from juvenile wood, and because the product uses thin slices of timber, drying problems, usually associated with wood from juvenile trees, are reduced.

The two major stages in producing the outer veneer layer of laminated flooring are to saw the logs into 'cants', and then to mill the cants into veneers. It has been suggested that producing cants at the plantation site would be more cost effective than transporting whole logs to a mill. A portable mill, at an average cost of \$10,000-\$15,000, could be used to produce cants in the field. The capital required for processing the cants into veneers, however, is significantly more expensive at around \$2 million. Clearly this type of investment would need to occur at a regional level, requiring growers to transport the cants to a central mill site.

Transport distances to MDF plants will need to be minimised, irrespective of whether mill residues or trees are used in the MDF plant. The profit margin for MDF production is generally lower than for solid wood products, due to higher processing costs and lower returns. As such, it is likely that MDF from agroforestry stands in low rainfall areas would be sensitive to transport costs and trees would have to be grown within a certain distance of a MDF plant. The quantities of product required might be difficult to assemble cost-effectively in low rainfall agroforestry. As an indication of the volume of input required for an MDF plant, potential output capacity of a new MDF plant was estimated at 150,000 m<sup>3</sup> and would require 280,000 m<sup>3</sup> of input material per annum (RIRDC, 1996). This equates to 56,000 hectares of hardwood trees harvested each year to support one mill (based on one hectare of trees in the 400-600mm rainfall zone producing 5m<sup>3</sup> per hectare per year).

### **3.2.3 Summary & Conclusion**

The prospect of producing laminated flooring from juvenile timber in low rainfall Australia appears promising, although it is subject to the technology being proven at a commercial level. The cost of production is likely to be lower than conventional timber production, as silvicultural practices are reduced, and returns are likely to be received more frequently, as the harvest rotation is significantly reduced. In addition, the processes required to mill the timber to produce laminated flooring has been demonstrated at a trial level, and although significant capital investment is required, milling could be justified at a regional level. However, effort is required to secure markets for this product, in terms of quantity and price. If juvenile timber used in laminated flooring can be marketed effectively, then agroforestry production in low rainfall zones could benefit. However, this will depend on the availability of alternative domestic sources for juvenile hardwood, such as could be used from thinnings of native stands.

Another potentially promising product market for low rainfall agroforestry could be in hardwood MDF. Ideally waste material would be used, to keep costs of production down. The cost of transport of the hardwood waste from low rainfall areas to an MDF plant could be a constraint, unless production areas in low rainfall areas increased to support regional MDF plants. Based on hardwood growth rates, an estimated area of 93,000 hectares would need to be harvested each year, with a much larger area planted to trees, to support one MDF plant. The economics of producing MDF from low rainfall hardwood species will depend on the cost of transporting the

raw material to a MDF plant, versus any extra return hardwood MDF may achieve over softwood MDF.

In conclusion, there are potential markets for wood panel products, particularly laminated flooring and MDF. However, issues of scale, costs of production and processing, and the potential market penetration are still uncertain. These factors are likely to inhibit potential and work against an economically viable operation.

Further, agroforestry production for wood panel products is more likely to be commercially viable if alternative products (e.g. posts, firewood, biomass for electricity) are sold from the agroforestry planting, so as to spread the risk associated with singular markets and to utilise the majority of the wood produced, which can be up to 80% of the log. As well, it allows cost sharing of establishment and management costs across multiple products.

### **3.3 Posts/ Poles**

#### **3.3.1 Market Overview**

One of the main differences between posts and poles is the age and size of the tree from which they are sourced. Posts are generally harvested as an output of forest or plantation thinning. While there are usually specifications on the shape and size of the post, the size and quality required are generally not as tightly specified as poles. As a result, the markets for each are different. Posts are used as inputs for vineyards and farm fencing, for landscaping and industrial use. Poles, on the other hand, have an application in the electricity industry, although this may be declining, and limited use in housing as supports and features.

The number of electricity poles in Australia in town areas with more than 30,000 people was estimated at almost 2.5 million (Dept of Communication and the Arts, June 1998). It was identified that approximately 1.4 million of these would be removed, as part of a national program to replace electricity poles with underground cabling. It is unclear as to how many of the 1.4 million are wood poles, however industry reports suggest that the wood market for electricity poles is more likely to decline than increase. Pilot programs, which are targeting new development areas, are being initiated in some capital cities, including Perth, Darwin and Brisbane. The aim is to install underground cabling for electricity (and other telecommunication cabling) for new developments while building and landscape work is being done.

In South Australia, it has been estimated that there are approximately 1 million electricity poles, constructed either from a combination of steel and concrete ('stoby' pole) and constructed by spun concrete only (cylindrical shape). Underground cabling is used in new areas, where distances are not great. All new subdivisions, since the 1970's, have used underground cabling (Schinnik, S. 1998, pers.comm.). Wood poles have always been difficult to source in SA, even since the 1920's.

Wood electricity poles are principally used to distribute electricity in non-urban areas in Western Australia, while steel poles are used in urban areas. Once again, it is difficult to estimate the proportion of each type of pole to the total, although the total number of electricity poles has been estimated at around 1 million. As with SA, all

new subdivisions in Perth utilise underground cabling for electricity distribution. In any case, the wood electricity pole market in WA is well supplied by local jarrah timber, which meets with the height requirement of 9.5-10 metres (Legena, F. 1998, pers.comm.).

In Queensland, wood electricity poles are common, probably because they are produced closer to the end use than they are in other states such as South Australia, with relatively lower costs. However, Brisbane is also to undergo a pilot program of establishing underground electricity cabling. The market for timber electricity poles in south east Queensland has been estimated to decline, rather than increase (Bartlett, G. 1998, pers.comm.). The number of poles in south east Queensland was estimated at around 600,000 (Tunny, J. 1998, pers.comm.).

In summary, the future market opportunity for wood used in the production of electricity poles in Australia is very limited. The trend in supplying electricity to consumers is to use underground installations or use cement and steel posts. There may be a continuing role for the use of electricity poles in rural areas but so far no estimate of the size of this market has been made. While there is also a market for specialty use of poles, such as feature supports in housing, this market is not significant in size, and is subject to trends of the day.

Posts for use in vineyards have traditionally been sourced from softwood timbers, mainly *Pinus radiata*, grown in the higher rainfall areas of Australia. The posts are produced as a derivative of thinning softwood plantations in coastal areas, and because they are produced relatively quickly in this rainfall zone, have generally been lower in price than hardwood species. Hardwood species, even in coastal areas, generally require more time to achieve the same growth diameters as softwood species and are not produced in the same volume. Subsequently, hardwood species grown in a plantation situation for post production have been unable to compete successfully with softwood species, due to cost of production. Posts for farm use, such as fencing, utilise hardwood timbers, although these are usually from existing native vegetation stands.

There are qualities of hardwood posts which are now being considered superior to softwoods for vineyard posts. While hardwood species take longer to achieve the same growth diameter, the wood usually exhibits greater strength and durability than those from softwood species. As a result, smaller diameter posts can be used in trellising with the same strength as larger diameter softwoods. This is an advantage because smaller size posts are less obtrusive to vineyard harvesters.

Market opportunities for hardwood post production are thought to exist in the grape industry. This market sector would be tied to the location and extent of plantings for wine and table grapes. The total area planted to vines in Australia (wine and table grape) for 1996-97p has been estimated at 88,474 hectares (ABS, 1997). Intended plantings for the 1997-98 season were estimated to be 5,895 hectares. It was indicated from other sources that plantings of wine grapes alone had reached its peak and that wineries (in the southern states) were not offering new contracts for grapes. It was estimated that new plantings for wine production would be around 2,000 hectares per annum over a 25 year period. However, the wine industry 'boom' saw 50% of this goal achieved in the period since 1995 (Weir, K. 1998, pers.comm.).

Even when existing areas of vineyards which already have trellises erected, are taken into account, these posts will only need replacing every 25-30 years (minimum). A quick stocktake of trellis posts used in the wine industry reveals that:

- South Australia uses all pine posts,
- NSW use mostly pine posts (60%), and a mix of pine posts with steel posts (30-40%),
- WA and Victoria use pine posts for uprights and steel posts elsewhere (approximately 30% pine posts and 60% steel),
- Queensland use is not certain, although the production area of wine grapes is relatively small compared to other states.

(Weir, K. 1998, pers.comm.)

Assuming an across the board timber post usage rate of 50% (for both wine and table grapes), and a standard trellising rate of 500 posts/hectare, the total market for vineyard posts for a production area of 88,000 hectares is 22 million posts. A standard timber post costs approximately \$5-\$6 each (depending where it is purchased). Therefore the value of the post market could be \$110 million over 25-30 years, or \$3.7 million each year (730,000 posts per annum), based solely on replacement of existing posts. However, it could be another 30 years before much of this market is available for replacement, considering the large plantings which have occurred in recent years.

A further indication of the potential market size for vineyard post replacement, involves assessing the likely area of trees required to fill the market each year. Assuming the requirement is for 730,000 posts to be replaced each year, and an average of 3 posts can be harvested per tree, the total area of trees harvested would be 240,000 per annum, or 240 hectares (assuming 1000 trees per hectare). Even if all vineyard trellis posts were timber, the total area of trees harvested each year to replace posts would only be 480 hectares.

Fence posts in rural areas could be another avenue for opportunity as the traditional source of supply becomes restricted. The market for fence posts in grazing areas is usually localised and draws on hardwoods growing naturally on private land or extraction from native forests. For this reason, the total "accessible" market may be quite small, because it may already be well supplied by local on-farm timber.

In addition, there have been suggestions that graziers could be moving away from timber fencing support and replacing it with steel supports (O'Dempsey, N. 1998, pers.comm.). The extent to which this further substitution may occur is not known, although the incentives for doing so at present, are not so much driven by the price for wood posts or steel posts, but more for the ease of erecting the posts. For example, steel posts are easy to drive into the ground and do not require holes to be dug or drilled, and hence reduce the labour cost for fencing.

### **3.3.2 Price & Cost of Production**

Certain specifications are set down for electricity poles, in terms of length, diameter, and straightness, and checks are made of end splits, knots, holes and other defects. As a guide, the height range for electricity poles can be between 8.5 and 20 metres,

depending on the load it is supporting and the terrain it crosses. Low-rainfall agroforestry pole production is not likely to pass as a viable option for electricity poles because specialised forest management is required to produce products with the appropriate dimensions, durability, and strength. More importantly, the rotation time for producing poles is lengthened in slower growing regions, such as those experiencing low rainfall.

It is claimed that using underground cables for electricity distribution, in certain areas, will incur lower costs for maintenance than for overhead poles. As well, the cost of maintenance for timber poles is greater than for steel and cement poles, because they need to be replaced more frequently, even though it can be up to 35 years. Prices for wood electricity poles can range from \$200 to \$1,500, depending on where they are purchased.

The opportunity for agroforestry to provide fencing material depends on the extent of substitution with steel posts and the degree of harvesting from native stands. Harvesting from native stands may decline in the long term due to conservation and sustainability reasons, thereby creating an opportunity for fence posts. The costs of production will also have a bearing on the economic viability of such an enterprise, however, time has precluded an analysis of the economics of production for fence posts in this report.

### **3.3.3 Summary & Conclusion**

The prospects for pole production from agroforestry in low rainfall areas of Australia are not particularly favourable. This is due to two main reasons:

1. The major market for poles is for electricity distribution. The size of this market is likely to decline as electricity distribution moves from overhead cabling to underground installations, and overhead distribution utilises cement and steel posts. However, there may be a continuing demand for such poles in rural areas, but such markets are likely to be restricted and localised.
2. Wetter climates in Australia, such as coastal Northern NSW where poles are currently produced, are more conducive to producing straight, sizeable trees faster than in drier areas of Australia. As well, more intensive management is required in the early years of production, to prune the trees. This means, that even if there were a significant market for poles, wood produced from low-rainfall agroforestry is not likely to be able to compete price-wise with other regions and may not return a profit to farmers so long as alternative sources of supply were available.

Similarly, the market potential for vineyard trellis posts is questionable. This is because production areas of vineyards may have already peaked, and the potential would exist only in replacing existing posts.

There may be greater opportunities for low rainfall agroforestry to produce fence posts. It is likely that fence posts would present an opportunity as a product from a multi-purpose agroforestry system, where the risk of the investment can be spread over a number of industries. For example, an agroforestry stand intended for the sawntimber market could be redirected to the post market if market conditions

deteriorate. As well, thinnings from agroforestry stands could provide an early income to what would otherwise be a long harvest rotation, such as for sawntimber. These fence posts would still be competing against those from remnants and native forests. However, these resources may be more sustainably managed in the future, thereby reducing their availability to the fence post market.

In summary, the demand for wood fencing, as opposed to steel fencing, varies between different regions in Australia. There could be growing opportunities for the replacement of fence posts in the future, particularly if harvesting from native stands is prohibited. It is expected there will be continuing, albeit restricted, demand for fence posts in the future. However, in the shorter term, the state of the grazing industries is likely to curb new fencing for a number of years and competition from steel posts could also reduce the size of the market.

### **3.4 Other Wood Products**

There may be more "niche" markets to which wood produced in the lower rainfall areas may be suited, for example, the musical instrument, craft and tool handle markets.

Markets may exist for wood products for use in musical instruments, such as flute heads, guitar frets, and violin bows. It has been suggested that the number of manufacturers of musical instruments in Australia is small, and are generally not interested in paying top dollars for timber for such uses. In contrast, international manufacturers of musical instruments are prepared to pay premium prices for Australian hardwood timbers, with prices possibly around \$3000/m<sup>3</sup>. International manufacturers of musical instruments have expressed interest over many years in Australian native timbers, like those commonly found in Western Queensland (Cause, M. 1998, pers.comm.).

While data are not available on the market size for timber used in musical instruments, there has been a suggestion that the value could be large, although the volume of timber is likely to be small compared with other wood industries, such as sawntimber. Rather than market size, perhaps the most important point to appreciate when considering low rainfall agroforestry for musical instruments, is the suitability of the timber and the harvest rotation required to achieve a minimum quality standard. For example, manufacturers of musical instruments seek very dense timbers. For this reason, timbers from native stands, which have been growing for many decades, may produce a superior product to that which would be produced in an agroforestry situation. Timber from agroforestry plantations, for use in musical instruments, may require long rotation times, to ensure the appropriate wood density is achieved.

Unless timber from agroforestry can be produced in long rotations, possibly even longer than has been suggested for sawntimber, timber for musical instruments may be better sourced from native stands. However, this is while harvesting from native stands is permitted. If this situation were to change, then the potential for agroforestry to supply timbers for musical instruments would need to be reassessed in terms of higher prices which might be received due to reduced supply, traded off against longer rotation times.

Specialty timbers for craft uses, such as wood turning and carvings, is another market niche which could be supplied from low rainfall agroforestry. It has been suggested that in Europe alone, there may be in excess of 1 million potential purchasers of wood for craft purposes.

As an example of the prices which might be received for wood sold in the Australian craft users market, Redgum burls were reported to have been sold for \$250/kg (State Forests of NSW, 1998). There is little doubt that the value of the market could be significant. Even though the craft market is likely to be larger than the musical instrument market in terms of timber volume, it is still likely to be a relatively small market compared with other wood markets. In addition, the harvest rotation required may also be very long.

Tool handles, which require hardwood timbers with exceptional strength and durability, may provide another niche market for low rainfall agroforestry. There are presently five manufacturers of tool handles in Australia, with over half of the total domestic market being supplied by imports. Imports of tool handles have traditionally been in the form of hickory wood from USA, but more laterally sourced from countries such as China. Manufacturers of tool handles are presently facing intense competition from suppliers of less expensive tools. For example, due to the lower prices of complete tools from China, consumers are electing to purchase new tools when tool handles break, rather than replacing just the tool handle. Competition for wood tool handles may also arise from non-wood products, such as fibreglass. While the tool handle market for wood is attractive in terms of the premium prices likely to be received, the potential for supplying this market is of a limited scale.

## 4. ENERGY

Wood biomass can be used to produce electricity or products such as charcoal, gas and liquid fuels to be used as energy sources.

Processes used to generate these energy forms include direct combustion (involving the burning of wood biomass, such as in biomass fired power stations using steam); gasification (in the presence of oxygen to produce combustible gas from biomass); pyrolysis (heating in the absence of oxygen to produce charcoal, gas or liquids); cogeneration (producing electricity in plants/factories as a by-product of normal steam generation processes); and production of liquid fuels (e.g. ethanol from the fermentation of biomass) (Mendelsohn & Sweeny, 1994).

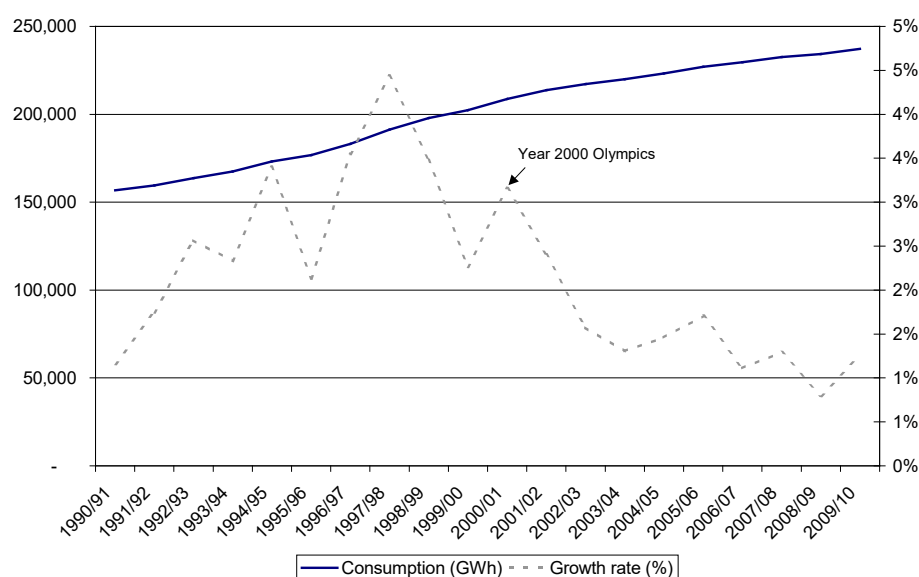
The efficiency and cost of conversion for each process varies, the technology available is more advanced for some processes than others, and the market size for products varies. With this in mind, the focus in this Chapter is on systems used to generate electric power (directly and indirectly) and liquid fuel. Wood combustion for domestic purposes (e.g. fires) is also addressed, as well as non-energy uses for charcoal, such as activated carbon.

### 4.1 Biomass for Electrical Energy

#### 4.1.1 Electricity Market Overview

Few would doubt the significant market size for electricity, present and future. Electricity consumption in Australia is almost 200,000 GWh and is expected to increase as population increases. The average growth in total consumption over the next 12 years is expected to be 1.8% per annum. This represents an overall drop in growth rate from 1998 onwards, even though total consumption continues to rise (see Figure 4.1.).

Figure 4.1. Electricity Consumption, Australia (1990-2010)



Source: Bush *et al* (1997)

Electricity consumption by state is shown in Table 4.1.

Table 4.1. Consumption of Electricity in Australia, 1997-98 (GWh)

| State             | GWh     | % of total |
|-------------------|---------|------------|
| NSW/ ACT          | 63,767  | 33%        |
| Vic               | 42,641  | 22%        |
| Qld               | 40,763  | 21%        |
| WA                | 19,700  | 10%        |
| SA                | 11,544  | 6%         |
| Tas               | 10,001  | 5%         |
| NT                | 2,836   | 1%         |
| Australia (total) | 191,252 | 100%       |

Source: Bush *et al* (1997)

Electricity in Australia is produced from a range of resources in each state, depending on the relative resource availability and price. The main inputs include black coal (used in NSW, Queensland and WA), brown coal (used in Victoria and SA), gas (used in SA, WA and Victoria) and hydroelectricity (used in NSW, Victoria, Queensland, and Tasmania) (Dalziell *et al*, 1993). Combustion to produce electricity is the dominant power generating process used in Australia.

The potential for biomass and other 'green energy' sources to take market share from traditional electricity generation inputs is promising, given the Federal Government commitment to increasing the utilisation of green power by an extra 2% by the year 2010. Legislation to support this initiative is being developed and is expected to take effect by the year 2000. It has been suggested, that existing green power sources (including biomass, water, sun, wind) will not be sufficient to achieve this goal. As a result, green power should find an easy market in the coming years. However, it is important to note that biomass marketed as 'green power' must qualify with 'green power' accreditation, such that utilisation of the resource does not have an overall negative impact on the environment.

Wood biomass for electricity will have to compete with electricity generated from coal, gas and water, or compete in areas where the true cost of electricity produced from these inputs is greater than the cost of producing electricity locally from wood biomass. Pricing in these rural markets is covered in Section 4.1.2.

In terms of utilising combustion technology, wood biomass from agroforestry must be able to compete in rural areas with electricity generated and transmitted from traditional sources, but also with alternative biomass sources. Alternatives include agricultural residues (from cotton and broadacre cropping), and domestic green waste. However, supply from some of these alternative biomass sources is disadvantaged, because it is seasonally produced and cannot be guaranteed.

Technology for the gasification of biomass to power is still in the development stage. A gasification unit (100kW) has been developed by CSIRO, but is not connected to an engine. The gasification to turbine process is well understood for inputs such as coal,

which has been used for decades, and also for municipal solid wastes. However, it is not well understood for wood biomass. There are no commercial applications of the gasification of wood biomass for power generation in Australia. Once the biomass is gasified, it is burnt in a turbine to generate electricity. It is this process which requires further research and development, as problems have been experienced with contaminants in the gas (tars, resins). Work is required on the cooling and cleaning of the wood biomass gas before it enters the turbine.

Alternative generators, such as wood gas-driven microturbines, potentially could be developed small enough for rural areas, without being exorbitantly costly. These could be regionally located, and established close to wood biomass sources. A suitable generating capacity may be up to 200 kW capacity, and this could be achievable with microturbines, although further development is required to achieve commercial status.

Gasification of wood technology overseas, however, is thought to be more advanced, with proponents of certain types of gasification technology claiming it is near commercial status (Webber, T. 1998, pers.comm.). Many companies are pursuing this technology. One company, Thermogenics Inc., is promoting its Thermogenics Gasification technology through its Australian licensee Bio-Lec. This particular technology has been designed in a modular format, with the equipment mounted on skids, for easy transport. The gasifier is linked to a standard natural-gas engine and generator for electricity production. Assumptions based on the Thermogenics Gasification technology (300kW capacity) is used in Section 4.1.3 for an economic analysis of wood biomass for electricity production.

Electricity generation is also possible as a by-product from factories which are already producing heat and steam from boilers. It is likely that all sugar factories will expand cogeneration over the next few years in order to better utilise excess bagasse. Bagasse is currently burnt in the existing mill boilers to produce steam for the mill's own use. A large cogeneration plant is currently under development at the Rocky Point Sugar Mill, in south east Queensland, to produce more electricity for external consumption. As well as the sugar cane biomass, additional biomass waste from the paper, cotton and timber industries are appropriate sources for electricity generation.

Cogeneration in sawmills is another possibility, with potential for mills to reduce electricity costs and generate their own electricity. For instance, a typical case might be where the mill burns its wood wastes in a boiler to drive a steam turbine and an alternator to produce electricity, either for the mill's own use or to feed into the main grid. In addition, steam could be extracted from the turbine to produce hot water, to be used in the mill's own processes, such as board-forming presses (Mendelsohn & Sweeney, 1994).

Technology used for the generation of charcoal, for use as activated carbon, can also be used to generate some electricity. This involves the partial burning of wood to produce charcoal, with the surplus carbon energy used to generate electricity. This process is covered in Section 4.4.

### 4.1.2 Prices & Cost of Production

One of the major effects of the deregulation of the electricity industry is that future pricing of electricity will reflect the true costs of production. This is already being experienced in south east Queensland where consumers have been given the option of purchasing "green power", but at a higher price. So while generators and retailers in the deregulated industry have the power to charge higher prices for differentiated electricity products, such as "green power", competition between green energy industries will work to reduce the market price. This may also affect the cost of inputs, such as wood biomass, thereby driving the price down.

While these issues are likely to affect pricing in the future, the true cost difference between providing electricity to rural and urban consumers is unlikely to surface. The true cost of producing and distributing electricity to rural areas in Australia is significantly greater than that for coastal and urban areas. This is because distribution lines have to be built and maintained to transmit the electricity to fewer users (O'Shae, T. 1998, pers.comm.). For example, estimates obtained from Ergon Energy and Energex, retailers of electricity in Queensland, charge an average of 12 cents per kWh for domestic usage. This average is based on a sliding scale of 15.14 cents for the first 100 kWh/month, 10.29 cents per kWh for the next 300 kWh/month, and the remainder charged at 9.18 cents per kWh. The price charged to all consumers of 12 cents per kWh subsidises the higher cost of supplying to fewer, more isolated rural users. It is the higher 'true' cost of supply to rural users, with which electricity generated from agroforestry biomass will have to compete.

Efficiencies in generation will partly determine the scope for electricity generation in rural areas. Diseconomies of scale start to increase with steam plants less than 2 MW in size (Anderson, C. 1998, pers.comm.).

Capital costs for a 10 MW generation plant, using direct combustion to produce electricity from biomass, were estimated to be \$9 million, with an annual operating cost of \$450,000 per annum (Mendelsohn & Sweeny, 1994). The cost efficiencies of this size plant, versus a smaller plant are demonstrated in the figures below, which refer to a 1 MW plant.

A 1 MW combustion plant would cost \$1.5-\$2 million to establish. To operate the plant, a reliable water supply is required. The quantity of water required is a function of the size of the generation plant and the quality of water. As well, the fuel requirement for a 1 MW sized plant is approximately 10,000 tonnes of biomass per annum. If the wood biomass is mostly logs or in a compact form, then it may be more efficient to transport the whole logs to the generation plant. However, if the biomass is mostly foliage and non-compact branches, then it will need to be chipped, prior to being transported to the plant. A chipper mounted on the back of a trailer could be used. It should be noted, that technology is being developed in the US which harvests and burns the whole tree, with zero requirement for chipping. However, for this process to be efficient, the plant capacity must be 100 MW, a size which is not likely to have commercial potential in the low rainfall areas.

In comparison, other technologies which involve the gasification of wood, and the use of the wood gas in engine-generator sets, could be priced at around \$750,000 for a

complete unit with a 300kW generating capacity (Webber, T. 1998, pers.comm.). However, this cost is an estimate only, based on gasification technology which is still being developed for commercial applications.

Other costs associated with generating and distributing electricity in rural areas include the cost of wiring. This is required to transport the electricity from the point of processing to the main grid. This cost is determined by the distance between the plant and the grid. If this distance is great, then it may be more efficient to transport the biomass to a generation plant which is located closer to the electricity grid.

While the example above refers to the costs of a 1 MW generation plant, steam turbines smaller than this are available on the market. These turbines go down to a generating capacity of 100 kW, but prices for these units per kWh increase exponentially the smaller the generating capacity. The same applies to mobile units. This is where the gas-driven microturbines would be highly preferable. The next section considers a 300kW gasification-generator plant, as has been constructed by Thermogenics Inc. in the United States.

### **4.1.3 Economics**

To ascertain the long-term economic feasibility of biomass for electricity production, an investment analysis was conducted. Base assumptions are summarised in Table 4.2. It is very important to note that these assumptions are based on best-guess estimates from a range of industry sources. Most estimates have been sourced from Bio-Lec in Australia, based on the gasification technology developed by Thermogenics Inc. in the United States.

An investment analysis was initially carried out with costs included for growing biomass specifically for electricity generation. The results of this preliminary analysis showed such a venture to be uneconomic, and hence the investment analysis that follows refers to variations in costs for the biomass. As it is likely that biomass for electricity generation would be sourced from wood waste, the cost of biomass in the base case has been set at \$0 per tonne.

One of the processes involved in the gasification of wood biomass for electricity generation includes the preparation of the feedstock, ready for feeding into the gasifier. This includes harvesting, chipping and drying the wood biomass to approximately 5 cm pieces. Ideally, the moisture content should be less than 30%, although some gasifiers will handle moister material. The harvesting equipment assumed in the investment analysis is based on the harvesting system proposed for eucalyptus oil production in Western Australia. This system involves harvesters cutting the stems of coppiced trees close to the ground, and feeding the stems through a chipper. The chipped leaf and wood material is separated with air, at the harvesting site, so that only the chipped wood biomass is transported to the gasifier. Waste heat from the gasification process (reactor, gas cleaner and gas cooling stages) is recovered for drying the chipped wood biomass, prior to being fed into the gasifier.

The next stage is the gasification of the chipped wood. The gasifier is based on the Thermogenics gasifier (Model #103) which can feed gas to an engine/generator set with a capacity of 300kW. It is important to realise that this particular model has not

been proven at a commercial level (Webber, T. 1998, pers.comm.). The gasification involves automatic feeding of the biomass, via an auger, to the reaction tank of the gasifier. At this stage of the gasification process, gas, unreacted solids and waste ash are produced. The ash is disposed of, the unreacted solids are fed back into the reactor, and the gas is fed to the gas cleaning and cooling stage of the process.

The gas produced from the gasification of wood biomass, based on the Thermogenics model, is suitable for input into a standard natural gas internal combustion engine. The engine is a standard "spark-ignited" gas engine, connected to a generator to produce electricity. While the generating capacity of the gasification-engine/generator plant described above is 300 kW, the plant is also required to operate at lower levels in non-peak times. The gasifier in this case, can be "turned down" to operate at 50% capacity.

Table 4.2. Base Assumptions Used in Investment Analysis for Electricity Production

| Variable                                             | Base Value |
|------------------------------------------------------|------------|
| <i>General</i>                                       |            |
| Cost of wood (green) per tonne (a)                   | \$0/t      |
| Ratio of dry to wet wood (b)                         | 50%        |
| kWh per tonne of dry wood (c)                        | 1100 kWh/t |
| <i>Cost of Production</i>                            |            |
| Gasification operating costs (\$/year) (d)           | \$157,375  |
| Electricity generation operating costs (\$/year) (e) | \$12,500   |
| <i>Capital Costs</i>                                 |            |
| Wood gasifier (f)                                    | \$500,000  |
| Gas engine & generator (g)                           | \$250,000  |
| <i>Returns</i>                                       |            |
| Electricity retail price per kWh (h)                 | \$0.12/kWh |

Notes:

- The cost of wood biomass (green) was assumed to cost \$0/tonne for the base analysis.
- The ratio of dry wood to wet wood was sourced from Primary Industries of South Australia in their Fact Sheet "Farm Forestry – woodlotting for timber, posts and firewood", Agdex No. 300/17, October 1995.
- The kWh of electricity produced from one tonne of dry wood was sourced from Bio-Lec for the Thermogenics gasification technology (Webber, T. 1998, pers.comm). The estimate was based on a gas-fired internal combustion engine-driven generator.
- Operating costs for the gasification unit are based on 24 hour operation for every day of the year and include one labour unit at \$15/hour, maintenance costs at 5% of capital (\$25,000/year), and ash disposal at \$25/tonne. The quantity of ash disposed is assumed to be 1.5% of the total input of wood biomass. In this case, the maximum requirement for dry wood was assumed to be 7.2 tonnes per day. It has also been assumed from information from Bio-Lec and Thermogenics that the diesel fuel required to start the gasifier would be minimal
- The operating costs for electricity generation are based on 5% of capital costs for maintenance. The same labour resource used in gasification is assumed and is not costed as additional to electricity generation.
- The capital cost for the wood gasifier was based on costings from Bio-Lec for the Thermogenics gasifier, Model #103, with a processing capacity to suit a 300kW generator.
- The capital cost for the engine-generator set was based on estimates from Bio-Lec, and was assumed to have a generating capacity of 300kW.
- The retail price for electricity was sourced from Ergon Energy's "Domestic, rural and commercial prices" booklet, and is the average of the three prices for Tariff 11 (15.14, 10.29 and 9.18 cents per kWh) = 11.53 cents, rounded to 12 cents/kWh.

The base results of the analysis found that it was economic to produce electricity from wood biomass at this scale, assuming that the wood biomass was obtained free of charge, and based on the other assumptions in Table 4.2. The NPV produced from the 30 year investment analysis was \$855,182, a B/C ratio of 1.2 : 1, and an IRR of 19%.

The assumptions used to estimate the NPV for the 30 year investment analysis are based on some very rough estimates, particularly with regard to the capital equipment and maintenance costs for gasification. The existing cost of producing and delivering electricity to regions in the low to medium rainfall zone is also uncertain, and for the purposes of this analysis has been assumed equal to the average retail price in Queensland (about 12 cents per kWh). Because of this uncertainty, a sensitivity analysis of these variables and others, was conducted. The results are charted in Figure 4.2 and are based on the variations in Table 4.3.

Table 4.3. Assumed Range of Specific Variables for Wood Biomass to Electricity Investment Analysis

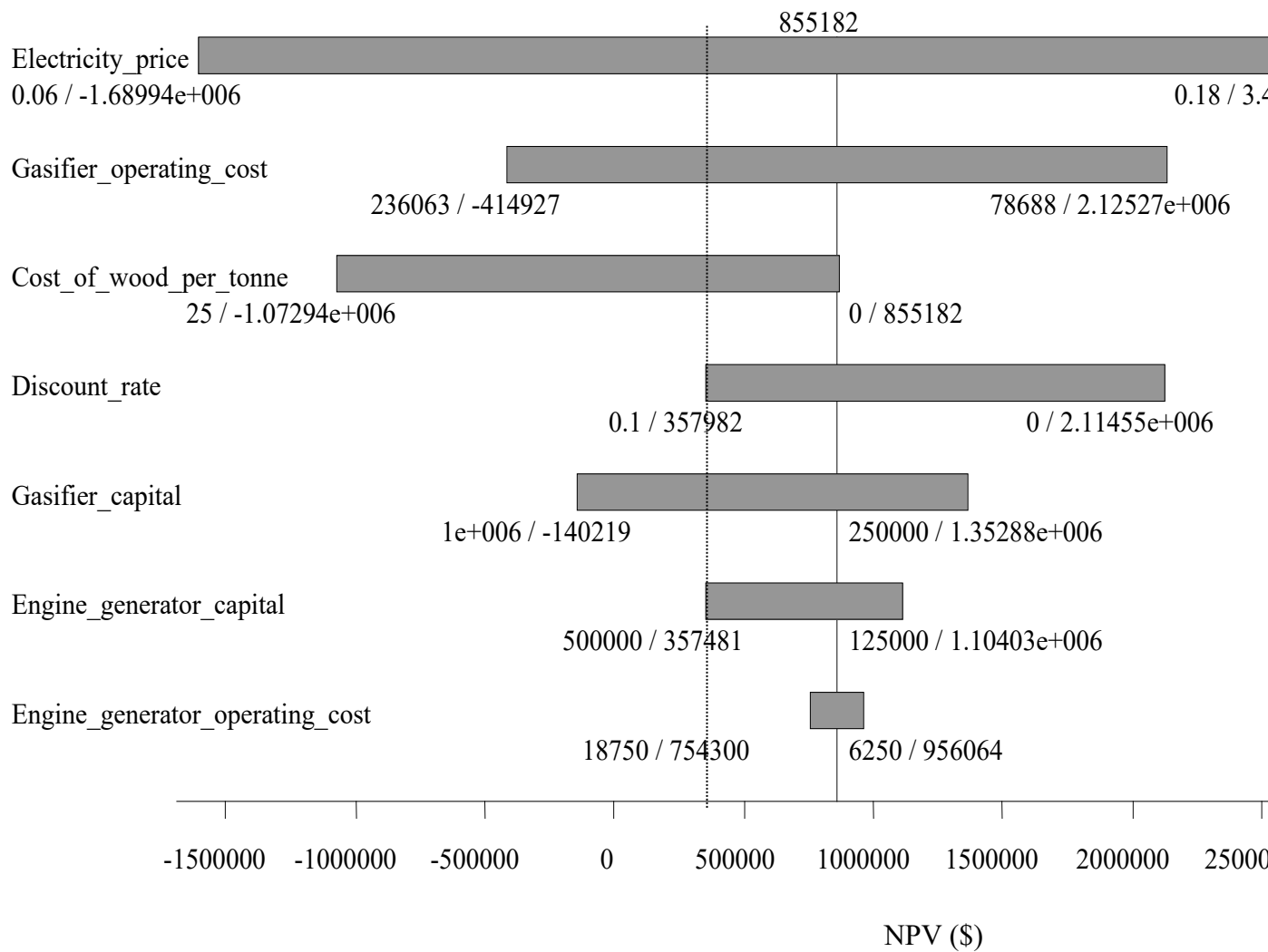
| Variable                               | Minimum    | Maximum     |
|----------------------------------------|------------|-------------|
| <i>General</i>                         |            |             |
| Discount rate                          | 0%         | 10%         |
| Cost of wood biomass per tonne (green) | \$0/t      | \$25/t      |
| Electricity price (a)                  | \$0.06/kWh | \$0.18/kWh  |
| <i>Operating</i>                       |            |             |
| Gasifier operating cost (a)            | \$78,688   | \$236,063   |
| Engine/generator operating cost (a)    | \$6,250    | \$18,750    |
| <i>Capital</i>                         |            |             |
| Gasifier capital (b)                   | \$250,000  | \$1,000,000 |
| Engine/generator capital (b)           | \$125,000  | \$500,000   |

Notes:

- a) The electricity price, and operating costs for the gasifier and engine/generator were varied by 50%.
- b) The capital for the gasifier and engine/generator were halved and doubled to test the sensitivity on NPV. The capital costs were doubled to show the impact if reserve equipment was installed to guarantee supply continuity.

The results of the sensitivity analysis in Figure 4.2 show that increasing the electricity price by 50% to \$0.18/kWh will increase the NPV of the project from \$855,182 to \$3.4 million. While the true cost of providing electricity to rural areas is greater than the cost of providing to areas closer to the point of power generation, some subsidisation of these prices occurs to ensure the retail price for domestic electricity is the same for rural residents as it is for urban residents. In light of this, the cost of electricity to rural areas, such as in the low rainfall zone, is likely to be at least \$0.12/kWh, if not more, due to the cost of transmitting the electricity to distant areas. Under these conditions, the investment can afford to pay \$22/dry tonne for the biomass when the electricity price is \$0.12/kWh, or \$88/dry tonne when the electricity price is \$0.18/kWh, in order to obtain a 5% rate of return. However, any excess electricity generated that has to be fed back into the grid for consumption elsewhere would no doubt be sold at a lower price than \$0.12 /kWh. Such excess electricity could be minimised as the plant can be 'turned down' to attempt to equate supply with demand. More accurate information regarding the actual cost of supplying electricity to rural areas should be assembled to provide verification of the results of the analyses presented here.

Figure 4.2. A Sensitivity Analysis of Changing Variables on the NPV for Electricity Production from Wood Biomass



#### 4.1.4 Summary & Conclusion

In summary, wood biomass produced from low rainfall agroforestry would need to be produced at a price which is competitive in the rural electricity market, while still ensuring the production is economically viable. The true cost of present electricity production is higher in rural areas because there are higher infrastructure costs, transmission costs, and transmission losses (due to friction in the lines) per kW, for electricity being transmitted to fewer users.

Also, the Federal Government's mandatory goal of more green power being utilised to produce electricity, combined with the deregulation of the electricity generation and supply markets, will enable 'green power', such as wood biomass, to be priced higher than electricity generated from non-green sources.

The options for electricity generation in the low rainfall areas of Australia are limited by the scale of generating equipment which is presently, or likely to be, available. For example, conventional steam-driven generation is unlikely to find an application in these areas, because of the large-scale nature of the equipment. Smaller generating equipment is available, although the capital costs increase significantly the smaller the generating capacity.

Electricity generation for small rural communities is more likely to be in the form of small scale gasification units, which could either be coupled to an engine driven generator, or to a gas-driven microturbine. Microturbines, driven by wood-gas, could allow the linkage between biomass and electricity to rural areas. This is because the technology is likely to be available to establish gas-driven microturbines of a suitable size (e.g. 200kW) in areas relatively close to low-rainfall agroforestry. However, microturbine technology, driven by wood-gas, is not commercially available.

Engine driven generators, however, are commercially available, and can be fuelled by relatively small scale wood gasifiers to generate electricity. An economic analysis of this technology showed that, utilisation of wood biomass to generate electricity was economically viable, when the electricity was sold for \$0.12/kWh and the biomass was sourced at zero cost. This assumes that the biomass would have to be sourced as a waste product of another agroforestry enterprise. However, the price paid for the dry wood biomass could increase to \$22/dry tonne before the investment became uneconomic. The estimate of the price of \$0.12 /kWh is uncertain. This figure would need to be based on the true cost of delivering electricity generated from traditional sources to low rainfall areas. No authoritative estimate of this cost was able to be made.

Cogeneration is another process which should be considered as a viable option for wood biomass utilisation. The main application would be adoption by factories already operating in the 400-600 mm zone.

## **4.2 Biomass for Liquid Fuel**

### **4.2.1 Market**

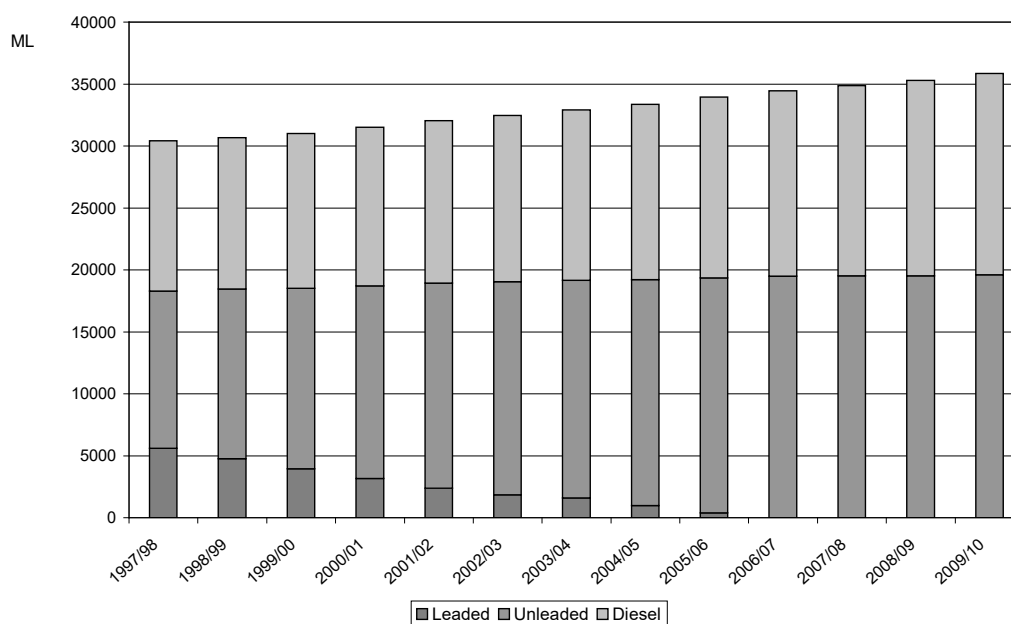
Biomass, used in the manufacture of liquid fuels, is a subject which has been researched extensively in the past. For example, agricultural crops, particularly sugarcane for ethanol production has attracted attention as an alternative fuel source since the 1920s and ethanol is presently manufactured for industrial uses. The two major producers of industrial use ethanol in Australia are CSR (using molasses from sugar) and the Manildra Group (using wheat starch). Wholesale prices for ethanol in this market range between 70 and 90 cents per litre. A retail example of this industrial material is methylated spirits.

Apart from the well-established conventional sugar and starch based processes, research has been conducted on woody biomass as a source of ethanol, although processes have yet to be commercially demonstrated in Australia. These processes involve converting the cellulose portion to its component sugars. Ethanol can be produced from the distillation of sugar, starch or cellulose. Biomass suitable for ethanol production includes sugar cane, cereal crop residues (such as the stalk remaining after harvesting of maize and grain sorghum), oilseed crops (canola, sunflower, safflower), potato, timber thinnings (from native stands and plantations), sawmill wastes, municipal solid wastes (MSW), crops grown specifically for cellulose production, woody weeds and home garden prunings.

World-wide consumption of industrial-use ethanol is currently in the order of 12,000 megalitres annually. As a liquid fuel, ethanol is also widely used, either blended with gasoline (petrol) or neat, as an alternative fuel in modified gasoline engines. Ethanol can not be substituted as neat fuel for diesel engines but, at up to 15 percent, can be blended with diesel fuel without any engine modifications. Ethanol's potential demand as a liquid fuel is determined by reference to the demand for and cost of petrol and diesel fuels.

Consumption of petrol and diesel in Australia in 1997-98 was estimated at over 30 billion litres, with potential to grow by almost 18% by 2010. The expected future consumption of petrol and diesel is charted in Figure 4.3.

Figure 4.3. Expected Consumption of Petrol and Diesel, ML (1997 to 2010).



Source: Bush *et al* (1997)

With a total petrol and diesel market forecast for 1998/99 in Australia at almost 31 billion litres, the potential for ethanol, at 20% market penetration, is 7 billion litres per annum. Estimates suggest the rate of biomass conversion to ethanol is 1000kg of dry biomass to 300 litres of ethanol. At this rate, the volume of biomass required to fill 20% of the fuel market in Australia would be 24 million tonnes each year. This is equivalent to approximately 480,000 hectares harvested each year. Even 1% penetration of this market (359 million litres of ethanol) would require 1.2 million tonnes of biomass each year, or 24,000 hectares harvested annually. The tonnes of biomass required at various market penetration rates is summarised in Table 4.4.

Table 4.4. Potential Market for Ethanol

| % ethanol substituted for Petrol/ Diesel | Market size (million L) | Million tonnes dry biomass required p.a. |
|------------------------------------------|-------------------------|------------------------------------------|
| 1%                                       | 359                     | 1.2                                      |
| 5%                                       | 1,793                   | 6.0                                      |
| 10%                                      | 3,586                   | 12.0                                     |
| 15%                                      | 5,378                   | 17.9                                     |
| 20%                                      | 7,171                   | 23.9                                     |
| 50%                                      | 17,928                  | 59.8                                     |
| 100%                                     | 35,855                  | 119.5                                    |

## 4.2.2 Prices & Cost of Production

The true cost of petrol and diesel fuel is the bowser price less federal excise and the various state taxes (for example state taxes exist in NSW, but not in Queensland, and state taxes within NSW vary between regions). In June 1998, the wholesale list price for petrol and diesel in Queensland (metropolitan) was 64.84 cents/litre for leaded, 62.67 cents/litre for unleaded, and 59.98 cents/litre for diesel. The current federal excise on automotive fuel is 34.7 cents/litre for unleaded petrol and diesel and 36.87 cents/litre for leaded fuel. The resulting net price (wholesale less excise) is the refinery price plus distribution. Leaded and unleaded petrol is 27.97 cents/litre and diesel is 25.28 cents/litre. Despite recent substantial reductions in the spot price of crude oil, the wholesale fuel prices have not varied markedly and are thus considered likely to remain stable in the near future.

Also for the near future, ethanol's longstanding exemption from Commonwealth excise and some (e.g. NSW) State fuel taxes are expected to remain. Nevertheless, foreshadowed restructuring of Australia's taxation system may result in the abolition of all such imposts, in which case ethanol's excise free status will no longer provide any competitive advantage in the liquid fuel sector. Consequently, as a substitute liquid fuel, ethanol's potential viability is considered below in terms of the pre-excise prices of diesel and petrol.

Ethanol processing plant sizes between 50ML and 100ML of ethanol output each year were considered suitable sizes for commercial operations. Costings for establishing and operating an ethanol plant were estimated by Gorton Timber Company Pty Ltd in 1994. The costs were estimated for a 2ML ethanol plant, and scaled up by Gorton Timber to a 50ML plant. The principal costs are summarised in Table 4.5.

Table 4.5. Establishment and Operating Costs of 50ML Ethanol Plant

| Cost Category                                    | \$/litre ethanol |
|--------------------------------------------------|------------------|
| Capital (a)                                      | \$0.07           |
| Labour operating costs (b)                       | \$0.05           |
| Feedstock cost for dry biomass (c)               | \$0.17           |
| Other consumables (d)                            | \$0.01           |
| Overheads (communication, insurance, land taxes, | \$0.18           |
| Energy operating costs (e)                       | \$0              |
| Cost to produce ethanol                          | \$0.48           |

Source: Gorton Timber Company Pty Ltd (1994)

Notes:

- Capital includes equipment in Year 1 of \$42.657 million, site and infrastructure costs of \$16 million, and working capital of \$11.636 million. In addition, plant upgrade was included for 30 years, including \$2.5 million in the 5<sup>th</sup>, 10<sup>th</sup>, 20<sup>th</sup> and 25<sup>th</sup> years, and \$25 million in the 15<sup>th</sup> year. A return of \$5 million in the 30<sup>th</sup> year came from selling the plant and site. The capital cost per litre of ethanol is based on the net capital cost over 30 years divided by the ethanol produced over 30 years. Capital equipment includes the cost of a combined heat and power (CHP) cogeneration facility to convert the by-product lignin to steam and electricity to run the plant.
- Labour operating costs includes the labour component of receiving the feedstock, labour used in conversion processing, ethanol dispatch, and plant management, estimated in total at \$2.5 million annually. It is also assumed that there is continuous operation of the plant for 330 days per annum.

- c) The price of feedstock per L of ethanol is based on the conversion efficiency of the feedstock and the price per tonne paid for the feedstock. A feedstock price of \$50/tonne of dry wood and a conversion ratio of 3.3kg of feedstock to 1L of ethanol were assumed.
- d) "Consumables" in the ethanol plant include sulphuric acid, yeast, lime and potassium carbonate. Significant volumes of water are also consumed in the plant, estimated at 500 million litres of water for a 50ML ethanol output plant. Water has been included at a cost of \$0.50 per kL.
- e) The solid lignin waste is consumed within the plant to generate steam and electricity to operate the plant. It is assumed that excess electricity and energy is not sold. The efficiency of conversion of solid lignin to electricity and steam is assumed to be 30%.

It should be noted that the costs in Table 4.5 assume the cost of feedstock is \$0.17 per litre of ethanol. This estimate was based on \$50/tonne of dry wood biomass and a conversion ratio of 3.3 kg feedstock to 1 litre of ethanol. In Gorton Timber's feasibility study, however, a more precise calculation for the biomass required to produce ethanol was incorporated. As a result, the selling price for ethanol was calculated at \$0.44/litre.

Other research into converting lignocellulose into ethanol has identified that lower costs are incurred if the material is chipped prior to being transported to the processing plant. For example, a study funded by the NSW Office of Energy (Fraser *et al*, 1995) found that it cost \$10 per tonne of biomass more if the material was transported whole. The cost of harvesting and transporting the chipped biomass (from existing woody weed stands) to the processing plant was reported as \$21-\$26 per tonne (Fraser *et al*, 1995). This compares with ERDC's estimate of the cost of sourcing wood biomass as a harvesting or processing by-product of annual or short-rotation crops at \$20-\$36 per tonne (dry) (Mendelsohn & Sweeny, 1994). Also by comparison, the Gorton Timber study's estimate of \$50 per dry tonne is based on the current costs of harvesting and freight for forestry residues exhibiting a moisture content substantially higher than most of the materials considered by these other studies.

The costs associated with large scale production of ethanol from biomass as estimated by Mendelsohn and Sweeny are summarised in Table 4.6.

Table 4.6. Comparing Costs of Production of Wood Biomass to Ethanol, in a Plant Processing 50-120 million litres p.a.

| Method of Ethanol Production                                                                                                                                                                                                                                  | Cost of Ethanol \$/L |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 1. Cost of producing ethanol, based on agroforestry biomass being produced as a by-product of another agroforestry industry (e.g. sawntimber). Price paid for agroforestry biomass \$20-\$36/ dry tonne.                                                      | \$0.60 - \$0.70      |
| 2. Cost of producing ethanol, based on the full cost of production for agroforestry biomass and includes a mix of cereal straw to produce the ethanol. Price paid for agroforestry biomass \$118/ dry tonne plus price paid for cereal straw \$40/ dry tonne. | \$0.70 - \$0.85      |

Source: Mendelsohn & Sweeny (1994)

Mendelsohn and Sweeny (1994) estimated the cost of producing ethanol to be \$0.60-\$0.70 per litre. This was based on a price paid for agroforestry biomass of \$20-\$36/dry tonne. The cost, when based on a mix of agroforestry biomass and cereal straw at a price of \$118 and \$40/dry tonne respectively, increased to \$0.70-\$0.85 per litre of ethanol. These costs of producing ethanol are significantly different to those estimated in the Gorton Timber study, even though the cost of sourcing the biomass was greater in the Gorton Timber study than the Mendelsohn & Sweeny examples. An explanation for the significant variation in costs of producing ethanol between the two reports could be the consideration of different technologies to produce the ethanol (Reeves, R. 1998, pers.comm.).

Mendelsohn and Sweeny (1994) highlighted that the largest cost in the processing of ethanol from wood biomass is the cost of handling and treating the biomass (hydrollysing the cellulose to fermentable sugars). They envisaged that this cost could be reduced with further research and development to improve efficiencies. Another issue to consider in the establishment of an ethanol plant is water consumption in the plant. For example, high water consumption for an ethanol processing plant could present a problem if a plant was to be established in the lower rainfall zones of Australia. Wastewater disposal should also be considered. These issues appear to be addressed by the conversion process on which the costings for the Gorton Timber study are based.

The preferred situation for agroforestry would be if the resource stock for ethanol production were produced as a by-product from another agroforestry industry. In this case, much of the cost of production of biomass would be covered by the 'mainstream' production, such as timber or eucalyptus oil. The costs and management techniques associated with wood biomass in this case would depend on the 'mainstream' use. For example, biomass produced for eucalyptus oil uses coppiced stands where stems would only be small in diameter. Production of biomass for ethanol from a timber stand, however, would be associated with thicker stems and may be the result of thinning management or waste production at a sawmill or other wood processing operations.

The examples quoted here for ethanol production assume a large-scale operation. A 50 megalitre plant as considered by Gorton Timber would require an annual feedstock supply of 170,000 dry tonnes, and other processes as considered by the ERDC study, more. Such supply would involve the annual harvest of 3,400 hectares at a rate of 50 dry tonnes per hectare. Given a dryland agroforestry growth rate of 1 green tonne per hectare per annum, and assuming the fuelwood component to be one third of that, a regional resource of 1,020,000 hectares would be needed to sustain an annual demand for 170,000 dry tonnes of biomass feedstock. Of course were other timber demands lacking, more than one third of that annual growth would be available as fuelwood and thus the necessary resource base would be less than the 1.02 million hectares suggested above.

Compared with the potential scale of electricity generation considered earlier, ethanol production is not only very large but complex. There is little prospect of ethanol production being viable at less than 50 million litres annual capacity. Nevertheless a regional resource base of 1.02 million hectares (being 10,200 square kilometres) is little more than one third of a circular catchment having a radius of 100 km.

Again referring to Section 4.1 and dry wood biomass costing \$22 per tonne for electricity production to break even, it is most unlikely that feedstock supplies of the scale needed for ethanol production would be available at that price. However, in circumstances where large quantities of higher valued wood material are processed (e.g. sawmills), there is likely to be significant quantities of residues available. As a potential fuelwood, such residues could well be cost-effectively supplied, at \$22 per dry tonne or less, for either ethanol production or electricity generation.

In terms of the Gorton Timber study, the assumed \$50 per tonne feedstock cost would be reduced accordingly if residues could be utilised. Despite this possibility, there is presently no firm basis for presuming a low rainfall agroforestry resource will generate any large yield of processing residues, except perhaps for eucalyptus oil. Consequently, it is considered more realistic to ignore any prospect of \$22 per dry tonne feedstocks for ethanol and, rather, to consider ethanol's potential viability on the basis of \$50 per tonne feedstocks and an output price of 48 cents per litre.

As noted earlier, the current price of industrial-use ethanol ranges between 70 and 90 cents per litre. Compared with that, biomass produced ethanol at 48 cents per litre could be highly competitive in a world market presently of the order of 12,000 megalitres per annum.

Apart from the likely competitiveness of 48 cents per litre for ethanol as an industrial grade material, the question remains as to its viability, at that price, as a liquid fuel. In that case potential demand could be entirely domestic, whereas access to the industrial use market would require some export orientation.

Total replacement with existing liquid fuels would be difficult for ethanol based on the price differential. However, to be a liquid fuel wholly compatible with the existing demand infrastructure, ethanol's role has always been proposed as a blend with conventional petroleum fuels. As such the extent of blending well-established as most compatible is:

- With petrol – 10 percent as gasohol E10
- With diesel – 15 percent as diesohol E15

Both these blends are well established as imposing virtually no need to modify the consumption infrastructure, while at the same time offering demonstrated benefits regarding pollution without offsetting performance losses.

Fuel ethanol at 48 cents per litre appears costly by comparison with the untaxed wholesale price of diesel (25 cents per litre) and petrol (28 cents per litre). With 10 or 15 % substitution by ethanol the prices for the blend rise only to 28.45 (diesohol E15) and 30.0 cents per litre (gasohol E10).

Having regard to the various issues for Australian liquid fuels supply, resource security, refinery balance, self sufficiency air pollution and greenhouse, such price premiums may be achievable in the same way that premiums may be achieved by 'green power' electricity.

### 4.2.3 Summary & Conclusion

There are two major reservations as to the potential for viable ethanol production from agroforestry production in the low to medium rainfall zone. Of these the more important is the capacity for any such region to supply conversion feedstocks at the minimum scale of 170,000 dry tonnes per annum as considered necessary by the Gorton Timber study. The other important reservation is that the preferred conversion process has yet to be commercially developed. However, it is noted that a pre-commercial demonstration plant is presently proposed by State Forests of NSW, in association with the Manildra group and substantially assisted by Commonwealth funding.

Presuming that this demonstration supports an ethanol production cost of 48 cents per litre, there is potential in biomass production for the industrial grade ethanol market. Whether the low to medium rainfall areas are competitive in biomass production with more favoured areas is an important question. Opportunity costs of land may be lower but growth rates and assembly costs of biomass may be higher (greater dispersion of the resource) in the low rainfall zone. The likelihood of the biomass for ethanol requirement being met by larger scale plantings in higher rainfall areas is greater.

As a potential substitute for conventional petrol and diesel fuels, ethanol blends could offer considerable benefits with respect to various issues associated with Australia's liquid fuel demand. These issues include self sufficiency, refinery balance and polluting emissions, both as to urban air quality, and greenhouse gases.

Based on the untaxed costs of wholesale supplies, ethanol blends impose a 10-15 per cent price surcharge. This surcharge might be acceptable to Australian consumers on a small scale, similar to the concept of green electricity being promoted by governments.

## 4.3 Domestic Firewood

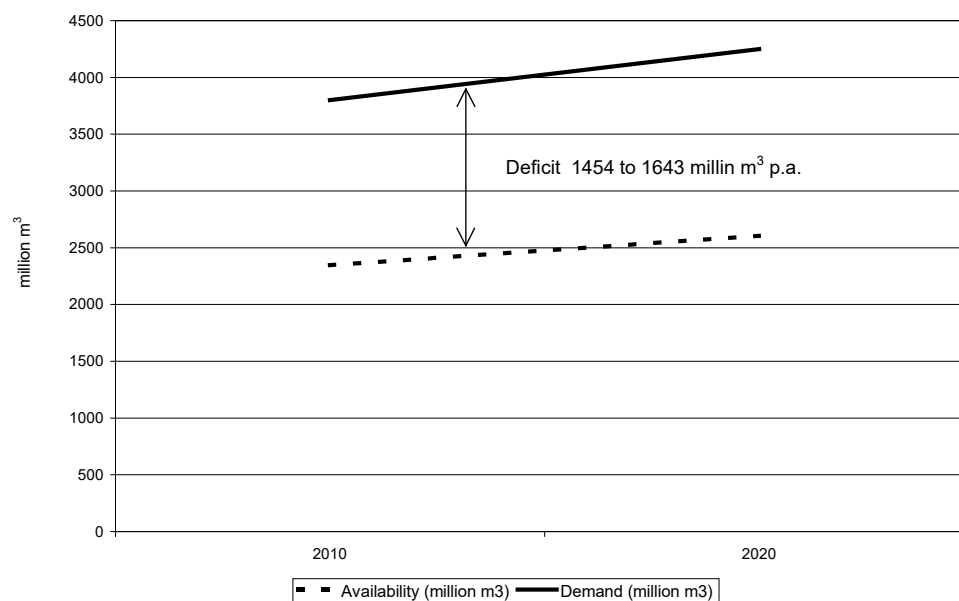
### 4.3.1 Market

In Australia and other developed nations, firewood for heating houses, is still a popular option, even though there are many electric or gas alternatives available. This may be due to a number of reasons such as low cost, effective heating, and visual appeal.

Ease of splitting, low moisture content (or ability to dry fast), high density, and slow burning are the qualities which are sought after in firewood. Firewood is marketed as 'clean block' or 'split' firewood. There is usually a positive correlation between high wood density and heat produced per unit of weight, meaning that hardwood species are the preferred choice for firewood. Hardwood species generally take longer to grow than softwood species, but burn for a longer time. Two common species suitable for firewood, which are found in remnant vegetation in the lower rainfall areas of Australia include the Box and Ironbark (*Eucalyptus spp.*). Other species which are suitable include certain Acacia species and Casuarina species.

The world market for fuelwood (including charcoal) is 1.7 billion metric tonnes per annum, made up of 89% hardwood and the remainder softwood (Hanson & Stewart, 1997). Future world demand and supply for fuelwood (including charcoal) illustrates a severe shortfall, averaging 1.5 billion m<sup>3</sup> per annum. This deficit is likely as more environmental pressure is put on existing stands, and population increase in developing countries demands more resources. The total deficit for all fuelwood (industrial and domestic) is highlighted in Figure 4.4. High transport costs relative to the market value of firewood, is likely to keep Australian suppliers out of the international market. However, the international pattern of increasing shortfalls in supply is indicative of the trends being experienced in Australia.

Figure 4.4. Future World Demand and Supply of Fuelwood (including charcoal) (million m<sup>3</sup>).



Source: Hanson & Stewart (1997)

In Australia, energy consumption from wood and wood based products was 6.8 million tonnes for 1997-98 (Bush *et al*, 1997). While these figures are based on wood used as an industrial fuel and for domestic lighting, heating and cooking, it was suggested that the bulk of consumption for wood in the energy sector is from the residential sector (Bush *et al*, 1997).

The Australian Home Heating Association (AHHA) estimates that 1.5 million households use firewood for heating in Australia, and consumption is estimated at 4 tonnes per household per annum. This is based on consumption in Canberra, with 20,000 households consuming 80,000 tonnes of firewood (dry) per annum. The market for firewood in Australia is located mainly on the east coast and in the south, in line with the location of population and cold climates in the southern part of this area.

Supply of firewood is mostly from remnant vegetation on private land, with some wood being sourced from state forests, via the use of permits (Mogg, B. 1998, pers.comm.). The total area of native Eucalypt and Acacia stands in Australia is 103 million hectares, with 15% (15 million hectares) falling in the 400-600 mm rainfall zone (BRS client request from National Forest Inventory, June 1998).

The problem with sourcing firewood from remnant vegetation, however, is that this resource may not be sustained under the present harvest rates. The need to more effectively manage firewood harvesting from remnant vegetation has been identified. This has potential for agroforestry to pick up market share from remnant vegetation.

A new initiative between the AHHA and Victorian Government is looking at ways of utilising the waste material from thinning and logging state hardwood forests. A Fuelwood Committee has been formed with the goal of marketing the wastes of logging as firewood. This wood waste has traditionally been burnt at the forest site, with Victoria burning 1 million tonnes of forest waste per annum. Once the Victorian pilot has been set up in 12-18 months time, other states are expected to follow, with NSW already expressing interest. It has been estimated that this potential new source of firewood will eventually fill the metropolitan demand for firewood, with agroforestry production possibly supplying the rural market. Demand for firewood in the 400-600 mm rainfall zone could be estimated by the proportion of the total population in this zone, together with climatic factors.

In the total Australian market for firewood of 6 million tonnes per annum, if all consumption was purchased from harvested low rainfall agroforestry plantings, and each hectare of trees yield 22.5 tonnes of dry biomass after 15 years, then 267,000 hectares of trees would be harvested each year. This equates to a total planting of 4 million hectares of trees, assuming that the harvest rotation for firewood is 15 years. However, it is more realistic that some of the market for firewood will always be supplied from selected harvesting of remnant vegetation for private use. Even with controls in place, unmanaged harvesting is still likely to occur. As well, the development of strategies to market state forest wood waste as firewood will reduce the available market size even further, although the impact is uncertain. Some of the possibilities for market size are illustrated in Table 4.7.

Table 4.7. Agroforestry Share of Firewood Market  
and Implications for Land Areas Required

| % supplied by agroforestry | No. trees harvested p.a. | No. trees in ground | No. hectares planted |
|----------------------------|--------------------------|---------------------|----------------------|
| 10%                        | 400 million              | 4 billion           | 4 million            |
| 20%                        | 800 million              | 8 billion           | 8 million            |
| 50%                        | 2 billion                | 20 billion          | 20 million           |
| 100%                       | 4 billion                | 40 billion          | 40 million           |

### 4.3.2 Prices & Cost of Production

Prices for firewood vary depending on the location of the market. For example, firewood prices in rural areas range from \$40 per tonne to \$65 per tonne, while city prices range between \$150 and \$185 per tonne. The reason that firewood in metropolitan areas is substantially higher than rural areas (up to 3 times higher), is probably due to transport costs.

Long distances between low rainfall areas and metropolitan centres increase the cost of transport for split firewood, and therefore the cost of production. This means that it is more difficult for agroforestry in the low rainfall zone to supply metropolitan markets which can otherwise be supplied by closer production areas (for example, coastal plantation thinnings). The markets in Perth and Adelaide, two major metropolitan centres which are located relatively close to low rainfall areas, may be exceptions.

Preliminary estimates by the Australian Home Heating Association (AHHA) show the cost comparison of heating options between wood, gas and electricity. Based on these figures, wood appears to be the lower cost option, even with pricing at \$150 per tonne. Assuming it takes 350 MJ of energy to heat a home each day in the cooler months, the rates in Table 4.8 would apply.

Table 4.8. Cost Comparison – Wood vs. Alternatives

| Ranking | Heating source | Avg use/day | Price            | Total cost/day  |
|---------|----------------|-------------|------------------|-----------------|
| 1       | Wood           | 40 kg       | \$50-\$150/tonne | \$2.00 - \$6.00 |
| 2       | LPG            | 9kg         | \$1.00/kg        | \$9.00          |
| 3       | Electricity    | 100 kWh     | \$0.10/kWh       | \$10.00         |

Source: AHHA

The price of firewood in urban areas could rise as high as \$225/tonne before it is unable to compete with the alternative heating sources (LPG, electricity), based on the above prices and usage rates.

### Investment Analysis

An investment analysis of firewood production was undertaken to ascertain the long term feasibility of firewood production from low rainfall agroforestry. Where available, production data for *Eucalyptus camaldulensis* was assumed. It was also

assumed that firewood was the only product produced from the stand of trees. The base assumptions used in the investment analysis are summarised in Table 4.9.

Table 4.9. Assumptions for Base Investment Analysis

| Variable                                        | Base value                |
|-------------------------------------------------|---------------------------|
| <i>General</i>                                  |                           |
| Discount rate                                   | 5%                        |
| Opportunity cost (a)                            | \$60/ha                   |
| Planting density (b)                            | 1,000 stems/ha            |
| Harvest rotation (c)                            | 15 years                  |
| Drying time after harvest (d)                   | 1 year                    |
| <i>Cost of Production</i>                       |                           |
| Cost of seed/ha (e)                             | \$208/ha                  |
| Ground preparation & direct seeding (f)         | \$80/ha                   |
| Fencing (g)                                     | \$380/ha                  |
| Contract harvesting (h)                         | \$20/m <sup>3</sup>       |
| Contract splitting (h)                          | \$10/m <sup>3</sup>       |
| Transport distance for logs to splitter (i)     | 50km                      |
| Transport distance for firewood to consumer (i) | 50km                      |
| Log transport rate (j)                          | \$0.15/m <sup>3</sup> /km |
| Log unload rate (j)                             | \$1.50/m <sup>3</sup>     |
| Split firewood transport rate (j)               | \$0.44/m <sup>3</sup> /km |
| Split firewood load/unload rate (j)             | \$10/m <sup>3</sup>       |
| Storage cost of split firewood (k)              | \$0.01/m <sup>3</sup>     |
| <i>Price &amp; Yield</i>                        |                           |
| Growth rate per annum (c)                       | 5m <sup>3</sup> /ha/year  |
| Ratio of dry firewood to green (l)              | 50%                       |
| Firewood price (rural, retail) (m)              | \$45/m <sup>3</sup>       |

Notes:

- The opportunity cost of the land is based on a sheep gross margin for Victoria, and has been extracted from ABARE's "Farm Surveys Report 1995".
- The planting density of 1,000 trees per hectare was assumed as being a suitable density for *Eucalyptus camaldulensis* (Doran & Turnbull (1997) "Australian Trees & Shrubs").
- The harvest rotation and growth rate were based on estimates for *E. camaldulensis* and were sourced from Doran & Turnbull (1997). CSIRO also confirmed that growth rates for most native species in the 400-600mm rainfall zone were around 5m<sup>3</sup>/ha/year.
- Drying time after harvest was estimated to be approximately 1 year.
- The cost of seed for one hectare was based on the survival rate, quantity of seed per kg, and the price per kg of seed. The survival rate for *E. camaldulensis* (sourced from DNR's Trees Facts (No. T06) "Direct Seeding" which suggests that average survival rates for direct seeding of *Eucalyptus* species is 0.1%. The cost of *E. camaldulensis* seed/kg was taken from QDPI Forestry's "DPI Forestry Seed Centre 1998-99 Catalogue". There are approximately 750,000 *E. camaldulensis* seeds per kg.
- Ground preparation and direct seeding costs were estimated at approximately \$80/ha, based on 2 hours/ha operating time for ground preparation and 2 hours/ha for direct seeding, with each activity requiring one labour unit at \$10/ha (\$40) plus an equivalent amount (\$40) for fuel and maintenance.
- The cost of fencing was based on \$3000/km for a 10 hectare block, with a fence perimeter of 1.26km and a cost per hectare of \$380.

- h) The rate for contract harvesting and splitting was estimated by Chris Blackwood of Blackwood Engineering, Traralgon (Victoria), as recommended by the Australian Home Heating Association. The contract rate for harvesting includes a loading component to load the logs onto a truck.
- i) The transport distance for logs and split firewood was assumed to be 50km each.
- j) The log transport rate, log unload rate, firewood transport rate, and firewood load and unload rates were estimated by Chris Blackwood of Blackwood Engineering in Victoria.
- k) The storage cost of firewood for one year assumed that the firewood could be stored uncovered on the ground, as confirmed by Chris Blackwood of Blackwood Engineering. The cost was estimated for 1m<sup>3</sup> of split firewood occupying 1m<sup>2</sup> of land, valued at \$60/hectare (see Note (a) above).
- l) The ratio of dry firewood to green wood was estimated by Primary Industries of South Australia in their Fact Sheet "Farm Forestry – woodlotting for timber, posts and firewood", Agdex No. 300/17, October 1995.
- m) The rural, retail price for firewood was sourced from Read Sturgess & Associates unpublished report on firewood production for 1m<sup>3</sup> of firewood.

The base results of the investment analysis show that firewood production was not economic, based on the assumptions in Table 4.9. When the cost of establishment was included in the analysis, the NPV was almost -\$26,000 for 10 hectares of trees, with a B/C ratio of 0.02 : 1. When establishment costs were excluded from the analysis, the NPV was close to -\$19,000, with a B/C ratio of 0.03 : 1. These results indicate that firewood production is not economic, either when establishment costs are included or excluded.

While the base investment analysis does not present an economically feasible outcome for firewood production, slight variations on the base assumptions may result in a positive NPV. Sensitivities of NPV's to various assumptions were tested, and the results are presented in Figure 4.5. The range of variation for each variable is provided in Table 4.10.

Table 4.10. Minimum and Maximum Values for Variables used in Firewood Investment Analysis.

| Variable                                              | Min.    | Max.     |
|-------------------------------------------------------|---------|----------|
| <i>General</i>                                        |         |          |
| Discount rate                                         | 0%      | 10%      |
| Opportunity cost of the land (\$/ha) (a)              | \$0     | \$60     |
| Growth rate (m <sup>3</sup> /ha/year) (b)             | 2       | 10       |
| <i>Cost of Production (c)</i>                         |         |          |
| Cost of seed/ha                                       | \$104   | \$416    |
| Contract harvesting cost (\$/m <sup>3</sup> )         | \$10    | \$40     |
| Contract splitting cost (\$/m <sup>3</sup> )          | \$5     | \$20     |
| Transport distance for logs (km)                      | 25      | 200      |
| Transport distance for split firewood (km)            | 25      | 400      |
| Log transport rate (\$/m <sup>3</sup> /km)            | \$0.08  | \$0.30   |
| Split firewood transport rate (\$/m <sup>3</sup> /km) | \$0.22  | \$0.88   |
| <i>Yield &amp; Price</i>                              |         |          |
| Ratio of dry firewood to green wood (d)               | 25%     | 60%      |
| Firewood price (retail) (\$/m <sup>3</sup> ) (e)      | \$22.50 | \$200.00 |

Notes:

- f) The opportunity cost was assumed to vary between \$0 and \$60, with \$0/ha representing zero value of the land for sheep grazing, and \$60/ha representing the base gross margin for sheep grazing.

- g) Growth rate was assumed to vary between  $2\text{m}^3$  and  $10\text{m}^3/\text{ha}/\text{year}$ , to represent the variation in yield which may occur within the low rainfall zone. For example, it is more likely that higher growth rates would be achieved in the higher rainfall areas of the low rainfall zone (e.g.  $> 500\text{mm}$ ) than in the lower margin of that zone (e.g.  $400\text{-}500\text{mm}$ ).
- h) The cost of production estimates were varied by 50%.
- i) The ratio of dry firewood to green wood was varied by 50% for the minimum value, but changed by only 20% for the maximum value (from 50% to 60%).
- j) The retail firewood price ranged between \$22.50 (50% of the base value) and \$200, representing possible retail prices in city markets.

Figure 4.5. A Sensitivity Analysis of Changing Magnitudes of Variables on the NPV for Firewood Production.

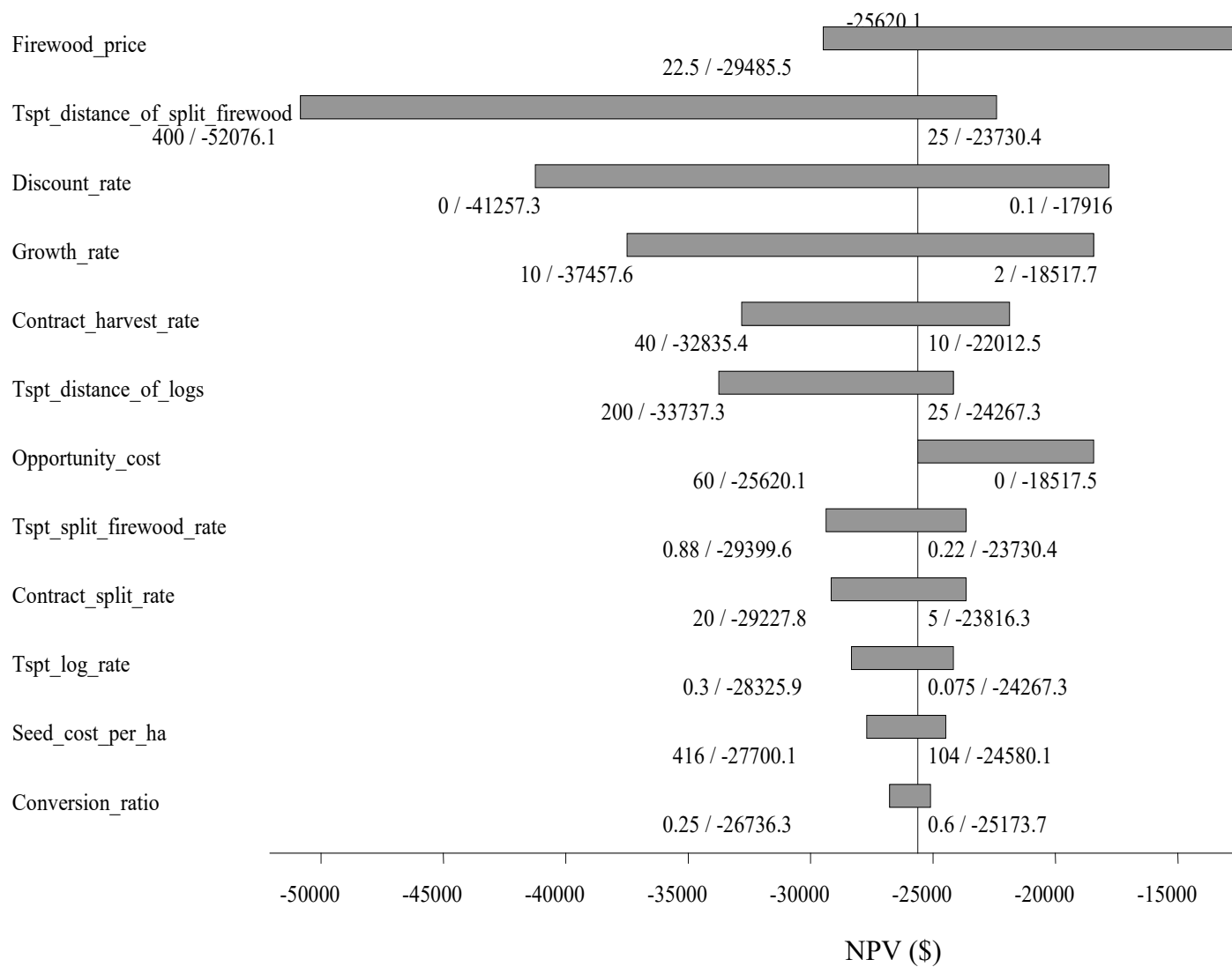


Figure 4.5 illustrates the point at which NPV becomes positive. Based on the previously assumed minimum and maximum values for each variable (Table 4.10), the only variable to significantly impact positively on NPV was the retail price for firewood. However, even the price for firewood would need to increase substantially, from \$45/m<sup>3</sup> to \$194.13/ m<sup>3</sup>, for the investment in firewood production to produce a positive NPV. In addition, higher prices for firewood are more likely to occur in city areas rather than rural areas, and hence the distance for transporting the firewood to market would most likely increase as the price increases. As a result the true effect on NPV would be a combination of price and transport distance, as shown by the top two bars in Figure 4.5, resulting in almost no change to NPV.

To protect the competitiveness of firewood in the heating market, it is likely that prices would have to decline in the future, due to potential price reductions in other industries. For example, consumers of electricity are on the verge of having access to a deregulated industry which is likely to result in lower prices for domestic electric heating. Comparing price estimates with the estimates from the AHHA, a retail price of \$194/m<sup>3</sup> for firewood means that it cannot compete with alternative forms of heating. This is based on the AHHA estimates in Table 4.8 which indicate that the price of firewood in urban areas could rise as high as \$135/ m<sup>3</sup> (\$225/tonne) before it is unable to compete with the alternative heating sources (LPG, electricity).

However, if firewood was sourced as a waste product from other agroforestry enterprises, its sale could add a significant revenue item. Such waste would have to be of a form suitable for home heating such as thinnings or substantial offcuts rather than sawdust or residue from eucalyptus oil production.

The transport distance for the split firewood had the second largest impact on NPV, with an 8-fold increase resulting in just over a 100% reduction in NPV. The transport distance for the logs was also important in determining the economic viability of firewood production, although the impact was not as important as for transporting the split firewood.

A combination of other factors could have a combined effect of improving the NPV of firewood production, to the point where it could be economically viable. For example, a reduction in growth rate, contract splitting rate, transport rates, the cost of seed, the opportunity cost and a slight increase in the price of firewood, would need to occur simultaneously to generate an economically viable outcome for low rainfall firewood production.

Figure 4.5 shows the impact of varying the growth rate on the NPV. As the growth rate increases (e.g from 5m<sup>3</sup>/ha/year to 10m<sup>3</sup>/ha/year), the cost of harvesting, processing and transport outweigh the additional returns from the firewood.

The issue of emissions from woodheaters is likely to have varying impacts in the short and long term. In the short term, concerns about smoke emissions from woodheaters is unlikely to have a significant impact on the domestic wood heating industry. Regulations have already been set down which control the level of emissions from wood heaters, through the Australian Standard AS4013. These regulations have more than adequately been met by industry, and have already been achieved for the year 2001 target level. These results have been achieved through the design and

manufacture of cleaner burning and more efficient wood heaters for release onto the market (Mogg, B. 1998, pers.comm.). In the longer term, however, there could be implications for the woodheating industry, as pollution is likely to increase in populated areas. The height of flues could become an important consideration for local governments, to divert emissions away from the local atmosphere. However, emissions also have global implications and the trend for countries to reduce greenhouse gas emissions could impact the most on woodheating in the long term.

### **4.3.3 Summary & Conclusion**

The reduction in supply of firewood from traditional sources, such as stands of remnant vegetation, present opportunities for firewood production in Australia. As well, supply from these sources is likely to come under tighter management in the future, as the damaging effect on biodiversity and the environment is increasingly recognised and acted upon.

At the same time that the security of existing firewood sources are being questioned, alternative sources of firewood are already being investigated, such as waste material from high rainfall hardwood forests. The potential for this source of firewood, if fully realised, could be to supply a significant part of the metropolitan firewood market. This, in effect, would make firewood production from low rainfall areas less attractive as it has to compete with higher rainfall product, located closer to metropolitan markets. However, the potential for firewood production from low rainfall agroforestry could be in the distribution to local markets where hardwood forest waste is less likely to compete and where transport distances from the low rainfall agroforestry stand are likely to be low.

The price of firewood is an important determinant of any future economic viability of an agroforestry enterprise. A sensitivity analysis of retail firewood prices and the extent to which they impact on NPV, found that the firewood would have to be priced at \$194/m<sup>3</sup> (retail) before the NPV of the investment became positive. However, in terms of its competitiveness with other forms of heating, the retail price for firewood could increase to only \$135/m<sup>3</sup> before its competitiveness is eroded (AHHA).

Price aside, there are other issues which may affect the competitiveness of firewood with alternatives in the domestic home heating market. For example, environmental restrictions on the level of domestic emissions, may impact on the choice of domestic heating, causing consumers to move away from fire heating to lower emitting alternatives.

In summary, production of firewood as a sole product from the low rainfall areas of Australia is not likely to be economically viable. The greatest potential for firewood production from this zone could be as a byproduct from other agroforestry systems, such as thinnings from sawntimber production or residues from milling operations. Firewood sold from thinnings is likely to be more profitable than firewood production as a stand-alone operation, because the cost of production is largely recouped by the sawntimber production.

In addition, due to potential increasing supply from high rainfall hardwood stands, the firewood market for low rainfall agroforestry may only be small and localised,

centering around rural areas which contain large urban centres and where transport costs and competition with forest waste are minimised. The only exception to this could be the city markets of Perth and Adelaide which are located reasonably close to the 400-600 mm rainfall zone.

## **4.4 Charcoal, Briquettes & Activated Carbon**

### **4.4.1 Market**

Charcoal is produced from wood biomass through a process of partial burning. CSIRO technology for converting wood into charcoal, known as fluidised bed carbonisation, is being promoted in Australia (Stucley, C. 1998, pers.comm.). This technology is being considered as an addition to sawmill enterprises, where the by-products (volatiles) of carbonisation can be combusted in the sawmill as a source of heat for the mill's timber drying kilns and electricity generation (see cogeneration in Section 4.1) to operate the mill's machinery.

There are a few different market alternatives for charcoal. First, the charcoal can be compressed and made into different shapes and sizes to form briquettes, either for industrial or domestic use. (Note that "domestic" in this section refers to residential uses). In terms of industrial uses, the briquettes could be used as substitute inputs in coal-fired power stations. Domestic uses include a fuel for outdoor heating and barbeques. The market for briquette consumption for outdoor heating and barbeques, however, is not large in dollar value or volume terms, and is unlikely to increase significantly (Mogg, B. 1998, pers.comm.).

In terms of the highest value use for charcoal, however, there is little doubt that activated carbon stands alone. Activated carbon is formed through a steam or chemical process, from materials containing carbon such as coal and charcoal, coconut shells, nut shells and seeds (e.g. stonefruit). These inputs enter a process of partial heating which releases gases, and transforms the substance into a pure carbon form. Activated carbon is commonly used to remove impurities from water, air, oil and minerals (gold). It has a wide range of applications including the waste treatment, gold mining, soap and toothpaste manufacturing and softdrink manufacturing industries. The world market for activated carbon has been estimated at 450,000 tonnes per annum (Stucley, C. 1998, pers.comm.).

All activated carbon consumed in Australia is imported. Most of this is sourced from countries including Sri Lanka, India and Indonesia, where it is produced mainly from coconut shells, and also extruded peat. As coconut shells are a limited resource, there is an opportunity for Australian produced activated carbon to take market share from activated carbon produced in other countries. Production of activated carbon is likely to increase as the CSIRO technology for producing charcoal is established throughout Australia (Stucley, C. 1998, pers.comm.).

The domestic market for activated carbon has been estimated at 7,000 tonnes per annum (Fung, P. & Stucley, C. 1998, pers.comm.). While a major use for activated carbon in Australia is for extraction in the gold industry, it is expected that the requirement for water treatment may increase, especially if particular problems associated with blue-green algae develop.

Activated carbon used in gold extraction in Queensland and Western Australia requires the use of hard, granular activated carbon. Activated carbon produced from coconut shells has traditionally been regarded as being a superior product in the gold mining industry because of its effective gold adsorption and minimal attrition effect. However, research has been conducted on the suitability of activated carbon produced from Eucalyptus species. The research found that certain species (e.g. *Eucalyptus marginata*) produced highly active carbons, which were twice as effective in adsorption rates than activated carbon sourced from coconut shells. The research also found that while the hardness of these wood carbons may not be as high as activated carbons produced from coconut shells, this may be compensated by the faster/ higher adsorption rates. Another trade-off to consider is that activated carbon, produced from harder substances such as coconut shells, can be re-used, whereas activated carbon produced from wood may only be used once, due to its higher rate of attrition.

#### **4.4.2 Prices & Costs of Production**

The price for activated carbon ranges in value between \$1,500 and \$5,000 per tonne. There is a wide variation in the unit price of activated carbon, based on its adsorption and attrition (and if it can be reused) qualities. The industry in which activated carbon is used determines the characteristics and the associated price. Some niche markets may even command prices up to \$10,000 per tonne of activated carbon (Stucley, C. 1998, pers.comm.).

The options available for wood biomass carbonisation are to have a centralised carbonisation plant, or to have a series of smaller plants installed in sawmills, for example. As the production of activated carbon requires significant quantities of raw material (wood biomass for charcoal), it may be more economic to locate manufacturing facilities close to the raw material source. As well, significant savings in the cost of transport could be achieved if there is minimal transport of the low value and high volume wood input, as opposed to the high value and low volume activated carbon output. In addition, it has been reported that the benefits of reduced transport costs would outweigh any economies of scale associated with one large plant.

The fluidised bed system can utilise both green and dry wood material. Both sawdust and woodchip material can be used, although complete carbonisation of woodchips takes longer than for sawdust. An average carbonisation rate for sawdust and woodchips was estimated at 0.5 tonne per hour at a CSIRO pilot plant (Fung, not dated).

Agroforestry products which are suitable for charcoal production, and ultimately activated carbon, include coppiced material, thinnings, branches and other forestry waste (sawdust). Recovery of charcoal from dry wood is assumed to be approximately 19-22%. The typical calorific value (gross, dry ash-free) of wood charcoal is approximately 30 MJ/kg. It has been estimated that approximately 30% of the weight of raw materials is retained after converting the biomass to charcoal, and 50% of this remains after the charcoal is activated.

#### **4.4.3 Summary & Conclusion**

In summary, the opportunities for gaining commercial value from the production of agroforestry biomass to charcoal initially, and then activated carbon are likely to be promising, although no economic analysis has been undertaken in the current study. The technology is available and is being pilot tested. The economics of producing activated carbon will be even more promising if its production can be incorporated as part of another agroforestry industry, such as sawntimber or eucalyptus oil production.

In comparison with the activated carbon produced, the scale of biomass required is large, since only 15% weight of the biomass is retained to produce the activated carbon. For example, the Australian market would require almost 47,000 tonnes of biomass each year to produce 7,000 tonnes of activated carbon, from a harvested area of 1,600 hectares (producing 30 tonnes ( $50\text{m}^3$ ) per hectare after 10 years) and a total planted area of 16,000 hectares. The world market would require 3 million tonnes of biomass each year to produce 450,000 tonnes of activated carbon, from a harvested area of 100,000 hectares, and a planted area of 1 million hectares.

## 5. EUCALYPTUS OIL

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### 5.1 Market Overview

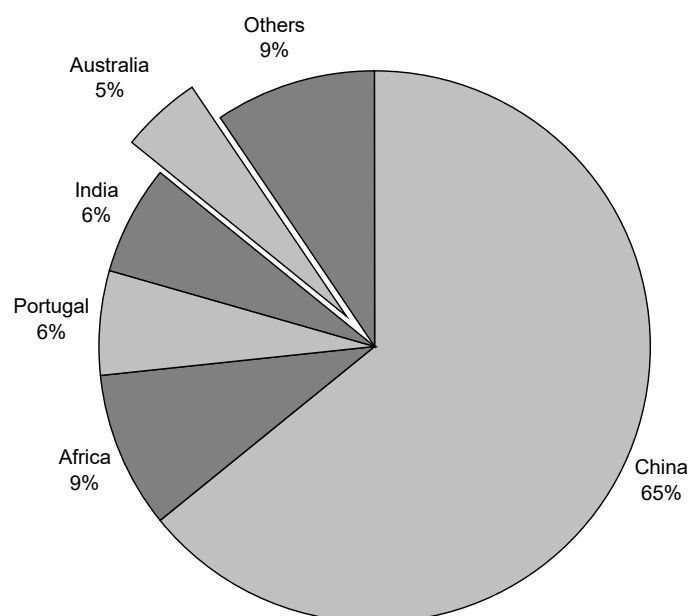
Eucalyptus oil, derived from Eucalypt species, is valued for its cineole content. Cineole is used in significant amounts in pharmaceuticals and has applications for the industrial solvent market. Markets for pharmaceutical and industrial solvents are briefly scoped in this section.

#### 5.1.1 Pharmaceutical Market

Pharmaceutical products produced from eucalyptus oil include decongestants, pain relief products, aromatherapy products, and fragrances in products like shampoo. Competitive products include tea tree oil and essential oils from herbs and flowers (e.g. lavender). However, each species has slightly different characteristics which are used to market the oils as products in separate markets.

Eucalyptus oil production for pharmaceutical use dominates the total world eucalyptus oil market at approximately 3,000 tonnes per annum (approximately 75% of the total world market for eucalyptus oil) (McKelvie *et al*, 1994). China is the major supplier to this market, and this is illustrated in Figure 5.1. During the past four years, China's share of the market has remained constant. It should be noted, however, that China is still not at full production, and could easily increase supply to the market, if the price encouraged it. However, it is becoming more and more difficult for China to supply to the world market at low prices, as costs of production rise due to alternative use of resources including labour.

Figure 5.1. World production of eucalyptus oil for pharmaceutical use (1991).



Source: McKelvie *et al* (1994)

The market for pharmaceutical eucalyptus oil has been over-supplied by China to the extent that other producers have exited, albeit in the short term. Spain, Chile, Portugal and India trade minimally in eucalyptus oil, mainly because of China's dominance in the market and the downward pressure exerted on prices. However, this is short term, and if prices increase, these countries could quickly respond by supplying more eucalyptus oil to the market.

The pharmaceutical market is supplied by two grades of cineole: 80% cineole and 99.5% cineole which is known as 'eucalyptol' or pure cineole. China dominates production in the 80% cineole market and if the cineole content drops below the 80% level, the oil can be supplemented with eucalyptol. Therefore, cineole content of a particular oil is not a critical issue when competing on the world market.

Illustrated in Table 5.1 are Australia's imports and exports of eucalyptus oil. Australia is a net importer of eucalyptus oil, although most oil imported into Australia has lower cineole and has to be enhanced with higher quality oils (e.g. Blue Mallee oil at 80-90% cineole). The "enhanced" oil is then exported. The table shows Australia imports mostly from African countries (South Africa and Swaziland), consuming just over half of their production (53%).

Table 5.1. Imports and Exports of Eucalyptus Oil – Australia (1989-90)

| Trade                  | Quantity (tonnes) |
|------------------------|-------------------|
| Exports from Australia |                   |
| US                     | 21                |
| Hong Kong              | 16                |
| Thailand               | 14                |
| Other                  | 20                |
| Total                  | 71                |
| Imports to Australia   |                   |
| Africa                 | 135               |
| China                  | n/a               |
| Other                  | n/a               |
| Total                  | >135              |

Source: McKelvie *et al* (1994)

In Table 5.1, note that Africa includes Swaziland and South Africa. The oil produced in these countries is generally lower quality, and is blended with Australian blue mallee oil, and re-exported, although this is not reflected in Australia's export figures (Table 5.1). The quantity of Australia's imports from China has not been specified, but was reported as being greater than imports from Africa (McKelvie *et al*, 1994).

As opposed to the generally lower cineole oil produced by overseas countries, Australian production of eucalyptus oil is generally high cineole, but production quantities are not large. For example, Australia produces less than 5% of eucalyptus oil for the world pharmaceutical market (see Figure 5.1). Most of the eucalyptus oil produced in Australia is sourced from enhanced natural stands of mallee in Victoria

and New South Wales, and from plantations in Victoria and South Australia. There are about 2,000 hectares of trees associated with this production. Extensive plantings of Eucalyptus oil-rich trees on-farm have occurred in WA since 1994, predominantly to combat rising watertables and salinity, but also with the intention of developing a low cost eucalyptus oil industry based on new technology. The goal of planting to combat salinity in WA is set at 500 million trees by 2025. Most trees are oil mallee species although it is likely that some *Melaleuca* spp containing high oil levels will also be planted.

### 5.1.2 Industrial Solvent Market

Uses for industrial solvents include degreasers, paint strippers, and all purpose solvents which are used for mechanical and electronic purposes.

Previously, the world market for industrial solvents was dominated by trichloroethane. However, trichloroethane was banned from use in 1996, because of its negative effect on the ozone layer. World sales of trichloroethane at the peak of its production were 1 million tonnes (Barton, A. "Western Oil Mallee Project", 1998). The opportunity for Eucalyptus oil to penetrate this market is favourable, considering it is a natural, chemically stable, and biodegradable product. However, strong "eucalyptus" odour in industrial solvents, is not favoured by some international markets, e.g. Japan. Blending eucalyptus oil from different species with varying cineole content can reduce the problem of odour and produce more effective solvents (improves degreasing qualities).

Estimates of the number of trees that would need to be planted and harvested to service different proportions of the world industrial solvent market are presented in Table 5.2. If eucalyptus oil could fill 10% of the market for industrial solvents, then 0.6 billion trees would need to be harvested per annum and a total of 1.7 billion trees would need to be planted, based on a 3 year harvest cycle. It is also assumed that 1 tonne of trichloroethane equals 1 tonne of eucalyptus oil as inputs for the industrial solvent market, the yield per tree is 0.176 kg oil per annum, the planting density is 2200 trees per hectare, and for every hectare planted with trees, another four hectares of land benefit through watertable impact.

Table 5.2. Potential Industrial Solvent Market for Eucalyptus Oil

|                               |           | <b>Trees harvested per annum</b> | <b>Trees in ground</b> | <b>Area affected by tree benefits (ha)</b> |
|-------------------------------|-----------|----------------------------------|------------------------|--------------------------------------------|
| World solvent market (tonnes) | 1 million | 5.7 billion                      | 17.0 billion           | 31 million                                 |
| Penetration of Eucalyptus Oil | 1%        | 57 million                       | 170 million            | 0.3 million                                |
|                               | 5%        | 0.3 billion                      | 0.9 billion            | 1.5 million                                |
|                               | 10%       | 0.6 billion                      | 1.7 billion            | 3.1 million                                |
|                               | 20%       | 1.2 billion                      | 3.4 billion            | 6.1 million                                |

Note: The "area affected by tree benefits" in Table 5.2 assumes that benefits only accrue to the area between where the trees are planted, and not the land on which the trees are planted.

Also summarised in Table 5.2 is the area of land between the trees which may benefit, through lowered watertables, from the eucalyptus plantings. For example, at 1% market penetration, 170 million trees would need to be planted, and the area of land between the trees which would be affected in this case is estimated at 300,000 hectares.

In the industrial solvent market, cineole competes directly with other natural products such as pinene (from *Pinus* spp.), a by-product from paper making, and limonene from citrus peel. All three products are preferred for industrial solvents, because they are natural and do not contribute to ozone-depletion. However, Eucalyptus oil faces strong competition from pinene and limonene because both products can be produced at lower cost than the traditional system of producing Eucalyptus oil. The major supplier of limonene on the world market is Brazil.

### **5.1.3 Market for Other Solvents**

The hand cleaner market is another potential market for eucalyptus oil production. World consumption for the hand cleaner market has been estimated at 20,000 tonnes of oil input per annum, and world prices are generally higher than for the industrial solvent market.

Limonene presently supplies some of the hand cleaner market, but has not been very successful because it can cause skin irritation in some users. As eucalyptus oil is low irritant, this presents a potential opportunity for eucalyptus oil to gain market share from limonene.

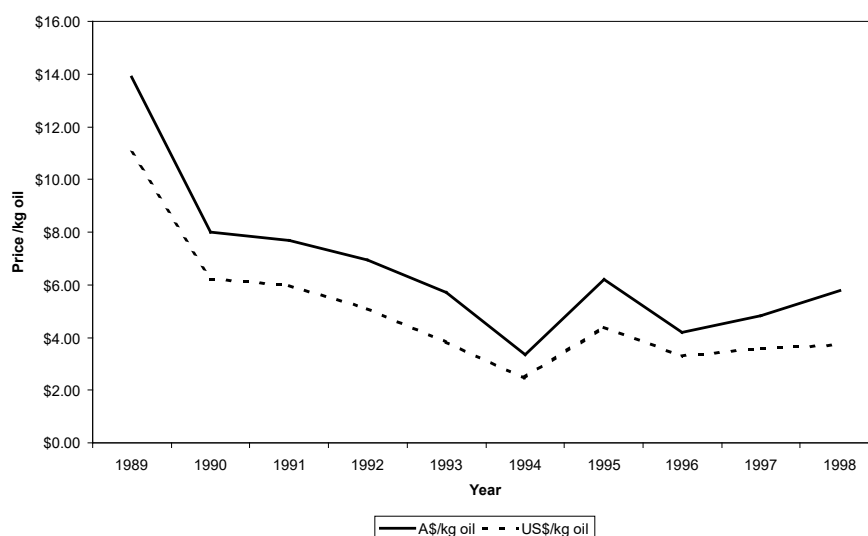
There may be other niches in industrial markets where eucalyptus oil may compete strongly.

## **5.2 Prices**

### **5.2.1 Pharmaceutical Market**

During the past eight years, the world price for eucalyptus oil in the pharmaceutical market has seen highs and lows ranging from US\$2.45 to US \$11/kg oil. The average price received for eucalyptus oil in the pharmaceutical market over the past 8 years was US\$5.11/kg oil, while the average in the last 4 years was US\$3.44/kg oil. The historical prices are graphed (in US dollars) in Figure 5.2. The current 1998 world price for eucalyptus oil in this market is US\$3.60/kg oil.

Figure 5.2. Prices for Eucalyptus Oil at 80 per cent Cineole, 1989 – 1996



Sources: McKelvie *et al* (1994), Davis, R. & Abbott, P. 1998, pers.comm.

One alternative market outlet for Australian eucalyptus oil is the local market, supplying a niche pharmaceutical product. This could include selling a "quality Australian product" to the tourist trade, or to local consumers. This market would need to rely heavily on smart marketing initiatives, but has the potential to compete with overseas products. Development of any niche pharmaceutical market could be accompanied by replacement of some imports of oil into Australia. It is feasible a significant quantity (say 100-200 tonnes) could be produced in Australia and sold into the Australian and world pharmaceutical market without depressing the world price of US\$3.60/kg oil.

Attributes such as level of impurities, consistency and odour are factors which are likely to influence the price for eucalyptus oil, rather than a marginal difference in cineole content. However, specialty and local markets can achieve premium prices. Eucalyptol (pure cineole) receives a current premium price of US\$5.50/kg oil. Australian eucalyptus oil, when marketed locally, can attract prices up to A\$8.00/kg. This is approximately US\$1.45/kg more than the world price for pharmaceutical oil (Davis, R. 1998, pers.comm.).

### 5.2.2 Industrial Solvent Market

The industrial solvent market is large, at around US\$1.5 billion annually, based on market size of one million tonnes and a world price of US\$1.50/kg oil.

The volume of the industrial solvent market is large, but prices for eucalyptus oil would be generally lower than received in the pharmaceutical market. The price for eucalyptus oil in the industrial solvent market can be estimated from competitive products such as limonene and pinene. The price for limonene has ranged from US\$0.60 to US\$6.00/kg oil in previous years. However, the average price for limonene is around US\$1.50/kg oil, and this price could be expected to set a maximum for eucalyptus oil in the general industrial solvent market. This is

significantly lower than the price currently received in the pharmaceutical market (US\$3.60/kg oil).

### **5.2.3 Other Markets**

Some of the niche industrial solvent markets and other markets that eucalyptus oil could enter could be higher priced than the base industrial solvent market, for example, hand cleaner products. In these cases, a price of US\$3 per kg of oil might be achieved, although the market size may be restricted. Further market research and analysis would need to be undertaken.

## **5.3 Economics**

### **5.3.1 Introduction**

The economics of producing, processing, transporting and marketing eucalyptus oil is dealt with in this section, with most assumptions sourced from examples in Western Australia. Specifically, the costs of production are estimated, with the results used in an investment analysis of mallee oil agroforestry over a 30 year period. The investment analysis considers a base example, and provides results of sensitivity analysis for changes to specific variables.

### **5.3.2 Cost of Production Estimate**

*Eucalyptus globulus* is the major source of supply for the world's eucalyptus oil, even though the oil content of the species is not as high as other species, such as *Eucalyptus polybractea* (Blue Mallee). This is because *E. globulus* has been chosen primarily for timber production in other countries, with oil produced as a low-cost by-product.

Countries which produce eucalyptus oil as a by-product of timber production, generally exhibit a comparative advantage over Australia in the cost of production. Costs associated with tree establishment and any other growing costs can be recouped by the timber revenue. As well, labour costs tend to be lower in these countries. Such a country is China, the major supplier to the eucalyptus oil market, growing mostly *Eucalyptus globulus* for wood.

Historically, China has been able to achieve low production costs. However, labour costs are starting to rise and the Chinese are finding it more difficult to supply product at the low world market price. However, they continue to opt for the associated foreign exchange earnings rather than profitability. As well, there is increasing competition amongst the Chinese, as the number of export permits has increased.

The Western Australian mallee oil initiative, based on regular harvesting (1-3 years) with subsequent coppicing, faces three major cost areas - the cost of establishment, harvesting and processing.

Presently seedlings cost \$0.23 each. This cost appears high in relation to the cost of seedlings in other oil industries, for example, tea tree oil. Although planting into an

unirrigated environment would mean the root mass of the mallee oil species would have to be larger than the tea tree seedlings, requiring larger pots and higher costs, it is reasonable to assume that \$0.23 can be reduced to some degree.

Secondly, the distribution of mallee oil trees across the landscape in a row design means higher harvesting costs than with block plantings, as the plantings will be generally dispersed, within farms and between farms. Difficult terrain and any long distances between mallee belts on the same farm, as well as between farms, increases the cost and time of moving and operating the harvester. However, as agroforestry plantings increase and economies associated with critical mass emerge, these costs could decline.

The third main area which may keep the cost of production in Western Australia high is the cost associated with transporting and processing the biomass. Again, the distribution of plantings throughout the landscape contributes to these high costs.

The cost of producing eucalyptus oil in the Western Australian system has been estimated at \$1.71/kg of oil, including the average opportunity cost of the land. The \$1.71 is an indicative cost only and may be somewhat optimistic. A breakdown of this estimate is summarised in Table 5.3.

Table 5.3. Optimistic Estimate of Cost of Production of Eucalyptus Oil.

| <b>Cost of Production Detail (a)</b>                                         | <b>Cost \$/kg oil</b> |
|------------------------------------------------------------------------------|-----------------------|
| Average establishment cost (b)                                               | \$0.18                |
| Harvest, distillation & transport capital cost (interest & depreciation) (c) | \$0.34                |
| Harvest & transport operating cost                                           | \$0.22                |
| Distillation operating cost (d)                                              | \$0.72                |
| Total cost of production activities                                          | \$1.46                |
| Average opportunity cost of land (e)                                         | \$0.26                |
| Total cost of production<br>(including average opportunity cost of land)     | \$1.71                |

Notes:

- a) Marketing or transport costs for the oil are not included in the above table.
- b) The average cost of establishment is based on the seedling and planting costs per tree and the survival rate of the trees, converted to a cost per kg of oil and annualised over the life of the project.
- c) The capital cost for one harvest, distillation and transport unit was based on the total capital cost of \$750,000, which was estimated to cost 20% each year (10% depreciation & 10% interest). Each harvest unit can harvest up to 1134 hectares of eucalyptus trees each year.
- d) Distillation operating cost includes labour, fuel, power, water and repairs.
- e) The opportunity cost of the land was based on the annual opportunity cost of land per hectare, divided by the oil yield (kg) per hectare.

More information on the source of assumptions and cost estimates in Table 5.3 are contained in Table 5.4.

Opportunities for reducing the cost of production in Australia are briefly covered in Section 5.4. Block plantings could result in lower costs, because there is less area that the harvester has to work over. However, block plantings would probably be less effective in combating rising watertables.

Eucalyptus oil production in low rainfall areas of Australia may face competition from production in higher rainfall areas, mainly due to higher comparative growth rates. However, the cost of land would need to be taken into account as well as the potential unsuitability of large tracts of high rainfall land for large-scale harvesting operations.

In the industrial solvent market, competitive products are produced as by-products from other industries. The two examples are pinene from the paper industry, and limonene from citrus peel. Limonene is a by-product of orange juice/concentrate production, so establishment, growing and transport costs are already covered. Based on the estimated cost of production for eucalyptus oil of A\$1.71/kg oil (equivalent to US\$1.20), including the opportunity cost of the land, it appears that Australian production of eucalyptus oil may be able to compete with pinene and limonene in the industrial solvent market, where they are priced at about US\$1.50.

If account was taken of other land sustainability impacts other than the land on which the trees were planted, the cost of production could be viewed as even lower. The cost estimates used are only indicative and, while partly based on various discussions with the Oil Mallee Association and others, they have not been rigorously evaluated.

### 5.3.3 Investment Analysis

#### Assumptions

An investment analysis incorporating the costs and benefits associated with eucalyptus oil production over a 30 year period was constructed with information provided by CALM, the Oil Mallee Association in Western Australia, and the Oil Mallee Company of Australia. The analysis was based on a total planting of almost 51 million trees, or approximately 23,000 hectares of land, with plantings made over an eight year period.

The assumptions used in the analysis are summarised in Table 5.4. It was assumed that the wood biomass was not transported or processed with the leaf biomass. Hence the costs associated with transport are almost half of what they would have been if the wood biomass had been taken off farm.

Table 5.4. Assumptions Used in Eucalyptus Oil Investment Analysis.

| Variable                                                  | Base value             |
|-----------------------------------------------------------|------------------------|
| <i>General</i>                                            |                        |
| Discount rate                                             | 5%                     |
| Opportunity cost (a)                                      | \$100/ha               |
| Harvest rotation (b)                                      | 3 years                |
| Planting rate required to affect land sustainability (c)  | 20%                    |
| Years before land sustainability benefits take effect (d) | 10 years               |
| Survival rate of trees (e)                                | 90%                    |
| <i>Prices &amp; Yield</i>                                 |                        |
| Total biomass yield at each harvest (f)                   | 10 kg/tree at harvest  |
| Leaf yield at each harvest (g)                            | 55% (of total biomass) |

|                                                  |                        |
|--------------------------------------------------|------------------------|
| Oil Yield at each harvest (g)                    | 3.2% (of leaf biomass) |
| Industrial price (h)                             | US\$1.50/kg oil        |
| Pharmaceutical price (i)                         | US\$3.60/kg oil        |
| Max. tonnes sold to pharmaceutical market (j)    | 200 tonnes             |
| <i>Production Costs</i>                          |                        |
| Cost of establishment (k)                        | \$0.48/seedling        |
| Distillation operating cost (l)                  | \$0.72/kg oil          |
| Harvest operating cost (m)                       | \$360/day              |
| Transport operating cost (m)                     | \$720/day              |
| Harvest, processing & transport capital cost (n) | \$750,000              |

Notes:

- a) The opportunity cost is based on a \$100 per hectare gross margin for wheat production in Western Australia.
- b) The average rotation length of 3 years was based on estimates prepared by the OMA and OMCA in "The Oil Mallee Industry. An Information Memorandum – Draft".
- c) The extent of revegetation required to impact on the total landscape was based on an estimate in OMA and OMCA's "The Oil Mallee Industry. An Information Memorandum – Draft".
- d) It was estimated by Agtrans that any sustainability benefits to the land between the trees would not take effect for 10 years.
- e) The 90% survival rate for eucalyptus trees planted was estimated by Agtrans.
- f) The total biomass yield of 10kg/tree at each harvest (every 3 years) was estimated by Agtrans. Estimates from CALM (Bartle, J, 1998, pers.comm.) suggest yields of 10kg/tree or more every 2 years.
- g) Percentages for leaf yield was sourced from an extract of personal communication with Rick Giles (1997) on "Harvesting and Transport Strategies and Costs". Oil yield was sourced from CALM (Bartle, J, 1998, pers.comm.).
- h) The industrial oil price was estimated by R. Davis (pers.comm.) and was based on the average price (US\$) for limonene.
- i) The price paid for oil sold to the pharmaceutical market was based on recent US prices, estimated by R. Davis (pers.comm.) and P. Abbott (pers.comm.).
- j) The quantity of oil to be sold to the pharmaceutical market was taken from estimates in OMA's Development Plan (May 1998).
- k) Estimates for the cost of establishment include planting and seedling costs and were extracted from "The Oil Mallee Industry. An Information Memorandum – Draft" prepared by the OMA with OMCA. The cost of seedlings was \$0.23, excluding \$0.08 of levies (Bartle, J, 1998, pers.comm.).
- l) Distillation costs were sourced from OMCA's Business Plan (1997).
- m) Operating costs for harvesting and transport were estimated by Agtrans and assumed that costs were made up of 50% labour and 50% fuel and maintenance. The labour costs for harvesting were based on 1 person @12 hours/day @ \$15/hour, while for transport it was 2 people @ 12 hours/day @ \$15/hour.
- n) Harvest, processing and transport capital costs were estimated as one harvester at \$300,000, six harvester bins at \$10,000 each, two field bins at \$50,000 each, one prime mover at \$150,000, and one mobile distillation plant at \$140,000. The cost of the harvester and distillation plant were taken from OMCA's Business Plan (1997) and from OMA's Development Plan (May 1998). Other capital costs were estimated by Agtrans. It was assumed that all capital equipment was replaced at the end of each 10 year period, one distillation plant was capable of producing more than 170 tonnes of oil each year, and the harvesting equipment was capable of harvesting almost 3,300 hectares of eucalyptus each year. It was also assumed that the harvester operated for only 90 days of the year, and for 6 hours (out of 12 hours) each day.

A conservative base value for sustainability benefits was initially assumed in the analysis. It was assumed there were no sustainability benefits and the wheat farmer would be losing land from agricultural production. The opportunity cost of the land for wheat was estimated at \$100/hectare.

## Base Results

The base results for the investment analysis for eucalyptus oil production are presented in Table 5.5. These results are based on the assumptions in Table 5.4.

Table 5.5. Base Results for Eucalyptus Oil Cost-Benefit Analysis, 30 years  
Discount Rate 5%

| Investment Criteria           | Base Case Results |
|-------------------------------|-------------------|
| Net Present Value (NPV)       | \$5 million       |
| B/C Ratio                     | 1.14 : 1          |
| Internal Rate of Return (IRR) | 6.9%              |

The results of the base case scenario indicate that the production of eucalyptus oil is economically feasible, with a positive NPV and IRR of 6.9%. The base case scenario included the assumption that the opportunity cost of growing trees on the land, in place of wheat, was \$100 per hectare. The following sensitivity analysis investigates how varying the "opportunity cost" of the land planted with trees and "sustainability benefits" of the area between the trees impacts on the NPV.

## Sensitivity Analysis

Variations were made on the assumptions used in the analysis. Expected minimum and maximum values for each selected variable were tested for their impact on the NPV. These changes in variables are summarised in Table 5.6 and the resulting impact is graphed in Figure 5.3.

Table 5.6. Expected Minimum and Maximum Values for each Variable.

| Variables subject to Sensitivity Analysis                | Minimum   | Maximum   |
|----------------------------------------------------------|-----------|-----------|
| Technical:                                               |           |           |
| Oil Yield (% of leaf yield)                              | 1.6%      | 4.8%      |
| Survival rate                                            | 50%       | 100%      |
| Economic:                                                |           |           |
| Discount rate                                            | 0%        | 10%       |
| Opportunity cost of lost wheat production (\$/ha) (a)    | \$0       | \$100     |
| Sustainability benefits (\$/ha) (b)                      | \$0       | \$400     |
| Costs:                                                   |           |           |
| Establishment cost (\$/tree)                             | \$0       | \$0.96    |
| Capital cost of mobile distiller                         | \$70,000  | \$210,000 |
| Capital cost of field bins                               | \$50,000  | \$150,000 |
| Capital cost of harvester                                | \$150,000 | \$450,000 |
| Capital cost of harvester bins                           | \$30,000  | \$90,000  |
| Capital cost of prime mover                              | \$75,000  | \$225,000 |
| Harvest operating cost (\$/day) (c)                      | \$180     | \$720     |
| Transport operating cost (\$/day) (c)                    | \$360     | \$1,440   |
| Distillation operating cost (\$/kg oil)                  | \$0.36    | \$1.08    |
| Prices:                                                  |           |           |
| Industrial price of eucalyptus oil (US\$/kg oil) (d)     | \$0.60    | \$6.00    |
| Pharmaceutical price of eucalyptus oil (US\$/kg oil) (d) | \$2.45    | \$11.00   |
| Max. tonnes sold to pharmaceutical market                | 0         | 800       |

**Notes:**

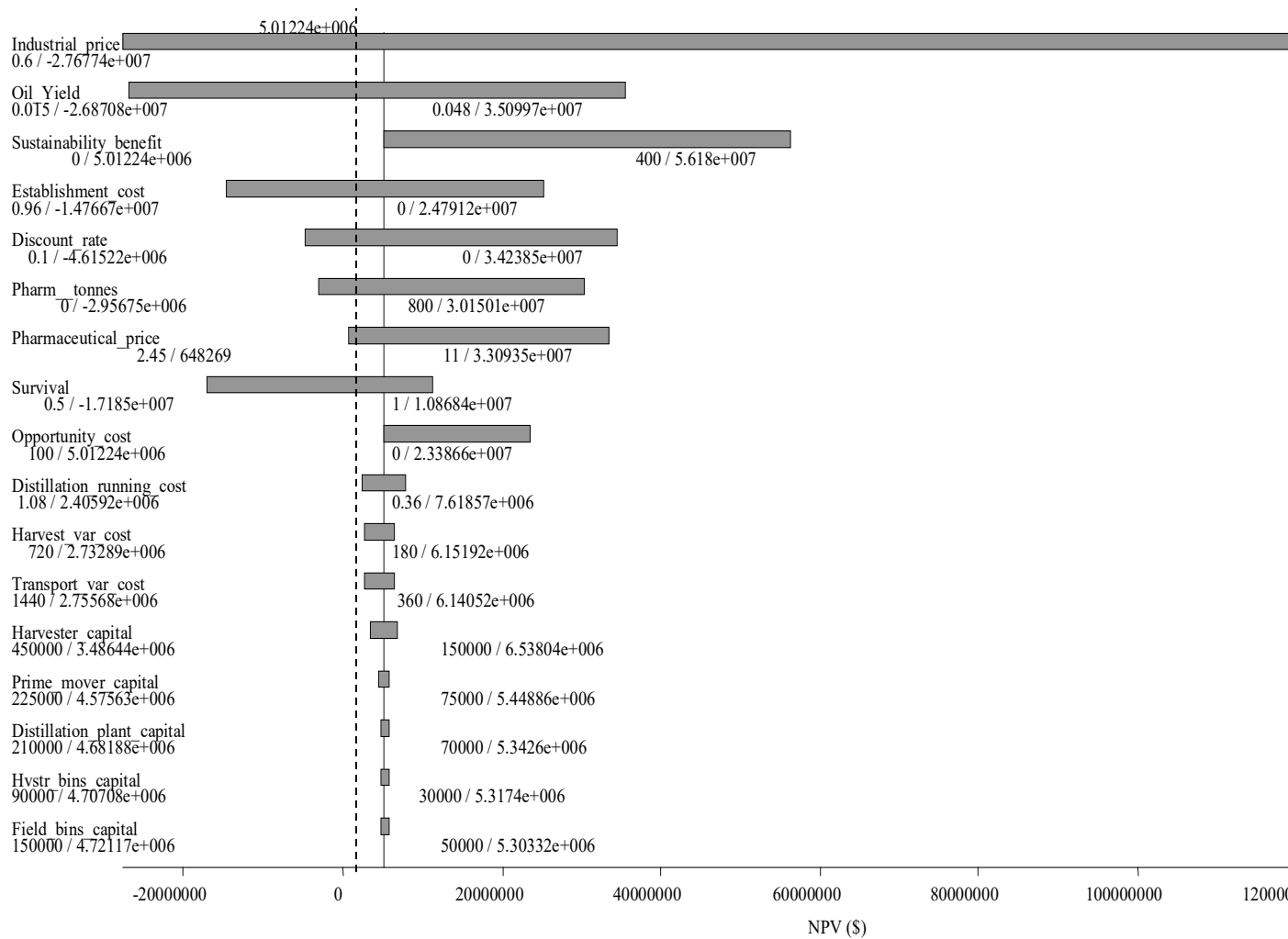
- a) The opportunity cost is varied from \$100 to \$0/hectare. At \$0, this assumes that the land planted to trees would have been lost to salinity anyway in ten years time.**
- b) The sustainability benefits (\$400/hectare) are based on 20% of the land area planted to trees affecting 80% of the land through effect on the watertable, thereby allowing the farmer to use 80% of the land (producing \$100/ha) which would have otherwise been lost to waterlogging/salinity in ten years time.**
- c) The variation in harvest and transport operating costs used in the sensitivity analysis is 50% above and below the base figures of \$360 and \$720 respectively.**
- d) Historical prices for limonene and eucalyptus oil were used to determine the minimum and maximum prices for industrial eucalyptus oil and pharmaceutical eucalyptus oil, respectively.**

The NPV remains positive at a discount rate of 5% even when the industrial oil price drops to \$1.36 per kg of oil or when the opportunity cost of the land rises by \$18 per hectare to \$118 per hectare. It was assumed in the analysis that the sustainability benefits would not take effect until 10 years after each planting. As a result, total sustainability benefits in the investment analysis became constant from year 18. Similarly, the NPV remains positive when the pharmaceutical price falls to US\$2.28/kg oil, or when the quantity of oil supplied to the pharmaceutical market drop to 74 tonnes.

It is important to note in Figure 5.3 that while the industrial oil price and the sustainability benefits have the greatest impact on NPV in their own right, that other factors, when combined, would also contribute significantly to further improving NPV. For example, combining the outcomes of reduced establishment costs, reduced cost of distillation, increased tonnes of oil sold to the pharmaceutical market and a higher pharmaceutical price, could produce a significant overall improvement in NPV.

Reducing the opportunity cost of the land, from \$100 per hectare to \$0 per hectare after the first 10 years, also had an impact on NPV, improving the total NPV from \$5 million to over \$23 million. Changes in other variables which had the least impact on NPV on their own were capital equipment prices, including the distiller, harvester, prime mover, field and harvester bins.

Figure 5.3. A Sensitivity Analysis of Changing Magnitudes of Variables on the NPV for Eucalyptus Oil Production.





## **Conclusion**

These analyses allow some observations to be made about the potential feasibility of eucalyptus oil production. Eucalyptus oil production appears viable, based on the assumptions used in the investment analysis. This is the case, even when the price for oil in the industrial and pharmaceutical markets falls. However, if either of these prices were to fall below US\$1.36 and US\$2.28, for industrial and pharmaceutical prices respectively, it would not be economically viable to produce eucalyptus oil. Also, if less than 74 tonnes of eucalyptus oil are sold to the pharmaceutical market, the investment would not be economically feasible.

In addition, combinations of other scenarios, which on their own have little impact on improving the investment's economic feasibility, may have an overall substantial impact. For example, further improvements in harvesting, transport and distillation design and costs could further improve the economic viability of eucalyptus oil production, as would further improvements in oil yield.

It should be noted that these results depend heavily on the assumptions made regarding oil yields and the technologies and costs of producing the oil from the biomass.

## **5.4 Further Areas for Development**

One of the most promising areas for improvement in production of eucalyptus oil in Australia is harvesting. For example, potential Western Australian production, with lines of trees scattered across the landscape, means that harvest costs are increased compared to what they would be under block plantings. Variable costs of harvesting are estimated to be A\$0.22/kg oil, including harvester transport between farms. This cost can be expected to decline marginally in the future as more plantings of eucalyptus occur on each farm, thus increasing the work carried out by the harvester on each farm. The most important impact on reducing harvester costs, however, will be the development of more efficient machinery and handling and transport systems. A development which would reduce the cost of processing (presently estimated by the Western Australians at \$0.72/kg oil), is a mobile distilling unit, mounted to the harvester.

While the potential for enhancing processing equipment is unknown, development has already commenced on a continuous flow distillation plant, and future work is planned for an evaporative cell plant. Improvements from both types of processing plant could make processing more efficient in terms of cost, and have the added benefit of reducing transport costs, in the case of evaporative cell technology. As the wood harvested is not transported to the distillation plant, it could be used on farm, for example as mulch, or used as a biomass source for electricity generation. In addition, centrally assembled wood may have a value greater than the additional transport costs incurred, for example in electricity generation.

This leads to another area for research and development focus which involves the processes, techniques and markets for the utilisation of by-products of oil production such as stems. For example, woody stems could be used as fuel for boilers in steam

distillation, production of activated carbon, or in electricity generation (see Chapter 4).

Other avenues to increase the revenue-cost ratio of eucalyptus oil production include the development of higher yielding plants and lower cost planting material. The probability of being able to develop genetic material with improved yield performance is high, and the impact this has on the profitability of eucalyptus oil is clearly shown in Figure 5.3. An area where lower establishment costs could be pursued is in the cost of production of seedlings. A valid starting point to reduce the cost of seedlings would be investigating methods to enhance the germination rate of the Eucalyptus species, as well as possibilities for rationalisation of nurseries to take advantage of scale economies, improve efficiency and reduce costs.

Other areas of R&D of importance are:

- research to assess the prospects of eucalyptus oil in the industrial solvent market,
- the proportion of area required to be under trees to provide sustainability benefits.

## **5.5 Summary & Conclusion**

The pharmaceutical market for eucalyptus oil has remained relatively constant over the past four years with a total world market around 3000 tonnes per annum. It is highly unlikely that this market will grow significantly, unless new value-added products are formulated and marketed.

The limited market size for pharmaceutical eucalyptus oil, combined with China's aggressive dominance of the world market and commitment to supply, even below cost, make the possibilities for increased Australian supply to the world market quite dismal. However, this situation may be reversed if Australia can produce eucalyptus oil at a lower cost than is presently envisaged, so that some Chinese production may be replaced. History supports this hypothesis, with Australian agricultural producers generally well regarded for their efficiencies, through mechanisation, in production.

An alternative market outlet could be in supplying eucalyptus oil to local, niche pharmaceutical markets, by ensuring the product is differentiated from other eucalyptus oil products.

In summary, the potential for Australia to supply to the pharmaceutical market, internationally and domestically, will require significant effort, either through research and development to make the product more competitive, or through the development of niche markets.

The solvent market for eucalyptus oil could offer the greatest potential for expanding oil production from agroforestry, as synthetic products like trichloroethane have recently been banned for their negative effects on the atmosphere. Estimates indicate that the world market is certainly large enough to support large scale production of eucalyptus oil in Australia. This potential, however, is subject to commercial cost of production being similar to what has been estimated in the current analysis.

There may be potential in supplying to the other niche solvent markets, such as hand cleaners, where world prices may be greater (e.g. up to US\$3.00/kg oil). Some of

these 'niches' may still be of a significant size so that substantial oil production may be warranted. Certain qualities, such as being a natural product and low irritant, allow for easier marketing of eucalyptus oil in this market. The potential for Australian producers to target the hand cleaner market could be significant, especially when compared with the size of the present total eucalyptus oil market. For example, if 10% of the 20,000 tonne hand cleaner market were penetrated by eucalyptus oil, then the market available to Australian producers would be an extra 2,000 tonnes of oil per annum, or approximately 5,000 hectares of trees harvested each year or about 15,000 hectares in the ground.

There appears good prospects for producing eucalyptus oil at competitive prices, disregarding any sustainability benefits. The estimated costs of production appear to be at a level that could enable such an industry to develop in the future.

## 6. FODDER

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Fodder refers to fodder trees, shrubs, and pasture species such as lucerne. This chapter includes information on trees and shrubs only. In this chapter, "tree/s" refers to woody stemmed plants with one main stem. "Shrubs", also have a woody stem, but may branch out and have more than one main stem, and are usually shorter in height than trees.

An estimated 80% of Australia's total fodder production is for on-farm use, with much of it made and used on the same property. In recent times, there has been an expansion in the area of planted fodder trees and shrubs. And although the fodder market is potentially large for off-farm export, the growing of fodder trees is mainly directed to on-farm consumption.

The perceived benefits of tree planting in maintaining sustainable land forms varies considerably from species to species, as does the ability of different species to provide nutritional fodder/feed reserves. For example, many native trees and shrubs can provide valuable reserves of fodder and alternative food sources for stock. Fodder trees may not only provide valuable feed supplements for incorporation into regular grazing patterns, but more importantly, they may enable farmers/graziers to sustain larger proportions of their livestock numbers in times of drought. If managed correctly, tree fodder may be substantially beneficial throughout drought periods as it can often still be green and nutritious when grass and herb feed has dried off.

### 6.1 Native Fodder Trees

In considering the various fodder trees available for growth in low rainfall areas, native species endemic to these areas must be a primary consideration. Possibly the best known native fodder tree is mulga, which grows in south west Queensland. Mulga has traditionally been cut from native stands as sources of fodder in dry times. It is not known, however, how mulga would grow from plantings and in an agroforestry situation, or how long it would need to grow for if it was planted in an agroforestry situation.

There are also a number of tree species in other areas which are useful sources of fodder. For example, various forms of saltbush (*Atriplex* spp.) are a valuable fodder source in dry, saline areas. Saltbush will not often tolerate prolonged waterlogging and therefore, is not well suited to low lying areas subject to flooding. There are six main species of saltbush that are commonly found, all exhibiting similar characteristics.

- **River Saltbush** (*Atriplex amnicola*) - Preferred species based on productivity and tolerance to salt and waterlogging.
- **Wavy leaf saltbush** (*A. undulata*) - Easier to establish by direct seeding than river saltbush but is not as salt and waterlogging tolerant.
- **Quail saltbush** (*A. lentifortnis*) - Tolerance similar to wavy leaf, but shorter lived.
- **Grey saltbush** (*A. cinerea*) - Has erect and prostrate forms, the prostrate form being more suited to grazing.

- **Oldman saltbush** (*A. nummularia*) - Tolerant of high salinity but is not as tolerant to waterlogging. Very suitable for dry salt (“magnesia”) patches and low rainfall areas.
- **River Murray saltbush** (*A. rhagodioides*) - A local species that shows potential to be a versatile and productive shrub.

*Atriplex nummularia* and *A. amnicola* are being propagated in Western Australia, and distributed nationally to Landcare groups for fodder and revegetation purposes.

Golden wreath wattle (*Acacia saligna*) is native to Western Australia and grows on a wide range of soil types, including sands and saline soils. It can withstand rainfall as low as 250 mm annually, making it very suitable for areas of the pastoral/sheep zone in Western Australia. *A. saligna* is also fast growing and tolerates heavy grazing enabling it to be included as a regular supplement to livestock grazing production. However, it possesses lower feed nutrient contents than many competitor species. With similar potential uses to that of saltbush, *A. saligna* offers significant benefits to overall environmental sustainability and productivity. There is limited information in regards to the commercial potential of this species as a wide spread fodder tree, however the characteristics which are known make it worthy of further investigation.

Although saltbush and mulga are the two most diversified and prominent native fodder tree species already found in some low rainfall areas, there are other native species which have the potential to generate quality fodder. Native species such as kurrajong, supplejack and wilga all possess very high fodder values, are reasonably widespread in low rainfall areas and are very palatable. However, little is known about their prospects as potential widespread fodder tree plantings. There are many other native fodder trees of similar characteristics, however, lack of knowledge and research into determining factors such as:

- establishment costs and procedures,
- management, and
- risks and long-term viability, make it difficult to evaluate possible alternatives.

## 6.2 Exotic Fodder Trees

Some of the earliest plantings of trees on farms, in Queensland for example, were exotic fodder trees. They were imported from places like Pakistan, South America and Africa. Although these trees can produce high quality fodder and protect lands from soil erosion and salinity problems, many also have the potential to become serious environmental weeds. Species such as *Gleditsia triacanthos* (honey locust) and *Prosopis spp.* (mesquite), which were originally introduced as fodder species, are now on the declared plants list of the Department of Natural Resources (Queensland) and are not to be planted under any circumstances.

While the establishment of introduced fodder species must be screened and monitored carefully, their inclusion into low rainfall farming systems may have considerable long-term benefits to livestock production and environmental sustainability. For example, *Leucaena* has become an important exotic fodder species, particularly in Queensland, with some graziers exhibiting the capacity to grow animals at the rate of 1 kg per head per day consistently throughout the year. However, *Leucaena* is best

suited to areas with rainfall above 650mm, even though it tolerates a relatively broad range of climatic conditions. *Leucaena* for low rainfall areas, although not recommended, should not be ruled out entirely as trees have been known to grow in drier areas (Lowry, B. 1998, pers.comm.).

The most prominent exotic fodder tree capable of withstanding harsh conditions of low rainfall areas is tagasaste (*Chamaecytisus palmensis*). Tagasaste is a perennial, leguminous shrub which is native to the Canary Islands off the coast of Africa. There, it has been used as a source of fodder for domestic animals for centuries. Introduced into Australia over 100 years ago, tagasaste has gradually developed as an important new forage species, capable of rapidly increasing liveweight gains of cattle or sheep through the production of nutritious leaf matter. In terms of management of tagasaste, it is relatively easy to establish, fast growing, and requires high stocking rates in order to keep the excess growth of branches and leaves at a grazable height. As a result, it is capable of withstanding constant grazing for periods up to ten years.

Tagasaste is well regarded for its sustainability potential in low rainfall areas, as it has the ability to penetrate deep into subsoil horizons, making it effective at keeping water-tables from rising to the surface. It does not, however, tolerate waterlogging. Tagasaste is growing successfully in areas with as little as 300 mm rainfall. For example, tagasaste grows well on the pockets of poor sand that occur throughout the WA wheatbelt. Many of these sands have perched water-tables that result in seeps and salinity lower in the landscape.

Another consideration for native fodder trees could include *Albizia lebbbeck* (Indian siris). *A. lebbbeck* has both native and exotic forms occurring in Australia. While some reports suggest *A. lebbbeck* requires high rainfall (> 1000mm per annum) to grow successfully (Doran & Turnbull, 1997), other sources have indicated that it has potential to grow successfully in higher margin of the lower rainfall zone, for example 600mm (Lowry, B. 1998, pers.comm.), or at the very least, in northern and central zones in Queensland with rainfall as low as 450mm per year (DNR Tree Facts). The potential for *A. lebbbeck* in the low rainfall zone will also be determined by the livestock grazing it, as sheep, unlike cattle, generally do not eat large amounts (Turnbull & Doran, 1997). The interesting point to note about *A. lebbbeck* is its capacity to provide quality fodder through both leaf fall and prunings. The relevance of fodder trees providing feed through leaf fall becomes important when dual purpose fodder trees are considered.

Oak acorns, from the *Quercus ilex* species, is an exotic species to Australia, and is produced worldwide primarily for its contribution to high quality fodder. For example, *Q. ilex* acorns are used to fatten and finish pigs in Spain. Maximum yield for oak acorn is reached at 30 years, and therefore does not appear competitive with other fodder species suitable for the low rainfall zone.

### 6.3 Dual Purpose Concept

While trees can be considered as being planted for fodder only, the commercial reality may dictate that trees are produced for dual purposes. Trees species capable of producing fodder and enhanced pasture growth, while also producing quality timber, have been identified (Lowry, B. 1998, pers.comm.). While the species identified were

predominantly tropical species, *Albizia lebbeck* was one that was identified as a dual purpose tree, and serves as a good example in this case. *A. lebbeck*, as mentioned previously, has the potential to provide fodder through fallen leaves, pods and flowers. The advantage to this form of forage "grazing" is that the woody biomass of the tree remains intact, and can be grown long term for timber production (Lowry, B. 1998, pers.comm.). The alternative to this would be to "lop" branches from the tree, which would damage the tree growth and form for timber production.

Dead finish (*Albizia basaltica*) was another species which was initially considered a useful dual purpose fodder species, although its ability to provide adequate leaf and pod fall has been evaluated as not being very promising, due mainly to its small leaves and pods (Lowry, B. 1998, pers.comm.).

Other dual purpose fodder trees may include a range of native fodder species, which generally would be suitable for biomass for electricity, and the denser timbers suitable for firewood. Exotic species too would be suitable biomass sources for electricity generation. Also, alternative products from fodder trees may be less obvious than the more tangible products of firewood and biomass. For example, tagasaste is capable of promoting excellent crop rotation growth when incorporated into inter-row alley farming. The identification of other dual purpose fodder trees for low rainfall Australia could be worthwhile in trying to promote commercial prospects for this zone.

## **6.4 Cost of Production & Economics**

The use of fodder trees as an on-farm commodity essentially creates a closed market, in that there is very little off-farm selling of the harvested product. The competition of other forage crop products and forage grains greatly reduces the market potential for the possibility of processing, packaging and selling, harvested fodder tree material. However, there are several fodder trees species that possess very palatable and highly nutritional feed and thus further research into the potential viability of fodder trees as a harvestable product, may open the door to new markets.

There are various establishment and management procedures required for different fodder tree species that need to be followed to ensure maximum emergence and survival of a planted population. For example, the establishment of saltbush requires that compacted soils are ripped and planting occurs in mounds to reduce waterlogging. Direct seeding of saltbush is possible and a germination test of the seed to be used is critical to determine appropriate sowing rates. Seedlings, although more expensive to establish, are the most reliable form of saltbush establishment, with plants requiring an initial 18 months of growth before they are suitable for grazing. Regular (yearly) grazing of shrubs produces the highest quality fodder and prevents the shrubs from becoming too woody. Saltbush combined with grass pastures can carry high stocking rates (e.g. 20 DSE/ha for 2 to 3 months) and are capable of surviving for prolonged periods.

Similar to saltbush, tagasaste can also be established through direct seeding or seedlings, although it is mainly established in the form of bare rooted and tubestock seedlings. This is done either manually or with the aid of a planting machine. Direct seeding is an economical and effective method to establish tagasaste, but seed must be

sown into a moist seed bed to achieve good results. Establishment costs for tagasaste can range between \$50 and \$200 per hectare, depending on the method of establishment, design and site conditions. There is minimal maintenance and management costs once the tagasaste is established, although pruning maintenance can be important, particularly when grazing sheep. Generally sheep do not graze as high as cattle, so the tagasaste requires pruning. Tagasaste can become an invasive weed in native vegetation if allowed to flower and shed seed, highlighting the need for good grazing/pruning management for control. Stands/sites of tagasaste can still maintain maximum stocking rates at 20 years of age if managed and monitored carefully.

Tagasaste can grow extremely fast. A combination of sheep and cattle grazing is therefore beneficial, as cattle can reach to the taller shoots, reducing the need to mechanically prune. When grazing with sheep alone, plants need to be constantly monitored to ensure bark stripping does not occur. Young plants can be grazed lightly with cattle at about 18 months, with full production from 3 years of age. Tagasaste grazed regularly will have a greater proportion of the more nutritious young leaves and shoots. Stocking rates suggest that grazing with sheep at high stocking rates (about 50 to 100 DSE/ha) for short periods (e.g. less than 5 weeks) with a 10 month rest period over winter and spring produces good results. Cattle stocking rates achieve good results at a consistent rate of 10 to 15 DSE/ha (PISA Fact Sheet, June 1997).

## 6.5 Summary & Conclusion

While it important to consider all species of fodder tree that possess potential for increased farm production and sustainability, native species are often easier to establish and generally pose less risk to the environment.

The native Saltbush species have potential as a fodder trees in low rainfall Australia. It's natural distribution is widespread and abundant and thus survives well in dry, harsh and saline conditions. Commercial distribution of saltbush seedlings has already commenced in Western Australia for national distribution, with species such as *Atriplex amnicola* and *Atriplex nummularia*.

The exotic species tagasaste offers the greatest economic potential for increased livestock carrying capacities throughout the drier areas of Australia. While it is capable of withstanding areas of low rainfall and possesses excellent water drawing capabilities, it also offers an excellent source of feed supplementation that can be incorporated into grazing sheep and cattle diets. It is well adapted to the varying harsh conditions of low rainfall Australia and is capable of withstanding a wide range of climates.

Finally, the concept of dual purpose fodder trees which can be established and maintained in the normal course of farming, for example, through alley farming systems, is important. Dual purpose production will allow more benefits, and particularly more "cash" benefits, to be realised, making the short and long term economic viability of fodder production look more promising. In addition, the ideal establishment method of dual purpose fodder trees would call for the use of existing farm machinery, and an agroforestry design which incorporated, or at least

complemented, existing agricultural operations. One such example of agroforestry design is alley farming, and this could lead to cost reductions in management, as well as improved sustainability benefits, which all lead to the long-term economic viability of dual purpose fodder trees.

## 7. OTHER PRODUCT FORMS

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### 7.1 Introduction

Previous chapters have focussed on what might be considered the "mainstream" products that might be generated from agroforestry in the low to medium rainfall zone. This chapter lists other more specialised products and enterprises that could be included. Time has not permitted comprehensive analysis of all products listed. The specialised products considered in this chapter include:

- Olives
- Sandalwood
- Jojoba
- Carob
- Guayule
- Tannin
- Flowers
- Bushfood
- Cork
- Gum arabic
- Essential oils and other chemicals
- Carbon credits

### 7.2 Olives

There are about 2000 ha of olives in Australia and these plantings have increased significantly over the past few years. Most olives are destined for the pickling market with only a limited proportion used for extraction of olive oil. It is likely that processing of olives for oil production will develop over time.

The olive tree is a hardy perennial and can adapt to wide range of climatic and soil conditions, although the tree favours well drained and alkaline soils and can withstand moderately saline conditions. Irrigation may be required at establishment. While it is drought resistant to a large extent, unless adequate water is supplied at critical growth stages, production and quality of olives can be low. For example fruit yields may be around 10 tonnes per hectare under irrigated conditions but only say 3 to 4 tonnes under dryland conditions. Most olive production in Australia is irrigated and uses high density plantings of 240-300 per hectare, high input systems and mechanical harvesting.

The market size is significant. Currently about 23 million litres of olive oil are imported each year into Australia. Assuming a per hectare production of olives of 3000 kg fruit per hectare under dryland conditions and a 20% oil content, total Australian production could be serviced from 38 000 hectares of dryland production.

Rainfed olive growing may be possible down to a rainfall of about 400 mm per year. A key question is whether olive trees would survive in such conditions without

supplementary irrigation, particularly in the 400-500 mm range where evapotranspiration is high.

An analysis of dryland growing of olives by Primary Industries and Resources SA has estimated that the internal rate of return for such a dryland venture would be only about 1% and therefore would be uneconomic.

Most olives in Australia are being grown under irrigation and it may be difficult for olive trees without irrigation to compete unless other attributes such as sustainability benefits or livestock grazing were included. An alternative system could be envisaged where olive trees were planted mainly for sustainability reasons with opportunistic harvesting depending on the market and seasons. Some maintenance operations in the form of weed control may be necessary although grazing under trees may be possible after trees are mature. Layouts could accommodate possible mechanical harvesting or hand held harvesters could be used. The technical feasibility and economics of such an operation could be considered further.

In summary, it may be possible to grow olives commercially under dryland conditions in this zone but it is more likely that irrigation will be required. While there may be geographic niches in the zone that are suitable for olive production and where irrigation water is available, it is not likely that olives will provide a significant area of trees unless an extensive olive/grazing system can be developed that integrates livestock grazing and is still able to use harvesting aids or mechanical harvesting.

### 7.3 Sandalwood

Sandalwood is valued for its oil and wood – oil for the manufacture of cosmetics and perfumery, and wood for ceremonial pieces and structures, such as temples, coffins, and incense sticks.

In Australia, sandalwood is sourced from native stands of *Santalum spicatum*. *S. spicatum* requires a host to grow, a suitable choice being *Acacia acuminata*, but other host trees are available. This species does produce oil as well as wood, but not to the extent of the exotic and more tropical species *Santalum album*, which produces 3 times more oil and, as a result, dominates the world market for sandalwood oil.

It is difficult to estimate the total world demand for sandalwood, except to say that demand is reported to be greater than present supply. There appears to be particular interest from Japan, who purchased an average 200 tonnes p.a. over 2 years from India.

Australian production of sandalwood is from Western Australia, from native stands of *S. spicatum*. This species of sandalwood is used mostly for incense sticks, with some timber use. Legislation in Western Australia restricts the volume of sandalwood harvested from native stands to 2,200 tonnes per annum.

The true export market value per tonne of wood is \$6,500. However, prices for sandalwood harvested from native stands in Western Australia are controlled by legislation, and the price is set below the true market price, at around \$1,500 per

tonne. Sandalwood produced on plantations would not be subject to legislative control, and therefore a price of \$6,500 per tonne could be expected.

If the presently supplied market was supplied from plantation sandalwood rather than from native stands, approximately 8,250 hectares of sandalwood would need to be established, so that 110,000 trees could be harvested each year. This assumes a yield of 20kg per sandalwood tree, over 30 years, and a planting density of 400 trees per hectare.

It has been suggested that domestic demand for sandalwood could be increased through promotion as craft wood, and for use in "cottage" industries. However, it is thought the market potential for use as a craft wood is likely to be relatively small when compared with the incense and oil markets.

While current exports from Australia (2,200 tonnes) could be increased, the market may have difficulty in absorbing anything like a 100% increase. As most of this market is currently supplied from non-plantation sources in very low rainfall areas, any plantations established in Australia would be competing with the existing native stands. It has been estimated that there is at least 50 years worth of harvesting from such native stands in the pastoral areas of Western Australia.

The market for sandalwood oil is significant, although the ability for *S. spicatum* to supply this market is not as favourable as the exotic tropical species *S. album*, which is grown in India and increasingly in north-western Australia. Demand for sandalwood oil comes mainly from India, for traditional uses. Demand is also driven by the cosmetic market, for use in perfumes and other products.

In summary, due to species suitability, growth rates and limited market potential, the opportunity for plantation sandalwood in low to medium rainfall areas of Australia is typically "niche", with a small level of production and possibly higher prices than currently received from native stands.

## 7.4 Jojoba

Jojoba oil, produced from the exotic shrub *Simmondsia chinensis*, is used in the cosmetic industry for moisturisers and hair care products, and in the industrial sector as lubricants (printing inks, varnishes, paints), candle-wax, and components in heat resistant rubbers, plastics, insulation and oils.

Most production in Australia centres around the Carnarvon region in Western Australia. Jojoba is drought resistant and suited to southern areas of Australia with low to medium rainfall. The optimal rainfall range is between 350 and 600 mm per annum, making it an ideal crop for the low rainfall zone. However, it should be noted that jojoba is susceptible to waterlogging.

Australia's production of jojoba constitutes less than 1% of total world production, with world production at around 1,000 tonnes per annum. Australia's present stands of jojoba have been established since the early 90's, from about 25 hectares in 1992 to approximately 200 hectares of high yielding varieties in 1996.

Harvesting of jojoba starts at around the 4<sup>th</sup> year of production, but doesn't peak until the 11<sup>th</sup> or 12<sup>th</sup> year, where yields from non-irrigated areas are around 1 tonne of seed per hectare. One tonne of seed sells for around \$4,500 per tonne, and produces approximately 500 litres (0.5 tonne) of oil. Jojoba is planted at a rate of approximately 1,250 plants per hectare. With this in mind, the 200 hectares of jojoba already planted will produce approximately 100 tonnes of oil when it reaches peak production, or 10% of the total current world market.

While the current world market for jojoba oil is relatively small (1,000 tonnes per annum), the potential for the world market has been estimated at between 64,000 and 200,000 tonnes of oil per annum. Australia's ability to fill part of the potential market could be promising, due to climate suitability and the use of high-yielding "cloned" varieties, unlike those used in other countries.

Some costs are available for jojoba production in Australia and are held by Agtrans, although this information is not complete.

In summary, the market opportunity for jojoba could be significant, if the potential world market is ever realised. Based on current world production, and the existing plantings of jojoba, Australia should have a 10% market share when present plantings peak in production after the year 2000. To reach 50% of current world production would require another 400 tonnes of oil to be produced from Australia, from 800 hectares or 1 million trees. If the world market for jojoba expanded significantly, it is likely that prices would also need to fall significantly.

## 7.5 Carob

Carob (*Ceratonia siliqua*) is an exotic tree species grown in Australia and is planted primarily for shade and shelter, although a few large scale plantations (approximately 8,720 trees in total) exist for the production of carob products (Curtis & Race, 1998). Carob products include 'carob bean gum' used as a food additive and emulsifier, carob powder (cocoa substitute) and supplementary stock feed. The stock feed and carob powder are produced from the carob pod, while the carob bean gum is produced from the seed which is housed in the pod. Carob possesses attributes which make it suitable for production in low rainfall areas, such as high salt and drought tolerance, although the impact of such factors on yield is not certain.

Fruiting commences usually between the 7<sup>th</sup> and 10<sup>th</sup> years, with each carob tree producing in the vicinity of 40kg of pods each year, or the equivalent of 4 kg of seed, under dryland conditions. In comparison, irrigated and fertilised carob produces around 100kg of pods/tree per annum. Planting densities vary according to climate, soil, management and varieties and may range between 100 and 200 trees per hectare. Based on a planting density of 100 trees per hectare and a yield of 4kg of seed per tree, one hectare of carob would produce approximately 400kg of seed.

Even though mechanical harvesting of carob is possible, most of the world's carob is harvested by hand due to irregular plantings and unsuitable terrain (hilly, rocky) for harvesters. It has been suggested that mechanical harvesting would be necessary for Australian production, to reduce labour costs. Regular tree spacing and flat, even terrain are required for mechanical harvesters to operate effectively.

Demand for carob bean gum in Australia has been estimated at 1,400 tonnes per annum, with most (86%) being consumed by the pet food industry and the remainder used in human food products. World demand for carob bean gum has been estimated at 21,875 tonnes (assuming 1:1.6 ratio of carob bean gum to seed). Spain produces almost half of total world production. The nearest rival to Spain is Italy, with one third of the production of Spain. In terms of hectares of trees required to meet Australian and world demand for carob bean gum, approximately 5,625 hectares would need to be harvested each year to meet Australian demand, and 87,500 hectares would need to be harvested each year to meet world demand.

As well as utilising carob seeds as a food additive and emulsifier, carob pods (pulp) have the potential to be used as a supplementary fodder source. Prices around \$150 per tonne (pods) can be expected for carob pods (pulp only) sold as fodder. However, the pod pulp may also be roasted and ground into carob powder, with prices around \$1,500 per tonne, making this option more attractive than selling the pod pulp as fodder. The RIRDC report on the economic feasibility of carob production (Curtis & Race, 1998) concluded that the internal rate of return varied according to the products marketed. The analysis assumed 100 hectare of dryland carob production in a medium rainfall area (500-700mm per annum), with a yield of 40kg of pods per tree. The IRR ranged from -5.3% when the carob was marketed as stock feed only (\$150/tonne of pod), through to 17.9% when it was marketed as higher value seed (\$160/tonne of pod) and carob powder (\$1,350/tonne of pod).

In summary, even if Australia were to meet 10% of the total world demand for carob bean gum, approximately 8,750 hectares would need to be harvested each year, from a planting of the same size (carob trees yield pods every year, once mature). This scale of planting is likely to have a medium impact on the total landscape in the low rainfall areas of Australia.

## 7.6 Guayule

Guayule, *Parthenium argentatum*, is native species of the arid areas of America, and is utilised for its wood and resin, but predominantly harvested for rubber contained in its bark. Most of the world's natural rubber is sourced from the hevea rubber tree (*Hevea brasiliensis*).

It has been suggested that the market for guayule rubber is in enhancing rubber production, not replacing production from the hevea rubber tree. However, there may also be potential for Guayule to replace hevea rubber in some markets, as there have been some allergy problems associated with hevea rubber used in medical applications (e.g. gloves, capsules etc). The supply of guayule into this market, without the competition from hevea rubber, could increase the price for guayule.

Australian research in the 1980s found rubber yield from guayule produced in Australia to be notably less than was identified in earlier US research (Milthorpe *et al*, 1994). The Australian research also found that it was not economic to produce guayule, even under irrigation. High establishment costs, as a result of having to use transplants, combined with poor rubber prices and low yields, mean that guayule production, under present circumstances, is unlikely to be economic (Milthorpe, P.

1998, pers.comm.). Significant changes in establishment costs, rubber prices, yields, or changes in a combination of these variables, would need to occur before guayule production became profitable.

## 7.7 Tannin

*Acacia mearnsii*, commonly known as Black Wattle, is an Australian native tree which contains high levels of condensed tannin in its bark. While other Australian species contain tannin, *A. mearnsii* is known to be the richest source of tannin.

Many countries around the world are involved in the cultivation of *A. mearnsii* for the production of tannins, amongst other products. These countries include Brazil, China, India, South Africa, and eastern Africa (Kenya and Zimbabwe). Indonesia also cultivates *A. mearnsii*. It has been estimated that the areas under *A. mearnsii* cultivation in Brazil, South Africa and China are 200,000 hectares, 160,000 hectares, and 30,000 hectares, respectively (Doran & Turnbull, 1997).

Native stands of *Acacia mearnsii* in Australia have been in decline since last century, due to the overexploitation of native stands for tannin and the intersection of native stands with population growth and development. Harvesting of *A. mearnsii* from native stands in Australia continued until the 1970's. Cultivation on private lands since then has been for local, small scale use, and not necessarily for tannin. The area of native stands of *A. mearnsii* is reported to be very small in Australia today, and is located in Victoria, southern NSW, and Tasmania. There are no longer any commercial *A. mearnsii* plantations in Australia. Australia sources tannin mostly from South Africa.

*A. mearnsii* is capable of growing in a range of rainfall situations, from 440-1600 mm of rainfall per annum, although in its natural state it grows best in the cooler, moist areas of south-eastern Victoria. It is fast growing, with maximum growth reached at 3-5 years, is sensitive to severe drought, and has a life span of approximately 15-20 years. Yields from *A. mearnsii* production in South Africa are in the vicinity of 21 tonnes of dry bark per hectare over 10 years. With a tannin composition of approximately 35-51% of dry bark, the tannin yield ranges between 7.4 and 10.7 tonnes of tannin per hectare over 10 years. It should be noted, however, that the yields taken from the South African example most likely overestimate the yields which could be expected from agroforestry plantings in lower rainfall areas, because most South African plantations are in the summer rainfall band of 870-1050mm per annum. As well as climatic factors, yields of tannin are also affected by genetic variability or tree maturity.

Tannin is used around the world in products such as adhesives, including wood adhesives, and for use in the leather tanning industry. This is also true for Australian consumption. Imports of "wattle bark extracts" into Australia during 1985-87 ranged between 2,830 and 5,480 tonnes. Using an average of 4,155 tonnes, 462 hectares of *A. mearnsii* would need to be harvested each year to replace imports, assuming a tannin yield of nine tonnes per hectare. Based on a 10 year rotation of *A. mearnsii*, 4,620 hectares of *A. mearnsii* would need to be established, so that 462 hectares could be harvested each year. It is not known how large the world market for tannin is, although, it might be argued, with world plantations generally occurring in higher

rainfall areas than those proposed for low rainfall agroforestry in Australia (400-600mm), that there may be limited potential for tannin as a commercial option for low rainfall agroforestry.

## **7.8 Flowers**

The international floriculture market has been estimated at \$4 billion annually, with Australian exports totaling less than 1% of the total market in 1994 (Foster & Bills, 1994). The floriculture market consists of flowers and foliage from trees, shrubs and traditional flowers such as roses and carnations. Potential flower production from the low rainfall areas of Australia, for the purposes of this report, is assumed to concentrate on flowers and foliage from trees. Suitable genera for the low rainfall zone would include Acacias, Eucalyptus and Banksias, although more research is required on which species are suitable for cultivated production in the 400-600mm rainfall zone. Australian exports of native fresh flowers have been estimated at approximately \$15 million annually, and exports of fresh foliage at \$0.5 million annually.

With foliage and cut flowers (for all flower types) averaging \$0.25/stem, the total international market is in the vicinity of 16 billion stems annually. While only a small portion of Australian flowers from trees would make up this market, the area of trees required to fill the entire market is still only relatively small, at approximately 160,000 hectares, based on plantings of 1,000 trees per hectare and each tree yielding 100 stems annually. If Australia were to meet 2% of this market from agroforestry plantings in the low rainfall areas, approximately 3,200 hectares would need to be harvested each year.

Production of flowers and stems requires intensive management regimes, to produce quality product. In terms of profitability to individual producers, it has been estimated that a 7-10% return on capital invested could be achieved from growing Acacia species for flower production (Hyde, 1998).

In conclusion, while there may be commercial opportunities to produce flowers in the low rainfall zone, the size of the market and the need for quality and consistency may drive such production to intensive operations. It is unlikely therefore, that any landscape scale impact would be apparent.

## **7.9 Bushfood**

An increasing interest and demand has developed over the past decade for Australian bush food. The bush food industry relies principally on the harvest of material from native stands (75 to 80%). As the demand grows, it is likely that further supplies of some foods may be obtained from planted stands of these natives. Planted stands may give reliability of supply, a higher consistency of quality, and may take the pressure off the harvesting of natural stands where these may be threatened. Commercial plantings of bush foods have been limited to date.

While more than 300 species are used in the bush food industry, the Australian Native Bushfood Industry Committee identified 11 ‘core’ species with the best potential for further development (Rural Research 172, Spring 1996).

The eleven core species were:

- Bush tomato (*Solanum centrale*)
- Illawarra plum (*Podocarpus elatus*)
- Kakadu plum (*Terminalia ferdinandiana*)
- Lemon aspen (*Acromychia acidula*)
- Lemon myrtle (*Backhousia citriodora*)
- Mountain pepper (*Tasmannia lanceolata*)
- Muntries (*Kunzea pomifera*)
- Quandong (*Santalum acuminatum*)
- Riberry (*Syzygium luehmannii*)
- Wattleseed (*Acacia spp.*)
- Wild limes (*Eremocitrus glauca*, *Microcitrus spp.*)

Only a few of the ‘core’ species are suited to drier areas. These include the quandong, wattleseeds and some of the wild limes. Particularly suited to low rainfall as well as saline areas is the quandong which has been the topic of much research in the past. Other species in the ‘core’ list such as Lemon Myrtle are native to the higher rainfall areas.

Domestic and export demand for these foods is still only small with the initial market developed being in the novelty restaurant sector within Australia. If production of some of the above species were proven to be commercially viable in the low rainfall zones, it is unlikely that significantly sized markets could be developed due to the cost of production and the specialised niche markets from which demand currently emanates. Where the establishment of bush food species can contribute to sustainability issues through providing diversity and addressing particular issues in the landscape, commercial viability may be enhanced. However, it is still unlikely that plantings of bush food species for commercial purposes will provide any significant landscape scale change within the foreseeable future.

## 7.10 Cork

Cork is harvested from *Quercus suber*, known commonly as Cork Oak. *Q. suber* is grown commercially in the drier areas of Spain, Portugal and northern Africa for processing into cork seals, as used in wine bottles. Plantings of *Q. suber* in Portugal are continuing under a reforestation program. Even without further plantings, it has been estimated that Portugal, which supplies approximately 51% of the world's cork, will be able to supply cork for another 70 years.

While cork from *Q. suber* has traditionally enjoyed market leadership in the wine bottling industry, there has been a recent move by a large Australian winery to employ synthetic seals for bottling. It has been suggested that the winery aims to replace all of its cork imports with the synthetic seal.

Production of *Q. suber* for cork may not be economic, since the first harvest of bark does not occur until the 43<sup>rd</sup> year. As well, two strippings are done prior to this, in the 25<sup>th</sup> and 34<sup>th</sup> years, to ensure quality cork is generated for the first harvest of bark suitable for wine corks. Specialist/skilled labour is also required at each harvest to

ensure the cork is stripped correctly from the trees. As well, investment in cork processing plants is expected to be significant, but would be necessary if farmers were to obtain fair prices for cork.

In conclusion, while there is a market for cork, demand is supplied by established producers who are able to produce quality cork, and these producers are likely to be producing cork for many years to come. In addition, the long rotation and expensive harvesting and processing costs, mean that cork production in Australia is not likely to be significant.

In addition to cork, *Q. suber* produces acorns, which provide a fodder source for livestock, although the yield and quality are not as high as *Q. ilex* (see Chapter 6).

## 7.11 Gum Arabic

Gum arabic is extracted from species of *Acacia*, predominantly *A. senegal* and *A. seyal*. The main uses for gum arabic, or gum acacia as it is sometimes called, include glues and food additives, including emulsifiers and thickeners. It should be noted that the glues produced are not particularly suitable for timber gluing, but are more suited for paper gluing. Most of the world's supply of gum arabic comes from Sudan (70%), with other African nations providing much smaller quantities of gum arabic. These countries include Nigeria, Senegal and Mali.

Gum arabic is produced from injured or unhealthy trees. The process of harvesting involves cutting and stripping the bark to expose a tree wound, where gum forms in approximately 3 weeks. From here, the gum is harvested every 10 days, allowing a young tree to produce between 0.4 and 7 kg of gum annually.

The potential for producing and processing gum arabic in Australia is limited, due to a combination of factors. These include the high costs associated with stripping the bark from the trees, high capital costs for processing equipment, competition from other countries with lower labour costs, and competition from synthetic products, particularly synthetic glues (Collins, P. 1998, pers.comm.).

## 7.12 Essential Oils & Other Chemicals

Essential oils are produced from a host of species, including both trees and shrub species. One of the well known group of trees, which have already found commercial success from production in the high rainfall areas of Australia, are species from the *Melaleuca* genus, particularly *M. alternifolia* and *M. linearifolia*. While *M. alternifolia* and other species found in the high rainfall zone are used for the production of tea tree oil in that zone, such species may also be grown in the upper margin of the lower rainfall zone (e.g. 500-600mm). Also, there are other *Melaleuca* species which may be worth considering for the low rainfall zone.

One of the more important prospects for *Melaleucas* in low rainfall areas of Australia could be in the production of betaines. Betaines are plant growth regulators, and the particular betaines found in one particular species of *Melaleuca*, that grows in the lower rainfall area, can be extracted and manufactured into crop chemicals (Bodapati,

N. 1998, pers.comm.). These betaine products, when used on crops, could alter the water efficiency of the plants, so that they become more tolerant of dry conditions.

### **7.13 Carbon Credits**

"Carbon Credits", although not in existence at present, could have potential to be associated with low rainfall agroforestry. It is expected that carbon credits would be traded on the stock exchange, as a marketable product, allowing emitters of greenhouse gases the privilege to continue emitting greenhouse gases.

The potential suitability of trees as carbon "sinks" would apply to agroforestry situations and plantations, most likely with the requirement that the trees were planted relatively recently. Factors which are likely to grade a stand of trees as being superior carbon sequesters to other stands, include species selection (for leaf surface area and growth rates), harvest cycles, and tree age. In terms of age, young trees have high growth and photosynthetic rates, and therefore absorb more carbon. Mature trees are also important, although the absorption rate is not likely to be as high.

Carbon credits may provide an additional source of income for low rainfall agroforestry ventures. For example, economic analyses of some of the products covered in this report (e.g firewood) have found that establishing, managing, harvesting, and selling products from trees may not be economically viable on their own, given present technology and markets. If a market develops, carbon credits could provide the extra return required to ensure commercial viability for any "almost commercial" low rainfall agroforestry products.

## 8. SPECIES LIST

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### 8.1 Introduction

The purpose of this chapter is to provide a list of species, which may be suitable for the various product forms, identified in earlier chapters. The species list presented should be considered indicative rather than prescriptive. The aim is to provide some indication of species that might be best suited to produce potentially commercial products in the low rainfall zone.

Sources of information for the compilation of this species list included personnel from CSIRO Forestry and Forest Products (Clayton and Yarralumla), personnel from the Western Australian Department of Conservation and Land Management, Queensland Forestry and Department of Natural Resources personnel, timber traders, SA Forestry, as well as literature and other research publications.

Information is lacking on how low rainfall native species will grow in a plantation situation or in plantings of different designs. While researchers are confident of a relationship between plantation design and density, sub-surface hydrology and rainfall volume and frequency, the degree to which they impact on each other is unclear. As an example, plantings of trees in the lower rainfall areas of Australia are likely to be wider spaced than in the higher rainfall zone, due to low rainfall and varying hydrology issues, although any design recommendations for these areas may be need to be site specific.

There is also limited documented evidence of how low rainfall species will grow in higher rainfall areas. Low rainfall species grown in higher rainfall environments may experience faster growth rates, and researchers believe that timber characteristics will change, although it is unclear whether these would have beneficial or negative effects on the timber. A drawback to growing low rainfall species in higher rainfall areas is likely to be the increased threat of pests and diseases, such as fungal attacks.

Rather than the scenario where low rainfall species are planted in high rainfall areas to meet a certain market, it is more likely that effort would be put into identifying high rainfall species which could duplicate the marketable qualities of the low rainfall species.

The potential for high rainfall species to be grown in low rainfall conditions is not known as there has been little research completed in this area, although some trial work is presently being conducted.

Section 8.2 includes a list of those species which might be grown in the lower rainfall zone only, as opposed to the list in Section 8.3 which presents a list of species which, although suitable for the low rainfall zone, may also be grown in the higher rainfall areas. Section 8.4 presents species for other product forms that were not considered in the species lists in Section 8.2 and 8.3. These include species producing commercial products such as olives, jojoba, and carob, and product forms such as energy. Where possible, information has been provided on sustainability benefits that might be expected from the various species.

## 8.2 Species Particularly Suited to Low Rainfall Areas

This section lists those species particularly suited to the low rainfall zone which may not grow as successfully in the higher rainfall zones. Table 8.1 includes mainly those species which have the potential to produce specialty timbers with unique characteristics, based on the assumption that faster growth rates in higher rainfall zones may not produce the same density, strength and colour characteristics as in the low rainfall zone. It should be noted that the division of species into Tables 8.1 and 8.2 is based partly on evidence and existing knowledge. However, much of it is subjective and subject to further verification.

**Table 8.1. Species Particularly Suited to Low-Rainfall Areas**

| Species name                                                                                | Common name                                         | Product Form                                                       |                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Low Rainfall Zone only</b>                                                               |                                                     |                                                                    |                                                                                                                                                                                                |
| <i>Acacia acuminata</i>                                                                     | Raspberry Jam, Jam Tree                             | Specialty timber, Posts (fence).                                   | Suitable host species for sandalwood; tolerates drought & moderate salinity; air-dry density 1100kg/m <sup>3</sup> .                                                                           |
| <i>Acacia aneura</i>                                                                        | Mulga                                               | Specialty timber, Firewood, Fodder (supplementary), Posts (fence). | Hard timber, very slow growth rate, small log. Agroforestry opportunity may be limited due to large native stand (communities up to 1.5 million km <sup>2</sup> ).                             |
| <i>Acacia colei</i>                                                                         | Cole's wattle                                       | Fuelwood.                                                          | Air dry density 870kg/m <sup>3</sup> , high calorific value of wood and charcoal.                                                                                                              |
| <i>Acacia murrayana</i>                                                                     | Sandplain wattle, Colony wattle                     | Fuelwood                                                           | Small size stems (rarely more than 10cm diameter).                                                                                                                                             |
| <i>Acacia salicina</i>                                                                      | Cooba, Doolan, Willow wattle                        | Specialty timber (furniture), Posts.                               | Tolerates waterlogged land & moderate salinity, relatively fast growing, coppices well when young, grows into a single stem, air dry density 675kg/m <sup>3</sup> .                            |
| <i>Acacia shirleyi</i>                                                                      | Shirley's lancewood                                 | Specialty timber, Firewood, Posts (fence)                          | Heavy wood but durability in ground uncertain; natural occurrence NT, north-western Qld; air-dry density 1025kg/m <sup>3</sup> .                                                               |
| <i>Acacia stenophylla</i>                                                                   | River cooba                                         | Sawntimber (furniture), Posts (fence)                              | High salt & moderate drought tolerance; air dry density 900kg/m <sup>3</sup> .                                                                                                                 |
| <i>Acacia victoriae</i>                                                                     | Prickly wattle                                      | Fuelwood                                                           | Small diameter wood; could be used as small firewood; life span 10-15 years; fast growing; spiny form.                                                                                         |
| <i>Allocasuarina luehmannii</i>                                                             | Bull oak                                            | Firewood, Posts.                                                   | Fast growing, tolerates drought, waterlogging & moderate salinity. Air dry density 1100kg/m <sup>3</sup> .                                                                                     |
| <i>Archidendropsis basaltica</i>                                                            | Dead Finish, Red Lancewood                          | Specialty timber (craft)                                           | Air dry density 1200kg/m <sup>3</sup> .                                                                                                                                                        |
| <i>Atriplex</i> spp. (e.g. <i>A. amnicola</i> , <i>A. undulata</i> , <i>A. nummularia</i> ) | River Saltbush, Wavy Leaf Saltbush, Oldman Saltbush | Fodder                                                             | River saltbush tolerant to salinity and waterlogging, Wavy leaf saltbush not as tolerant but can direct seed, Oldman saltbush tolerant to salinity but not waterlogging.                       |
| <i>Callitris glaucophylla</i>                                                               | Cypress Pine                                        | Sawntimber (softwood)                                              | Native softwood species, grows in low rainfall zone.                                                                                                                                           |
| <i>Carrisa ovata</i>                                                                        | Currant Bush                                        | Specialty timber                                                   | Orange wood, used in craft, carvings and furniture inlays.                                                                                                                                     |
| <i>Eucalyptus argophloia</i>                                                                | Queensland Western White Gum, Chinchilla White Gum  | Sawntimber, Poles, Specialty timber                                | Good form (straight), attractive dark red timber, good coppicing, drought tolerant, air dry density 1055kg/m <sup>3</sup> threatened species and therefore potential for harvesting not known. |

|                                                                                     |                               |                                                                 |                                                                                                                                                                     |
|-------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Eucalyptus astringens</i>                                                        | Brown Mallet                  | Specialty timber; Sawntimber, Firewood, Posts (fence), Tannins. | Very dense timber (air dry density 980kg/m <sup>3</sup> ), ideal for tool handles; poor coppicing, drought & moderate salt tolerance, native to WA.                 |
| <i>Eucalyptus camaldulensis</i>                                                     | River Red Gum                 | Specialty timber, Firewood/ Fuelwood.                           | High drought & seasonal waterlogging & salt tolerance; dense wood; good coppicing; provenance is critical to zones in which it can be grown.                        |
| <i>Eucalyptus cladocalyx</i>                                                        | Sugar Gum                     | Sawntimber, Specialty timber; Fuelwood, Posts.                  | Could be used for furniture, although 'gluability' is a problem, grows extensively in wheat belt; air dry density 850-1100kg/m <sup>3</sup> .                       |
| <i>Eucalyptus crebra</i> , as an example of a range of Ironbarks.                   | Narrow Leaf Ironbark          | Sawntimber (structural), Specialty timber.                      | Air dry density 1090kg/m <sup>3</sup> , previously considered too heavy for furniture.                                                                              |
| <i>Eucalyptus loxophelba</i> ; <i>Eucalyptus loxophelba</i> ssp. <i>Lissophloia</i> | York Gum                      | Specialty timber, Eucalyptus oil                                | Requires pruning; demonstrated ability to grow in low rainfall areas in WA, high oil concentration.                                                                 |
| <i>Eucalyptus occidentalis</i>                                                      | Flat-topped Yate              | Sawntimber, Specialty timber, Posts, Firewood                   | Salinity, waterlogging & drought tolerant; coppices well; air dry density 850-900kg/m <sup>3</sup> .                                                                |
| <i>Eucalyptus polyanthemus</i>                                                      | Red Box                       | Firewood, Flowers                                               | Good, durable timber; good growth rate.                                                                                                                             |
| <i>Eucalyptus polybractea</i>                                                       | Blue Mallee                   | Essential oil                                                   | High cineole content; coppices well; moderate salt tolerance; suited to lower rainfall areas of NSW.                                                                |
| <i>Eucalyptus sideroxylon</i>                                                       | Mugga Ironbark, Red Ironbark  | Specialty timber, Firewood                                      | Air dry density 1090kg/m <sup>3</sup> .                                                                                                                             |
| <i>Grevillea striata</i>                                                            | Beefwood                      | Specialty timber, Posts (fence)                                 | Very slow growth; air dry density 880kg/m <sup>3</sup> .                                                                                                            |
| <i>Lysicarpus angustifolius</i>                                                     | Budgeroo, Brown Hazelwood     | Specialty timber                                                | Air dry density 800kg/m <sup>3</sup> , poor form and small log length, suitable for craft purposes.                                                                 |
| <i>Santalum lanceolatum</i>                                                         | True Sandalwood, Plumwood     | Specialty timber                                                | Used for incense sticks, air dry density 930kg/m <sup>3</sup> .                                                                                                     |
| <i>Santalum spicatum</i>                                                            | Western Australian Sandalwood | Sandalwood oil, Specialty timber (fragrant wood)                | Drought resistant, sandy loam soils, susceptible to waterlogging, requires host species.                                                                            |
| <b>Higher rainfall margin of the Low Rainfall Zone</b>                              |                               |                                                                 |                                                                                                                                                                     |
| <i>Acacia cambagei</i>                                                              | Gidgee                        | Specialty timber, Firewood, Posts (fence)                       | Drought tolerant; dark reddish brown wood, natural occurrence NT, Western Qld, north western NSW, very slow growth.                                                 |
| <i>Acacia harpophylla</i>                                                           | Brigalow                      | Specialty timber (cabinet), Firewood, Posts (fence)             | Very strong, dense timber (basic density 900kg/m <sup>3</sup> ), very slow growth rate, native to southern Qld and northern inland NSW, problems with storing seed. |
| <i>Eucalyptus coolabah</i>                                                          | Coolabah                      | Specialty timber, Posts (fence), Firewood.                      | High density (air dry density 1150kg/m <sup>3</sup> ), small tree; drought tolerant.                                                                                |
| <i>Eucalyptus melliodora</i>                                                        | Yellow Box                    | Specialty timber, Firewood, Honey; Sawntimber                   | Furniture and niche markets; subject to insect attack, slow growth; air dry density 1100kg/m <sup>3</sup> .                                                         |

**Note: Air dry density is the average mass divided by the volume at 12 per cent moisture content. Basic density is the oven-dry mass divided by green volume (CALM, Timber Advisory Notes, No. 25). Timber density should not be confused with timber strength. Density is measured in terms of weight per volume ( $\text{kg/m}^3$ ). Measurements of strength take into account elasticity, crushing strength, and hardness of the timber.**

## 8.3 Species Suited to Low Rainfall Areas as well as High Rainfall Areas

This section lists species possibly suitable for production in low rainfall areas, but acknowledges that these species may have the potential to be produced in higher rainfall areas as well (Table 8.2). It is difficult to support this species selection with documented evidence, as relatively little research has been conducted on the adaptability of low rainfall species to the higher rainfall areas. In particular, it is uncertain whether products would be of the same quality if grown in the higher rainfall areas.

Table 8.2. Species Suitable for Low Rainfall Areas, which could also be Grown in Higher Rainfall Areas

| Species name                                                           | Common name                                  | Product Form                                               | Comments                                                                                                                                                                       |
|------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Acacia saligna</i>                                                  | Golden Wreath Wattle                         | Fodder (supplementary)                                     | Grows on sandy and saline soils, fast growing, tolerates heavy grazing, coppices well, lives 10-15 years.                                                                      |
| <i>Albizia lebbbeck</i>                                                | Indian siris                                 | Fodder, Fuelwood.                                          | Native species; coppices well; drought & moderate salt tolerance; high quality fodder.                                                                                         |
| <i>Allocasuarina huegeliana</i>                                        | Rock Sheoak                                  | Specialty timber                                           | Not tolerant to salinity and waterlogging, very dense wood.                                                                                                                    |
| <i>Brachychiton populneum</i>                                          | Kurrajong                                    | Fodder, Bushfood.                                          |                                                                                                                                                                                |
| <i>Callitris endlicheri</i>                                            | Black Cypress Pine                           | Fuelwood (charcoal), Posts (fence), Sawntimber (furniture) | Initial slow growth (first 10-20 years); air dry density 710kg/m <sup>3</sup> .                                                                                                |
| <i>Casaurina cristata</i>                                              | Belah                                        | Specialty timber (craft), Firewood                         | Tolerant to drought, salinity & waterlogging; air dry density 1150kg/m <sup>3</sup> .                                                                                          |
| <i>Casaurina cunninghamiana</i>                                        | River She-oak                                | Firewood                                                   | Fast growing; coppices well; tolerates drought & moderate salinity & waterlogging; air dry density 770kg/m <sup>3</sup> .                                                      |
| <i>Casuarina glauca</i>                                                | Swamp She-oak, Swamp Oak                     | Sawntimber, Firewood, Posts.                               | Good growth rates; coppices well; tolerant of drought, salinity & periodic waterlogging; air dry density 900-980kg/m <sup>3</sup> .                                            |
| <i>Casuarina obesa</i>                                                 | Swamp She-oak, Western Australian Swamp Oak. | Posts (fence), Firewood                                    | Poor appearance, high tolerance to salinity and waterlogging, timber suitability unknown, hard, heavy and difficult to work.                                                   |
| <i>Chameacytisus palmerisis</i>                                        | Tagasaste                                    | Fodder                                                     | Exotic species, suited to deep sandy soils, will not tolerate salinity or waterlogging, fast growing, requires pruning if grazed by sheep; unsure of possibility of weediness. |
| <i>Cupressus arizonica</i>                                             | Arizona Cypress                              |                                                            | Exotic softwood species.                                                                                                                                                       |
| <i>Cupressus dupreziana</i>                                            | Sahara Cypress                               |                                                            | Exotic softwood species.                                                                                                                                                       |
| <i>Eucalyptus angustissima</i>                                         |                                              | Eucalyptus oil                                             | Demonstrated ability to grow in low rainfall areas in WA, coppice, high oil concentration.                                                                                     |
| <i>Eucalyptus citriodora</i>                                           | Lemon Scented Gum                            | Sawntimber (hardwood)                                      | Tolerates a range of soil types and conditions.                                                                                                                                |
| <i>Eucalyptus horistes</i>                                             |                                              | Eucalyptus oil                                             | Demonstrated ability to grow in low rainfall areas in WA, coppice, high oil concentration.                                                                                     |
| <i>Eucalyptus kochii</i> ssp. <i>kochii</i> and ssp. <i>plenissima</i> |                                              | Eucalyptus oil                                             | Demonstrated ability to grow in low rainfall areas in WA, coppice, high oil concentration.                                                                                     |
| <i>Eucalyptus leucoxydon</i>                                           | Yellow Gum, South Australian Blue Gum        | Specialty timber, Sawntimber,                              | Drought tolerant; coppices well; air dry density 770-1200kg/m <sup>3</sup> .                                                                                                   |

|                                                                         |                        |                                                |                                                                                     |
|-------------------------------------------------------------------------|------------------------|------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                                         |                        | Firewood, Posts (fence)                        |                                                                                     |
| <i>Eucalyptus maculata</i>                                              | Spotted Gum            | Specialty timber, Sawntimber (hardwood), Poles | Strong timber (air dry density 970kg/m <sup>3</sup> ), suited to sandy soils.       |
| <i>Eucalyptus microcarpa</i>                                            | Manna Wattle, Grey Box | Firewood/ fuelwood, Posts (fence)              | Heavy, durable timber; tolerates waterlogging.                                      |
| <i>Gleditsia triacanthos</i>                                            | Honey Locust           | Fodder, Sawntimber.                            | Exotic species, deciduous, suckers well, very good in dry climates.                 |
| <i>Melaleuca</i> spp. (e.g. <i>M. latifolia</i> , <i>M. acumanata</i> ) |                        | High cineole oil, Other essential oils         | Similar oils to mallee oils, and can mix OK with other oils.                        |
| <i>Melia azedarach</i>                                                  | White Cedar            | Sawntimber                                     | Saline tolerant, deciduous, fast growing.                                           |
| <b>Pinus brutia</b>                                                     |                        | Sawntimber (softwood)                          | Exotic species being trialed in 450-600 mm rainfall zone in SA.                     |
| <i>Pinus canariensis</i>                                                | Canary Island Pine     | Sawntimber (softwood)                          | Exotic species.                                                                     |
| <i>Pinus halepensis</i>                                                 | Aleppo Pine            | Sawntimber (softwood)                          | Exotic species.                                                                     |
| <i>Pinus pinaster</i>                                                   | Maritime Pine          | Sawntimber (softwood), Panel products          | Exotic species, plantings established in WA; air dry density 560kg/m <sup>3</sup> . |
| <i>Robinia pseudacacia</i>                                              | Black Locust           | Fodder, Specialty timber (craft), Firewood.    | Fast growing, deciduous tree.                                                       |
|                                                                         | Various 'box' species  | Firewood                                       | Box trees are some of the most popular species for firewood.                        |

## 8.4 Other Product Groups

Sections 8.2 and 8.3 identified species suitable for a range of specific products.

Product forms, such as wood for electricity generation may potentially be sourced from a wide range of species. An important attribute is production of wood with a low moisture content. Similarly the production of charcoal and activated carbon could potentially be sourced from a range of species in the low rainfall zone, but ideally would be sourced from hard, dense species, such as many of the native *Acacia* and *Eucalyptus* species.

Bush food may potentially be sourced from a range of species in the low rainfall zone. Species used for bush food have not been identified in this section as such species are unlikely to be planted on a scale sufficient to significantly alter the landscape (see Chapter 7).

Other product forms derived from particular genera or species of tree, are listed in Table 8.3.

Table 8.3. Species for Other Product Forms.

| Product Form                    | Species name                                                      |
|---------------------------------|-------------------------------------------------------------------|
| Bush Food                       | Various                                                           |
| Carob                           | <i>Ceratonia spp.</i>                                             |
| Cork                            | <i>Quercus suber</i>                                              |
| Essential oil & other chemicals | <i>Melaleuca alternifolia</i> , <i>M. bracteata</i>               |
| Flowers                         | <i>Acacia spp.</i> , <i>Banksia spp.</i> , <i>Eucalyptus spp.</i> |
| Guayule                         | <i>Parthenium argentatum</i>                                      |
| Gum arabic                      | <i>Acacia spp.</i>                                                |
| Jojoba                          | <i>Simmondsia spp.</i>                                            |
| Oak acorns                      | <i>Quercus ilex</i>                                               |
| Olives                          | <i>Olea europaea</i>                                              |
| Sandalwood                      | <i>Santalum spicatum</i>                                          |
| Tannin                          | <i>Acacia mearnsii</i>                                            |

## **9. PROSPECTIVE ENTERPRISES FOR LOW RAINFALL AGROFORESTRY**

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### **9.1 Assessment Criteria**

In order to identify those agroforestry enterprises that appear to have the best commercial prospects in the 400-600 mm rainfall zone, a preliminary set of assessment criteria has been identified. These criteria may be used in assessing such activities as proposals for R&D investment or more generally identifying priority areas warranting further investigation.

The criteria could include the following:

#### **1. Technical feasibility**

Technical feasibility refers to an assessment of whether technology is currently available for the enterprise to be viable, excluding economic factors. The potential for R&D contributing to future technical feasibility could be included here also.

#### **2. Climatic zone suitability**

This is an assessment of the extent of the climatic zones within the 400-600 mm zone in which the enterprise could be established. For example, could the product be produced over the whole zone or only the 500-600 mm rainfall zone in southern Australia, only in the northern areas of Australia etc.

#### **3. Robustness to land and soil types**

Some enterprises will only be suitable to particular soil types and land forms; other enterprises will be quite robust to a range of land forms and soil types.

#### **4. Integration with existing farming systems and culture**

This may be a key factor influencing adoption rates of agroforestry enterprises.

#### **5. Size of market**

This is a subjective assessment of how large the market might be for the product form in mind and includes both domestic and international markets.

#### **6. Likelihood of market penetration**

This is a subjective estimate of the difficulty of penetrating the market.

#### **7. Commercial profitability**

This is an assessment of how close the enterprise comes to being commercially profitable in the conventional sense of rate of return to agroforestry investment at a 5% discount rate.

#### **8. Commercial profitability including capturable long-term sustainability benefits**

This is an assessment of how close the enterprise comes to being profitable at a 5% discount rate but includes valuation of sustainability benefits that can be captured by the investor. Sustainability benefits to others in society are not included.

### **9. Societal profitability including both capturable internal benefits and external benefits**

This is an assessment similar to number 8 but includes benefits to society that are not captured by the investor. These external benefits will need to be estimated subjectively in most cases.

### **10. Riskiness**

This is an assessment of the riskiness of the venture to the investor and includes technical, market and financial risk.

### **11. Flexible product potential**

Due to the time periods for agroforestry to produce some marketable products, the most suitable markets and product forms that may be present at time of harvest may differ from what was originally envisaged. While there would be merit in many cases of continuing to produce for an initial target market, enterprises that provide some flexibility on the product form to be harvested may have some advantage over more rigid production systems.

### **12. Multiple product potential**

If more than one product can be marketed from a specific agroforestry investment from the outset, it is more likely that cost of establishing and maintaining agroforestry operations can be covered by future revenue. Each agroforestry venture could be assessed in relation to its ability to provide joint products.

### **13. Likely extent of enterprise**

This requires an integration of assessments on how large the enterprise could grow to given potential market and economic constraints as well as any climatic, and land and soil type constraints.

The above assessments ignore current or future policies or responses by society or government to assist agroforestry enterprises to develop. However, depending on the profitability assessments in 7, 8 and 9 above, society via governments may wish to consider support in one form or another. Certainly R&D support is currently evident and part of this study is to assist in identifying those enterprises that have the greatest potential to be profitable in their own right. If it appears that there are limited opportunities for commercially profitable enterprises even with R&D support, then the possibility remains of government policy assisting those enterprises that are closest to commercial profitability, using the commercial profitability assessment with internalised sustainability benefits to investors, as well as those external to the investor, as key guiding criteria in the selection of those enterprises that may be considered for particular support. In this regard, criteria 7, 8, 9 and 10 could be further developed, quantified and aggregated for use as a commercial assessment indicator. This has not been effected in the present study.

## **9.2 Applying Assessment Criteria**

An attempt has been made in Table 9.1 to apply these assessment criteria to a range of product forms covered in this report. The assessments are made subjectively and are meant to be indicative rather than definitive. The scale used is 1 to 5 where 5 represents the most favourable assessment.

Table 9.1 Agroforestry Enterprises Ranked According to Assessment Criteria

| Assessment Criteria                                                                       | Agroforestry Enterprise |                |                         |                   |            |       |                     |                     |                               |                     |       |
|-------------------------------------------------------------------------------------------|-------------------------|----------------|-------------------------|-------------------|------------|-------|---------------------|---------------------|-------------------------------|---------------------|-------|
|                                                                                           | Fodder                  | Eucalyptus Oil | Biomass for Electricity | Domestic Firewood | Sawntimber | Posts | Biomass for ethanol | Wood panel products | Charcoal and activated carbon | Specialty wood uses | Poles |
| 1. Technical feasibility                                                                  | 4                       | 4              | 2                       | 5                 | 5          | 5     | 3                   | 4                   | 4                             | 5                   | 2     |
| 2. Climatic zone suitability                                                              | 5                       | 3              | 4                       | 4                 | 3          | 3     | 4                   | 3                   | 4                             | 4                   | 1     |
| 3. Robustness to land & soil types                                                        | 4                       | 3              | 4                       | 3                 | 3          | 3     | 4                   | 3                   | 4                             | 3                   | 1     |
| 4. Integration with existing farming systems & culture                                    | 5                       | 4              | 3                       | 3                 | 2          | 2     | 3                   | 2                   | 4                             | 2                   | 1     |
| 5. Size of market                                                                         | 5                       | 4              | 5                       | 3                 | 3          | 2     | 5                   | 3                   | 3                             | 2                   | 2     |
| 6. Likelihood of market penetration                                                       | 4                       | 3              | 2                       | 3                 | 3          | 3     | 2                   | 3                   | 2                             | 4                   | 1     |
| 7. Commercial profitability                                                               | 3                       | 4              | 3                       | 2                 | 2          | 2     | 2                   | 2                   | 2                             | 1                   | 1     |
| 8. Commercial profitability including capturable long-term sustainability benefits        | 4                       | 5              | 4                       | 3                 | 2          | 3     | 3                   | 2                   | 2                             | 1                   | 1     |
| 9. Societal profitability including both capturable internal benefits & external benefits | 4                       | 5              | 4                       | 3                 | 3          | 3     | 3                   | 2                   | 2                             | 1                   | 1     |
| 10. Riskiness                                                                             | 4                       | 3              | 2                       | 4                 | 2          | 3     | 2                   | 3                   | 2                             | 2                   | 1     |
| 11. Flexible product potential                                                            | 2                       | 3              | 2                       | 3                 | 4          | 3     | 2                   | 4                   | 3                             | 2                   | 3     |
| 12. Multiple product potential                                                            | 2                       | 3              | 3                       | 3                 | 4          | 4     | 3                   | 4                   | 3                             | 4                   | 3     |

|                                 |           |           |           |           |           |           |           |           |           |           |           |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 13. Likely extent of enterprise | 4         | 3         | 3         | 2         | 2         | 2         | 2         | 2         | 2         | 1         | 1         |
| <b>Total</b>                    | <b>50</b> | <b>47</b> | <b>41</b> | <b>41</b> | <b>38</b> | <b>38</b> | <b>38</b> | <b>37</b> | <b>37</b> | <b>32</b> | <b>19</b> |

When the individual assessment scores are aggregated (unweighted), the results indicate that fodder and eucalyptus oil are to be preferred. The next highest scoring group of enterprises included biomass for electricity, and domestic firewood.

### **9.3 Summary of Economic Analyses**

Economic analyses were carried out for four agroforestry enterprises: sawntimber, firewood, biomass for electricity and eucalyptus oil production.

The analysis conducted for sawntimber was based on a block planting and a project life of 47 years. The analysis found that it was not economic to produce sawntimber, given a discount rate of 5%. The investment produced a net present value (NPV) of -\$16,710. The benefit-cost ratio (B/C ratio) was 0.69 : 1 and the internal rate of return (IRR) 2.7%.

Similarly, the firewood investment analysis found that it was not economic to produce firewood, even if the discount rate was 0%. The NPV was -\$25,620 at a 5% discount rate and the B/C ratio was 0.02 : 1. The internal rate of return was negative. The analysis assumed a project life of 17 years and a planted area of 10 hectares. However, it is likely that particular locations in the low rainfall areas may be able to produce firewood for higher price city markets that are in close proximity.

Biomass for electricity was found to be economically viable given the assumptions made. The NPV was \$855,182 for a 30 year project, at a 5% discount rate. The B/C ratio of the investment was 1.2:1, and the IRR 19%. However, the investment assumed a zero cost of biomass. Hence, the investment would only be suitable for operators which could source biomass at low cost and would be ideal to take sawdust from milling operations or wood residues from thinnings or eucalyptus oil enterprises. If the full cost of producing biomass was included in the analysis, the investment returns were negative. Also, the assumption of the opportunity cost of providing electricity through traditional grids to rural areas in the low rainfall zone was uncertain.

Of the four enterprises analysed, the most economically viable, complete operation for low rainfall agroforestry was eucalyptus oil production. Based on a cumulative planting of 23,000 hectares of trees, a 30 year project life, and a discount rate of 5%, the analysis found that the NPV for eucalyptus oil production of this scale is just over \$5 million. The B/C ratio was 1.14 : 1 and the IRR 6.9%.

Comparisons between the four enterprises analysed should be viewed as only indicative as each has required a series of assumptions regarding planting designs, cultural practices, opportunity costs, and markets.

### **9.4 Summary of Best Prospects**

The most promising commercial opportunities identified for the low rainfall (400-600 mm rainfall) zone include the following:

- i. Planting of fodder species. While economic analyses were not effected for fodder tree/shrub establishment, such activities scored well in the assessment criteria exercise

- and must be concluded as having strong prospects for use in the low rainfall zone, particularly those species with dual purposes.
- ii. Production of eucalyptus oil. Production of eucalyptus oil from coppiced mallee oil species and targeted at the pharmaceutical, hand cleaner and other industrial solvent markets. Technology exists for production, harvesting and processing, and is being improved. Eucalyptus oil production was found to be economic in the long term, and higher returns are likely if the waste wood can be utilised (e.g. for electricity, activated carbon or ethanol).
  - iii. Production of electricity from biomass waste from sawmills, thinnings or eucalyptus oil residues. Technology for electricity generation on a small scale that may be suited to agroforestry biomass resources in the low rainfall zone is presently being developed. Alternatively, use of wood and timber residues in electricity generation processes could be feasible where sufficient mass of material is available to support a reasonably sized boiler and where use of energy by other agroforestry value adding enterprises is required (e.g. steam). Preliminary analysis indicates that generating electricity from biomass is potentially economic when the biomass can be sourced up to \$22/dry tonne.
  - iv. Ethanol production from biomass. This is not likely to be economic while oil prices are maintained at low levels, or biomass production costs remain at the present estimated levels. The use of blends of ethanol with petrol and diesel would increase excise-free prices by some 10-15%. While this could be possible with 'green' government policies, it is more likely that ethanol produced from biomass could enter the industrial market for ethanol. The large scale of operations for ethanol production may pose a significant constraint for production in low rainfall areas, unless large quantities of residues from other agroforestry enterprises are available.
  - v. Production of hardwood species for timber targeted at furniture, high value craft and specialty markets. The products need to be high value and unique timbers to be the most competitive. Some of these markets may be small initially. The development of domestic and export markets would be a critical factor in the success of such agroforestry enterprises.
  - vi. Softwood species. Some *Pinus* species may find particular biophysical niches in the low rainfall areas as well as niche markets. Production of softwoods such as native *Callitris glaucophylla* and *Pinus pinaster* (exotic) may have to compete price wise against *Pinus spp.*, especially *Pinus radiata*, grown in the high rainfall areas. Product differentiation will be vital to avoid direct price competition with *P. radiata*.
  - vii. Production of laminated flooring products from juvenile hardwoods. While there are potential markets for these products, issues of scale and cost of production need to be examined more closely. The economics of producing laminated flooring would be improved if the waste wood (up to 80% of the sawlog) could be utilised.
  - viii. Use of wood and timber residues to produce charcoal and activated carbon. The technology is available and the production needs to be incorporated with another agroforestry enterprise to utilise waste wood or residues.
  - ix. Investing in growing firewood from suitable species to service the needs of rural provincial towns and cities and some capital cities did not appear economic, although some high priced markets could be serviced from production in low rainfall areas. While societal pressures will tend to restrict availability of wood from existing sources, firewood is likely to be generally supplied in the form of waste from existing agroforestry operations rather than purposely grown.
  - x. Production of round and split posts. Market potential could increase if harvesting for posts from remnant vegetation and native stands declines in the future. While

- agroforestry specifically aimed at post production is unlikely to be economic in its own right, posts could be produced from thinnings of other agroforestry enterprises.
- xi. Small niches, in both a biophysical and market sense, may exist in the low rainfall zone for various products such as carob, jojoba, olives, sandalwood and some essential oils.

Two important concepts in considering commercial prospects are that of flexible production systems and multiple products. In many cases the production of commercial products from agroforestry, especially in the lower rainfall zones, can take considerable time periods. Markets for products can change over this period. If production systems allow products to be targeted at alternative markets as circumstances change, these could be preferred by producers and represent a less risky investment.

Also, it is apparent that agroforestry enterprises which can produce more than one product (apart from 'sustainability' products) are more likely to be commercial than those where a co-product is not a possibility. Agroforestry systems producing wood where significant value adding is required (e.g. sawmilling) and that produces waste material may well have to develop systems of waste utilisation in order to prove economic in the low rainfall areas (e.g. electricity generation, firewood supply).

Eucalyptus oil production where the wood biomass could be used as a coproduct to produce electricity or activated carbon is another activity that illustrates the advantages of multiple product agroforestry systems.

A number of uncertainties exist for low rainfall zone agroforestry which could affect the economic viability of agroforestry enterprises in general. These include the threat of species dying after a series of poor seasons. The low rainfall zone is inherently risky in terms of climate. Existing biophysical predictive models mostly do not account for rainfall variability over a series of years and improvements in this regard could be made. Also, limited knowledge is known about how many of these species might adapt to a plantation situation. This adaptation could well be related to the planting design including spacing. Design could also be very important in the capturing of sustainability benefits that might be targeted from low rainfall agroforestry. When included in economic assessments of the agroforestry enterprises, sustainability impacts can have a significant impact on the economic viability from the viewpoint of the private landholder, as well as society.

As well as sustainability benefits, carbon credits, if they eventuate, could provide additional income required to make the 'almost commercial' enterprises economically viable.

In conclusion, commercial agroforestry in the low rainfall region of Australia is unlikely to be as profitable as in the high rainfall zone due to lower growth rates, less established infrastructure and greater distances to markets. However, this study has demonstrated that significant prospects exist and benefits should be capturable with further private and public R&D investment and encouragement of innovation and infrastructure support by government.

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