A SUMMARY OF STUDIES
ON THE FOREST INDUSTRIES OF AUSTRALIA

JENNIFER HOLMES

1993 GOTTSTEIN FELLOWSHIP REPORT

JOSEPH WILLIAM GOTTSTEIN MEMORIAL TRUST FUND

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are,

1. Fellowships - each year applications are invited from eligible candidates to submit a study programme in an area considered to be of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

Further information may be obtained by writing to,

The Secretary,
J.W. Gottstein Memorial Trust Fund,
Private Bag 10,
Rosebank M.D.C.,
Clayton, Victoria, 3169 Australia

ABOUT THE AUTHOR

Jenny Holmes (nee Goode) is Product Development Manager for Koppers Hickson Timber Protection Pty limited. She has a B.App.Sc in Chemistry/ Biochemistry and gained her M.App.Sc in Biotechnology from Swinburne University of Technology in 1993 for her thesis "The development of biological probes to aid investigations into the enviromental toxicology of arsenic." She began her career with Koppers Australia as a Technical Officer in a joint venture research program between Koppers Timber Preservation, Koppers Hickson Timber Protection and CSIRO Division of Forestry and Forest Products at CSIRO's Clayton Laboratories in 1990.

The research program focussed on emulsion technology and in particular the development of wood preservatives incorporating Copper-Chrome-Arsenic and petroleum oils, creosote and water-borne pigment dispersions. During the 8 year joint progam, patents for a CCA/Oil wood preservative and for Pigment Emulsified Creosote (PEC) were applied for and received.

From there, Jenny transferred to Koppers Hickson's Brisbane office to undertake two years of Technical and Customer Service work, gaining invaluable knowledge of the working, management and maintenance of commercial-size pressure treatment plants. In early 1996, Jenny moved back to Melbourne to take up the position of Product Development Manager at Koppers Hickson's Trentham Manufacturing Operation, where she coordinates R&D work for Koppers Hickson in Australia and maintains technical support for its customers.

The purpose of Jenny's Gottstein Fellowship, conducted in 1993, was to gain a greater knowledge of the Timber Industry in Australia.

The focus was on learning about silvicultural, harvesting, drying and processing techniques used on our native hardwoods and plantation softwoods.

Jenny spent time with key personnel in Western Australia's Department of CALM, Queensland's DPI Forestry, New Zealand's FRI and various other industry groups and commercial timber processors.

Jenny's contact details are:

Mrs J. Holmes
Koppers Hickson Timber Protection
P.O Box 19,
Trentham, 3458, VIC

Tel:	(03) 5424 1530
Fax:	(03) 5424 1288
Mobile:	018 733 030

J. W. GOTTSTEIN MEMORIAL TRUST

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by

JENNIFER HOLMES

Kopper Hickson Timber Protection Pty ltd
15 Blue St, North Sydney, 2060, NSW

ACKNOWLEDGEMENTS

My sincere thanks to the trustees of the J.W. Gottstein Fellowship Trust Fund for the support extended to me and the opportunity to visit centres of excellence in Forestry and Forest Products. I would also like to thank Koppers-Hickson Timber Protection Pty Ltd for the generous allocation of time that has been given to me towards this study.

In undertaking this Fellowship, I spoke with many people in many organisations, in either research facilities or industry both in Australia and New Zealand. All offered their time, enthusiasm and expertise so willingly that I am honoured to be involved in the Forest Industries.

PREFACE

In undertaking this Fellowship, my prime motivation was personal growth and development. This is an aspect that my employers take very seriously and encourage strongly. Having been involved with the formulation of preservative systems for softwoods and hardwoods, I felt the need to better understand the resource that I was treating. Perhaps by understanding the techniques and philosophies used in such areas as tree breeding, forest management and timber processing, I could contribute to the development of more advanced treatment processes.

I spent a total of three weeks at four research establishments, Forest Research Institute (NZ), Queensland Forest Service, Department of Conservation and Land Management (WA) and CSIRO Division of Forest products (Vic) and visited several sawmilling and processing companies in Queensland, Western Australia and Victoria. I found that a certain amount of introductory information on each of the areas I looked into was necessary for my understanding, so this report has been written to include some technical dialogue. I collected information on wood structure and properties, forest management, seasoning and processing of timber, as well as two chapters that hopefully introduce new perspectives from industry. These latter chapters contain ideas and attitudes collected from industry and industry associations, about the industry at present and in the future. A bird's eye view, if you like, of the Forest Industries.

The information and attitudes expressed in this report are entirely my personal views and do not necessarily reflect those views held by my employers.

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EXECUTIVE SUMMARY

This report was written upon completion of a series of tours of research facilities in Australia and New Zealand. While my prime motivation was for personal growth and development, I identified an opportunity to increase my knowledge of the timber industry and assist the industry with its aim to add value to our timber resources. One of my objectives was to investigate the technologies used in the silviculture, forest management, seasoning, processing industries. I have summarised twenty nine hardwoods and eight softwoods of both native and exotic species as valuable commercial timbers for structural, non-structural and decorative uses grown in Australia. I have also assembled a table of data incorporating physical and mechanical properties of these timbers. This report summarises the information I collected over a period of three weeks at Forest Research Institute (NZ), Department of Conservation and land Management, Queensland Forest Service and CSIRO Division of Forest Products.

Previously the characterisation of timbers for purposes such as pulp evaluation and density control had been laboriously measured by hand. I was interested to come across three projects (at FRI and CSIRO DFP) aimed at automating these measurements using spectroscopy and electromagnetic imaging. While characterisation of timbers has received much interest so too has much effort been channelled into establishing methods, guidelines and standards for assuring a minimum quality in our timber products. Hence we have hazard levels for preservative treatment, and stress grades and strength groups for structural applications. What remains to be done is the implementation and policing of a national standard for these methods and guidelines that is consistent with World's Best Practice.

Interestingly, the Resource Assessment Commission has recently published an extensive study on the timber industry in Australia. It suggests our forest resources consist of 43 million Ha of forested land covering 5% of our land mass. To achieve self-sufficiency we must aim for 25% coverage. While the use of plantation timbers is assisting that self sufficiency process, we are limited by our arid landscape and aggressive climate. A handful of large privately owned companies are establishing their own hard and softwood resources. This is mainly to supply chip for pulp and paper manufacture but ultimately to bypass the issue of unstable resource security. The conservationists are fighting against the use of native forest for timber production and hence want to see the abolition of resource security. Already several tropical, subtropical and alpine forests have been removed from timber production use. This situation has left many small sawmills without a resource and has caused the loss of many hundreds of jobs nationwide. It also unfortunately undermines the confidence of international investors when they are considering putting capital into ventures such as pulp and paper manufacture and further processing of forest products.

Each state in Australia has their own code for managing forests. Each state also has their own method for evaluating the volume, age and health of their forests. I was fascinated to observe the logistics of forest management; from tactical planning to the sophisticated computerised systems that allow data to be collected and analysed on soils classification and effects of different silvicultural regimes. Different management techniques can be modelled and simulated on these systems also. Now more than ever, we as an industry, have the opportunity to demonstrate the effectiveness of good management principles and ensure Australia's forest are healthy and productive. We have the opportunity to show that all forest values can be conserved and enjoyed by all.

Several institutes (FRI, CALM, QFS) have undertaken extensive tree breeding and tree quality research to improve our timber resources. The extent of environmental influence compared to genetic control of tree growth and form was graphically displayed at the FRI Rotorua site. While superior Growth and Form was to a large extent under environmental influence, superior pulping properties and resistance to disease were just two examples of genetic control.

While tree breeding may assist in improving the form of plantation timbers, I found that timber seasoning technology has received renewed interest particularly in the hardwood industry for improving the dimensional stability of juvenile hardwoods. With the introduction of the Victorian Timber Industry Strategy (1986) and similar strategy in Western Australia, and the RAC's Forest and Timber Final Report (1992), research into drying facilities has focussed on solar and evaporative cooler type systems (CALM and QFS). These provide a gentle schedule of drying for many difficult-to-dry Australian hardwoods such as Jarrah and Karri. The faster, high temperature batch and continuous type kilns have been used for the drying of softwoods (CSIRO and FRI).

Maximising the value of forest hardwoods and producing higher quality structural and decorative softwood timbers have been the goals of the timber industry for the past decade. By utilising new drying and sawing technologies, juvenile hardwoods in particular, have been studied for their potential as veneer, furniture and laminated products. This allows the mature hardwoods to be placed in the higher valued added markets of decorative and cabinet timbers. The softwood industries, on the other hand, have been marketing their products as cheaper, more consistent, easier working alternatives to hardwoods for framing, fencing and flooring.

Value adding does not stop at the sawmill. The use of timber preservatives enhances the value of timber commodities by protecting them against biological, mechanical and physical degradation. Impregnation and remedial products are essential for extending the life of timbers used in hazardous or exposed applications.

While sawmill wastes such as sawdust, chip, bark and offcuts have traditionally been left to decompose or be burnt, progressive companies have found that productivity can be improved and costs and health hazards lowered, by selling and using these wastes. For example bark can be sold into garden supplies centres, chip can be sold to pulp mills or used to fire kilns and boilers, sawdust can be used to fire kilns or boilers, offcuts can be sold for firewood or used to fire boilers. Some research centres have begun to look at bark for its insecticidal properties and filtering properties. Other centres have used chip and offcuts in laminated timber, jointed timbers and particle board.

While there are many progressive companies searching for new opportunities, I found that there are also companies that have identified issues that give rise to longterm planning difficulties and ultimately industry conflict. Lack of confidence in government decision making processes was one such issue, and another was the need for a more proactive approach to policing of Australian Standards and Acts in order to make timber products more consistent in quality and performance. Perhaps these problems can be resolved by the installation of a framework in which all parties in the debate or conflict can be heard. Indeed it may mean that we need to benchmark; to look outside our country and search for a more efficient or productive approach on which to base our measures and controls.

One attitude that was expressed by most people I spoke to however, was that of optimism. The timber industry of the future it seems, will be one in which good management principles will be practiced not only in the office but in the field and on the production floor.

INTRODUCTION

Fire was used as a means of managing forests and hunting game by the indigenous people of Australia. This is believed to have caused an increase in eucalypt dominated forests, particularly in north Queensland, over the last 9000 years. The distribution of plants in Australia is due to a number of influences that can be categorised into the three groups shown in Table (i). Putting the history of seed-bearing plants into perspective, it has taken 135 million years to evolve our forests and only 200 years to significantly alter the composition of those forests.

Table (i) Factors influencing the distribution of plants in Australia

Geographical	Climatic	Cultural (man)
soil profile	temperature	politics
latitude	radiation	development
altitude	rainfall	innovations
available nutrients	wind	
water drainage	fire	
	animals & insect pests	

A clear and concise account of the species and their distribution in Australia is given by Boland *et al.* (1984) (1).

The Gymnosperms are represented by only one order in Australia (the Coniferales) that produces marketable woody material. It includes the families Araucariaceae, Cupressaceae, Podocarpaceae and Taxodiaceae. The dicotyledonous Angiosperms include approximately twenty-seven families of which the Myrtaceae is the most commercially important. The eucalypts belong to this family.

Boas (2) had tabulated a list of commercial timbers in Australia (Table (ii)). Several of these species are no longer cut for commercial use. With the importation of exotic plantation softwoods of the *Pinus* genera from North and South America in the early 1900s, the range and type of commercially valuable timber available in Australia changed dramatically. The use of plantation grown native hardwoods and the increasing concern being expressed over the logging of our native forests, has also influenced this range.

It has been generally accepted that Australia joined Antarctica to form Gondwanaland along with New Zealand, Africa, South America and India during the early Cretaceous period 135 million years ago as shown in Figure (i). Gymnosperms such as Araucariaceae and Podocarpaceae had evolved and Angiosperms were beginning to evolve.

There evolved over a period of 100 million years a series of tropical/sub-tropical as well as temperate plant species migrations from Africa, South America and Indonesia into and out of Australia. While the last 9 000 years have been relatively climatically stable, about 75 000 to 10 000 years ago during the last glacial period there was a massive contraction in woodland and forested areas due to cold temperatures and low rainfall. Some expansion of eucalypt forests occurred as the temperature was subsequently raised.

Of the approximately 1700 seed-bearing plant genera in Australia, one third are particular to Australia alone. This figures suggests a great adaptive ability for many species to particular geographical and climatic niches. Some examples of adaptation include the fire tolerance of some eucalypts (thick bark, woody fruit, epicormic bud formation), poor-soil tolerance of *Casuarina/Acacia* (nitorgen fixing ability, large root system) and the wind tolerance of *Araucaria/Casuarina* (sturdy stem, complex root system).

It is known that Australian soils are relatively infertile due to the enormous upheavals created by the continental drift and the corresponding climatic changes. Large areas have soil horizons indicative of successive cycles of erosion, leaching and redeposition, creating layers with different textures, ages and nutrient levels. Leeper 1970 (3) and Stace *et al.* 1968 (4) provide excellent information on soils in Australia.

To halt the potential destruction of forest resources and depletion of nutrients in valuable arable land regions, and to provide forest products to our communities in perpetuity, the Resource Assessment Commission's Forest and Timber Inquiry Final Report (5) and the National Forest Policy Statement (1992) (6) are involving the State, Territory and Commonwealth Governments to develop 'Ecologically Sustainable' Management Policies.

Figure (i) The development of Australia (135 million years ago)

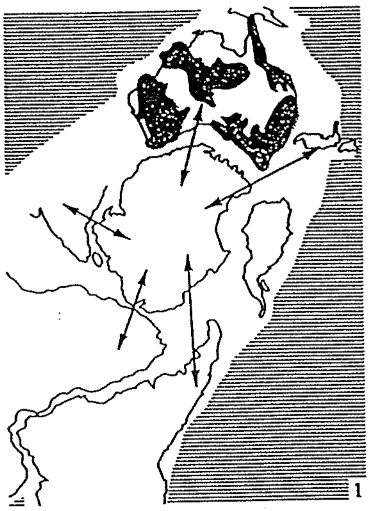


Figure 1. Gondwanaland in early Cretaceous times (135 million years ago): Gymnosperms are well developed and widespread. Development of angiosperm families has begun and migration amongst all the southern continents is possible. Land surfaces of Australia are shown stippled.

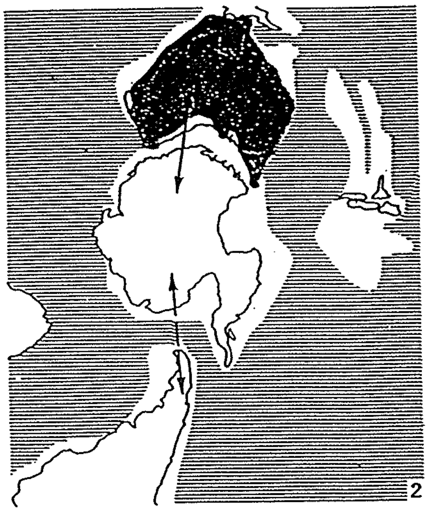


Figure 2. Southern continents in early Eocene times (55 million years ago): Africa, India, New Zealand and South America have separated and Australia is about to separate from Antarctica. This is the last opportunity for the overland entry of Gondwana plants into Australia.

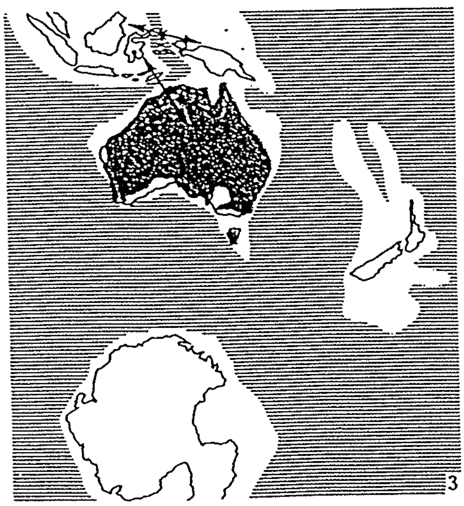


Figure 3. Australia's neighbours in Miocene times (15 million years ago): The Australian plate has moved away from Antarctica and collided with the Asian plate. Migration of plants between Australia and Asia, across a narrow sea barrier, is possible

reproduced from *Boland et al. (1)*

Table (ii) Commercial Timbers of Australia.

Group 1. Softwoods Standard trade name	Botanical name
Kauri, Queensland, North	*Agathis palmerstonii* F. v. M *Agathis microstachya* Bailey and White
Kauri, Queensland, South	*Agathis robusta* F. M. Bail
Pine, Black	*Podocarpus amara* Bl.
Pine, Brown	*Podocarpus elata* R. Br
Pine, Bunya	*Araucaria bidwillii* Hook
Pine, celery-top	*Phyllocladus asplenifolius* Hook
Pine, Cypress, Black	*Callitris calcarata* R. Br
Pine, Cypress, Brush	*Callitris macleayana* F.v.M
Pine, Cypress, Coast	*Callitris columellaris* F.v.M
Pine, Cypress, White	*Callitris glauca* R. Br
Pine, Hoop	*Araucaria cunninghamii* Ait.
Pine, Huon	*Dacrydium franklinii* Hook
Pine, King William	*Athrotaxis selaginoides* D. Don
Pine, Radiata	*Pinus radiata* D. Don

Group 2. Hardwoods Standard trade name	(Eucalypts) Botanical name
Ash, Alpine	*E. delegatensis* Hook. F.
Ash, Blue Mountains	*E. oreades* R.T Bak.
Ash, Mountain	*E. regnans* F. v. M.
Ash, Silvertop	*E. sieberiana* F. v. M.
Ash, White	*E. fraxinoides* Deane and Maid.
Barrel, Brown	*E. fastigata* Deane and Maid.
Blackbutt	*E. pilularis* Sm.
Blackbutt, Western Australian	*E. patens* Benth.
Bloodwood, Red	*E. gummifera* (Gaertn.) Hochr.
Box, Coast, Grey	*E. bosistoana* F. v. M.
Box, Grey	*E. hemiphloia* F. v. M. *E. largeana* Blakely and De Beuz.
Box, Red	*E. polyanthemos* Schau.
Box, Yellow	*E. melliodora* A.. Cunn.
Gum, Blue, Southern	*E. globulus* Labill. *E. bicostata* Maid., Blakely & Simmonds
Gum, Blue, Sydney	*E. saligna* Sm.
Gum, Grey	*E. punctata* DC. *E. propinqua* var. *major* Maid.
Gum, Grey, Mountain	*E. goniocalyx* F. v. M.
Gum, Maidens	*E. maidenii* F. v. M.
Gum, Manna	*E. viminalis* Labill. *E. mannifera* (A. Cunn. Herb.) Mudie
Gum, Mountain	*E. dalrympleana* Maid.
Gum, Red, Forest	*E. tereticornis* Sm. *E. blakelyi* Maid. *E. seeana* Maid. *E. bancrofti* Maid.
Gum, Red, River	*E. rostrata* Schecht.
Gum, Shining	*E. nitens* Maid.
Gum, Sugar	*E. cladocalyx* F. v. M.
Gum, Spotted	*E. maculata* Hook. *E. citriodora* Hook.
Gum, Yellow	*E. leucoxylon* F. v. M.
Ironbark, Grey	*E. paniculata* Sm. *E. fergusoni* R. T. Bak.

Group 2. cont. Standard trade name	Botanical name
Ironbark, Red	*E. sideroxylon* A. Cunn.
	E. siderophloia Benth.
	E. crebra F. v. M.
Jarrah	*E. marginata* Sm.
Karri	*E. diversicolor* F. v. M.
Mahogany, Red	*E. resinifera* Sm.
	E. pellita F. v. M.
	E. kirtoniana F. v. M.
Mahogany, Southern	*E. botryoides* Sm.
Mahogany, White	*E. acmenoides* Schau.
	E. carnea R.T. Bak.
Mallet	*E. astringens* Maid.
Peppermint, Black	*E. salicifolia* Cav.
Peppermint, Broad-leaved	*E. dives* Schau.
Peppermint, Narrow-leaved	*E. radiata* Sieb. var. *australiana* Blakely.
Peppermint, River	*E. lindleyana* DC.
Peppermint, Sydney	*E. piperita* Sm.
Peppermint, White	*E. linearis* Dehn.
Peppermint, Brown	*E. capitellata* Sm.
	E. blaxlandi Maid.
	E. baxteri Maid.
Stringybark, Messmate	*E. obliqua* L'Herit.
Stringybark, White	*E. eugenoides* Sieb.
	E. globoidea Blakely.
Stringybark, Yellow	*E. muellerana* Howitt.
Tallowwood	*E. microcorys* F. v. M.
Tuart	*E. gomphocephala* DC.
Wandoo	*E. wandoo* Blakely.
Yertchuk	*E. consideniana* Maid.

Group 3. HARDWOODS Standard trade name	(non Eucalypt) Botanical name
Alder, Brown	*Ackama paniculata* Engl.
Alder, Rose	*Ackama australiensis* (Schl) C.T. White
Ash, Crow's	*Flindersia australis* R. Br.
Ash, Hickory	*Flindersia ifflaiana* F. v. M
Ash, Silver, Queensland	*Flindersia bourjotiana* F. v. M
Ash, Silver, Northern	*Flindersia pubescens* F. M. Bail.
Ash, Silver, Southern	*Flindersia schottiana* F. v. M
Bean, Black	*Castanospermum australe* A. Cunn.
Beech, Myrtle	*Nothofagus cunninghamii* Oerst.
Beech, Negrohead	*Nothofagus moorei* Maid.
Beech, White	*Gmelina leichardtii* F. v. M.
	Gmelina fasciculiflora F. v. M
	Gmelina macrophylla Benth.
Birch, White	*Schizomeria ovata D. Don.*
Blackwood	*Acacia melanoxylon* R. Br.
Bollywood	*Listae reticulata* Benth.
Box, Brush	*Tristania conferta* R. Br.
Boxwood, Yellow	*Sideroxylon pohlmannianum* Benth. and Hook
Brigalow	*Acacia harpophylla* F. v. M
Candlenut	*Aleurites moluccana* Willd
Carabeen, Yellow	*Sloanea woolsii* F. v. M
Cedar, Red	*Toona australis* F. v. M
Cheesewood, White	*Alstonia scholaris* R. Br.
Coachwood	*Ceratopetalum apetalum* D. Don

Standard trade name	Botanical name
Gidgee	*Acacia cambagei* R.T Bak.
Handlewood, Grey	*Aphananthe philippinensis* Planch.
Handlewood, White	*Pseudomorus brunoniana* Bur.
Ironwood	*Backhousia myrtifolia* Hook. and Harv.
Ivorywood	*Siphonodon australe* Benth.
Jam, Raspberry	*Acacia acuminata* Benth.
Leatherwood	*Eucryphia lucida* (labill) Bail.
Mahogany, Brush	*Geissois benthami* F. v. M
Mahogany, Miva	*Dysoxylum muelleri* Benth.
Mahogany, Rose	*Dysoxylum fraseranum* Benth.
Mahogany, Queensland	*Flindersia brayleyana* F. v. M
	Flindersia pimenteliana F. v. M
Maple, Rose	*Cryptocarya erythroxylon* Maid. and Betche.
	Cryptocarya patentinervis F. v. M
Mararie	*Geissois lachnocarpa* Maid.
Mulga	*Acacia aneura* F. v. M
Myall	*Acacia pendula* Cunn.
Oak, Silky, Northern	*Cardwellia sublimis* F. v. M
Oak, Silky, Red	*Stenocarpus salignus* R. Br.
Oak, Silky, Southern	*Grevillea robusta* A. Cunn.
	Orites excelsa R. Br.
Oak, Tulip, Red	*Argyrodendron peralata* (domin) Edlin
Oak, Tulip, Blush	*Argyrodendron actinophyllum* (Moore) Edlin
Oak, Tulip, Brown	*Argyrodendron trifoliatum* (F. v. M) Edlin
Persimmon, Grey	*Diospyros pentamera* F. v. M
Poplar, Pink	*Euroschinus grandis* F. v. M
Quandong, Silver	*Elaeocarpus grandis* F. v. M
	Elaeocarpus kirtonii F. v. M
Saffronheart	*Halfordia drupifera* F. v. M
	Halfordia scleroxyla F. v. M
Sandalwood	*Santalum spicatum* R. Br.
Sassafras	*Doryphora sassafras* Endl.
Sassafras, Southern	*Atherosperma moschatum* Labill.
Satinash, Grey	*Eugenia gustavioides* F. M. Bail.
Satinay	*Syncarpia hillii* F. M. Bail.
Silkwood, Silver	*Flindersia acuminata* C. T. White
Silkwood, Bolly	*Cryptocarya oblata* F. M. Bail.
Siris, Red	*Albizzia toona* F. M. Bail.
Sycamore, Silver	*Cryptocarya glaucescens* R. Br.
Tulipwood	*Harpullia pendula* Planch.
Turpentine	*Syncarpia procera* Salisb.
Walnut, Queensland	*Endiandra palmerstoni* C. T. White
Walnut, Yellow	*Beilschmiedia bancrofti* C.T. White
Yellowwood	*Flindersia oxyleyana* F.v. M

reproduced from *Boas 1947 (2).*

CHAPTER ONE WOOD STRUCTURE AND PROPERTIES OF SOME COMMERCIAL TIMBER SPECIES IN AUSTRALIA

SECTION 1.1 IMPORTANT COMMERCIAL SPECIES

Australia has many timbers, both native and exotic, that can be successfully used for domestic, agricultural or industrial applications. Some timbers are best used for value-added work such as furniture and turning, some are more suited to cladding, framing, flooring and panelling, and some are best used for heavy construction. Below is a list of commonly used timbers grown in Australia.

Table 1.1 Commercially available timbers in Australia

Botanical name	Standard trade name	Natural occurrence	Plantation-grown
Acacia melanoxylon	Blackwood	Qld, NSW, Vic, Tas	Tas, Vic, NSW
Argyrodendron actinophyllum	Blush Tulip Oak	Qld, NSW	
Eucalyptus acmenioides	White Mahogany	Qld, NSW	
E. amygdalina	Black Peppermint	Tas	
E. calophylla	Marri	WA	
E. camaldulensis	River Red Gum	Qld, NSW, Vic	NSW, Vic
E. dalrympleana	Mountain Gum	NSW, Vic, Tas	
E. delegatensis	Alpine Ash	NSW, Vic, Tas	Vic, Tas
E. diversicolor	Karri	WA	
E. globulus	Tas. Blue Gum	NSW, Vic, Tas,Qld	NSW,V,T,WA,Qld
E. grandis	Flooded Gum	Qld, NSW	Qld, NSW
E. laevopinea	Silvertop Stringybark	NSW	
E. maculata	Spotted Gum	Qld, NSW	
E. marginata	Jarrah	WA	
E. microcorys	Tallowwood	Qld, NSW	
E. muellerana	Yellow Stringybark	NSW, Vic	
E. nitens	Shining Gum	NSW, Vic	
E. obliqua	Messmate Stringybark	NSW, Vic, Tas, SA	Vic, Tas
E. pilularis	Blackbutt	Qld, NSW	
E. radiata	Narrowleaf Peppermint	NSW, Vic	
E. regnans	Mountain Ash	Vic, Tas	NSW
E. saligna	Sydney Blue Gum	Qld, NSW	
E. sieberi	Silvertop Ash	NSW, Vic, Tas	
E. Tereticornis	River Red Gum	all states	Vic, Tas
E. viminalis	Manna Gum	NSW, Vic, Tas, SA	
Syncarpia glomulifera	Turpentine	Qld, NSW	
Tristania conferta	Brush Box	Qld, NSW	
Araucaria cunninghamii	Hoop Pine	Qld, NSW	Qld
Callitris columellaris	White Cypress Pine	Qld, NSW	
Pinus caribaea	Caribbean Pine		Qld
P. elliottii	Slash Pine		Qld
P. pinaster	Maritime Pine		WA
P. radiata	Radiata Pine		All states
P. taeda	Loblolly Pine		NSW, some Qld
F1 hybrid	F1 Hybrid	Qld	Qld

note: nomenclature as defined in AS 2543 (1983) **(18)**

SECTION 1.2 PHYSICAL AND ANATOMICAL PROPERTIES OF THE TIMBER SPECIES

Basic information on the physical and anatomical properties of the various timber species are included with details of occurrence in Appendix 1.

SECTION 1.3 WOOD PROPERTIES AND UTILISATION

By measuring and observing parameters such as physical, mechanical and anatomical properties, we can characterise a timber for a particular end use. For evaluation purposes the following properties can be measured:

- density
- fibre length
- formation of growth rings
- earlywood/latewood ratio
- moisture content
- resin content
- heartwood/sapwood ratio
- strength
- durability
- cell wall thickness
- spiral grain
- texture
- silica content
- formation of reaction wood
- dimensional stability

Strength and durability are the major factors affecting structural timber. The current system of strength grouping a species is carried out in accordance with AS 2878 - 1986 'Timber - Classification into Strength Groups'. There are seven classes for unseasoned timber (S1 to S7) and eight classes for seasoned timbers (SD1 to SD8), with the highest strength species being S1 and SD1.

Stress grading is essential in the grading of structural dimension timber. A stress grade is an indication of the ability of a piece of timber, including defects, to perform adequately in a structural situation (9, 37). Visual grading involves the sorting of timber into stress grades according to the size and frequency of defects such as splits, knots, gum veins, sloping grain, shakes and insect attack, as described in AS 2082 - 1979 'Visually stress-graded hardwood for structural purposes' and in AS 2858 - 1986 'Timber - Softwood - Visually stress-graded for structural purposes'.

The stress grade can then be determined using the table below, which shows the dovetailing relationship in the system.

Table 1.2 Stress grading assignment of Australian timbers

Unseasoned Strength Group			S1	S2	S3	S4	S5	S6	S7
Seasoned Strength Group	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8	

Visual grades				**Stress grades**					
Structural 1	F43	F34	F27	F22	F17	F14	F11	F8	F7
Structural 2	F34	F27	F22	F17	F14	F11	F8	F7	F5
Structural 3	F27	F22	F17	F14	F11	F8	F7	F5	F4
Structural 4	F22	F17	F14	F11	F8	F7	F5	F4	--
Structural 5	--	--	--	--	F7	F5	F4	--	--

The strength groups of the common Australian timbers are listed in Table 1.3. 'What timber will I use' (38) is a useful reference for the D.I.Y market, to optimise selection of suitable species for structural applications.

Mechanical stress-grading allocates a stress grade based on a predetermined relationship between stiffness and strength as measured in laboratory tests. The commercial procedures are defined in AS 1748 - 1978 'Mechanically stress-graded timber' and AS 1749 - 1978 'Rules for stress-grading of timber'. The different stress grades are distinguished by a colour code, as defined in AS 1613 - 1974 'Colours for marking stress graded timbers'.

An alternate system is proof grading. Visual grading can be successfully used in conjunction with proof grading, by visually sorting to identify the marginal pieces that require proof grading. Proof grading is done by passing a piece of timber on edge through a machine set by the operator to apply the minimum load required for a particular size and stress grade, with safety factors and duration of load taken into account. Any board below the required grade is broken, and any board which meets the grade is passed and colour coded or branded. A board thickness of 2 inches is generally the maximum limit on thickness for machine accuracy. This method subsequently sets a lower limit on the stress grade and material of potentially higher stress grade is not distinguished. Because of this undervaluing of timber, most mills prefer to use mechanical stress grading.

Durability is a very important property for timber used in such hazardous environments as in-ground contact and water (marine) contact. Durability is defined for marine applications in AS 1738 - 1975 'Timber for marine craft'. Durability of a species can be estimated by an accelerated test involving rating the performance of wood samples in the presence of decay fungi and insects in a controlled environment. Performance in ground contact is related to the composition of the sapwood and heartwood: resins, wood extractives, lignin, silica, starch, carbohydrates and water all play a role in protecting wood from biological degrade and maintaining structural integrity.

Some researchers believe that current durability data do not adequately cover the specifications for timbers in terms of their engineering requirements. Data on permeability of the timber structure is one area where information is limited.

CSIRO Division of Forest Products (44) and the Forest Research Institute (FRI) of New Zealand (22, 23) have Accelerated Field Simulators used by researchers in rating the durability of chemically treated and untreated softwood and hardwood species.

Natural durability of timber is more accurately measured, however, by graveyard trials. CSIRO (45) has an ongoing research program involving an in-ground study of various untreated and treated stakes, and this program is in its 25th year. The Department of Primary Industry's Queensland Forest Service (QFS) have above ground and jointed samples in several different areas in Northern Australia under assessment.

Physical properties such as fibre length, density and angle of spiral grain have previously been measured manually. Samples are generally taken by an increment borer in which a small cylinder of wood is removed from the tree trunk. Two research groups working on the automation of such measurements, are FRI/PAPRO (Pulp and Paper Research Organisation) and CSIRO. Both groups are interested in these properties for the production of pulp.

FRI have a method for gathering data on density, carbohydrate content and extractives content of *Pinus radiata* using Near Infra Red (NIR), Fourier Transform Infra Red (FTIR) and Nuclear

Magnetic Resonance (NMR) Spectroscopy. It is hoped to establish predictions for solid wood properties (shrinkage, density, mc% and compression wood%) and pulp properties (Kappa number, tear strength, beatability, bleachability, lignin% and cellulose %) as well as spiral grain profiles using a similar system.

At CSIRO, an instrument called Silviscan (46) has been designed to rapidly measure variations in density and tracheid cross-sectional dimensions in *Pinus radiata*. The instrument contains sophisticated image analysis software, enabling the operator to obtain clear graphical information on density and wood fibre properties such as wall thickness and cell diameters. Other sophisticated methods include the use of vibrational spectroscopy and multivariate or regression analysis (47).

There are other less sophisticated instruments available for measuring density. These include the Densitometer (an instrument that uses ionising radiation from a radioactive source to measure density across a growth ring), the Torsiometer (a torque-measuring device attached to an increment borer that measures the force required to turn the borer in the tree) and the Pilodyn (an instrument with a spring-loaded pin that is fired into the tree, where depth of penetration is inversely related to density). By design they are more labour intensive than the electronic instruments.

The basic physical property of density directly influences a number of other wood properties including strength, drying characteristics, preservative treatment, and machining, as well as pulping properties. Pine wood density is intrinsically linked with earlywood and latewood proportions, and is under strong genetic control (49).

Several mechanical and physical properties of timbers are listed in Table 1.3. These properties were measured using the methods described by Mack (50) shown below.

Notes for Table 1.3

Mechanical properties

MOR: Modulus of rupture is a measure of the bending strength of a timber sample when an increasing load is applied over a few minutes. It is important for assessing suitability for structural use.

MOE: Modulus of elasticity is the measure of the sample's stiffness or resistance to deflection and is also important for load-bearing structural use.

Maximum Crushing Strength: Compression strength parallel to the grain is a measure of strength performance as a column.

Impact Strength: Impact strength using the Izod test is a measure of the energy required to break a test sample using a load supplied by a swinging pendulum.

Hardness: Hardness is estimated using the Janka Hardness test to measure the load required to embed a steel ball to half its diameter in a timber sample.

Physical properties

Density: Density is defined as mass per unit volume. Air-dried density (12 % moisture content) is air-dry mass divided by air-dry volume.

Shrinkage: Radial and tangential shrinkage of the timber from unseasoned (green) to a seasoned (12% mc).

Durability: Ability of the timber to withstand/resist the degrading effects of biological attack on the structural integrity of the wood matrix. CSIRO identified four classes according to years of service life in-ground contact:

class 1 - >25 years
class 2 - 15 - 25 years
class 3 - 8 - 15 years
class 4 - < 8 years

Lyctus Susceptibility: Susceptibility of sapwood of particular species to attack by the lyctid borer (powder post beetle), which attacks dry timber.

Table 1.3 Physical and mechanical properties of timbers

Botanical name	Standard trade name	Source	MOR (MPa)		MOE (GPa)		MCS (MPa)		IZOD (J)		Janka hardness (kN)	
			G *	D	G	D	G	D	G	D	G	D
Argyrodendron	Blush Tulip Oak	Qld	69	110	11.7	15.2	34.4	55.1	--	--	--	--
actinophyllum												
Acacia	Blackwood	Tas	70	99	13	13	33	48	15	13	4.6	5.9
melanoxylon												
Eucalyptus	White Mahogany	NSW	101	130	16	17	49	76	18	14	8.5	10
acmenoides	Black											
E. amygdalina	Peppermint		--	--	--	--	--	--	--	--	--	--
	Marri											
E. calophylla	River Red Gum	WA	78	125	14	17	41	66	20	23	6.6	7.1
E. camaldulensis	Mountain Gum	Qld, Vic	64	101	8	11	33	53	14	8.1	7.7	10
E. dalrympleana	Alpine Ash	Vic, NSW	67	117	11	13	32	50	15	8.2	5.1	5.7
E. delegatensis	Karri	T, V, NSW	63	110	11	15	33	60	13	18	4	4.9
E. diversocolor	Tas. Blue Gum	WA	73	132	14	19	36	72	21	24	6	9
E. globulus	Flooded (Rose)	Vic	78	146	11	20	40	83	16	23	7.3	12
E. grandis	Gum		--	--	--	--	--	--	--	--	--	--
	Silvertop											
E. laevopinea	Stringybark	NSW	87	143	15	18	38	73	17	18	5.5	8.8
	Spotted Gum											
E. maculata	Jarrah	NSW	99	150	18	23	50	75	20	24	8	11
E. marginata	Tallowwood	WA	68	112	10	13	36	61	13	10	5.7	8.5
E. microcorys	Yellow	NSW, Qld	106	134	18	18	51	73	20	17	7.6	8.6
E. muellerana	Stringybark	NSW, Vic	90	132	14	17	44	72	20	14		
	Shining Gum										6.3	8.5
E. nitens	Messmate	Vic	62	99	10	13	31	58	15	16	4.8	5.8
E. obliqua	Blackbutt	Vic, NSW	75	118	14	15	35	61	16	15	5.3	7.1
E. pilularis	Narrow-leaf	NSW, Qld	100	144	17	19	48	77	21	22	7.3	9.1
E. radiata	Peppermint	Vic	68	117	11	14	35	62	12	12	5	7.1
	Mountain Ash											
E. regnans	Sydney Blue	Tas, Vic	63	110	13	16	30	63	13	20	3.4	4.9
E. saligna	Gum	NSW	91	140	16	18	44	68	16	18	6.4	9
	Silvertop Ash											
E. sieberi	Forest Red Gum	NSW, Vic	69	136	10	17	38	70	12	20	7.2	9.5
E. tereticornis	Manna Gum	Q,V, NSW	85	123	12	14	44	70	19	16	12	12
E. viminalis	Turpentine	V ,T , NSW	48	90	13	14	34	61	18	12	5.4	6
Syncarpia		NSW, Qld	83	142	14	16	42	76	14	9.5	6.5	12
glomulifera	Brush Box											
Tristania		NSW, Qld	85	123	12	15	38	68	17	15	7.9	9.5
conferta	Hoop Pine											
Araucaria		NSW, Qld	48	90	10	13	28	53	9.1	5.6	3	3.4
cunninghamii	Cypress Pine											
Callitris		Qld, Vic	71	79	7.1	9	40	53	7.8	4.6	5.6	6.5
columellaris	Loblolly Pine											
Pinus taeda	Slash Pine	NSW, Qld	38	77	5.9	7.7	20	40	11	6.6	2	3.1
P. elliottii	Maritime Pine	NSW, Qld	42	85	7	9.7	22	41	8	5.6	2.1	3.4
P. pinaster	Caribbean Pine	Gt Britain	36	77	6.6	8.9	17	40			1.7	2.7
P. caribaea	Radiata Pine	NSW	46	67	5.3	5.4	20	35	3.4	2.2	2.7	--
P. radiata		Vic, SA	42	81	8.1	10	19	42	12	6.9	2.1	3.3
	F1 Hybrid	NZ	41	92	7.3	10.7	17	40	--	--	2.6	5.2
F1 hybrid		Qld	--	--	--	--	--	--	--	--	--	--

***G** = green, **D** = dry to 12% mc

Information for Table 1.3 was obtained from the following sources - *17, 19, 20, 21, 22, 24, 25, 27, 28, 33, 34, 36, 37, 39, 40, 41, 42, 43.*

Table 1.3 cont.

Botanical name	Common name	Density @ 12% mc	Shrinkage (%) R*	T	Strength group	Durability class/Lyctus# susceptibility	Bending
Argyrodendron	Blush Tulip Oak	850	4.3	8.7	S3 / SD3	4^{s}	--
actinophyllum							
Acacia	Blackwood	640	1.4	4.0	S4 / SD4	3^{s}	good
melanoxylon							
Eucalyptus	White Mahogany	990 - 1010	2.8	5.0	S2 / SD3	1^{ns}	good
acmenoides	Black						
E. amygdalina	Peppermint	770	5.5	9.9	S3	3	--
	Marri						
E. calophylla	River Red Gum	850	3.5	6.5	S3 / SD3	3	--
E. camuldensis	Mountain Gum	880	3.8	8.9	S2-5 / SD5	2^{s}	fair
E. dalrympleana	Alpine Ash	740	5.0	11.5	S4	4^{s}	
E. delegatensis	Karri	610 - 675	4.5	8.5	S4 / SD4	4^{s}	good
E. diversicolor	Tas. Blue Gum	900	4.5	9.9	S3 / SD2	3^{ns}	good
E. globulus	Rose (flooded)	900	6.0	12.0	S3 / SD2	3^{s}	--
E. grandis	Gum	620 - 800	4	7.2	S3 / SD4	3^{ns}	poor
	Silvertop						
E. laevopinea	Stringybark	860	5.0	8.5	S4	2/3	--
	Spotted Gum						
E. maculata	Jarrah	970 - 1010	4.3	6.1	S2 / SD2	2^{s}	good
E. marginata	Tallowwood	830	4.8	7.4	S4 / SD4	2^{s}	--
E. microcorys	Yellow	1000	3.7	6.1	S2 / SD2	1^{s}	fair
E. muellerana	Stringybark	860	3.9	7.5	S3	2^{ns}	poor
	Shining Gum						
E. nitens	Messmate	720	4.6	9.4	S4	4^{s}	--
E. obliqua	Blackbutt	770/ 830	5.5	11.3	S3 / SD3	3^{s}	good
E. pilularis	Narrow-leaf	900 - 930	4.3	7.3	S2 / SD2	2^{ns}	fair
E. radiata	Peppermint	720	6.6	13.5	S3	3^{s}	--
	Mountain Ash						
E. regnans	Sydney Blue	680	6.5	13.0	S4 / SD3	4^{ns}	good
E. saligna	Gum	900	4.5	9.5	S3 / SD3	$2/3^{s}$	--
	Silvertop Ash						
E. sieberii	Forest Red Gum	830	4.5	10.5	S3	3^{ns}	good
E. tereticornis	Manna Gum	1010 - 1100	4.8	8.6	S3 / SD4	$1/2^{ns}$	good
E. viminalis	Turpentine	730	5.2	9.5	S5	4^{s}	good
Syncarpia		900 - 995	6.5	13	S3 / SD3	1^{ns}	--
glomulifera	Brush Box						
Tristania		880 - 900	4.4	9.7	S3 / SD3	3^{ns}	--
conferta	Hoop Pine						
Araucaria		53- - 560	2.5	3.8	S6 / SD5	4^{ns}	poor
cunninghamii	Cypress Pine						
Callitris		680	2.4	2.8	S5 / SD6	1^{ns}	fair
columellaris	Loblolly Pine						
Pinus taeda	Slash Pine	550 - 630	3	4.6	S6 / SD6	4^{ns}	--
P. elliottii	Maritime Pine	530	3	4.8	S5 / SD5	4^{ns}	--
P. pinaster	Caribbean Pine	600	3	5.0	S6 / SD6	4^{ns}	--
P. caribaea	Radiata Pine	500	2	4.0	S6 / SD6	4^{ns}	--
P. radiata		450 - 580	2.5	3.9	S6 / SD6	4^{ns}	very good
	F1 Hybrid	440 - 480	2.9	4.8		4^{ns}	
F1 hybrid		--	--		--	4^{ns}	--

 # ns = not susceptible to Lyctus attack, s = susceptible to Lyctus attack

* **R** = radial, **T** = tangential

CHAPTER TWO AUSTRALIA'S FOREST RESOURCES

SECTION 2.1 TIMBER RESOURCES IN AUSTRALIA

Our forest resources include private ownership of native forest and plantations, as well as extensive public ownership of three types:

(i) **state** - multiple use public forest and plantations primarily for timber production of 11.5 Mha (7 Mha for logging and 4.5 Mha inaccessible or buffer zones)
(ii) **crown** - public forest without specific timber production management of 10.6 Mha (6.8 Mha for logging)
(iii) **conservation** - public forest for recreational/conservation purposes of 9.8 Mha
(iv) **private** - 11.3 Mha - (7.6Mha for logging)

A survey conducted by the Resource Assessment Commission (RAC) and reported as the 'Forest and Timber Inquiry 1992' (5, 6,7) showed:

(i) Australia has 43Mha of forested land covering 5% of total land area
(ii) 92 Mha of woodland
(iii) 14 Mha (32%) of forest is mixed woodland (native pine and forest of minimal timber production value)
(iv) 900 000 ha (2%) is mangrove and swamp.
(v) 25.8 Mha (60%) of forest area has been logged and 21 Mha of this is now regrowth forest.
(vi) 17.2 Mha (40%) of the forest has either been lightly logged or unlogged with one third of it now placed in conservation reserves.

Each year 200,000 ha of state/crown land are logged and regenerated. Australia currently has 915,000 ha of softwood plantations and 85,000 ha of hardwood plantations: each year 50,000 ha of softwoods are harvested and reforested, and 30,000 ha of new plantations are established, including more than 3,500 ha of hardwood forests.

The Australian Forestry Council (AFC) supported the survey by the RAC and has summarised information on timber production in Australia for 1990. The native and plantation holdings are shown in Tables 2.0, 2.1 and 2.2.

Table 2.0 The extent of Australian forest and woodland groups in different tenures, 1990

Forest group ('000 hectares)	State forest	Crown land	Conserv. reserves	Private forest	Total
Tropical rainforest	98	11	977	60	1146
subtropical rainforest	226	32	106	32	396
temperate rainforest	395	182	356	70	1002
mangrove and swamp	--	94	655	164	913
SW wet eucalypt forest	122	--	50	12	184
SW dry eucalypt forest	1321	--	404	495	2220
SE wet eucalypt forest	1511	727	1086	739	4064
SE ash forest	663	132	526	161	1482
SE dry forest and woodland	881	2258	592	2698	6429
SE coastal eucalypt forest	2480	166	747	382	3775
Central coastal eucalypt forest	1374	588	808	1470	4241
NE coastal eucalypt forest	941	740	400	657	2738
River red gum forest	178	117	61	100	456
Native pine forest and woodland	1108	1531	298	1081	4018
Northern dry forest and woodland	168	4043	2689	3220	10119
TOTAL	11 465	10 622	9 756	11 341	43 185

-- *information not available* *note* *figures exclude area of woodland outside the AFC regions (approx. 92 Mha)*

Table 2.1 Gross and net areas for timber production: by tenure, 1990. ('000 hectares)

Area	State forest	Other crown land	Conservation reserves	Private forest	Total
Gross area	11 465	10 622	0	11 341	33 428
Net available area	7 147	6 788	0	7 621	21 556
% of gross area	62	64	0	67	65

Table 2.2 Extent of public and private plantations, 1990. ('000 hectares)

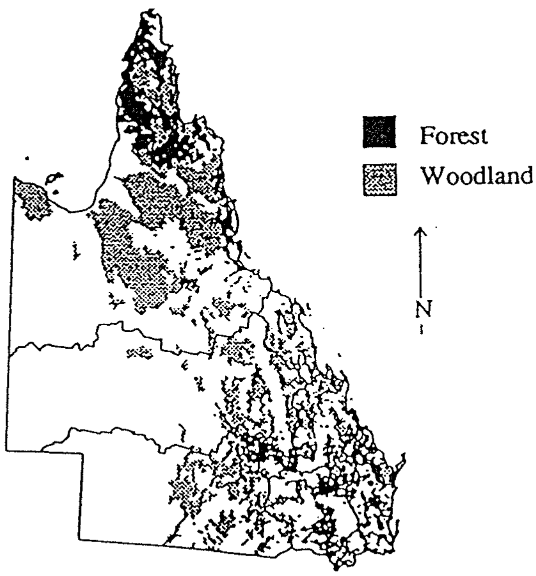
Plantation type	Public land	Private land	Total
Hardwood	45	40	85
Softwood	646	269	915
Total	691	309	1000

Queensland

Data indicates that Queensland has 9.95 Mha of forests of which 6.19 MHa (62%) is available for state-controlled logging (Figure 2.0 and Table 2.3). The Department of Primary Industries manages 4.3 Mha of State Forests and Timber reserves of which only 1.8 Mha is managed for sustainable timber production. A QFS business group within the Department of Primary Industries, is responsible for the planning and performance of the forest estate in Queensland (61).

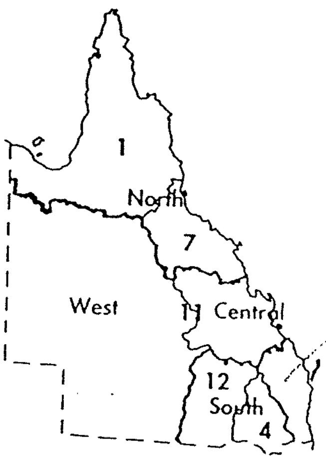
Figure 2.0

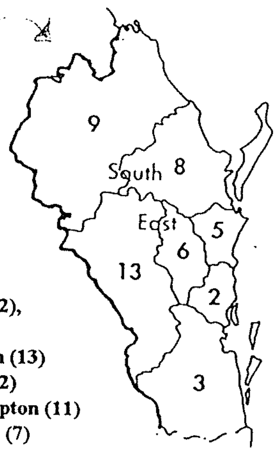
(a) Forest and Woodland in Queensland (5)



Australian Forestry Council regions
1. North Queensland , 2. Mackay,
3. Central Western, 4. Central Coast,
5. Western Cypress, 6. Eastern Cypress,
7. South Eastern

(b) Queensland Forest Service Regions (61)





South East Region Districts - Beerburrum (2), Brisbane (3), Gympie (5), Imbil (6), Maryborough (8), Monto (9) and Yarraman (13)
South Region Districts - Dalby (4), Roma (12)
Central & West Region Districts -Rockhampton (11)
Nth Region Districts - Atherton (1), Ingham (7)

Table 2.3 Wood Production in Areas of State Forest and Timber Reserves

Native Forest	State forest	Other crown land	Conserv. reserves	Private forest	Total
Total area	2 683	2 684	3 224	1 355	9 946
Unlogged	426	1 019	1 835	120	3 400
Regrowth area	2 257	1 665	1 389	1 235	6 546
Area available for logging	2 127	2 527	0	1 355	6 009
Plantation	**Public**		**Private**		**Total**
Hardwood	---		---		---
Softwood	167		23		190

The native hardwood and softwood resource of 1.63 Mha has undergone dramatic changes in tenure due to World Heritage Listing. Currently all native forest removals are well below the 1992 allocations (61) by 10 000 - 50 000 m^3.

QFS plantations cover 174 000 ha primarily in the state's South East corner (Table 2.4). Currently they produce 1 Mm^3 of log timber, with the aim of 2.2 Mm^3 by 2020. The composition of plantation production in 1991/92 was 80% final crop, 14% thinning sawlogs, 3% roundwood and 3% pulpwood.

Table 2.4 Composition of the Queensland Forest Estate (61)

Plantation Estate	Percentage composition
Slash pine	36
Caribbean pine	31
Exotic hybrids	4
Other exotic conifers (*P .taeda, P. radiata*)	3
Native conifers (*C. columellaris, A. cunninghamii, A. bidwillii, Agathis palmerstonii*)	26

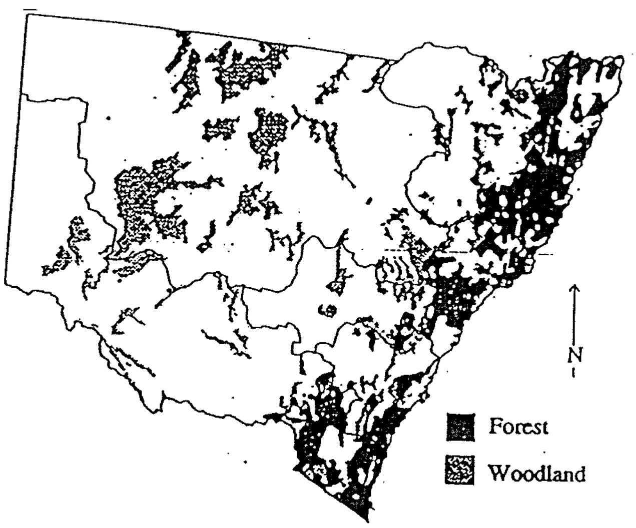
New South Wales

The AFC defines the NSW resource as 14.69 Mha of forest of which 2.7 Mha is available for state-controlled logging (Figure 2.1 and Table 2.5). The Forestry Commission of NSW is a commercial business unit that manages 200 000 Ha of exotic pine plantations and 25 600 Ha of hardwood plantations as well as native forests. Radiata Pine is the primary softwood species however there are small areas of Hoop and Cypress pine. Percentages of hardwood species used in plantations are:

flooded gum 32%
blackbutt 43%
river red gum, silvertop stringybark, blue gum and New England blackbutt 25%.

In 1992, 698 000m^3 of sawlogs and 613 000 tonnes of pulpwood were cut. In that same year, 703 000 tonnes of hardwood pulp and 20 000m^3 of timber were also cut (63).

Figure 2.1 (a) Forest and woodland (5) (b) Forestry Commission Regions (63)



Australian Forestry Council regions
1. Coffs Harbour, 2. Glen Innes, 3. Port Macquarie, 4. Dubbo, 5. Newcastle, 6. Albury, 7. Bathurst, 8. Batemans Bay, 9. ACT, 10. Eden

Table 2.5 The forest resource of NSW by tenure 1990, (5)

Native forest	State forest	Other crown land	Conservation reserves	Private forest	Total
Total	3 247	3 850	2 123	5 196	14 416
Unlogged	359	62	1 080	18	1 519
Regrowth	2 888	3 788	1 043	5 178	12 897
Area available for logging	1 997	573	0	2 014	4 584
Plantation	**Public**		**Private**		**Total**
hardwood	25		3		28
softwood	180		68		248
total	205		71		276

Australian Capital Territory

The Australian Capital Territory has 98,000 ha of conservation reserves and 17,000 ha of pine plantations. There are severe limitations on areas available for forestry activities, and there are limited processing facilities.

Table 2.6 Forest resource of ACT: by tenure 1990

Native forest	State forest	Other crown land	Conservation. reserves	Private forest	Total
Total	0	0	98	0	98
Unlogged	0	0	81	0	81
Regrowth	0	0	17	0	17
Area available for logging	0	0	0	0	0
Plantation	**Public**		**Private**		**Total**
Hardwood	<1		0		<1
Softwood	16		0		16
Total	16		0		16

Western Australia

The AFC reported that of 2.4 Mha of native forest in Western Australia, 1.4 Mha is available for logging (Table 2.7 and Figure 2.2). There are 75 000 ha of hardwood and softwood plantations, primarily consisting of *P.radiata*, *P.pinaster*, *E.globulus* and *E.astringens*. The Department of Conservation and Land Management (CALM) have an estate of 19.892 Mha under their care (64). This is 7.4% of the WA land area (Figure 2.3).

Figure 2.2 Forest and woodland in Western Australia

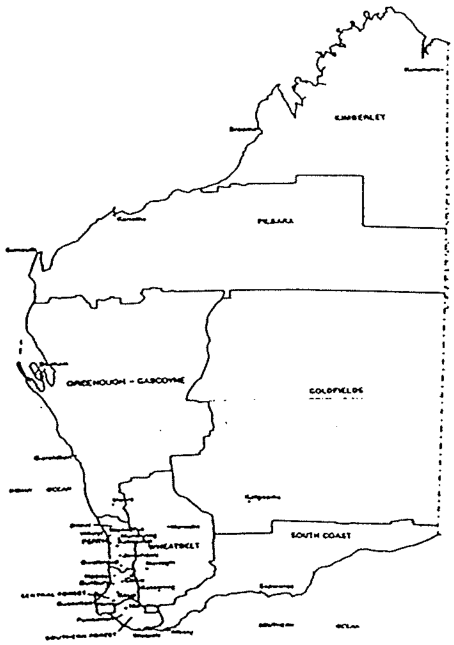
Australian Forestry C council regions
1. Northern, 2. Central, 3. Southern

Jarrah forests of 1.4 Mha located exclusively in the South West are managed to produce about 1.36 Mm^3 of timber per year, including marri for residues. Karri forests available for timber production and smaller areas of wandoo and brown mallet total 70 000 ha.. Establishment of softwood plantations (*Pinus radiata* and *P. pinaster*) and hardwood plantations (*E. globulus* and *E. astringens*) have bought plantation area up to 77 000 ha. Sharefarming has also increased, bringing the area of private plantations to over 30 000 ha.

Table 2.7 The forest resource of Western Australia: by tenure 1990

Native forest	State forest	Other crown land	Conservation reserves	Private forest	Total
Total	1 443	0	455	507	2 405
Unlogged	268	0	165	0	433
Regrowth	1 175	0	290	507	1 972
Area available for logging	1 443	0	0	507	1 950
Plantation	**Public**		**Private**		**Total**
Hardwood	5		10		15
Softwood	70		18		88
Total	75		28		103

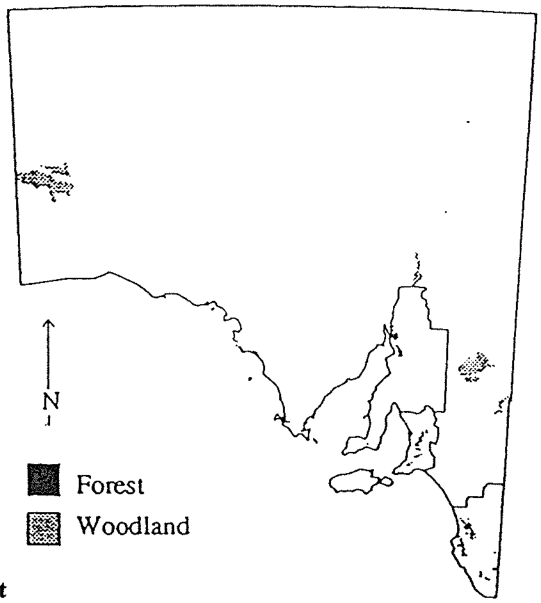
Figure 2.3 The CALM Administration Area



South Australia

South Australia similarly has very little native timber resource (Figure 2.4), with only about 27 000 ha of native forests. Forwood (a Government business unit) manages 69 000 ha of radiata pine plantations, while 26 000 ha of plantations are managed by private landowners (Table 2.8). Hardwood plantations in South Australia, consisting of blue gum, sugar gum and yellow gum, now total 750 ha.

Figure 2.4 Forest and woodland in South Australia



Australian Forestry Council regions
1. Northern, 2. Central, 3. South East

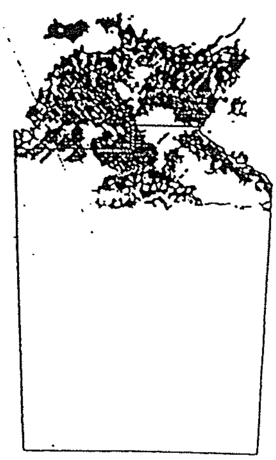
Table 2.8 Forest resources of South Australia: by tenure 1990

Native forest	State forest	Other crown land	Conservation reserves	Private forest	Total
Total	27	0	0	0	27
Unlogged	0	0	0	0	0
Regrowth	27	0	0	0	27
Area available for logging	27	0	0	0	27
Plantation	**Public**		**Private**		**Total**
Hardwood	<1		---		<1
Softwood	69		26		95
Total	70		26		96

Northern Territory

The Northern Territory has a total native forest area of 9 Mha of which 3.5 Mha is logged for hardwood for domestic use (Figure 2.5 and Table 2.9). There are no government managed plantations, however, there are approximately 3.6 Mha of private forest and 4000 ha of plantation available for logging.

Figure 2.5 Forest and Woodland in Northern Territory



AFC region
1. NT1

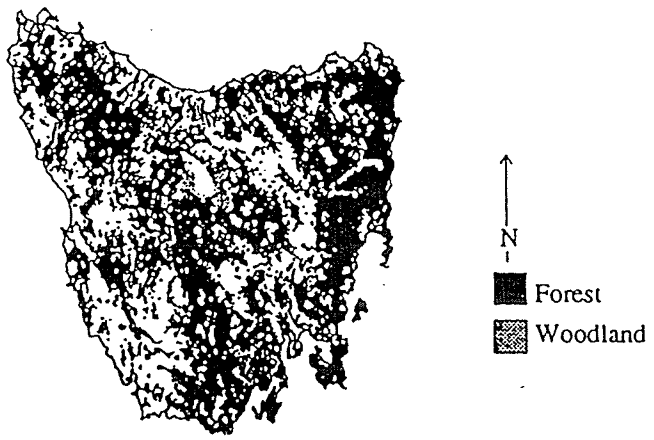
Table 2.9 The forest resources of Northern territory: by tenure 1990

Native forest	State forest	Other crown land	Conservation reserves	Private forest	Total
Total	0	3 499	1 881	3 661	9 041
Unlogged	0	3 499	1 873	3 660	9 032
Regrowth	0	0	8	1	9
Area available for logging	0	3 499	0	3 660	7 159
Plantation	**Public**		**Private**		**Total**
Hardwood	--		<1		<1
Softwood	--		4		4
Total	0		4		4

Tasmania

The Forestry Commission of Tasmania has 1.6 Mha of state forest in its care and approximately 55 500 ha of softwood and hardwood plantation established. The AFC estimates that the Tasmanian resource is 1.1 Mha (Figure 2.6 and Table 2.10).

Figure 2.6 Forest and woodland in Tasmania



In the year 1991/92 The Forest Commission sold 1.6 Mm^3 of native forest and 497 $00m^3$ of softwood plantation timber (65).

Table 2.10 The forest resource of Tasmania: by tenure in 1990 (5)

Native forest	State forest	Other crown land	Conservation reserves	Private forest	Total
Total	944	589	733	622	2 888
Unlogged	337	253	515	13	1 118
Regrowth	607	336	218	609	1 770
Area available for logging	498	284	0	330	1 112
Plantation	**Public**		**Private**		**Total**
Hardwood	4		19		23
Softwood	38		30		68
Total	42		49		91

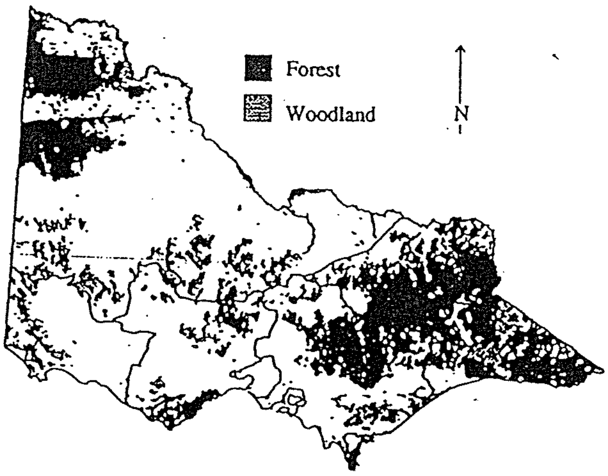
Victoria

The Department of Conservation and Environment (DCE) (now Conservation and Natural Resources) manages 8 Mha (38%) of Victoria's land mass (66). This consists of 3.49 Mha of state forest and 117 300 ha of plantations, primarily softwood (Figure 2.7 and Table 2.11). In 1992, sale of hardwood and softwood generated $57 M for the Victorian economy. The AFC estimated that Victoria has 1.3 Mha of forest available for logging from a total forest area of 4.97 Mha.

Table 2.11 The forest resource in Victoria: by tenure, 1990

Native forest	**State forest**	**Other crown land**	**Conservation reserves**	**Private forest**	**Total**
Total	3 122	--	1 243	605	4 970
Unlogged	1 145	--	668	--	1 813
Regrowth	1 977	--	575	--	2 552
Area available for logging	1 314	--	0	--	1 314
Plantation	**Public**		**Private**		**Total**
Hardwood	10		8		18
Softwood	106		99		205
Total	116		107		223

Figure 2.7 Victoria's forest and woodland areas



Australian Forestry Council regions,
1. Mildura, 2. North East,
3. East Gippsland,
4. Central Gippsland, 5. Portland,
6. Midland

RAINFOREST

Rainforest reserves in Australia comprise 6% of the total native forest estate with an area of approximately 2.5 Mha. There are five different types of forest, found in various states:

- Tropical - North Queensland
- Warm Temperate - Northern NSW, Victoria
- Dry Rainforest - Victoria
- Sub Tropical - Northern NSW
- Cool Temperate - Tasmania, Victoria.

Although only 0.25% of Australia's land mass is covered by rainforests, they contain up to 25% of all plant genera and many marsupial, vertebrate animal species, bats, frogs, reptiles, butterflies, birds, insects and spiders (67).

Logging of rainforests has virtually ceased in Australia (71). In 1986 logging in NSW, Victoria and Tasmania ceased, while Queensland ceased rainforest logging in 1988. Tall open forests (ie. wet sclerophyll) adjacent to rainforests are generally available for harvesting, and provide Queensland's most productive hardwood resource. Species include Rose (Flooded) Gum, Blackbutt, Tallowwood, Brush Box and Sydney Blue Gum (68).

SECTION 2.2 RESOURCE SECURITY

RESOURCE SECURITY LEGISLATION

For timber mills to function, a consistent and reliable source of raw materials is essential. Agreements between State Government forestry agencies and timber industry members generally consist of licences of 1 - 15 years. These are obtained by competitive tendering for the supply of graded sawlogs and pulplogs from native forests and state-owned plantations (69). In Queensland, plantations are sold by open tender in 20-year supply agreements with provision for price and volume renegotiation every five years (5, 70). Trees are sold as 'whole trees at stump' to individual purchasers.

The tendering processes nationwide have undergone re-evaluation to include compliance with the Code of Forest Practices and the Environmental Health and Safety Act.

Previously it was suggested that sawlogs and pulplogs were underpriced (5) and not used to best advantage. Allocation is now generally based on a commitment to value-adding in the area of processing beyond the green sawn state. Residual roundwood tendering is also controlled by the States, and material remaining after removal of quota logs is sold, in most cases to local users. In Queensland, if the annual cut for the tender is not taken by the licensee, then the allocation can be lost or reduced. There is a minimum annual log removal requirement of 85% of nominal entitlement (70).

The Australian Conservation Foundation (ACF) claims that the resource security legislation is an invitation for the development of large-scale pulp mills, and that legislation is *'subsidising industry to destroy native forests..'* and *'... it [resource security] slows the transition to plantations by locking the industry into the continued destruction of Australia's old growth forests'* (72, 74, 75).

Unfortunately the ACF has not pointed out that the Australian Hardwood Industry is composed of a majority of small operators who work close to their resource, and there is no domination by large pulp mills. The woodchipping and pulp and paper mills (for example APM, Boral and CSR in the Eastern States) have used extensive privately owned and company owned plantation wood (mainly Tasmanian Blue Gum and Radiata Pine), as well as residues from sawmills and forestry operations for many years. In line with the industry's commitment to a sawlog-driven industry, pulplogs are only recovered after the sawlog quota has been filled from any harvested area. The licensees and State organisations are then responsible for regeneration of the harvested forests.

The NSW Forestry Commission are taking a proactive approach to achieving greater resource security for their licensees. The preparation and presentation of Environmental Impact Statements for every forest area in the NSW estate is undertaken in collaboration with local community groups. This close liaison should achieve a greater focus and understanding of the concepts of Environmentally Sustainable Development and multiple use forestry. The Department will also prepare a database of EISs for all regions so that continual monitoring and immediate action can be taken in response to queries about tenure changes (76, 77, 78).

In the ACF's 'Alternatives to resource security legislation' (72, 73), their only offer is to sit and wait for the plantation softwood and hardwood resource to mature. What they fail to appreciate is the potential economic disaster of this 'wait-and-see' attitude. In an article prepared by the Centre For International Economics (75), it is highlighted that the Forest Industries have 'extensive links both direct and indirect, to other domestic industries and to international trade.' To make a valuable contribution to the economy, the Forest Industries must be competitive, however competitiveness is inhibited by insecure access to forest resources.' The Forestry and Forest Products Industry Council (FAFPIC 86) provided concise information on why plantation resources can only supplement native resources but not substitute for them in the medium term. The pressure groups are taking a position of philosophical purity rather than coming to a mutually beneficial agreement with the Forest Industries. The Government meanwhile faces the issue of making 'Good Public Choice' in determining a resolution to resource security. Certainly all sides of the debate have valid reasons for their views.

A disappointing behaviour I found during research, was the degree of emotional propaganda used by pressure groups. Many groups encourage the view that forestry activities are to blame for our changing forest resource. This is not correct because massive land degradation has occurred through soil erosion and water table disruption caused by the clearing for agriculture. Landcare programs are currently attempting to educate pastoralists and farmers on the value of agroforestry and shelterbelt farming. Timber production in multiple use forests carried out under a sustainable yield program, has in fact curbed the clearfelling of land for agriculture, and forestry practices are attempting to reintroduce the biodiversity of pre-European forest cover. As an example of this type of sustainable yield program, 'Rebuilding of the Cathedral' by R. Underwood, General Manager of CALM (87) describes the successful regeneration of four forests in South West Western Australia that were clearfelled during the late 1800s and early 1900s. The most controversial is the Treen Brook Karri forest south of Pemberton, which after strict silvicultural management is now a magnificent 50-year-old forest of active and healthy 60 m tall trees. The article highlights the robustness of native forests and their ability to regenerate naturally.

The second article is 'The regeneration of Highland Eucalypt Forests in Tasmania' by B. Ellis, CSIRO Division of Forestry (81), which describes the management and use of the highland forests over a period of several centuries. The aborigines patch-burned the forests to hunt game, leaving open stands of mixed age eucalypts and ground cover of grasses and scrub. In the 1920s, there was a frenzy of clearfelling for farmland followed by a period of abandonment where natural regeneration occurred. In the 1970s, large export markets for woodchips apparently led to the destruction of forests irrespective of condition, leaving behind poor quality stands unable to regenerate. Foresters now use prescriptions for harvesting and regeneration that rely on the natural seeding cycles of native species (eg. seven years for *E. delegatensis*) and accommodate the harsh climate conditions where daily temperature variations can be -5^{o}C to +40^{o}C. The trend is for extensive rather than intensive management. Rotations are longer and the seedlings regenerating after hot burn prescriptions are protected by the recovering overstorey of adult trees.

NSW is reintroducing biodiversity while developing a sustainable timber industry. Dr Hans Drielsma quoted that the forest resources in Australia are growing by 22 000 ha of softwood plantation and 15 000 ha of hardwood plantation per annum, and that only 1% of available native hardwood forest is logged per annum (82).

Plantation Establishment

A concern of Australian sawmillers and processors is continued access to sufficient good quality timber to meet consumer demands, and for many producers this includes plantation timbers. In Victoria no native forest has been cleared for the establishment of softwood or hardwood plantations since 1987 (Timber Industry Strategy 1986 (83)), and similar situations are found in Western Australia and Queensland. For example, 50 000 ha of softwoods a year are being harvested and replanted nationally, and 30 000 ha are being newly established on marginal agricultural land. About 3500 ha a year of hardwoods are being established (5).

For Australia to approach self-sufficiency for timber resources, our current 5 - 6% of land mass holding marketable wood must be increased considerably. In fact, 25% is the guideline figure for self sufficiency and that corresponds to a total of 860 Mha. Comparisons with forested land mass in such countries as Canada (38%), Russia (44%) and New Zealand (27%) indicates that Australia has a significant undersupply of forest resources (12), but on a per capita basis we are third in the OECD countries. For more plantations to be established, the land must be bought or leased from private land owners, appropriated from marginal agricultural areas, or obtained in ventures such as sharefarming and agroforestry.

The most suitable areas for plantation establishment are unfortunately ex-forest and ex-pasture sites, which generally are either unavailable or expensive to purchase. The infertile soils and arid regions of inland Australia are also unsuitable owing to the costs of fertilising and irrigating.

The shortage of suitable land is the result of low rainfall, low soil fertility and steep topography, because there is a high demand for productive land for agriculture and stock farming. A report by Booth and Janovic (1991) of CSIRO Division of Forestry for the National Plantation Advisory Committee, however, suggests that of 18.5 Mha of marginal productive agricultural land suitable for plantation in Australia, 1 Mha had high plantation potential and a further 400 000 ha had medium plantation potential (94).

The FAFPIC 1989 (85) plan developed by government, unions and industry groups was intended to counteract the account deficit of 30% of forest product needs coming from imports. The plan required 13 000 ha of new softwood plantations being established each year in Australia from 1988 to 2030; with Victoria planting 100 000 ha in that period. This seems possible given the indications in the Booth and Janovic report. The FAFPIC Plan (86) also stressed the need for hardwood plantations to supplement our native forest resource as well as provide for pulp and paper industries and the export wood chip market.

At present unfortunately, there are financial disincentives in establishing private plantations:

(i) tax disadvantages or changes in taxation policy
(ii) lack of ability to provide shareholder returns (unfavourable cash flow profile for investors) due to long rotation times for crops (84)
(iii) lack of incentive for farmers to invest land in agroforestry or sharefarming. Agriculture presently has greater returns per hectare and less risk. Up front costs (preparation and planting) are large and there are increasingly higher insurance premiums on the trees as the plantation matures.
(iv) annual rate payments of $ 1 - 7 per ha per year for private plantations are mandatory in comparison to no rate payments extracted from public plantations (85)
(v) lack of resource security as perceived by overseas investors.

An approximate costing for softwood plantation establishment shown below, was quoted by Timberland Forests Pty Ltd 1993 prospectus (82).

COSTS	PER HECTARE	Example 8 Ha LOT
Land Cost (assume land plantable was 90%)	$ 500	$ 4 000
Initial Development Fee	$4150	$33 200
Management Fee	$ 125 second year $ 75 first year	$ 1 000 $ 600
Other costs	?	Council rates, insurance

Costs for Tasmanian Blue Gum (*E. globulus*) pulpwood plantation crops have been estimated in an article produced by Western Australian Department of Conservation and Land Management (87) as follows:

COSTS	ACTIVITY	RANGE $/ha
Establishment costs		
Year 0	plan, prepare & supervise	100 - 300
	rabbit control	0 - 20
	fencing	0 - 80
	ripping & mounding	100 - 200
	pre-plant spray	100 - 150
	seedlings	270 - 370
	planting	80 - 100
	fertiliser	50 - 70
	fertiliser application	40 - 70
	insect surveillance	0 - 20
	insecticide & spray	0 - 30
	weed control	100 - 150
Year 1		
Growing costs		
Years2 - 15	fertiliser	400 - 600
Year 11	thin coppice	300 - 500
Years 0 - 20	firebreaks	10 - 20
	insurance	0 - 50
	overheads	0 - 100
Harvesting costs		
Years 10, 20	harvesting	$10 - 15/cu m
	harvest supervision	$2 - 3/cu m
	haulage (~$2 + 12 c/t/km)	$5 - 20/cu m

The New Zealand Forest Service (88) also produced an article as a guide to the small woodlot industry.

The New Zealand Forest Service (88) also produced an article as a guide to the small woodlot industry.

Even considering the disincentives, large companies such as Bunnings and APM, have developed skills and acquired land, with 12 000 ha in WA (89, 91) and 49 000 ha in Victoria (92) respectively to service their woodchipping and pulp industries. There are also extensive hardwood plantations in northern Tasmania which are contracted to supply chip to the Burnie paper mill. The possibility of cooperatives as suggested in the RAC Inquiry 1992 (5), in which farmers, government and industry arrange contracts for the management and harvesting of private plantations, is an alternative that appears feasible. There is a possibility of the corporatisation and eventual privatisation of government-owned plantations (eg. as occurred in New Zealand), however, according to discussion in 'The challenges of Privatisation: New Zealand's experience with Forestry', by Bilek and Horgan (1992) (93), it should be an economically driven and not a politically driven change if it is to be embraced by all in the Forest Industry.

One important issue not as yet raised, is the availability of land near current and future processing sites (e.g. sawmills, drying kilns, treatment plants, pulp mills). Only 286 700 ha of land within a 100 km radius and a further 175 000 ha within a 200 km radius of existing processing centres have been identified (5, 91, 96). The optimum distance of plantations from processing plants for cost justification is a 70 - 100 km radius. The cost of transport makes planting in some marginal areas uneconomical, as the plantation not only must have suitable climate, topography and nutrition, but also be sited near a processing facility. A study completed by FRI (227) has evaluated the use of portable sawmills, but this option is not viable for mid-to-large sized companies.

SECTION 2.3 SILVICULTURE AND FOREST MANAGEMENT

Forest management which integrates silvicultural, harvesting and establishment techniques, is the activity that distinguishes a healthy, productive and profitable stand of trees from a degraded, non-productive forest. Location, climate, species, soil and plant nutrition, site preparation, fire and pest control, as well as harvesting techniques all contribute to achieving optimum tree growth. These techniques are extensively studied by all forestry research institutes.

Location

The topography of the forest site is important for the development of productive trees. Most plantations are sited on relatively flat (or gently undulating) and well drained land. Hilly areas with steep gradients and deep gullies make planting and harvesting difficult, and they are susceptible to soil erosion and drainage problems.

On the other hand, some native forests thrive on land that is very steep. Forests such as the Ash forests of Victoria, southern N.S.W and Tasmania thrive on hilly, moist areas where they create a canopy for understory species to grow. A great diversity of plant and animal life may also co-exist due to adaptation of species to wet, steep or windy sites.

Species

An important part of plantation forestry is the choice of the most appropriate species of tree for the particular site and end use, and the exotic softwoods (*pinus* spp) planted in Australia are a good example of this.

- Radiata pine (*Pinus radiata*), which occurs naturally in California, was first cultivated in England in 1833 and distributed in Victoria in 1859 (95, 97). The first commercial plantations were established in 1880 in Victoria. Its range of latitude of approximately 28° - 37° North has been successfully translated to the southern hemisphere (Figure 2.3). Radiata pine requires gently undulating sandy soil that is well drained, has a tolerance to salt spray, wind and some frost, and requires over 600mm rainfall per year. It is a hardy species that responds well to intense management and has been successfully grown in all States except for the Northern Territory.
- Slash pine (*Pinus elliottii*) occurs naturally in Louisiana, Mississippi, Florida, Georgia and South Carolina at 25° - 27° North (Figure 2.8), and was introduced into Queensland in the 1920s. It requires a more tropical climate with a higher rainfall than radiata pine, and has been planted extensively south of Maryborough in Queensland.
- Carribean pine (*Pinus caribaea* var *hondurensis*), a native of Central America at 14° - 18° North, also requires a more tropical climate than that of radiata pine, but prefers better drained soils than slash pine and is planted north of Maryborough (99, 99A). Smith *et al.* of the QFS (60) found that basic density of exotic pines (slash and Carribean) varied inversely with elevation, latitude and site quality.
- Maritime Pine (*Pinus pinaster*) originally from SW Europe and Africa, thrives on soils too poor for radiata pine, and was substituted for radiata in Western Australia in the 1950s. It has a slower growth rate than radiata pine (26).
- Hybrid F_1 (*P. elliottii* x *P. caribaea* var *hondurensis*) is a vigorous straight-stemmed cross that is now used extensively in Queensland plantations rather than slash and Caribbean pine. It has been specifically selected for Queensland conditions by the QFS and has genetically improved growth and form with the best features of each of its parents (99, 99A).

Hoop pine (*Araucaria cunninghamii*) occurs naturally from Papua New Guinea to northern New South Wales, with best development on deep loams or sandy to clay type soils. It prefers sites of ex- rainforest or wet sclerophyll forest containing rainforest species. It is especially well suited to coastal or windy sites and is relatively frost tolerant, but is extremely sensitive to fire and intolerant to shade as a seedling. Hoop pine grows poorly inland, and is best suited to coastal areas where radiata, slash and Caribbean pines grow poorly. It does not regenerate vigorously and seeds only every 3 to 4 years. It does however, produce even textured and easily worked clearwood (100).

Of our native hardwood species, distribution is related to latitude, altitude, rainfall and soil type. Commercial native species suitable for seaside areas include *E. maculata, E. tereticornis* and several *Melaleuca, Grevillea* and *Casuarina* species. Where there is sandstone or shale, species such as *E. acmenoides* and *E. maculata* do well, while in salty soils *E. camaldulensis, E.sieberi* and *E.botryoides* perform well. For heavy clay soils, *E. camaldulensis, E. tereticornis, E.saligna, E.muellerana, E.botryoides* or *E. microcorys* are preferred (101, 102, 103, 104, 105). The fifteen formally identified forest groups in Australia are listed in Table 2.13.

Several studies conducted in Tasmania on plantations of *E. regnans, E. nitens, E. grandis* and *E. globulus* (106, 107) confirmed that latitude, altitude and rainfall have a direct influence on tree growth and form, and consequently on the volume of recoverable wood per hectare..

A number of hardwoods are currently being evaluated or developed as plantation species owing to their good timber or pulp properties and adaptability. Researchers in New Zealand (108) have classified potential eucalypt plantation species according to climatic regions of warm temperate, cool temperate or cold temperate. Species of interest in New Zealand include *E. saligna, E. botryoides, E. nitens, E. fastigata, E. muellerana, E. pilularis* and *E. obliqua*. The major species evaluated in Australia include those listed in Table 2.12.

Figure 2.8a Latitudes across the continent of Australia

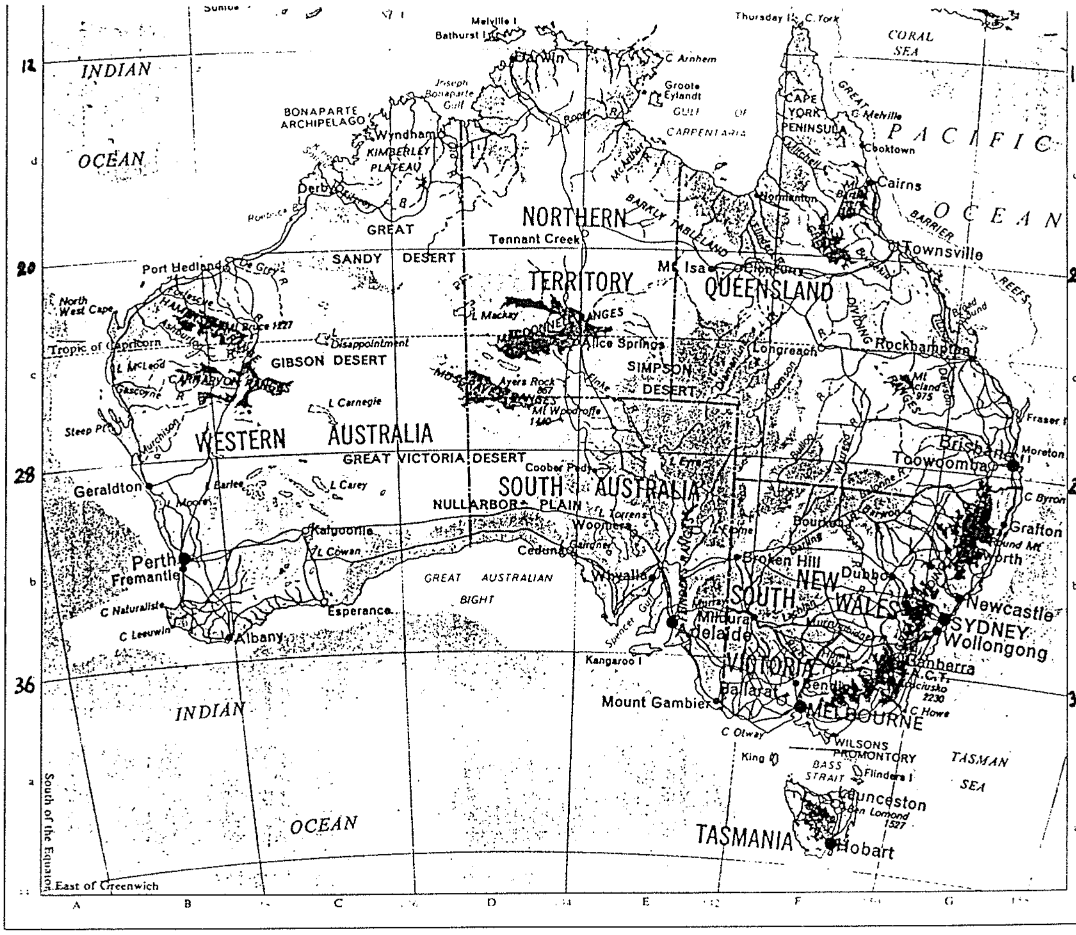


Figure 2.8 b Latitudes across the continent of North America

The growth stresses inherent in eucalypts make some plantation timbers unprofitable for the sawlog market. A study by CALM (225) found that while a 30.5% green sawn recovery was achieved through processing of plantation-grown Tasmanian Blue Gum, the majority of material was only suitable for lower grades because of kino, knots and gum veins. Material required careful selection before Clear grades were obtained. Continuing processing changes and improved efficiency, sawing technology and drying techniques in the future should improve the eucalypt plantation outlook.

Table 2.12 Eucalypt plantation species under evaluation

Botanical name	Standard trade name	Use	State
E. globulus	Tasmanian Blue Gum	Pulplogs	Tas, Vic, SA, WA, NSW
E. regnans	Mountain Ash	Pulp & sawlogs	Tas, Vic
E. pilularis	Blackbutt	Pulp & sawlogs	NSW, Qld
E. grandis	Rose Gum	Sawlogs	Qld, NSW
E. cloeziana	Gympie Messmate	Sawlogs	Qld
E. nitens	Shining Gum	Pulp & sawlogs	Tas, Vic, NSW
E. diversicolor	Karri	Pulp & sawlogs	WA
E. cladocalyx	Sugar Gum	Landcare	SA
E. leucoxylon	Yellow Gum	Landcare	SA
E. astringens	Brown Mallet	Landcare	WA

Other species of importance are brigalow (*Acacia harpophylla*) scrub and cypress pine (*Callitris* spp.) forests, particularly in the arid regions of central and western Queensland, northern Victoria and north west NSW (109). Such reserves have the potential to:

(i) stabilise salt levels in subartesian water as many of theses species are deep rooted and salt tolerant
(ii) stabilise soil horizons for the above reason
(iii) provide shelter and fodder for live stock
(iv) protect water catchment areas.

The establishment and/or protection of these types of forest communities are being considered in shelterbelt, sharefarming and agroforestry, as well as the many Landcare programs being conducted in rural Australia. Several agroforestry studies were reported by Western Australia's Department of CALM (110, 111, 112, 113).

Table 2.13 Major forest groups identified by the forest resource survey

Tropical rainforest: represents all tropical, gallery and monsoonal rainforest types of northern and north-eastern Australia. Widespread species include *Araucaria cunninghamii* and *Canarium australianum*, but most forests are characterised by the absence of dominant species. *Eucalyptus* species are generally absent.

Subtropical rainforest: represents the rainforest types of south-eastern Queensland and New South Wales. Characterisitic species include *Lophostemon confertus, Sloanea woolsii, Dendrocnide excelsa* and *Argydendron actinophyllum*. *Eucalyptus* species are sometimes present.

Temperate rainforest: Distributed across the cooler, wet regions of south-eastern Australia and Tasmania. Dominant species include *Acmena smithii, Atherosperma moschatum, Eucryphia lucida, Doryphora sassafras* and *Nothofagus cunninghamii*. *Eucalyptus* species are sometimes present.

Mangrove and swamp forest: Dominant mangrove species include *Avicennia marina* and *Rhizophora stylosa*. Swamp forests are distributed in the coastal flood plains of northern Australia and along coastal dunes and river flood plains of eastern Australia. Two subgroups are recognised: the paperbark forests and woodlands dominated by *Melaleuca* spp: and the *Eucalyptus* swamp forests and woodlands.

SW dry eucalypt forest: Three subgroups are recognised: the coastal tuart (*E. gomphocephala*) forest: the wandoo forest and woodland (*E. rudis, E. wandoo*): and the jarrah-marri (*E. marginata, E. calophylla*) forest.

SW wet eucalypt forest: Confined to the high rainfall region of south-western Australia and dominated exclusively by karri (*E. diversicolor*) forests.

SE dry forest and woodland: Mixed forests and woodlands of New South Wales, Victoria and south-eastern South Australia. Dominant eucalypts include *E. albens, E. macrorhyncha* and *E. melliodora*. Small areas of mallee and mulga are present.

SE wet eucalypt forest: Forests distributed predominantly over the high rainfall, montane regions of New South Wales, Victoria and Tasmania. Dominant tree species include *E. globulus, E. obliqua* and *E. viminalis*.

SE ash forest: Represents the most productive part of the area occupied by SE wet eucalypt forest and is characterised by the presence of *E. delegatensis, E. nitens* and *E. regnans* either as single species or occurring with other species.

SE coastal forest: Forests mostly confined to the coastal lowlands of NSW and Victoria. The northern limit includes *Angophora costata* and *E. gummifera*, and to the south *E. globoidea* and *E. sieberi* are widespread. Subtropical and temperate rainforest species occur with eucalypts.

Central coastal eucalypt forest: Widespread forests extending from NSW to Qld. Dominant tree species include *E. grandis, E. microcorys, E. pilularis, E. propinqua, E. umbra* and *Lophostemon confertus* (brush box).

NE coastal eucalypt forest: Forests and woodlands of the coastal lowlands extending from northern NSW to Cape York Peninsula. Dominant tree species include *E. intermedia, E. tessellaris, E. tereticornis* and *E. crebra*.

River red gum forest: A widespread group characterised by the dominance of *E. camaldulensis*.

Native pine forest and woodland: A mixture of forests and woodlands characterised by the presence of species of native pines from the genus *Callitris*. A number of *Eucalyptus* species often occur with *Callitris*.

Northern forest and woodland: Eucalypt and non-eucalypt open forest and woodland types. Tropical tree species include *E. miniata, E. tetradonta* and *Acacia shirleyi* (lancewood). North-eastern species include *E. caleyi, E. dealbata* and *E. populnea*.

reproduced from *RAC (5)*

SOIL AND PLANT NUTRITION

The condition of the soil that supports plant growth is important for the healthy maturing of plants. Studies have shown that the elements required by plants are: carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, boron, iron, manganese, copper, zinc, molybdenum, chlorine, vanadium, sodium and silicon. The first five of these elements constitute the living matter of trees; the other mineral nutrients are classed as either secondary (eg. calcium, magnesium and sulphur) or micro-elements. In fact chlorine and silicon have not been formally classified as micro elements because their role in plant nutrition is unknown (114). The important soil nutrients as described in Table 2.14.

Good soil structure and composition is essential to the health and productivity of trees. In its uncultivated state, the humus (ie. organic carbon and hydrogen) content of soil reaches an equilibrium that is determined by soil texture, topography and climatic conditions. In general, humus content is highest in cool, moist fine-textured soils, and under grassland vegetation. The humus level in forested areas is much lower. In cultivated areas, if soils are not supplemented by fertilisers and organic matter, the soil structure will break down, leaching of potassium, calcium and magnesium will increase, and the soil may become waterlogged. The soil micro-flora which aid in nitrogen fixation may also be destroyed (114).

A new approach to fertilising has found some researchers studying effluent clarification combined with plantation irrigation (116). They have proposed that water purification can be accomplished and forest trees can be fertilised by percolating sewage effluent through the soil and humus horizons of young regrowth or plantation forests. Studies have shown that nutrients are removed by chemical and biochemical reactions in the soil and potential effluent pathogens are destroyed by soil microorganisms. Surface water is purified and able to filter down to the ground water table.

Trials in New Zealand (117), Melbourne (93), USA, Europe and South America have all demonstrated encouraging results for the safety of the effluent treatment operation for human consumption. Results in New Zealand indicate that nitrogen does leach through the soil but in concentrations below that allowed by health authorities. Phosphorus is completely removed from the effluent and absorbed by plant and microorganism growth.

Another effect of effluent irrigation is the growth and health of the forest. Researchers found that understorey vegetation became more lush and vigorous. There was considerably more breakdown of forest litter (eg. pine needles, fallen branches, debris). This was due to the increase in soil insects and microorganisms. It was encouraging to read that native animal species were observed to frequent the irrigated forests more often, foraging for food (117). Further study on the utilisation of these nutrients by more mature forests is currently being undertaken.

Plantations are also affected by the condition of the soil parent material, before and after plantation establishment. There have been many studies on comparisons of plantation growth between ex-pasture and ex-forest sites. Radiata Pine has been found to have poor form on ex-pasture sites owing to high mineral nitrogen levels and insufficient levels of boron, sulphur and phosphorus (118). While high productivity has been observed, the actual merchantable volume taken from ex-pasture sites is significantly less than from ex-forest sites. The concept of plant and soil nutrition therefore is intrinsically linked with good growth and form. Ultimately this is reflected in the best use of the wood during processing, seasoning and preservative treatment and the higher value placed on it by consumers.

Table 2.14 Important soil nutrients for tree growth

- Nitrogen is by far the most important soil mineral nutrient for growth. Rhizobia and symbiotic bacteria help to fix nitrogen in a form suitable for uptake by plant roots. Nitrogen is essential for the formation of proteins and the chlorophyll molecule, and is associated with vigorous, lush, green vegetation and the utilisation of carbohydrates. Nitrogen deficiency is recognised in *Pinus* species when the tree becomes stunted and yellow, with the yellowing of needles (chlorosis) first appearing on lower branches and extending upwards as deficiency increases (115). When the roots are unable to absorb sufficient nitrogen, the nitrogen compounds in the older tree parts are sacrificed (ie undergo lysis), solubilised and translocated to actively growing sites. The affected needles are generally shorter than normal, the branches are smaller and the crowns narrow. Sandy soils and areas where the top soil has been scraped or blown away, have potential nitrogen deficiencies.
- Phosphorus has been linked with the maturing of plant reproductive parts and strong root growth. It is a constituent of nucleic acid, phytin and phospholipids, and is essential in energy transfer processes such as glycolysis, amino acid metabolism, fat metabolism and sulphur metabolism. A phosphorus deficiency in *Pinus* species appears as a general retarding of growth with short needles, yellow needle tips, a narrow or thin crown and fusing of needle fascicles (115).
- Unlike nitrogen and phosphorus, potassium does not constitute a part of the plant such as protoplasm, lipid or cellulose. Potassium has a catalytic function involved in carbohydrate metabolism, nitrogen metabolism, activation of enzymes, control and regulation of some mineral elements, neutralisation of physiologically important organic acids, promotion of meristematic tissue growth and maintaining plant robustness (114). A deficiency in radiata pine will show up in the development of yellow needle tips on the previous year's growth during spring, and a retardation of seed yield (115). As potassium deficiency generally occurs in soils with nitrogen and phosphorus deficiencies, nitrogen/phosphorus/potassium (NPK) fertiliser is often used routinely on plantation or clearfelled sites in Australia. Potassium deficiency is also associated with a decrease in resistance to plant diseases.
- Magnesium is an integral component of the chlorophyll molecule and without magnesium the plant would fail to photosynthesize. Magnesium is also required for carbohydrate metabolism and along with sulphur, the synthesis of plant oils (eg. the mustard and onion plant families). As it is a very mobile element, it is translocated readily from old to younger growth in times of stress. A magnesium deficiency will appear on the lower, older growth as a yellowing of needle tips of the previous year's growth during the dry months of summer (115).
- Sulphur is absorbed as the sulphate ion, and is not readily translocated from old to young plant growth. It is required for synthesis of sulphur-containing amino acids, is a constituent of certain vitamins and oils, and is also associated with the structure of the cell protoplasm. Deficiencies in sulphur have a retarding effect where the plant undergoes chlorosis. The tree is stunted, the needles yellow, and the branches thin and spindly.
- Boron has an influence on cell development by the control it has on polysaccharide formation. It is involved in translocation of sugars across membranes, and inhibits excess starch formation. Deficiencies of boron lead to cessation of shoot and bud formation on leaders and ramicorn branches. Following basal tissue breakdown, young needles become twisted and terminal growth ceases, which usually occurs in the dry summer months.
- Iron functions with the chlorophyll-producing mechanism and is active as a replacement for several mineral cofactors such as molybdenum, manganese and copper. A deficiency will cause cessation of growth as the young tips and buds develop chlorosis and turn yellow then white.
- Manganese is quite immobile and does not translocate from old to new growth. It functions in the activation of carbohydrate metabolism enzymes. A deficiency of this mineral is exhibited by pale yellow-white colouring of new needles in springtime. In large quantities, manganese (like boron) can be toxic to plants.
- Copper is an activator of several enzymes and is absorbed by roots and leaves. Symptoms of deficiency are the severe twisting of leaders and branches and the weakening of smaller branches (115).
- Zinc functions in plants as an activator of enzymes and is also easily absorbed by roots and leaves. Deficiencies of zinc lead to retardation of shoot and bud growth which manifest themselves as rosetting of buds on the leader tip. There are other elements not mentioned here which are not considered essential for higher plants, although they are essential for simple plant life. With any potential mineral deficiency, there is always the possibility that fungal growth, root damage or mechanical damage may be the cause, however, application of broad spectrum fertilisers such as NPK or ashing of forest waste before planting ensures that the major nutrients are present.

SITE PREPARATION

Good preparation of planting sites is another important element in achieving health and profitability in plantations. The layout of the plantation, including boundaries, roads and drainage points, should be undertaken at least two years before planting. The site should be cleared and burnt if necessary, and ploughed and treated with herbicides at least one year before planting. After planting, fertilising and weeding need to be done for up to two years while the young plants establish themselves. The topography, soil type, native vegetation , climate and cost will determine the regime that is ultimately used (119). On ex-forest sites a more mechanical approach may need to be taken, with all stumps and vegetation burnt and reduced to ash (120, 121).

As young plants grow, they are vulnerable to invasion by weeds that compete for nutrients, water and sunshine. Researchers at FRI have studied the effect of weed control (123) and 'Oversowing' (124). By controlling the growth and establishment of weeds for up to seven years after the planting of forest stock, a marked increase in tree growth can be achieved.

Rather than apply chemical herbicides, researchers at FRI have also introduced less competitive, easily managed legumes, which while nitrogen fixing, also grow in low fertility soils, and are relatively acid tolerant and resistant to many insect pests. These plants can provide adequate livestock forage in areas where grazing is used, keeping the weeds at bay and improving the diameter at breast height (DBH) of trees in grazed and non-grazed stands.

Reports by Wilkins and Horne (126), Wilkins and Kitahama (127) and Wilkins (128), showed that the growth and wood density variations of *E. grandis* in response to silvicultural regimes indicate that a higher mean log density is associated with treatments which produce faster growth rates:

i) insecticide, thinning and ploughing
ii) weeding, thinning and ploughing
iii) fertiliser, thinning and ploughing
iv) insecticide, fertiliser, weeding, thinning and ploughing.

FIRE CONTROL

Australia's eucalypts have evolved and spread with the occurrence of periodic fires. Species such as *E.regnans. E.nitens, E. obliqua, E.pilularis, E.globulus* and *E.diversicolor* actually require disturbances such as fire to stimulate germination of seeds (125). The eucalypts have an ability to form epicormic buds on trunks of fire ravaged trees and these can be seen only days after a fire has passed through the crown of a tree. Two other forms of growth after fire are coppicing and lignotuber development as seen in *E. marginata, E. calophylla,* and *E. globulus* (129). Controlled fire can be used successfully to avoid much higher risk fires and control the growth and spread of annual weeds and grasses that have replaced native plant species. Fire does, however, do much damage to delicate ecosystems, so when designing a Fire Management Plan, foresters keep two things in mind:

i) Sound ecological management. The fire plan should encourage vegetation health and flora and fauna biodiversity.
ii) Prevention/Avoidance of fire hazard. The fire plan should be confined to areas where high ignition risks and distinct hazards have been identified.

The Forestry Departments in all States undertake controlled burns in public reserves and roadside verges to avoid the sort of fires seen in the Black Friday Fires (Victoria in 1939), the Ash Wednesday Fires (Victoria and South Australia in 1983) and the Black Sunday Fires (N.S.W in 1994). Grasses, scrub and forest debris all contribute to form a potentially large volume of fuel for a fire, particularly when a mild, wet winter is followed by a hot, dry summer season. The objective of fuel-reduction or controlled burning is to minimise debris and encourage forest tree growth while minimising soil disturbance or erosion. Fires can be initiated by aerial burns and ground burns.

There are several factors that contribute to the success of a burn (130),

i) **Frequency**: the fire should only be put through when there is sufficient hazard, ie. five to seven years. As trees regenerate by seeding and sprouting, they should be mature enough to withstand the next burn.

ii) **Seasonality**: the condition of the plants and the general weather pattern determine whether a fire will burn slowly or quickly. Generally an autumn burn will allow seed and sprouts to regenerate in the ashbeds with forthcoming winter rain.

iii) **Intensity**: some trees respond well to high intensity burns as this encourages fruits to open and seed coats to crack. Other plants are damaged by intense fires, for example cypress pine in Qld and NSW. The Forestry Departments generally choose the low intensity burn (cool burn) as this allows animal refuges to be maintained and ensures that the mature habitat trees and young sprouts are not killed.

THINNING AND PRUNING

The management approach to thinning and pruning of native, regrowth and plantation timbers is critical to the performance of the stand. Depending on the type of stand, there are several management regimes that can be applied to maximise a stand's productivity, including regimes for roundwood, clearwood, framing material, pulpwood and agroforestry (120, 122). In the case of plantation softwoods, pruning is performed to maximise clearwood and thus improve the quality of the recoverable log. The size of the defect core (containing knots from previously pruned branches) affects the value of the wood, and an FRI pamphlet clearly demonstrates this concept (134). Pruning is generally suggested to a minimum height of 3 m at year 7, and then an optimum height of 6 m at year 9, or that height required to produce a peeler, veneer or sawlog.

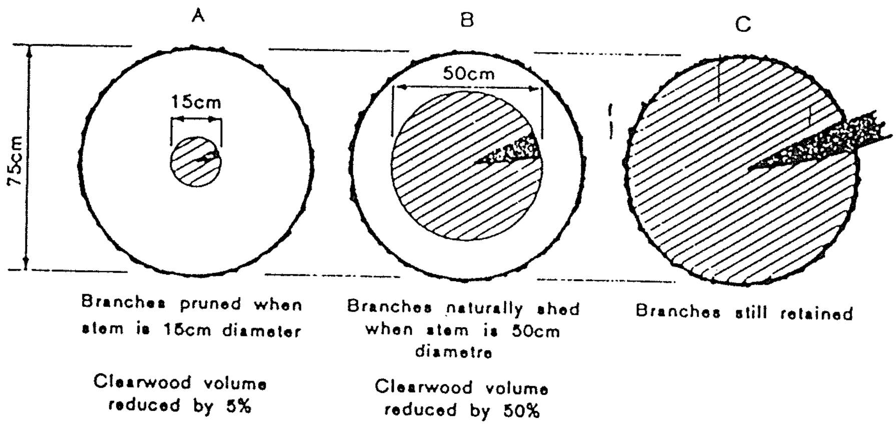
In Queensland it is recommended that pruning of hoop pine be carried out in two stages to obtain quality clearwood. The *Pinus* species plantations generally reach rotation age at 30 - 35 years, while the native hoop pine plantations take 50 - 60 years. QFS gives a concise summary of thinning and pruning regimes carried out on the exotic and native softwood resource of Queensland (70), while an FRI pamphlet shows how New Zealand-grown radiata pine is pruned (132, 133,135).

In NZ, researchers at FRI have studied the effect of 'form pruning' (136), which is the removal of any ramicorn (leader) branch that is steeply angled and may compete with the stem. It was hoped that Form Pruning could supplement 'clear bole pruning' and provide high quality clearwood timber. The overall result is that a lower initial stocking is required for a higher volume of premium grade wood. While form pruning is effective, it is not always economically viable in all situations. The best applications were considered to be agroforestry, timberbelts (shelterbelts) or sites where specialty timbers were being grown.

Hardwood plantation trees also require pruning technology, and even though eucalypts tend to shed their branches, it is insufficient to ensure small defect cores. It is recommended that pruning be carried out before the branch diameter exceeds 3 cm (137). Figure 2.9 shows the effect of knots on the defect core in plantation hardwoods.

As the final crop stocking has a major influence on log size and the cost of harvesting, final crop stocking of 250 sph is recommended for high quality clear wood softwoods. Pre-commercial and production thinning therefore can maximise quality and profitability of a stand, assuming that there is a market for pulplog material. Initial stockings of 1000 sph ensure that trees grow straight with small limbs, and pre-commercial thinning at three to four years removes useless trees and allows trees of good form more growing space. Thinnings at 15 and 21 years allow the development of a high quality clearwood, with thinnings generally sold for woodchips for pulp or for roundwood for preservative treatment.

Figure 2.9 Defect cores



reproduced from *(137).*

For hardwood plantations a final stocking of 100 - 300 sph is recommended with an initial stocking of 1200 sph. Eucalypts often have a wide variability in growth and form with young saplings having bushy crowns. If planting spacing is too wide, this encourages large bulky lower branches to persist (138). Two thinnings can be carried out; one at sapling age (< 6 years) and one at pole stage (12 years). Alternatively, one thinning at 12 years of age with pruning to 6 m height at the same time is acceptable (133).

STAND MANAGEMENT

Stand management to improve productivity in plantations and native forests is essential for economic viability. Each State Forestry Department therefore has facilities for monitoring and improving such productivity, using techniques such as

(i) systems for estimating unsold volumes of sawlogs, pulplogs, lower grades and residues
(ii) systems for simulating silvicultural regimes on timber stands to assist the forester in maximising the returns from the forest estate.

All systems are designed to accumulate and sort information, and present that information in a way that helps the forester make decisions on the performance of the timber stand.

eg.
- (i) forest site - soil, topography, rainfall, nutrition, landform
- (ii) forest type - plantation, native, agroforest, shelterbelt
- (iii) tree species -growth characteristics, annual increment, diameter,height, provenance, GF factor
- (iv) planting - year
- (v) stocking levels - volume, basal area
- (vi) pruning and thinning histories
- (vii) product type required - sawlog, pulplog
- (viii) labour and equipment available.

These factors are required to:
- (i) schedule a program for tending operations to maximise the volume of the stand based on requirements for log type or utilisation
- (ii) list an annually updated inventory of stand age, class, type, and productivity
- (iii) calculate the value of specific stands or crop types
- (iv) simulate cutting plans for future harvests that identify lengths, diameters & quality of logs
- (v) keep updated records of growth and yield for stands under different silvicultural regimes (fertilised, irrigated, thinned, pruned, sprayed) and different establishment types (forest, shelterbelt, agroforest).

In Victoria, NSW and WA, information is currently being collected to ascertain the exact condition and extent of the Public Forests (63, 64, 78, 144, 145). This information will assist the Forestry Departments in confirming the suitability of the sites for timber production and identify needs for protection of flora and fauna values

In New Zealand there are software systems such as 'PC-Standpak' (139, 140), a modelling system that simulates all phases in the growth and management of a single pine stand. This can also be expanded to analyse whole forests. The 'Standmaster' (140) is a database system that carries out realtime management tasks on tending operations, inventories and productivity. It has been used extensively by commercial forestry companies in New Zealand. The 'StandIn' (141) and 'Micromarvl' (142) systems are less expensive, general purpose inventory packages. The 'Permanent Sample Plot' (PSP) database system (143) at FRI holds data on 14 000 plots of experimental species and growth yield plots of plantation forests.

LOGGING

Each Australian State has prescriptions that describe the regulations surrounding removal of trees from the forests.

- NSW -'Code of Logging Practice - Native Forests, State Forests and other Crown-Timber lands. 1993.'(146)
- Victoria - 'Code of Forest Practices for Timber Production. 1989' (147) and 'Grading Instructions And Interpretations: Hardwood Sawlog Grading 1989' (148)
- Western Australia - 'Forest Management Regulations 1993' (149).

Each specification contains essentially the same guidelines based on sound principles of sustainable yield (150). Where they differ is in the areas of who selects the resource, who removes the resource, and who is responsible for the regeneration of the harvested area.

In Queensland, for example, all native forests of public ownership are selectively harvested. The logging contractors hired by the licensee are certified by the Forest Service to mark and remove certain trees of certain dimensions, and forestry personnel oversee the harvesting work. Over-mature trees are removed first, and then mature and millable smaller trees. All seed trees are retained, particularly in areas where tree numbers are low. Once harvested, the same area will not be logged for at least 30 years (151, 152). It has been observed that cypress pine, harvested on a sustainable yield basis in western Queensland, regenerates prolifically from natural seedfall (153).

Native forests are reforested with species native to the area, to maintain species patterns and genetic pools. The Australian Tree Seed Centre (154) and various Forest Department nurseries (155) have seedlings of the most appropriate provenances.

Livestock grazing and honey production is often allowed in dry open forests, tall open forest is sustainably harvested in small areas (coupes) using techniques to simulate the natural cycle of wildfire (152). The regeneration of *E. pilularis* (blackbutt) is an example of this type of cycle, and the result is a mosaic of forest areas where there is a mixture of age classes.

In NSW, Victoria,Tasmania and Western Australia, the Forest Service itself is responsible for selecting and harvesting, and in some cases restocking, the forest trees. Logging companies are contracted and certified by the Forest Service to perform the duties. In accordance with Victoria's Timber Industry Strategy 1986 (83), procedures for accrediting Log Graders and Log Grader Trainers have been put in place in Victoria. Stump height must be minimised to obtain maximum merchantable volume and the defective quarters measured against the Hardwood Sawlog Grading Card (148).

Other forms of harvesting in NSW, Victoria (159, 160), Tasmania and Western Australia and the indigenous forests of New Zealand (158) involve the planning of mosaics where:

(i) coupes are harvested in any one area allowing a mosaic of mixed age-class timbers to grow. (20 ha in WA, and 40 ha but generally 10 - 20 ha in Victoria (161))
(ii) wildlife habitats are preserved by the creation of buffer zones or protection strips. A 50 m (WA) or a 20 m (Vic) zone either side of a waterway or a riparian zone, and a 200 m zone either side of a roadway ensure visual and ecological stability
(iii) seed trees are retained.

Plantation harvesting is done entirely by clearfelling using chainsaws or feller bunchers. In most states, compartments of 100 ha or less are clearfelled and the harvesting is rotated through the forest. This ensures a visually acceptable horizon as well as minimisation of soil disturbance (152).

Cable logging (or skyline logging) is undertaken in steep, hilly areas to remove clearfelled plantation timbers. This method avoids disruption to soil horizons and hazards to logging contractors. Logging debris is burnt during coupe and clearfelling operations to provide a seedbed for regeneration of new plants and to reduce fire hazards associated with dry debris. Mulching, ploughing, ripping, windrowing, mounding and roller crushing are employed when a burn is not appropriate, and in most cases replanting is undertaken straight away to reduce soil movement or erosion.

Buffer zones of native species are generally required in plantations. These zones provide corridors for the native fauna and are found along riparian zones and environmentally sensitive areas. Often foresters leave buffer zones of up to 200 m along the roadside to improve the aesthetics of timber production areas.

SECTION 2.4 TREEBREEDING AND TREE QUALITY

There are various techniques available for controlling and improving the quality of timber in forest and plantation stands. These techniques involve tree breeding, tree nutrition and tree silviculture. They differ from site to site and species to species, depending on the required end use of the timber in question.

Such centres as FRI (163), QFS (164, 165), CALM (26) and CSIRO have intensive programs for tree breeding and improvement, in particular for plantation species such as radiata, slash and Caribbean pine, eucalypt species such as Tasmanian blue gum and *Acacia* species such as blackwood. Studies on heritability using genetic manipulation and molecular biology techniques have shown that the greatest gains can be made in tree volume, straightness and branching characteristics. Companies such as Bunnings Treefarms and APM Forests are using that knowledge and their own expertise to develop commercial 'tree farms' for use in pulp and paper product manufacture and as sawlogs.

Two basic approaches can be taken in tree breeding:

(i) natural selection of the best tree in each family. This is based on observation of tree height and stem form, and measurement of wood density and fibre length. A controlled crossing between parents (provenances) gives rise to known progeny. Unfortunately production of known progeny in 'family forestry' can be a slow process if not well managed. The best example of breeding within the species is progeny from the radiata pine parent 'K55' grown extensively in New Zealand for pulp manufacture (59).

(ii) hybridisation of two distinct species with known genetics giving a hybrid with superior Growth and Form (GF). When two distinct species are cross-pollinated, the resulting seeds are the first generation cross (1st filial generation, F_1). Their growth is vigorous and GF is very uniform (166). The major hybrid of importance in Australia is the F_1 hybrid of *Pinus elliottii* and *Pinus caribaea* var. *hondurensis* grown in plantations extensively in Queensland.

Following both these techniques of natural selection and hybridisation, tree-breeders select suitable parent trees for establishment of seed orchards for seed and pollen collection. The aim is to produce large quantities of seed for further research and commercial applications. Open-pollinated seed orchards generally are based on cuttings or grafts taken from superior trees, and when the female flowers are fertilised, the pollen comes from an unknown superior parent. In control-pollinated seed orchards, on the other hand, female flowers are protected by bags, and pollen from a known parent (which has been collected and stored previously), applied to receptive flowers. After the cone develops, the seeds are harvested for research or commercial nursery use (167).

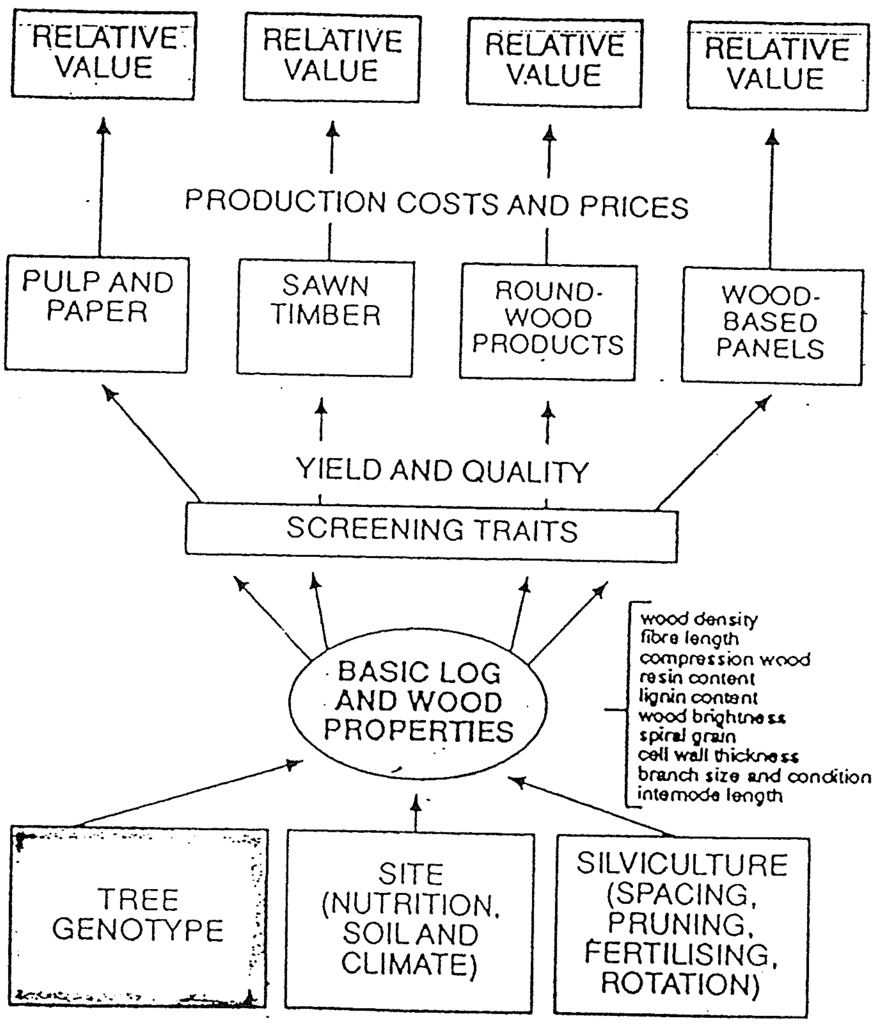
TREE GENOTYPE - TREE QUALITY IMPROVEMENT

Tree quality improvement can be achieved by genetic and physical techniques as shown in Figure 2.14, reproduced from (168). Tree quality improvement in the *Pinus pinaster* resource of WA for example, was achieved by the following:

(i) improving stem straightness and maintaining vigour of the dominants
(ii) increasing volume of stand, allowing wider spacing & lower establishment & tending costs
(iii) improving branch quality and reducing knot size.

The objective of the exercise was to produce large dimension, straight sawlogs with minimal branching, small limbs and vigorous growth. While these are physical methods, seed from seed orchards of superior quality trees planted in the mid 1960s was used to establish the plantations. This increased the total volume production by 36%. A second generation seed orchard has recently been established with the most superior families and will be yielding seed this year (59).

Figure 2.10



Establishment and genetic improvement research also led to a superior quality *P. radiata* tree in New Zealand (169, 170). The changes included:

(i) seedlings grown from improved stock
(ii) controlled crossing of selected clones and vegetative propagation to produce seedlings with greater GF factors
(iii) improved nursery practice, hygiene and transporting systems
(iv) lower final crop stockings (initial stocking reduced) ie. 1000 sph thinning to 250 sph.

Genetic improvement of Queensland exotic and native conifers (164) has focussed on developing:

(i) a long internode length Hoop Pine population from superior clonal seed orchards
(ii) *P. elliottii* x *P.caribaea* var. *hondurensis* F_1 hybrid with smaller knots and more robust GF
(iii) statistics on family forestry and clonal forestry in planting programs.

In Melbourne, a hybrid hardwood species (*'Hybrid Australis'*) was developed using tissue culturing and DNA splicing techniques. Its owner believes the hardwood can grow 18 metres in height and 25 cm in diameter in six years. Government legislation at present however, prevents its further development (171).

PROPAGATION - SEEDS

High quality seed from known provenances is essential for plantation establishment and to a lesser degree native forest restocking. The CSIRO Division of Forestry operates the Australian Tree Seed Centre where seed samples of more than one thousand Australian species are available. The Centre conducts collection, authentication and research into genetic improvement of hardwood and softwood species (155).

In addition, the QFS and CALM (WA) give out informative brochures on propagation of trees from seeds, and CALM has seeds and seedlings available at its nurseries in the south west of the State (172,173,174). While Greening Australia has an extensive library of information on tree and seed care, a private company, Queensland Tree Seeds Pty Ltd, can supply native seed to nurseries or for revegetation, reafforestation and food crop programs Australia wide (156).

The three essential qualities of seedlings for survival are healthy roots, and adequate nutrient supply and water. In determining growth potential for establishment of forest plantations, there are several morphological and physiological indicators that can be used. NZFRI have established parameters for Radiata Pine as seen in Table 2.16.

Table 2.15 Seedling specifications for Radiata Pine

Indicator	Specification	Measuring Technique	How to achieve specification
Root Growth Potential	4 - 5 on a 0 - 5 visual scale	Lift, grow lift, assess new root growth	Wide spacing, regular conditioning, hand-lifting
Mineral nutrients *	14 - 16		
nitrogen	1.2 - 1.4		
phosphorus	~3.5		
potassium	0.6 - 0.8	Analysis of seedling tops	Judicious application of fertiliser
magnesium	~ 1.0		
calcium	~ 1.2		
sulphur	~ 0.008		
boron	0.002 - 0.003		
copper	0.025 - 0.04		
iron	0.005 - 0.014		
manganese	0.005 - 0.01		
zinc			
Water Potential	< -0.5 MPa	Measure seedling top on needle fascicle in a pressure bomb	Adequate watering before/during lifting, wet and cool storage, careful handling
Height	20 - 40cm	From root collar to top	Careful timimg of sowing and undercutting or topping
Diameter	> 5mm	At root collar	Wide spacing, regular conditioning
Sturdiness	40 - 60	Height / Diameter	Wide spacing, regular conditioning
Frost Tolerance	-12°C winter -6°C summer	Test using artificial frost rooms	Grow seedlings at high elevation, inland nurseries

* *Quantities are minimum requirements in grams of element per kilogram of seedling top dry matter.*
reproduced from *What's New FRI (170)*

CUTTINGS

The ability of a plant part to make a successful cutting depends upon its ability to change in function. Cells must be able to divide and produce new cells which will form new organs such as shoots and roots. Hormone preparations are available that assist in stimulating root formation, and these often contain fungicides to combat fungal attack before rooting takes place.

Studies undertaken at FRI show that the age of the cutting has a significant effect on growth and stem form of the mature tree, and that cuttings will have better growth and form than seedlings of the same age (175, 176).

A stock plant can be used for up to four years for cuttings as long as it is slashed or hedged back to 10 - 20 cm in height. Stock plants that have been hedged for four years produce cuttings that behave similarly to 1.5 year old cutting material. The diameter of the stem of the cutting will determine the number of roots produced as the cutting sets in the nursery bed. If the stock plant is root pruned, the cutting will root later and be smaller than a cutting from an unconditioned plant. The conditioned cutting, however, will be stiffer and easier to handle.

High humidity (mist propagation), indirect sunlight and suitable temperature are important for optimal growth of roots, while a mixture of minerals, sand and peat ensures uniform supply of moisture and oxygen. Examples of genera that are best generated by cutting include *Cupressus, Grevillea, Leptospermum* and *Melaleuca,* while genera that can be generated by grafting include *Pinus, Fagus* and *Picea.*

TISSUE CULTURE

Initially tissue culture techniques were developed for use in identifying the function of certain cell types and chemicals in the growth of plants (177).

Currently studies are being undertaken to isolate and characterise specific genes and areas of plant DNA in order to control gene expression. For example, genetic control for herbicide resistance and virus resistance in plantation species is important for healthy plantation stands. Finger printing and paternity testing are other techniques utilising genetic engineering concepts (personal communication FRI).

Another example includes the 'wetwood' phenomenon in Hoop Pine. The wetwood patches were thought to be linked with bacterial infection. A resistance to the bacterial pathogen or a genetically engineered trigger that causes the release of an antibiotic from the tree itself in the presence of the pathogen, could be of considerable economic importance.

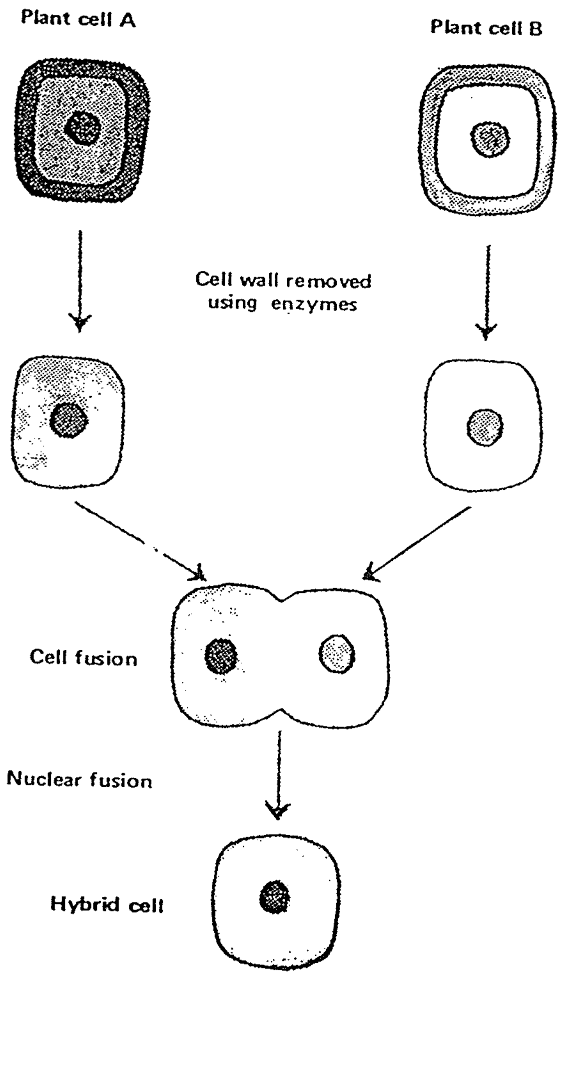
The development of a suitable vector for transporting cloned genes into plants for resistance or tolerance to certain insects, bacteria and viruses is yet to be found, however, it has great potential to improve the genetic stock available to tree breeders.

The technique of tissue culturing is quite simple. A small sample of growing tissue from a stem, needle or leaf of a tree can be induced to develop into a callus (i.e. a rapidly growing undifferentiated mass of cells) on special nutrient media. By manipulating growth hormones, the callus can be induced to form shoots and roots (organogenesis) and so develop into a tree. Many hundreds of tiny pieces of material can be sectioned off from the callus and grown into individual trees, thus a way of mass-producing or cloning trees of superior genetics has been established. This is referred to as micropropagation.

Alternatively somatic hybridisation can be used, where fusion of cells of two superior but distinctly different parent trees form a callus. Large numbers of progeny can be created without the time consuming sexual process of pollination (179). This is shown in Figure 2.15.

The technique of micropropagation has been developed extensively in New Zealand and FRI are trialing a commercial nursery combining normal vegetative methods of cuttings and grafting, with micropropagation methods (180).

Figure 2.11 Somatic Hybridisation



CHAPTER THREE TIMBER SEASONING

SECTION 3.1 OPPORTUNITIES FOR SEASONED PRODUCTS

In previous decades Australians have used imported hardwood timbers from UK, USA, South Africa and various rainforest timbers from Indonesia for high value products such as cabinet making, furniture and flooring. These timbers were perceived to be abundant and well suited to the market. In comparison, many Australian timbers were difficult to season and sometimes difficult to dress e.g. the greasiness of white mahogany and tallowwood; and the splitting of mountain ash (183). Consequently these native species were relegated for use as low value products such as fencing, framing, crates, pallets and poles. With the latest technology in timber seasoning however, our native species and plantation timbers can be successfully used for all timber needs. It is essential that seasoning technology be embraced and developed by every processor to ensure high quality, consistency of product and commitment to standards.

The future of the timber industry in Australia is 'Value-adding. With the abundance of plantation softwood timbers available for framing, furniture, veneers and decking, traditional hardwood processors must begin to compete in an increasingly aggressive national market. Similarly, both softwood and hardwood processors must begin to compete internationally and companies must offer high quality products, improved efficiency and innovative processing attitudes.

In the mid 1980s, the push began in Victoria and Western Australia with their Timber Industry Strategies (83) to achieve a sawlog-driven industry committed to a 'Value Added Utilisation System' (VAUS). These strategies were proposed to develop two aspects:

(i) Balance between economic and environmental concerns- to provide sustainable management of forest resources aimed at a multiple use scenario and to encourage the development of processing of timber beyond the green state.

(ii) International competitiveness against countries such as Brazil, Chile, South Africa and New Zealand, who have undertaken to dramatically improve efficiency, productivity and production costs.

SECTION 3.2 DRYING FACILITIES AVAILABLE TO INDUSTRY

There are many different types of drying/seasoning facilities available in Australia. Historically, the accelerated drying of timber was begun as early as the 1860s with a brick kiln heated by steam pipes. In the 1890s a natural circulation kiln was developed that humidified the unit by trapping 'flash' steam condensing in charcoal trays (181). It was not until the 1930s, however, that Utilisation Officers were appointed by the various State Forestry Departments to work with industry personnel to improve seasoning and handling practices, and to begin to set standards and seasoning grades. It was found that each State had different problems and requirements depending on climate and species. In Western Australia, Jarrah and Karri timbers needed to be felled, processed and seasoned quickly to avoid splitting and checking due to the harsh hot and dry climate of the summer months. In Queensland, the hardwoods and softwoods required spraying/dipping treatments immediately after felling, followed by seasoning, to avoid staining of the sapwood by fungi.

Seasoning is necessary for the preparation of all timber products including sawn timbers, veneers, roundwood, moulded timbers and timbers marked for preservative treatment. There are many choices available (182, 201, 202, 205a) and during my study tour I observed the following methods in use:

i) **Conventional air seasoning,** either under partial or total cover depending on the severity of the climate, is the most simple and economic method for drying sawn and round hardwoods. As confirmed by many researchers, correct stack placement that captures maximum air movement is critical to the drying performance of sawn and round wood (206). Bunnings in Western Australia experimented in the 1980s with boards wrapped in a biodegradable plastic sheet, a method developed by Schaffner in Tasmania. The sheet allowed oxygen/carbon dioxide exchange. While splitting and checking were slightly reduced, it was found to be quite expensive and labour intensive, and drying rates were too slow. It was, however, one of the first steps towards an industry commitment to value-added timber production in Australia.

The general rule of thumb for air drying of green hardwood boards was that, for every 25 mm in thickness, three to five months of air drying is required to bring the moisture content to 25%. Six to twelve months is required for conditioning to local equilibrium moisture content. Softwoods generally season faster than hardwoods with air drying, with 25 mm thickness timber taking two to three months to reach 15% (184). In some cases, air drying can be disadvantageous where land costs are high, where there is poor drainage, or where drying is slow and uneven. In this case, a combination of drying processes is best. CSIRO have produced a concise volume 'The principles of air seasoning' (186) which discusses these matters.

ii) **Conventional kiln drying** in Australia has meant the use of a stationary (or compartment) reinforced concrete block/ brick kiln, often lined with bituminous paint to aid insulation. Modifications using aluminium and timber constructions are also available. The kiln contains an internal fan system with cross circulation with the air movement provided by reversible, propeller-type fans mounted on cross shafts. The kiln conditions are changed as the drying progresses, with a trend towards automatic temperature and humidity control. Generally six to ten kilns are built in series and heated by indirect steam. Quite often the wood waste (off cuts, sawdust and chips) can be used for fuelling the steam generator that feeds steam into the kiln radiators. Each kiln is designed to take a standardised drying charge that has been stickered and stacked in a frame. A transfer pit runs across the kiln frontage allowing loading and unloading of kilns on a rail system.

iii) **Combination air/kiln drying** is commonly used for the drying of sawn hardwood products. The boards are stickered and placed under cover to condition to fibre saturation point (25 - 30% mc) before being kiln dried for 6 - 10 hours at 80 - 120°C to bring them down to 12% moisture content. Reconditioning is carried out in a steam chamber for four hours to recover collapse that may have occurred during the drying process. Bunnings and Whittakers (WA) commonly use this combination procedure for seasoning Jarrah and Karri timbers that can easily split and check during processing. They claim that the dried product has an improved appearance as it retains the rich red of the newly felled log more than after airdrying only. Many Victorian hardwood processors (such as Drouin West Mill) also use this procedure as the wet winter is not conducive to year-round air drying.

iv) **High temperature drying** of green off-the-saw softwoods (e.g. *P. radiata and P. elliottii*) has gained favour in Australia and to a lesser extent in New Zealand. CSIRO Division of Forest Products has developed schedules using temperatures upwards of DB120°C/WB70°C to DB200°C in a super saturated steam atmosphere to successfully condition radiata pine (187, 188, 189, 190, 196). Owing to the tendency of heart-in pine to warp and twist, heavy concrete weights are used to stabilise the charge during drying and cooling. Hardwoods can have serious degrade problems due to low permeability, and ash-type eucalypts in particular are susceptible to collapse. Softwoods are much more permeable, however, drying is limited by equipment design rather than degrade control.

Research in New Zealand has found that high temperature drying is most suitable for the structural grade export market where the time efficiency in drying allows for increased volumes of timber to be processed and exported.

v) **Dehumidifiers** have successfully been used for conditioning softwood and hardwood products after preservative treatment and for the conditioning of high value timber products. ACI Timber Products in Queensland use a schedule with DB70°C for four to five days to reduce the moisture content of treated softwood products to 15 - 20%. Bunnings Production Centre in Manjimup (WA) uses 60m^3 dehumidifiers for their sawn Jarrah products, while Drouin West Mill (Vic) use dehumidifiers for their sawn Mountain Ash boards. One hundred cubic metre capacity dehumidifiers are extensively used in New Zealand for the conditioning of radiata pine, however, they can only achieve 60°C which is insufficient to meet Australian Quarantine regulations for heat sterilisation.

The dehumidifier operates like a domestic evaporative cooler where warm moist air is drawn from the kiln and passed over cool evaporator coils in a refrigeration circuit (191). The moisture condenses and is removed from the system, and the cool dry air is reheated and pumped back into the kiln. The dehumidifier is energy efficient because no moist air is vented during operation and moisture is recovered and retained within a closed system. It does, however, require electrical energy for the heat/cool pumps. It is also suggested that timber be airdried to 40 - 60%mc before dehumidifcation drying to reduce the time taken in the drying unit (182).

vi) **The Pre-Drier** has found favour in WA where air drying is either too harsh in summer conditions or overall too slow and uncontrolled for Jarrah and Karri boards. Bunnings use dehumidifiers with either six or eight chambers as pre-driers to condition 25 mm, 38 mm or 50mm thick Jarrah boards to 25% mc before final drying in conventional kilns. This construction is a progressive drier where the loads are moved through several different areas of progressively warmer and more humid conditions. Timber of the three different thicknesses has six, nine or thirteen days respectively in each chamber. In the original pre-drier at Yarloop, this would be equivalent to thirty-six, fifty-four or seventy-eight days respectively for the three thicknesses to dry from green to 25%.
The pre-drier however,is commonly a large low-cost unit with a fan system that allows accelerated air drying. The construction allows for 4 - 8 parallel timber stacks to be placed in the unit and is loaded and unloaded like a conventional kiln. Most Australian hardwoods should take 18 - 22 days per 25 mm thickness to condition down to 25% mc in pre-driers.

vii) **Solar kilns** have been developed in Western Australia and Queensland where the climate allows for extended periods of sunshine. The Department of CALM has a solar kiln with steel framework covered by heavy duty plastic (192). It has provision for auxiliary heating by gas or wood burners to smooth out the seasonal and daily fluctuations in temperature. Temperatures of 20°C above ambient can be maintained throughout the drying schedule by automatic auxiliary heat control. It is recommended that 20 - 25m^3 is the optimum size for such a kiln drying timber to the 10 - 15% mc required by Australian Standards.

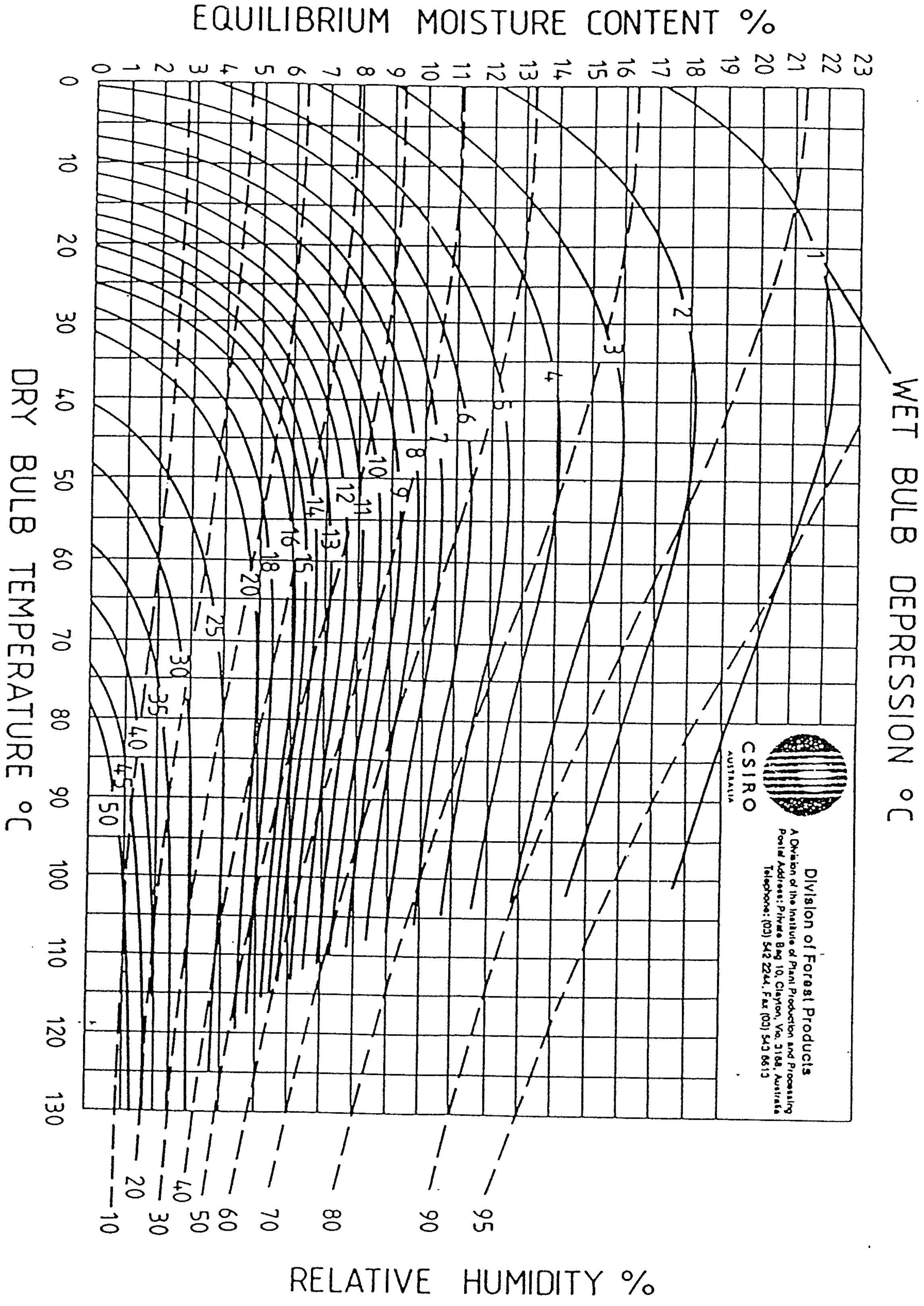
QFS has developed a low cost solar kiln based on a glasshouse whereby clear corrugated polycarbonate sheeting has been fixed and sealed to a timber frame (193). It is constructed with the south wall lined with timber outside and filled with polystyrene foam, and the north side open to load the chamber. The plenum has a timber floor and the stack chamber is concrete. A reversible fan circulates air and all surfaces exposed to sunlight under the plastic roof are painted flat black to minimise reflection of light within the kiln. This kiln has $15m^3$ capacity and operates 20°C above ambient temperature. Timbers such as Hoop Pine, White Cypress Pine and Narrow-leaved Red Ironbark can be dried to 12- 15% mc from the green condition of 40% mc in approximately 35 days. QFS recommend that the timber stacks be weighted with $250kg/m^2$ of stack area to avoid warping of material containing heartwood.

viii) **Continuous-feed or progressive** kilns have been developed at CSIRO (194, 195) in response to a need for well-dried, stable and straight structural grade timber. This kiln is suitable for species able to be high temperature dried without distortion, such as *P. radiata* and *P. elliottii.* The original horizontal continuous-feed drier had green boards loaded vertically on transport racks that were conveyed horizontally along a belt through drying, conditioning and cooling zones. High temperature-high air velocity drying at 140°C - 200°C was followed by conditioning below 100°C in high humidity and then cooling. The vertical unit had the hydraulic loading system place green boards on top, and allowed the load to pass successively down through drying, conditioning and cooling cycles before unloading at the bottom. The weight of the boards on top ensured restraint of the drying boards below to minimise distortion. Uniform drying of green radiata pine boards was accomplished in 4 - 8 hours depending on board thickness and species.

CALM have also investigated progressive kilns based on similar principles to their CSIRO counterparts, but there has been no recent research. The differences noted were based on the type of drying source (CALM used a centrifugal fan to blow air), the placement of timber (CALM used a system with timber stacks perpendicular to the kiln length), and the placement of the baffle system (197).

ix) **Steam reconditioning** is used extensively for relieving the stress of collapse in hardwood timbers such as Mountain Ash, Alpine Ash, Messmate Stringybark, Red Gum, Southern Blue Gum, Brush Box, Sydney Blue Gum, Blackbutt and some softwood timbers after kiln drying. Collapse in hardwoods is distinct from other forms of drying degrade and occurs before the timber has dried down to fibre saturation point. In fact collapse is often seen in air-dried timber. It is due to liquid tension forces pulling the cell walls inwards and flattening them. By reconditioning the seasoned timber in a chamber flooded with saturated steam, at atmospheric pressure, collapse can be relieved. For a stack containing 25 mm thick boards, a period of 4 - 8 hours steaming is required. The timber should be between 15 - 17 %mc and cool. The moisture content will rise 4 - 5 % with reconditioning and must be dried back to equilibrium moisture content. The chamber itself is normally of reinforced concrete and loaded similarly to a conventional kiln. It has a steam inlet at the rear of the chamber that pipes steam along the floor to the front.

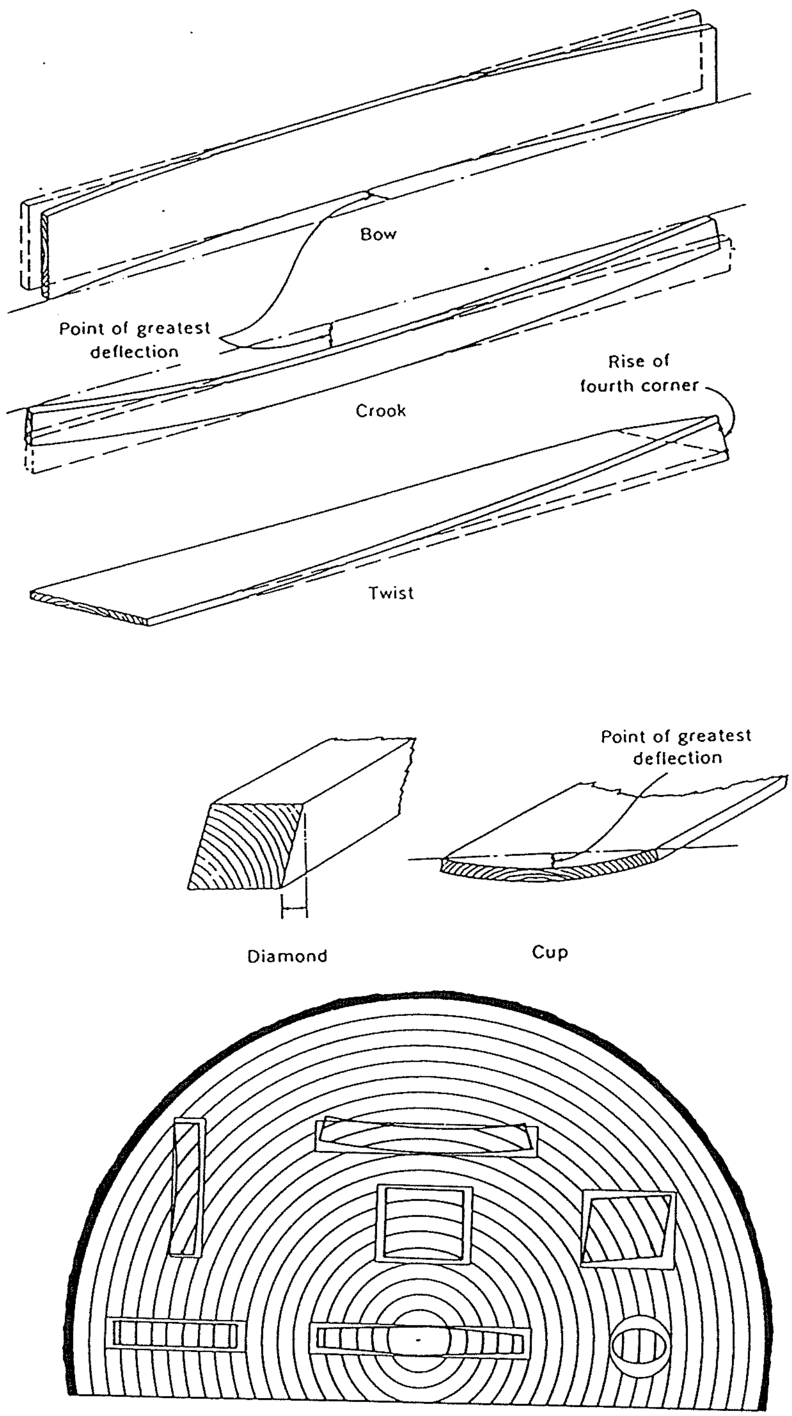
Figure 3.0 Equilibrium moisture content as a function of wet and dry bulb temperatures and relative humidity



SECTION 3.3 DRYING DEGRADE

Hardwoods and softwoods have completely different seasoning requirements. In general, hardwoods are less permeable than softwoods and require a slow gentle drying regime. High temperatures or low humidities accelerate casehardening and collapse. Softwoods can withstand harsher drying conditions but do need to be restrained by weights placed on top of the drying stack to prevent warping.

Figure 3.1 Common collapse and degrade observed in sawn timber



reproduced from *182 and 198.*

It is with the increasing need for quality control in timber drying that CSIRO have produced a review on collapse (200) which identifies two avenues for further study:

(i) minimisation of impact of drying stresses
(ii) use of genetic manipulation to improve resistance of hardwoods to drying stresses.

It is recognised that juvenile or regrowth timbers, in particular plantation hardwoods, are less stable than their more mature counterparts (e.g. Jarrah, Blue Gum, Mountain Ash, Douglas Fir). While steam reconditioning has proven to be effective in relieving drying collapse and stress of some timbers (199), timber technologists are looking for techniques to improve the stability of juvenile timbers in-service.

The Department of CALM (WURC), CSIRO DFP and FRI also carried out research programs to assess the effects of drying of juvenile timbers (e.g. the Small Eucalypt Processing Study,Young Eucalypt Program, and Exotic Special Purpose Species respectively).

The control of degrade caused by uneven moisture gradients and warping can be achieved by the construction of the kiln charge. The accurate stripping-out of the stacks and sorting of lengths to avoid overhang are simple techniques that eliminate distortion and stress. The maintenance of suitable air movement is also very important, as it ensures uniform drying of all boards. The consequences of inadequate drying include inability to treat timber using pressure impregnation methods, and the increased risk of decay in untreated timbers.

The kiln drying schedule is another factor of great importance. Traditionally there have been two methods, time-based or moisture-content based drying. Time-based schedules allow for automation and less operator attendance. Dry and wet bulb temperatures can be pre-set and sample boards taken at regular intervals. Shrinkage and stress values of many Australian and exotic timbers are discussed in Bootle (1983), and are available for operators to use when planning drying schedules. Other texts include:

(i) Forintek Canada Corp. on Western Canadian species (182),
(ii) CSIRO/AFDRI with an excellent comprehensive 'Index of kiln seasoning schedules'(203)
(iii) TRADAC/DPI with 'Hardwood drying methods and their economics in Queensland' (204).

These publications give objective and realistic information on the costs of accelerated drying options and schedules for specific species.

CHAPTER FOUR PROCESSING AND UTILISATION

SECTION 4.1 GROWTH FOR END-USE AND VAUS

The Timber Strategy (83) in Victoria and in Western Australia expounded on the idea of VAUS (Value Adding Utilisation System), wherein residual roundwood [is] to be taken only as a subsidiary to the sawlog operation'. The objective was to promote an industry awareness of the need to add value to the forest resource by the best use of wood taken from the forest and to reject a woodchip-driven industry. With the finalisation of the Timber Inquiry Report 1992, all State Governments have agreed to:

(i) commitment to sawlog-driven industry
(ii) reject a of pulpwood-driven industry with the exception of private companies that have established plantations expressly for that purpose
(iii) endorse VAUS directed towards value adding forest management practice
(iv) forest management to reflect multiple use in Australia's forests
(v) cessation of clearing of native forest for exotic pine plantations.

Since 1987, the Victorian Hardwood Industry has invested $10 million per annum in new milling and machining equipment, air drying stocks, kilns, pre-driers, reconditioners and mill rationalisation (210). This is an attempt to adapt to changing markets and to exploit new opportunities. Value-adding has included accelerated drying facilities to allow Australian hardwoods to be competitive in furniture grade timber markets and push a greater proportion of the resource away from green structural applications, with the major species in Victoria being Messmate, Silvertop Ash, and Grey Gum.

The benefits of value-adding can be seen in the increasing importance of New Zealand grown Radiata Pine in Australia. There are several concise reviews on the New Zealand resource (207, 208, 209).

In New Zealand, radiata pine has been selectively grown and managed as a production crop for over 50 years with specific end uses in mind. After following strict pruning and thinning regimes, a large supply of straight-grained clear timber for high quality end use (such as veneer and furniture) will be available at the turn of the century. Unpruned logs have been grown under silvicultural regimes designed to reduce knot size and maximise high density timber production to be used for structural grades. The onset of accelerated drying techniques, antisapstain treatment and comprehensive grading regulations, in addition to innovative genetic manipulation and selection for specific wood properties, has meant that the quality of New Zealand grown radiata pine is relatively high (221). The New Zealand Forestry Industry identified a need for more rigorous control over stress-grading to be more competitive in the Australian Market. The effect has been to focus sawmillers on the resources which give them the best grade-yield recoveries. This has subsequently resulted in a change in price structure for existing managed plantations.

In Australia, the QFS has begun working on a value-adding marketing strategy. The Queensland plantation program has focussed on high quality sawlog production as explained in the 'The Plantation softwoods of Queensland' (70). The Victorian Softwood Industry has approached the advantages of pine plantations by directing interest to the benefits of having local timber industries in rural Victoria. (Apart from employment, there is reduction of the effects of salinity and soil degradation and provision of population boosts to dwindling rural towns).

An important aspect of value-adding is the protection of wood against its natural enemies once it has been processed and seasoned. The protection enhances the value and performance of timber commodities and allows them to be used in a wide variety of applications. The timber preservation industry provides the link between the concept of timber as a natural resource and timber as a durable, high quality building material. While there are many protection and preservation techniques available, there are four that dominate the industry:

i) pressure impregnation
ii) dip diffusion
iii) in-service remedial care (brush, roll/spray-on)
iv) detailing incorporated by design.

The first technique is the most permanent. Pressure impregnation using water, oil, solvent and emulsion based preservative systems, offers the most lasting and effective treatment for the protection of timber against biological degrade, mechanical wear and weathering. It is the primary method for treatment of timbers requiring in-ground and marine water contact. The durability and service life of both hardwoods and softwoods benefit from pressure impregnation, and the industry has been conscientious in setting standards for treatment, based on the hazard level in which the timber will be used. Australian Standard 1604 (210A) is referred to Australia-wide and is supported by other Acts such as Queensland's Timber Utilisation and Marketing Act (1987) and NSW Timber Marketing Act (1978).

The most commonly used pressure-impregnated preservative in Australia is the Copper-Chromium-Arsenic (CCA) preservative which can be enhanced by water repellent additives such as waxes, oils and resins. Creosote, an aromatic oil derived from coal tar distillation, provides protection against biological degrade and weathering, and is used in conjunction with CCA in a double treatment technique for marine applications. The unique benefit of Light Organic Solvent Preservative (LOSP) treatment is the absence of swelling of timber during treatment, making the process suitable for internal structural applications.

In the past few years, considerable effort has been put into developing and testing the performance of non-chromium non-arsenic preservatives. While the CCA-type preservatives have proven their suitability and effectiveness over a sixty year history world-wide (210B), recent studies have suggested that copper azole-based and quaternary ammonium-based compounds have the potential to offer an alternative chemical treatment, albeit at a higher price and with a shorter service-life.

The other techniques referred to above, offer a remedial assistance. Examples of these include groundline maintenance systems for posts and poles, water repellent protective paints for decking and fences, anti-sapstain sprays for freshly felled softwood logs, dipping of poles and sawn material for immunisation against *Lyctus* borers, and capping of posts and stumps to deflect water from entering the end grain.

SECTION 4.2 PROCESSING OPTIONS FOR AUSTRALIA'S HARDWOODS AND SOFTWOODS

In Australia there are many timber products that are the result of VAUS research. In Western Australia, the Department of CALM has developed a product called VALWOOD®; a registered technology wherein juvenile or small dimension native and plantation hardwood species (eg. jarrah, blue gum) are dried and sawn and edge-and face-glued into panels for furniture and joinery use. The use of regrowth thinnings for VALWOOD® seems ideal when you consider the following factors: (i) a demand for high quality furniture (ii) a reducing forest area available for timber production, and (iii) seasoning difficulties with large solid timber sections. Regrowth thinnings are usually left on the forest floor to rot or are sold as firewood and pulpwood (211, 213). Evaluation of milling machinery has been undertaken to assess the commercial production of thin boards for the process (146), and indeed Jarrah and Karri samples have been evaluated for use as crossarms for transmission poles (214).

The QFS held a seminar entitled 'Timber furniture: what's happening in the 90s' (215), which identified four major reasons for taking the VAUS challenge with hardwoods:

(i) increasing volumes of seasoned and/or treated plantation pine on the market are decreasing the demand for green hardwood for fencing and structural use.
(ii) maximising the value of forest hardwoods as decorative timbers with good working properties, rather than low value-added green off-the-saw commodity items.
(iii) utilising the readily available local eucalypt species of Queensland because many traditional cabinet woods are no longer available (due to closure of rainforests for timber production)
(iv) drawing a parallel with Victoria and Tasmania where species such as Mountain Ash, Alpine Ash, Silver Ash, Manna gum and River Red Gum are popular for flooring and rustic furniture.

Rather than competing with the softwood industry, QFS propose that species such as Blackbutt, Brush box, Spotted Gum, Sydney Blue Gum, Rose Gum, are used as high value-added furniture and cabinet timbers.

Along the east coast of Australia, the availability of seasoned, dressed mechanically stress-graded pine (Radiata, Slash, Caribbean, and Hoop Pine) is rapidly displacing the traditional green hardwood market (210). This is a clear VAUS example where timbers with low durability to decay or insect attack, with low strength and hardness ratings have competed successfully with timbers of greater durability and higher strength. ABARE believes that the market share for softwoods in Australia will rise from 63% to 68% by the year 2000 (5), because of softwoods' suitability for prefabrication and its relative cheapness compared with hardwoods. In Queensland, the softwood resource has been grown to cater for the structural market, rather than competing with NZ cleargrade material (221).

In New Zealand, Australian eucalypts have been successfully grown, harvested and evaluated for recovery rate and seasoning (215). Species include *E. botyroides, E. delegatensis, E. fastigata, E. obliqua, E. regnans* and *E. Saligna*. The species *Paulownia*, a native of Eastern Asia, has also been successfully trialed in New Zealand for specialist turnery and furniture applications. The challenges that the New Zealanders face is their ability to forecast consumption and production in Japan, and to assess competing overseas resources (219, 218).

GluLam (Glue-laminated beams), finger jointing and LVL (Laminated Veneer Lumber) are examples of the first generation of value-adding where defective timber could be either hidden within laminations or cut from the board. Since then the New Zealand registered technology 'GreenWeld' has produced finger jointing that does not require seasoned timber prior to the jointing procedure (221, 222). Another example of value-adding that has potential is the 'Scrimber process developed by CSIRO, where forest residues are 'scrimmed' and then reconstituted with resin to form a structural product.

The most recent generation of value-adding, however, is in the field of process control. Improved milling operations designed for smaller diameter logs allow greater volume recovery. Sophisticated drying systems developed in Australia for Australian conditions and Australian timbers allow greater product reliability. Treatment with improved chemical fixation allows for greater consistency in preservative treatment. The automation and statistical quality control in all aspects of timber handling are reducing the possibility of human error or the need for quality control by mass inspection. In fact, the timber industry as a whole is heading towards the Total Quality Management (TQM) philosophy by necessity.

Portable computerised systems have been designed to produce best cutting solutions for individual logs based on log dimensions and sweep. These systems maximise either volume or quality, depending on the type of mill processing equipment being studied. Further information is given about FRI Autosaw in Appendix 3. These aids have also been upgraded to full scale equipment and installed in the green mill after debarking procedures.

A useful study conducted by FRI (223) evaluated the capital and operating costs for a modern softwood sawmill. This analysis allows a full in-depth study to be conducted using computer models linking silviculture, wood processing and market demand. Another alternative evaluated by FRI, for the small operator, is the portable sawmill (227).

The Department of CALM, in a report on sawing performance in Western Australia (224), discussed possible improvement of sawing performance in predominantly hardwood mills, and another useful report on value adding was CALM's 'Concluding Report on the Small Eucalypt Processing Study Out of the Woods' (226). This report summarised data on processing, seasoning and utilisation research in Western Australia on regrowth eucalypt forest timbers. It identified three commercial products (VALWOOD®, the CALM Solar-assisted Timber Drying Kilns and the GUMTREE computer model for resource evaluation

SECTION 4.3 UTILISATION OF FOREST AND SAWMILL WASTES

Waste management is an area where sawmill owners can make profits and establish new markets. Depending on mill efficiency and productivity, the type of resource being cut and the type of product required, a fair estimate of green sawn timber from hardwoods is 40 - 50% in sound timber (eg. Victorian Mountain Ash 48% and WA Karri 46%) and 35 -40% in poorer quality timbers (eg. Jarrah 34%). The residues are as follows:

bark	10 - 12%
sawdust	12 - 15%
edging, trimming, docking	15 - 20%
careless manufacture	5%.

These figures indicate that up to 50% of the hardwood log is being underutilised and has the potential to generate income.

With softwood logs, 38 - 40% is processed as useable sawn timber, and another 38 - 40% is processed as chips from offcuts and put into pulp and paper operations. Approximately 20% is sawdust, splinters and bark.

For mills to be competitive and efficient, considerable effort has gone into developing products that utilise wood waste. Bunnings in Western Australia claim that they now utilise 88% of their raw material (personal communication) due to efficient processes and to a market for their residue material. Products such as veneers, glulam beams and finger jointed products are manufactured by

Bunnings, along with structural and select grade timbers, and residues are used for charcoal production, energy production or horticulture.

Softwood sawmills located close to large populated areas are able to sell bark chips to local nursery suppliers and to local council depots for use in revegetation schemes. For sawmills who do not have this access, researchers have been looking at ways of breaking down the waste to form useful products. One project involves the 'pulping' of bark to form filter material for removal of organic waste (FRI personal communication). Also being studied is the removal and characterisation of resins and extractives from bark that may be useful in preservative treatment of non-durable timber, and for use as fungicides and insecticides (FRI).

Sawdust has been used to fire kilns, but also has a market in stock bedding and ground cover, and some retail outlets (ie. butcher shops) sprinkle it on floors. Large volumes of sawdust however, are burnt in stacks because the costs of transporting the material offsite is too high when distances from mill to selling point exceed 70 km. Researchers at FRI meanwhile, have been converting sawdust and chips to ethanol and methane for use as transport fuel blends. Ethanol can be mixed with petrol, but studies have shown that engine modifications are needed when either methane or ethanol is used (230).

Edging strips, dockings and trimmings are often chipped or burnt for fuel, or if in appropriate quality and quantity are sold to pulp mills. QFS claims that 28-32% of gross log volume is suitable for woodchip products. There has been heated debate about the harvesting of logs for woodchip. The National Association of Forest Industries have published a 'Forest facts' paper discussing the woodchip industry (233), where they quote: ' 1 cubic metre of log weighs about 1 tonne, and when processed as woodchips, is worth $79 on the world market. Compared to $61 a tonne for coal and $27 a tonne for iron ore, woodchips are a valuable export product.' The paper also states that pulpwood is removed from forests during 'Integrated Harvesting' in the form of defective native pulplogs, plantation pulplogs, forest residues or sawmill residues.

An interesting use for wood fibre processed from woodchips is as surfaces for racetracks, because research (229) has shown that the cushioning effect, low cost, stability to UV rays and consistent surface has proven valuable for reducing injuries to racehorses during training.

On a final note, Jarrah residues do not produce ash when burnt, and provide an excellent source of material for high quality charcoal for silicon refining. The extractives content is too high for Jarrah to be used economically for woodchips, however, Marri, Karri, Blue Gum and She Oak wastes are among the residue material chipped and pulped and either utilised within Australia or sold on the international market.

CHAPTER FIVE LIMITATIONS AND NEEDS FACED BY INDUSTRY

SECTION 5.1 CAN TALL POPPIES SURVIVE IN AUSTRALIA?

In assessing the needs of the timber industry, I encountered many varied ideas, attitudes and comments. These responses depended on the state of development of the company and the particular market they were in.

It would appear that the 'tall poppy' syndrome is alive and well. In striving to increase their market share or move to more innovative strategies, many companies come in contact with resistance. In the timber industry this may take the form of reduced government support, misinformation spread by pressure groups, or disproportional representation by industry associations during government hearings. Other common issues raised included:

* **A need to have confidence in the decision making process and its resultant decision.**

Some company representatives considered that there was no longer a stable framework within the government of the day to allow for longterm planning to be confidentially carried out by the company. Legislation on logging, on stability and fairness of royalty prices for log tenders, on woodchipping, on export policy, on tariffs, on Australian Standards for preservative treatment and timber marketing, and on the VAUS strategy, have been issues brought up as examples where there is great uncertainty for the management of small, mid and large-sized timber mills and treatment plants. Other examples include the closure of several State Forests for timber production (eg. Fraser Island and Daintree in Queensland, Central Highlands in Victoria). These areas were previously managed for timber production, and supplied old- and regrowth timbers to many local mills for over 100 years.

No sawmill representative contacted disputed the need for environmental protection. They did, however, object to the process by which misinformation and lack of clarity of purpose confused debate. Information can be passed on two ways; by a rational debate of issues, concerns and consequences, or by an emotional confrontation where issues are clouded by colourful adjectives. Examples of emotional confrontations include examples of forest closure given in the previous paragraph. Companies can no longer be guaranteed of future resource, and they are unable to proactively plan for plant improvement, plant expansion or diversification of product range when emotion rules the debate. They need to have confidence in the government's ability to make decisions that are rational, and will give the best result for all concerned, not just to the loudest voice. This concept has been referred to as 'Good Public Choice'.

* **A need for a proactive approach to policing of Standards and other industry regulating documents and Acts.**

While there are many companies that have accepted Total Quality Management (TQM), including statistical quality control, quality accreditation, and 'doing it right the first time', there are also many companies that need to focus on change and proactively create more effective procedures and practices. From the more proactive companies, I heard a cry for a more rigorous policing of the various industry standards. This would not only provide a better treated, seasoned or graded product on the market, but also a greater level of control (eg. stock control, throughput, turn over or overhead costs etc) within the individual mills and an improved regard for the quality of timber products on the market.

Two examples provided were the policing of the AS1604 Standard for preservative treatment of timber across Australia, and the introduction of a TUMA-style document for the southern states, requiring compulsory branding of all timbers (ie. Woodmark).

* **A need for consistent State and Federal Government support**

Many companies do not consider that the National Association of Forest Industries and its state representatives are supported adequately by the State Governments. Industry needs to see, from both State and Commonwealth Governments, a commitment to principles rather than popularity in decision making. In fact, an example of this occurred in 1992 during the threat of closure of the Central Highlands in Victoria. The Government pre-empted the findings of the Land Conservation Council Inquiry into the Central Highlands by specifying details of the establishment of parks and reserves in the Highlands, thus putting 4600 jobs and $200 million/year revenue in jeopardy. Fast action by industry, unions and community groups had this policy revoked and other agreements made.

Some small mills of south-west Western Australia were disadvantaged in 1983 when logging of the Donnybrook Sunklands, an area of degraded Jarrah forest not valuable for timber production and certainly not an attractive tourist area, was no longer possible. The reason was a Government ban on clearing native forest for plantation establishment, apparently based on the advice of local conservation groups.

* **A need for sustainable pricing strategies.**

Pricing strategies should enable timber supplies to be competitive with other building products, but also sustainable against increasing industry costs (eg. royalties, registration fees, research levies etc). The use of timber as flooring material in Australian houses has decreased from 34% to 18% in the past decade; and concrete has risen to 81%. Steel has been promoted as a substitute for roof trusses and frames (82), perhaps due to poor marketing and positioning of products rather than the cost of the timber products. As any marketing organisation knows, discounting price below actual cost only reinforces the concept of poor quality to the customer.

SECTION 5.2 A CALL FOR A PROGRESSIVE FOREST INDUSTRY

It was interesting to hear of the perceived limitations faced by industry in providing a high quality product to their customers. Forest resources were rarely mentioned as a limitation, although I had a pre-conceived idea that the inconsistent quality of the resource was a major obstacle to overcome in competing against concrete, steel and aluminium. In fact the limitations were as follows:

* **Identifying and meeting customer needs.** This limitation appears to be widespread, and should be of high priority. Customers are gradually becoming more aware and more informed of their negotiating rights/skills, and of their knowledge of product specifications, timber species and performance. Often customers require specialised products for the development of niche markets. This ability to interpret and fulfil customer needs is something that requires skill and innovation. It may mean new processing techniques, a fresh approach to marketing, a revised Unique Selling Point (USP), or commitment to TQM and quality accreditation. A proactive approach where the company

works with the customer is something that more businesses are taking seriously. BHP's Steel and Rod Division are committed to their Valid User Requirement Specification (VURS), a document that defines the customer's needs and clarifies function and requirement (234).

Hyne and Sons Pty Ltd in Queensland have involved themselves in extensive market research and interaction with customers to identify new market opportunities and improved customer services. Bunnings Forest Products Pty Ltd in Western Australia have developed new processing facilities and strict codes of practice for product coding and stock control. The Pine Centre in Melbourne has also instigated innovative techniques for improved customer services.

* **The technology available to industry.** Technology is far behind the wants of the consumer and often too costly for the small-to-mid sized plant to acquire. Seasoning is an example where fundamental research on wood structure and applied research on drying schedules have not been able to resolve the difficulties of drying many Australian hardwoods, although consumers are being encouraged to use those species in furniture and flooring as substitutes for imported species. On-line and in-grade testing for stress grading is another area that requires attention. Consumers have been offered choices with steel, aluminium and brick; it is now time for an engineering code for timber that describes not only strength but durability and permeability in all hazard classes.

* **Politically correct thinking or 'group think'.** The rate of change of a company's development is intrinsically linked with how enlightened its directors are. The company which does not assess its position, but relies on its past performance and only welcomes those recruits with the same viewpoint and attitudes as current staff, suffers from "group think". Politically correct thinking can do more damage to a company's reputation than poor service, and can cause a company to stagnate and to lose market share, reputation and integrity. Individuals within a company having a different perspective on a problem may be alienated or ridiculed if their view is innovative and different. This can occur both inside a company and throughout an industry, and involves the attitudes of people who refuse to listen to other points of view. Progressive companies are now beginning to develop multidisciplinary teams with each member able to contribute unique skills. The limitations of group think will be slowly overcome.

* **Human resources.** Many company representatives approached cited the desire for employees to have further training. Certificate, diploma and degree courses and specialist external and internal training courses were referred to. Often personnel in the mill yard are expected to do forklift duties, dressing and sorting of timber, and constructing kiln charges. With further education: including an understanding of wood structure, a knowledge of timber seasoning principles, and perhaps marketing, managerial and TQM skills, the employee would be in a better position to suggest new procedures or be constructive in the assessment of new facilities or changes in processing. The limitations come in being able to minimise disruption in production with an absent staff member, fund the education, and find the personnel willing to accept the responsibility. The actual educational courses are available through TAFE colleges, the Gottstein Trust Fund, and various industry associations and training centres. Vertical integration, that is, the bringing together of the combined expertise of personnel from business management to forest silviculture to seasoning, processing and treatment, is planned in large companies. They perceive limitations in resource supply and technology transfer, and by bringing in expertise and developing technologies in-house, can guarantee greater security for product quality. Self sufficiency is created by this approach, as opposed to other companies who are affected by the politics of the day.

* **Information transfer.** A concern expressed by companies involved with wholesaling of timber products was the transfer of information and technology from wholesaler to retailer to consumer. This applies particularly with the use of timbers treated with preservatives as CCA,

LOSP and creosote, where the treatment plants are concerned that the correct message on usage may not get conveyed at the point of sale. Another concern is the inappropriate use of timbers for in-ground and water contact. It seems that the limitation in this case is not the treated product, but the inadequate level of technical information received by the retail staff before dealing with customers' specific requests. While consumers in general (eg. architects, builders, engineers, DIYs) should be encouraged to learn of the versatility of timber in the home and work place, too often a timber product has failed not because of faulty manufacture, but because of incorrect application on the advice of a perceived 'expert'. In some cases, there is simply not the information available to retailer or consumer on the permeability, durability and strength of particular species.

* **Standardisation.** Standardisation within a company and across an industry enhances strength and a superior product. In reaching for standardisation, changes can't be implemented immediately, and some require extensive reorganisation and refocussing. The concept of a Quality System has appealed to companies as a way of focussing on what is important when designing statistical control systems, improving product performance, and improving customer service.

* **Financial limitations.** This area was briefly mentioned and is common to all industries. One major point is the question of pricing of forest products in comparison to the capital outlaid for product manufacture. All businesses require a return on investment. Competition from other building products such as steel, aluminium, brick and glass have forced the wholesale price of timber to a record low level. Does this mean that the sawmiller has to struggle to stay in business, to struggle to make a return on investment, or is this an opportunity for research programs to develop innovative methods for decreasing the cost of harvesting, milling, seasoning and treating timber products? I suggest that if the Forest and Forest Products Industry wishes to be proactive and progressive, then it is the latter case.

Indeed most representatives have claimed that a holistic approach is being taken in the Forest and Forest Products Industry where environmental, economic and political aspects are being taken into consideration for the continued sustainability and benefit of our natural resources and further generations. In effect, tall poppies can survive where striving to be the best is perceived as the normal situation.

CHAPTER SIX FOOD FOR THOUGHT

SECTION 6.1 NEED FOR A FRAMEWORK IN WHICH ALL PARTIES IN THE FOREST MANAGEMENT DEBATE CAN BE HEARD.

Is there a framework that will guarantee future balance, harmony, innovation and cooperation when dealing with forest management issues? If one reads the colourful interviews given in Roots 1993 (235) then the answer seems to be no. Industry and conservation groups seem to have different objectives and the Commonwealth Government seems to offer little in the way of rational debate or seeking agreement. It seems however, that the issues are not extreme: the problem is in the way in which they are being handled. There seems to be no attempt at concession making, particularly when one looks at the debate about closing rainforest and 'pristine' forest areas to logging. The approach that conservation pressure groups take has been labelled 'Hard Positional Bargaining'. An enlightening article called 'Greenspeak - believe it or not.' (241) gives numerous examples of misinformation meted out to the public by 'green' groups, all in the name of seeking victory.

An article in Brisbane's 'The Courier Mail' - 'Conflict deep in the forest' on 20 November 1993 (236), is a clear example of misinformation generated to maintain a hard bargaining position. It stated that clearfelling was being carried out in the rain forests of North Queensland, where in fact select felling overseen by the Queensland Forest Service is the method used. Any clearfelling occurs in mature softwood plantations. The photograph used in the article appeared to be a clearfelled softwood plantation.

Various policy and positional statements have been issued by industry and conservation groups (NAFI (239), ACF (238,239)) in response to the Forest and Timber Inquiry Final Report 1992, (5, 6). But do these counter-policies do anything else but promote larger and more aggressive debates? Why can't the forest management issues be resolved when all groups seem to be demanding 'Ecologically Sustainable Development'? I believe this is because industry applies a logical and rationalistic approach to ESD to achieve a return on investment, and it sees the management of native forests as part of that investment. Conservation groups, on the other hand, have not been able to provide satisfactory alternatives to native forest timber production: they wish to achieve ESD by preventing timber production anywhere but in plantations, but these plantations need to be established on valuable agricultural lands that farmers are not willing to give up.

An example of this scenario was observed in the 'Central Highlands Coalition Community Newsletter' (August 1992) (240).

> ***PLANTATIONS: A SUBSTITUTE OR A SUPPLEMENT FOR NATIVE FORESTS?***
>
> *Some groups have suggested that native forest harvesting should cease and that all future supplies should come from plantations.*
>
> *It has been calculated by the Department of Conservation and Lands in 1989 that such a transfer in Victoria would require the conversion of over 300,000 ha of good quality farmland at a cost of $3 billion and a loss of $60 billion per year in farm output. Hardwood plantations for sawlogs were not considered to be profitable and would need to be subsidised. This would merely be an expensive change in address for timber supplies for no net change in volume. Government attempts to plant a mere 30,000 ha of softwood in North East Victoria has met stiff opposition from farmers.*
>
> *The timber industry and unions are enthusiastic supporters of plantations, but on the basis of achieving growth through supplementing the existing production of the industry. After all, why close an existing operation that more closely fits the 'ecologically sustainable development' model than most other Australian income generating activities. In any case, there are thousands of other more urgent demands on Government funds than such a costly substitution program.*

These conservation groups would do better finding an alternative to Hard Positional Bargaining. They possible could benefit from a method called 'Principled Negotiation'. This method (shown Table 6.1) describes four basic elements of negotiation and suggests how they should be applied: People, Interests, Options and Criteria. The other extreme of positional bargaining is 'Soft Positional Bargaining'. The latter method relies on retaining friendly relations, seeking compromise and producing results quickly. It appears often that the Government bodies rely on this approach whereas pressure groups rely on Hard Positional Bargaining.

Fortunately, the Forest and Forest Products Industry has some very innovative companies that have bought their own land and grown their own trees for wood chipping, developed technologies for turning forest wastes into solid wood products, engineered faster growing and superior quality trees, and built more efficient or less costly seasoning facilities. This has occurred while we wait for a framework in which all parties in the production/environmental debate can be heard.

Table 6.1 Positional Bargaining : which game should you play?

SOFT	HARD	PRINCIPLED
Participants are friends.	Participants are adversaries.	• Participants are problem solvers.
The goal is agreement.	The goal is victory.	• The goal is a wise outcome reached efficiently and amicably.
Make concessions to cultivate the relationship.	Demand concessions as a condition of the relationship.	• Separate the people from the problem.
Be soft on people and the problem.	Be hard on the problem and the people.	• Be soft on the people and hard on the problem.
Trust others.	Distrust others.	• Proceed independent of trust.
Change your position easily.	Dig in to your position.	• Focus on interests, not positions.
Make offers.	Make threats.	• Explore interests.
Disclose your bottom line.	Mislead as to your bottom line.	• Avoid having a bottom line.
Accept one-sided losses to reach agreement.	Demand one-sided gains as the price of agreement.	• Invent options for mutual gain.
Search for the single answer: the one they will accept.	Search for the single answer: the one you will accept.	• Develop multiple options to choose from; decide later.
Insist on agreement.	Insist on your position.	• Insist on objective criteria.
Try to avoid a contest of will.	Try to win a contest of will.	• Try to reach a result based on standards independent of will.
Yield to pressure.	Apply pressure.	• Reason and be open to reasons; yield to principle, not pressure.

reproduced from "Getting to YES" by Fisher and Ury, 1981.

An example of the proactive approach to forest management taken by the Timber Industry can be found in the article 'Victoria's Green Gold: Ash regrowth from the 1939 Fires' (242) by VAFI, part of which is reproduced below.

THE FUTURE INCREASING THE RESOURCE BASE

The most important restriction on growth opportunities for the Victorian Timber Industry is availability of resource. Contrary to the claims of some pressure groups, the Timber Industry has access to a relatively small percentage of the State's forested land; almost three quarters (3.4 million ha) is not available. Further, the resource is not disappearing. In the 28% of forested land areas available for 'sawlog driven' production, harvested areas are fully regenerated. Despite some regional imbalances which are currently being rectified, on a State-wide basis, regrowth in production forests exceeds the rate of harvesting. In addition, the Department of Conservation, Forests and Lands has been replanting cleared areas with Eucalypts at a modest but steady rate. There is, of course, no question that Victoria like the rest of Australia has lost huge areas of forests during settlement through clearing for agricultural, pastoral and mining industries. However, it should be recognised that these industries have given us the prosperity that allows us to be conservation conscious today. It is clear that the area of public land covered by native forest is now increasing, not diminishing, largely as a result of commercial forest operations.

The Government's Timber Industry Strategy identified substantial areas of potentially productive unstocked ash sites on crown land due to frequent fires or unsuccessful clearing for agriculture in the early years. The main areas are the Central Highlands (16 000 ha), the Strzlecki Ranges (3000 ha) and the Otway Ranges (5000 ha). The Strategy commits the Government to replanting these areas at a rate of 2000 ha per year which will provide 'a well located, valuable timber resource and a greater diversity of local wildlife habitats'. While these sites will not produce timber for many years they do add to the growth in long term sustainable yield within the region. Once underway, this reforestation program will ensure that for each hectare of ash forest harvested and regenerated each year during the next decade, an additional hectare will be re-established on these unstocked sites.

As outlined in Table 6.1, it appears that the Forestry Industry has focussed on interests rather than positions, and has separated the personality (i.e. spokesperson's debating style) from the problem (Ecologically Sustainable Development). However, another problem that stands unresolved in the middle of the forest debate, is the reluctance of the Commonwealth Government to commit itself to procedures, guidelines and instructions detailing the implementation of the National Forest Policy Statement (1992). It attempts to reconcile all parties but in effect has simply fuelled the debate further. In the meantime, Western Australian, Victorian, Tasmanian and Queensland Forest Services have established policies and accreditation procedures for the Forest Industry in recognition of their commitment to ESD and the objectives of the NFPS.

The NFPS 1992 (5) is certainly an objective document that sets the scene for future cooperation. It must be reassessed regularly with involvement by all parties. With such a document in place and agreed upon by all State Governments, conservation groups and Commonwealth Government, surely a review of progress with unbiased adjudication is the framework our nation seeks.

SECTION 6.2 BENCHMARKING: EVOLUTION OR REVOLUTION?

In Australia, each State has authority over the use and management of its forests and woodlands. The State is responsible to the Commonwealth for that management, and it seems quite reasonable to accept that each State has unique expertise in the areas of silviculture and harvesting of timber from trees, and in producing timber from local species. All States aim to produce high quality timber products that can meet domestic demand within the State and be sold interstate or exported. With this scenario in place, there should be a *national* Timber and Marketing Utilisation Act that describes the minimum standard required for grading, treating, processing and application of timber products. Why is the industry not aligned so that timber seasoned and graded in one state can be used directly in another without being rejected or re-tested? Standardisation of processes and product quality is the first step in achieving a universally acceptable product.

The motor vehicle industry, for example, has clearly defined standards for safety, comfort and performance, and these are exhaustively tested by international racing teams and by the manufacturers themselves.

Rather than dealing in absolutes, that is, forcing the industry to conform to certain standards without due regard to consequences, the standards must be evolved over time. Therefore it was encouraging to hear at the 24th Forest Products Research Conference at CSIRO Division of Forest Products, Melbourne, in November 1993, that so much effort was going into Standard and Code reform.

As we head for the 21st century and a more internationally competitive market, the evolution of minimum standards and quality accreditation will become essential to each and every industry. The forest products industry nationwide, should apply the same approach to quality systems and standards. Bench marking can be achieved by observing what our competitors are doing (nationally and internationally) and modifying procedures to suit our unique political, environmental and industrial climate.

SECTION 6.3 CONCLUSION

The time spent with FRI (NZ), Department of CALM, QFS and CSIRO Division of Forest Products was rewarding, enjoyable and worthwhile for me on a personal and scientific level. The opportunity to gain knowledge of Australia's Forest Industries has allowed me a greater understanding of the role played by tree breeding, silviculture and forest management in the production of high quality timber products. The management of our native forests and plantations in the past has rightly been criticised, however, there is considerable research that proves that forests can be managed for multiple use and provide all the values required for the community in perpetuity.

I now have a better perspective on both arguments in the forest management debate, and I consider that an agreement acceptable to all parties is possible when it is accepted that there is no wrong or right side to the debate of timber production in native forests. There is a mutually beneficial agreement to be reached if decisions are based on sound principles rather than emotion. A forest should not be logged simply because it is convenient or appears to have valuable straight stemmed trees in it. Consequently, if it can be logged and retain its diversity of life forms, and the harvesting provides employment and growth to the region, then it should be considered by way of Environmental Impact Assessments.

In the next decade, when the emphasis will be on value adding and processing beyond green sawn timber, I feel that the timber preservation industry can make an enormous contribution. With more advanced treatment processes addressing dimensional stability, and a standardised nationwide approach to the utilisation and marketing of treated timber products, the range of applications for the use of timber products will grow greatly. Already we have seen the advent of alternative waterborne preservatives and the use of juvenile timbers for laminated products. With cooperation between all parties in the timber industry and adherence to the standards and codes of practice, the acceptance of timber products and the confidence in their quality will be assured.

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APPENDIX 1.

SECTION 1.2 PHYSICAL AND ANATOMICAL PROPERTIES OF THE TIMBER SPECIES

Acacia melanoxylon
(Blackwood)
Occurrence: Blackwood is distributed on the tablelands and coastal hills of eastern Australia from latitude 16 - 43°S in association with cool temperate rainforests, tall open forests and woodlands (associated species are *Eucalyptus regnans, E.obliqua, E. viminalis, Nothofagus cunninghamii* and *N. moorei*). It requires cool-moist to warm-humid conditions at an altitude from sea level to 1250 - 1500 m. Rainfall required is in the range 750 - 1500 mm, while the most productive soils are the forest podsols (acid sandy soil over an impervious/clay subsoil) and alluvia.

Physical description of tree: On good soils, blackwood can attain a height of 35 m with a diameter of 1 - 1.5 m. On poorer soils, it is generally 10 - 20 m and 0.5 m diameter. It has hard, longitudinally furrowed grey-brown bark, and leaves that are bipinnate (with 2 - 5 pairs of pinnae and 12 - 15 pairs of leaflets), oblong in shape and a mid-green colour. The inflorescences are white-to-pale-yellow and occur on globular heads of 3 - 5, each of 30 - 50 flowers and arranged on short lateral axes. Seeds are encased in a thin flat brown case that twists or coils when ripe. The blackwood regenerates readily after forest disturbance (i.e. fire, clearing, etc.).

Physical description of timber:

colour:	sapwood is white and heartwood is golden brown, often with a reddishtinge.
grain:	usually straight and even textured, but sometimes wavy with distinct growth rings.
density:	640 kg/m^3.
durability:	class 3

Argyrodendron actinophyllum
(Blush tulip oak)
Occurrence: The tulip oak is characterised as a scrub tree and is often found in areas of sub-tropical rainforest. It grows in the Mackay and Townsville areas, with a range of latitude from 19 - 32°S and altitude of 500 - 900 m. It enjoys a warm humid environment with an annual rainfall of 1000-1500 mm. It is best suited to well-drained alluvia, podsolics and basaltic soils found on plateaux or hillsides. Blush tulip oak is a co-dominant with *A. trifoliolatum, Cryptocarpa erythroxylon, Toona australis* and *Ceratopetalum apetalum.*

Physical description of tree: This tree can attain a height of 50 m and a diameter of 1.5 m. It generally has distinctive buttressing and a large crown of glossy dark green leaves. It has finely fissured bark of a grey to brown-black colour, and this sheds in small chunky pieces. The adult leaves are elliptical to lanceolate in shape and are arranged in groups of 5 - 9 leaves. The inflorescences are cream coloured and axillary with male and female on the same tree. The mature fruits are large, reddish-brown and ovoid. They have a soft and leathery texture and have a soft 'wing' that grows from one end.

Physical description of wood:

colour:	sapwood is pale brown or straw coloured, while the heartwood is adarker brown.
grain:	coarse and even textured with a generally straight grain
density:	850 kg/m^3
durability:	class 4
general:	pH of the wood is 5.2.

Eucalyptus acmenioides
(White mahogany)
Occurrence: Commonly found at latitudes between 16 - 34°S along the coastal areas of Queensland and New South Wales. It grows best in warm humid climates at altitudes from sea level to 1000 m with a rainfall of 700 - 1700 mm annually, on hills and ridges of open forest and tall open forest formation. It is associated with *E. pilularis, E. propinqua, E. paniculata, E. globoidea, E. gummifera, E. saligna, E. microcorys, E. maculata* and *E. tereticornis,* and occurs as scattered trees rather than a pure stand.

Physical description of tree: On good soils, white mahogany can reach 60 m in height and 1 m diameter. The trunk is generally half of the height of the tree and the crown is open. The grey-brown bark is rough and fibrous; it has shallow longitudinal fissures tending towards a stringy appearance, and is persistent over the whole trunk. The adult leaves are alternate and lanceolate in shape; thin green and tapering at the ends. The floral bud opercula are conical and the buds are pointed-ovoid; they contain 9 to 15 flowers. The fruits are hemispherical in shape with rim-level valves.

Physical description of wood:

colour:	sapwood is creamy brown and heartwood is yellow-brown to brown.
grain:	fine textured with some gum veins. It sometimes has interlocked grain and a greasy feel.
density:	990 - 1010 kg/m^3
durability:	class 1
wood:	The vessels are solitary, small-to-medium and uniformly distributed (occasional oblique chains). Tyloses are common with parenchyma difficult to see and rays fine and numerous. The wood is slow to dry.

Eucalyptus amygdalina
(Black peppermint)
Occurrence: Black peppermint is endemic to Tasmania and is scattered over the eastern half of the state. It occurs between latitudes of 41 - 43.5^{o}S at altitudes of sea level to 750 m, and requires 700 - 2400 mm rainfall annually. It grows on poor siliceous and acid soils, and tolerates hilly slopes as well as undulating lowlands. It prefers a cool humid climate. It can be seen in open forest alongside *E.tenuiramis, E. sieberi, E. rubida, E. dalrympleana* and *E. viminalis.*

Physical description of tree: Black peppermint can attain 15 - 30 m height and 1 m diameter on good soils. It has fine and fibrous bark with longitudinal fissures that generally persist on the trunk and larger branches, and bleaches to a grey colour. Its leaves are alternating, narrow-lanceolate and a dull green in adult form. The 15 or so clavate buds give the hemispherical shape to the opercula.

Physical description of timber:

colour:	the sapwood is creamy and the heartwood is pale brown.
grain:	straight grain with occasional gum veins; sometimes interlocked.
density:	770 kg/m^3
durability:	class 3.
wood:	timber is prone to collapse

Eucalyptus calophylla
(Marri)
Occurrence: Marri occurs in the south west of Western Australia at latitudes of 29 - 35^{o}S and at altitudes of sea level to 300 m. It grows best in sub humid to warm climates with 650 - 1500 mm rainfall annually. This species occurs in open forest formation and develops best in sandy loam alluvium. It does, however, tolerate lateritic sandy gravels and hilly areas. It can be found commonly with *E. marginata* and to a lesser extent with *E. diversicolor* and *E. wandoo.*

Physical description of tree: Marri generally attains a height of 40 m and a diameter of 1.5 m. It has a dense and heavily branched crown, and short-fibred tessellated grey bark which is commonly stained in patches to a brown-red by kino which exudes from the tree. Its leaves are alternate, broad lanceolate and green; its buds are clavate and flowers are cream coloured; its inflorescences are large, terminal and 3-to-7 flowered; its fruits are large, urceolate, woody and thick with deeply enclosed valves. Marri is a good honey tree.

Physical description of timber:

colour:	the sapwood is creamy and the heartwood is light brown.
grain:	coarse and even textured with gum veins; slightly interlocked.
Density:	850 kg/m^3
durability:	class 3.
wood:	tyloses are abundant but scattered, axial parenchyma are abundant.

Eucalyptus camaldulensis
(River red gum)
Occurrence: River red gum occurs widely over all of mainland Australia and particularly along water courses in semi-arid areas, preferring the plains and riverine locations between latitudes 12.5 - 38°S and altitude 20 - 700 m. It requires 250 - 600 mm rainfall annually but tolerates 150 - 1250 mm with seasonal flooding. Sandy alluvial soils and open forest or riverine sites are the best sites.

Physical description of tree: Commonly 20 m in height and 2 m in diameter, river red gum has smooth pale-grey or white bark with red-pink patches that sheds in strips or flakes but adheres to the base of the trunk. It has a heavy, large bole and an open spreading crown. The southern provenances are non-lignotuberous while the northern provenances are lignotuberous. Its adult leaves are alternate, lanceolate and grey-green in colour. Inflorescences are 7-to-11 flowered, opercula are varied in shape, and the fruits are ovoid with 4 fruit valves exserted.

Physical description of timber:

colour:	the sapwood is creamy and the heartwood is red
grain:	the interlocked, wavy grain has a fine texture
density:	880 kg/m^3
durability:	class 2. Susceptible to larvae of lepidopterous insects.

Eucalyptus dalrympleana
(Mountain gum)
Occurrence: Mountain gum occurs in the mountain forests of Victoria, New South Wales and Tasmania. It has a latitudinal range of 33 - 43°S and an altitude of 600 - 1700 m on the mainland and 300 - 900 m in Tasmania. It prefers deep loams of red or brown with clay subsoil, and rainfall of 800 - 1900 mm annually. It is found in tall open forests generally as the dominant species along with *E. pauciflora, E. delegatensis,* and at high altitudes with *E. fastigata, E. viminalis, E. radiata* and *E. dives.*

Physical description of tree: Mountain gum attains a height of 40 - 60 m and a diameter of 1.5 - 2 m. It has an open crown with alternate, lanceolate shaped shiny green adult leaves. The bark is rough and grey at the base of the tree but changes to a smooth creamy colour with occasional blotches of grey, pink or olive. The inflorescences are simple and 3-flowered while the buds are ovoid. The fruits are ovoid to hemispherical, and have 3 to 4 valves that are exserted.

Physical description of timber:

colour:	sapwood and heartwood are both straw-coloured to pink
grain:	growth rings are clearly defined and the wood is straight grained and slightly coarse textured.
density:	740 kg/m^3
durability:	class 4.

Eucalyptus delegatensis
(Alpine ash)
Occurrence: This species occurs in the cool high altitude areas of Tasmania, Victoria and New South Wales at latitudes of 35 - 43°S and altitudes of 900 - 1500 m. It requires annual rainfall of 700 - 2500 mm, and well drained soils of dolerite and granite. It grows in almost pure stands and is associated with *E. radiata, E. dalrympleana,* and *E. pauciflora,* and in Tasmania with *E. obliqua* and *Nothofagus* species in wet and dry schlerophyll forests.

Physical description of tree: Attaining a height of 40 - 90 m and a diameter of from 2 - 3 m, alpine ash regenerates readily after wildfires. It has a tall straight trunk and medium sized crown. On the lower trunk, the bark is rough, fibrous and longitudinally fissured, while higher up the tree, the bark sheds in long strips to leave creamy white bark often with insects 'scribbling' on it. The adult leaves are glossy green and falcate, while the inflorescences are simple and 11 flowered and the buds are clavate. The fruits are hemispherical with 4 valves enclosed.

Physical description of timber:

colour:	sapwood is white and heartwood is yellow-brown or pink-brown
grain:	straight grain with open texture
density:	640 kg/m^3

durability: class 4
wood: pH of 3.6: distinctive growth rings and tyloses. The wood is prone to collapse and checking.

Eucalytpus diversicolor
(Karri)
Occurrence: Karri occurs only in a small area in South-west Australia at latitude 34 - 35°S, in a high rainfall area (900 - 1300 mm), and an altitude of sea level to 300 m. It prefers acidic sandy soils with underlying granite bases and grows in tall open forests with *E. calophylla* and often *Acacia* and *Casuarina* species as understorey trees.

Physical description of the tree: The karri is a tall tree of 40 - 70 m and a diameter of 1.5 - 3 m. The trunk is straight and forms two-thirds of the tree height. After fire it coppices readily but does not develop lignotubers. The bark is thin and shed over most of the trunk in random lengths, leaving patches of smooth creamy white and brown. The adult leaves are broad-lanceolate and dull green while the inflorescences are 7-flowered with clavate shaped buds. The fruits are ovoid with 3 valves that are prominent and slightly below rim-level.

Physical description of timber:
colour: sapwood is pale and the heartwood red
grain: coarse and with slight interlocking
density: 900 kg/m^3
durability: class 3
wood: oblique alignment of vessels and moderate amounts of tyloses.

Eucalyptus globulus **subsp.** *globulus*
(Tasmanian blue gum)
Occurrence: Although there are four other subspecies of *E. globulus* (e.g. subsp. *pseudoglobulus* and *bicostata*), subsp *globulus* is found in Tasmania, Flinders Island, King Island and southern Victoria. Its latitude range is 38.5 - 43.5°S and altitude is sea level to 450 m. Tasmanian blue gum grows on loams, dolerite and humus soil in undulating country dominated by open forest and woodland. It is associated with *E. viminalis, E. obliqua, E. ovata, E. amygdalina* and *E. delegatensis* in valleys and moist areas up to the snow line. It has been extensively planted in Australia due to its adaptability and rapid growth.

Physical description of tree: In good soils and moist valleys, this tree can attain 70 m in height and 2 m in diameter. It has rough grey bark persisting at the base of the trunk with smooth yellow-grey bark up higher. The adult leaves are stiff, falcate green leaves while the juvenile leaves give the tree its characteristic blue-grey appearance. The blue gum has 1-flowered inflorescences with a prominent and rough looking bud; the fruit has a distinct ring around the rim and 4 valves that are slightly exserted.

Physical description of timber:
colour: sapwood is pale and heartwood is pale yellow-brown
grain: distinct growth rings with an open, even texture and interlocked grain
density: 900 kg/m^3
durability: class 3.

Eucalyptus grandis
(Rose or Flooded Gum)
Occurrence: Flooded gum occurs in tall open forest along the east coast in several major areas between latitude 16 - 33°S, from north Queensland to northern NSW. It prefers warm humid climates with 1000 - 3500 mm rainfall annually, and at altitudes of sea level to 600 m. The well drained deep loams of volcanic or alluvial origin situated in valleys and plains produce best growth, and the tree itself is associated with rainforest species as well as with *E. intermedia, E. pilularis, E. microcorys* and *E. resinifera*.

Physical description of tree: With height of 45 - 55 m and diameter of 1.2 - 2 m, flooded gum generally has a straight trunk that is three-quarters of the tree height. The base of the trunk has grey, flaky rough bark but the rest of the tree supports a smooth powdery, white or bluish white bark. Its adult leaves are dark green and lanceolate in shape; its inflorescences are 7 - 11 flowered with ovoid buds, and fruits are pyriform with 4 to 5 valves that are exserted and inward curved.

Physical description of timber:

colour:	sapwood is pale pink and heartwood is light red
grain:	coarse textured and straight grained with gum veins.
density:	620 - 800 kg/m^3
durability:	class 3
wood:	vessels are large; variable in number and diffusely distributed. They occur commonly in diagonal chains, and tyloses are common in mature wood. Parenchyma are scarce and rays are fine.

Eucalyptus laevopinea
(Silvertop Stringybark)
Occurrence: The distribution of silvertop stringybark is limited to latitudes between 28 - 33^{o}S. There are dense pockets of this species in the northern tablelands of NSW. It prefers warm sub-humid areas of hilly land with well-drained basaltic soils. At altitudes of 750 - 1400 m and with an annual rainfall of 800 - 1500 mm, silvertop stringybark occurs in open forest as one of the dominant species with *E. andrewsii, E. obliqua, E. saligna*, and *E. microcorys.*

Physical description of tree: Depending on the condition of the site, this tree can attain 20 - 40 m with 1 m diameter. It is straight trunked with long-fibred, thick cross woven bark that has longitudinal fissures. The outer bark in grey while the inner is reddish brown; the smaller limbs are smooth and pale. The adult leaves are alternate and falcate in shape, while the inflorescences are 7 - 11-flowered and have buds that are ovoid. The fruits are globular with ascending disc and 3 to 4 valves that are slightly exserted.

Physical description of timber:

colour:	sapwood pale and narrow, heartwood light brown
grain:	moderately fine textured with some interlocking
density:	860 kg/m^3
durability:	class 2 / 3.

Eucalyptus maculata
(Spotted gum)
Occurrence: This species is widely distributed in coastal areas from latitude 25 - 38^{o}S, from Maryborough in Queensland to Bega in NSW. It prefers warm humid to sub-humid climates of 750 - 1750 mm annual rainfall and open forest formations. Moist shales or sandstones on valley slopes are the most suitable sites for spotted gum. It can occur in pure stands or associated with *E.crebra, E.pilularis, E. microcorys, E. propinqua, E. punctata* and other genera such as *Callitris* and *Casuarina.*

Physical description of tree: Spotted gum generally grows to 35 - 45 m with a diameter of 1 - 1.3 m. It has a smooth thick bark that is shed in patches leaving pink, grey, bluish and white colours dotted over the trunk. The trunk is generally tall and straight and has dimples where the bark has weathered unevenly. The green adult leaves are alternate and narrow-lanceolate, while the inflorescences are termical and 3-flowered with ovoid buds. The fruits are ovoid with 4 valves that are descending and enclosed.

Physical description of timber:

colour:	wide, pale sapwood and light-to-dark brown heartwood
grain:	coarse textured,open and interlocked, often with fiddleback (wavy grain) and gum veins.
Density:	970 - 1010 kg/m^3
durability:	class 2
wood:	growth rings are absent and the vessels are small but prominent and arranged in short radial multiples. Tyloses and parenchyma are abundant and rays are fine and visible in the tangential plane. pH of the wood is 4.6 to 5.0.

Eucalytpus marginata
(Jarrah)
Occurrence: Jarrah is limited to South-west Western Australia between latitudes 30 - 35^{o}S and altitudes of 100 - 300 m. It prefers warm sub humid climates with 700 - 1250 mm rainfall annually, and grows best on lateritic soil

derived from granite or bedrock as well as deep red loams. It occurs in pure stands and also with *E. calophylla,* and adjacent to *E. diversicolor* and *E. gomphocephala* in wet and dry sclerophyll forests.

Physical description of tree: On good sites this tree can attain 30 - 40 in height and 2 in diameter. It has rough, stringy and fibrous bark of a red-brown to grey colour in long strips, which persists to the smaller branches. Adult leaves are alternate and lanceolate and glossy dark green. Its inflorescences are simple and 7 to 11 flowered, and buds are ovoid. Fruits are woody and thick with 3 valves that are slightly enclosed. It has the deepest rooting system of any eucalypt, with growth penetrating approximately 40 m. It also regenerates by lignotubers, which are carbohydrate stores found at the base of the stem. These ensure that the young plant can survive drought, fire and insect attack.

Physical description of timber:

colour:	heartwood is dark red to red-brown
grain:	coarse textured
density:	830 kg/m^3
durability:	class 2
wood:	pH of 3.0 - 3.7.

Eucalyptus microcorys
(Tallowwood)
Occurrence: Tallowwood is found along the eastern seaboard between South-east Queensland and Northern NSW, at a latitude of 33 - 35°S. It prefers a warm and humid climate with an annual rainfall of 1000 - 2000 mm and altitudes of sea level to 750 m. It grows best in moist fertile valleys adjacent to rainforest but will grow in tall open-forest along with *E. saligna, E. pilularis, E. grandis, E. acmenoides* and *E. laevopinea.*

Physical description of tree: This tree can reach 35 - 60 m in height with a diameter of 2 m. It has good form and a straight trunk. The bark is rough and fibrous and red-brown in colour. It persists to the smaller branches and is soft or spongy with horizontal fissures on the under layers. The adult leaves are alternate, long, green and lanceolate, while the inflorescences are simple and 7-flowered. The buds are clavate . The fruits of the tallowwood are obconical with 3 valves that are slightly enclosed.

Physical description of timber:

colour:	sapwood is pale yellow-brown and heartwood is dark yellow-brown, sometimes with green tinge
grain:	coarse texture and interlocked and somewhat greasy
density:	1000 kg/m^3
durability:	class 1
wood:	vessels are medium size, solitary and occasionally touching; some oblique chains. Tyloses are abundant and parenchyma are visible and also abundant. Rays are fine. pH of 3.6 - 3.8.

Eucalyptus muellerana
(Yellow Stringybark)
Occurrence: Yellow stringybark grows best in the warm humid climate around the southeast corner of Australia from Wollongong to Wilson's Promontory (latitude 34.5 - 39°S). It prefers sheltered slopes and valleys with deep clay loams in tall open forests in association with *E. sieberi, E. obliqua, E. globoidea* and *E. cypellocarpa.* It is found in areas with an annual rainfall of 700 - 1200 m and altitude from sea level to 600 .

Physical description of tree: Yellow stringybark attains a height of 25 - 40 m with a diameter of 1 m. Its bark is long fibred and thick, and persists to the smaller branches. It is grey-brown with a stringy appearance. The adult leaves are broad lanceolate, green and alternate, and the inflorescences are simple 7 - 11 flowered with clavate buds. The fruits are sub-globular with descending disc and 4 valves slightly exserted. The species is used extensively for honey production.

Physical description of timber:

colour:	sapwood is very pale brown, heartwood is yellow brown with pink tinge
grain:	coarse textured
density:	860 kg/m^3

durability: class 2
wood: free from kino veins,

Eucalyptus nitens
(Shining gum)
Occurrence: Shining gum is scattered in southern NSW and Victoria between the latitudes of 35 - 38°S, and is also found in isolated pockets in northern NSW. It occurs in cool sub-humid climates with 750 - 1750 mm rainfall annually on slopes and mountain tops in tall open forest formation. It prefers deep loam soils over clay and is found in pure stands and associated with *E. maidenii, E. cypellocarpa, E. delegatensis, E. regnans, E. fastigata, E. viminalis, E. pauciflora* and *Acacia dealbata.*

Physical description of tree: Shining gum generally has a good form, attaining a height of 40 - 70 m and a diameter of 1 - 2 m. The bark is smooth and grey, and sheds in long ribbons, leaving a few metres of rough bark at the base of the trunk. Occasionally there may be black horizontal insect marks on the trunk. The adult leaves are narrow lanceolate, alternate and dark green, while the inflorescences are simple 7-flowered with cylindrical buds. The fruits are ovoid and glossy with a descending disc and 4 slightly exserted valves.

Physical description of timber:
colour: sapwood is white and heartwood is straw-coloured or pale pink.
grain: straight grained with well defined growth rings.
density: 720 kg/m^3
durability : class 4.

Eucalyptus obliqua
(Messmate stringybark)
Occurrence: This species is widely distributed in South-eastern Australia between the latitudes 28 - 43.5°S. It enjoys a cool sub humid climate with annual rainfall of 50 - 2400 mm, and good quality loam soil. It is found on hilly country in tall open forest sites along with *E.nitens, E. cypellocarpa, E, fastigata, E. viminalis* and *E. delegatensis* in Gippsland, the Otways and Tasmania. It has been used as a plantation timber due to its good growth even in poor soils.

Physical description of tree: On good soils this tree can attain 45 - 90 m in height and 2 - 3 m in diameter with good form and a straight trunk. The bark is rough, thick, deeply furrowed and persists to the smaller branches. It appears stringy with interlacing fibres, and is grey and red-brown. The leaves are a glossy dark green and broadly lanceolate, while the inflorescences are simple 7-15 flowered and buds clavate. The fruits are truncate-ovoid with a broad disc and 4 valves enclosed.

Physical description of timber:
colour: sapwood is pale brown and heartwood is light brown to brown
grain: straight, open grain texture with well-defined growth rings
density: 830 kg/m^3
durability: class 3
wood: oblique alignment of vessels in earlywood. pH of the wood is 3.2.

Eucalyptus pilularis
(Blackbutt)
Occurrence: This species is distributed along the eastern coast from south Queensland to the Victorian border (latitude 25.5 - 37.5°S). It favours the warm humid climate with 900 - 1750 mm rainfall annually. Blackbutt is found on sandy loams or clays and volcanic soils in tall open forest on gentle slopes. It occurs as a pure stand and in association with *E. microcorys, E. saligna* and *Syncarpia glomulifera.*

Physical description of tree: Blackbutt has good form, and can grow to 40 - 60 m height and 3 m diameter. The crown is dense with the leaves alternate, green and lanceolate. The bark is rough, finely fibrous and grey-brown, and persists on the lower trunk leaving a smooth white or yellow-white surface. Insect scribbles can sometimes be found. Inflorescences are simple and 7 - 15 flowered with buds clavate. The fruits are truncate-globular with a descending disc and 4 valves slightly enclosed.

Physical description of timber:

colour:	sapwood is pale brown and heartwood is light brown or yellowish brown.
grain:	coarse textured and straight with small gum veins. Sometimes a wavy interlocking grain.
density:	900 - 930 kg/m^3
durability:	class 2.

Eucalyptus radiata

(Narrow leaved peppermint)

Occurrence: This tree occurs from northern NSW to southern Victoria, between latitudes 28 - 39^{o}C. It grows best in a moderate sub-humid climate at altitudes of 50 - 1200 m with annual rainfall of 650 - 1100 mm. Narrow - leaved peppermint is found in open forest on tablelands in sandy and volcanic loams. It is often found with *E. dives, E. viminalis, E.ovata, E. piperita, E. laevopinea, E. obliqua* and *E sieberi.*

Physical description of tree: Attaining a height of 20 - 30 m and 1 m diameter in good soils, narrow-leaved peppermint has fine, fibrous, brown-grey bark with longitudinal fissures, that persists on the trunk and large branches. Its adult leaves are alternate, green, narrow-lanceolate and thin, and have a distinctive peppermint smell when crushed. It has simple 11 - 20 flowered inflorescences and buds that are clavate. The fruits are globular-truncate in shape with 3 - 5 enclosed valves.

Physical description of timber:

colour:	sapwood is pale and heartwood is light brown
grain:	coarse-textured and straight grained with gum veins
density:	720 kg/m^3
durability:	class 3.

Eucalyptus regnans

(Mountain ash)

Occurrence: Mountain ash is distributed in the south of Victoria and the north east of Tasmania between latitudes 37.25 to 43.25^{o}S. It grows best in cool moist areas with annual rainfall of 750 - 1700 mm and an altitude between sea level and 1100 m. It occurs in tall open forest as pure stands in good soils, and mixed with *E. viminalis, E. nitens, Nothofagus cunninghamii* and *Acacia dealbata* in poorer soils. Deep friable clay loam soils in sheltered mountainous country produce optimum growth.

Physical description of tree: Attaining a height of 55 - 75 m and a diameter of 2.5 m, mountain ash has good form and a small open crown. The bark is rough and fibrous at the base for up to 15 m, and then becomes smooth greenish grey and thin, shedding in long ribbons. The adult leaves are alternate, broad-lanceolate, green and oblique, while the inflorescences are simple, paired and 9 - 15 flowered. The buds are clavate and the fruits pyriform with a broad disc and 3 valves at rim level.

Physical description of timber:

colour:	sapwood is indistinct and heartwood is pale brown with a pink tinge
grain:	open, straight grain with prominent growth rings
density:	680 kg/m^3
durability:	class 4
wood:	timber is prone to collapse.

Eucalyptus saligna

(Sydney blue gum)

Occurrence: This tree is distributed from central coastal Queensland to southern coastal NSW between latitudes 21 - 36^{o}S. It does best in a warm humid climate with annual rainfall of 900 - 1800 mm at altitudes of sea level to 1100 m. The best development of this tree occurs on well-drained alluvial sandy loams in tall open forest along with *E. pilularis, E. microcorys, E. maculata, E. grandis, E. punctata, E. propinqua, E. nigra* and *Tristania conferta.*

Physical description of tree: Growing to 30 - 55 m in height and 2 m in diameter, Sydney Blue gum has good straight form. It is one of the species that develops lignotubers. Its bark is rough, flaky and brown-grey, persisting to about 4 m, above which it sheds in ribbons to leave smooth blue-grey to white bark. The adult leaves are alternate, lanceolate and green, with simple inflorescences and 7 - 11 flowered. The buds are ovoid and the fruits are cylindrical with 4 valves protruding above the rim.

Physical description of timber:

colour:	sapwood is pale pink and heartwood is pink to red.
grain:	straight grain and coarse textured with gum veins common
density:	850 - 900 kg/m^3
durability:	class 2/3
wood:	pH is 3.6 - 4.2.

Eucalyptus sieberi
(Silvertop ash)
Occurrence: Silvertop ash occurs from central to south NSW to eastern Victoria, as well as in pockets in northern Tasmania. It grows between the latitudes 33 - 42°S in moderately cool and humid climates of 700 - 1400 mm annual rainfall and altitudes of sea level to 1100 m. It occurs in open forest and woodland on sandy soils over clay subsoil, often in pure stands, but also with *E. obliqua, E. fraxinoides, E. cypellocarpa, E. dalrympleana, E. pilularis, E. gummifera* and *E. piperita*.

Physical description of tree: The tree attains a height of 25 - 35 m and diameter of 0.6 - 0.9 m. Its bark is orange-brown when young, turning to black, hard and deeply furrowed in later years. The upper branches remain smooth and white, and the adult leaves are green, glossy and lanceolate. The inflorescences are simple and 7 - 15 flowered, the buds are clavate and the fruits are obconical with a broad disc, 3 valves and slightly enclosed. The tree does not seed often.

Physical description of timber:

colour:	narrow sapwood band is indistinct and heartwood is light brown withpink tinges
grain:	growth rings are distinct and the grain is occasionally interlocked
density:	830 kg/m^3
durability:	class 3
wood:	pH of the wood is 3.5.

Eucalyptus tereticornis
(Forest red gum)
Occurrence: This tree has a wide distribution range from latitude 15 - 38°S, generally occurring in NSW and Queensland with a small pocket in eastern Victoria. The climates vary from warm to hot and sub-humid to humid and wet. Forest red gum is generally found in dry open forest or woodland on alluvial soils, sandy or gravelly loams situated in flats and on gentle slopes. It is often associated with species of *Eucalyptus, Acacia, Casuarina, Melaleuca* and *Callitris.*

Physical description of tree: This tree attains from 20 - 50 m height and 2 m diameter. It has steeply inclined limbs and a straight trunk with bark that is shed in random plates, leaving the trunk surface smooth and white-grey-blue. A stocking of rough black bark is retained at the base of the trunk. Its adult leaves are alternate and narrow-lanceolate, while the inflorescences are simple and 7 - 11 flowered and the buds are fusiform to diamond-shaped. The fruits are truncate-globular with ascending disc and strongly exserted valves.

Physical description of timber:

colour:	sapwood is pale grey to cream and heartwood is light to dark red
grain:	a fine textured interlocked grain
density:	1010 - 1100 kg/m^3
durability:	class 1/2
wood:	pH of the wood is 3.7. Small to medium sized and uniformly distributed vessels. Tyloses are present, parenchyma are abundant and diffuse and contain resins. Rays are fine.

Eucalyptus viminalis
(Manna gum)
Occurrence: This tree occurs throughout southeastern Australia from latitude 28 - 43°S, growing in Tasmania, the Mt Lofty ranges in Adelaide, in Victoria except for the drier north-west, and scattered along the eastern seaboard of NSW. It is found in a moderate climate with 500 - 2000 mm annual rainfall at altitudes of sea level to 1400 m. It

grows best on well drained alluvial or sandy podsolic soils with clay sub soil in the valleys of hilly country. In tall open forest it can be found alongside *Eucalyptus regnans, E. delegatensis, E. obliqua, E. dalrympleana, E. nitens, E. radiata, Acacia melanoxylon* and *Banksia marginata.*

Physical description of tree: Manna gum generally attains a height of 30 - 50 m and a diameter of 1.5 m in good soil. It has an open crown with often drooping branches and signs of shedding bark hanging from branch forks. The bark is rough, grey and persistent at the base of the trunk, while smooth and creamy on the upper trunk. The adult leaves are alternate and lanceolate; the inflorescences are simple and 3 flowered while the buds are ovoid. The fruits are truncate-ovoid to hemispherical with a broad ascending disc and exserted valves.

Physical description of timber:

colour:	sapwood is pale and heartwood is pale pink/yellow
grain:	coarse texture and straight grain
density:	730 kg/m^3
durability:	class 4.

Syncarpia glomulifera
(Turpentine)
Occurrence: Turpentine is found along the east coast between the Atherton Tableland in Queensland and Batemans Bay, NSW, in the latitude range 16 - 36^{o}S. It grows best in warm sub-humid climates with 1000 - 2000 mm annual rainfall at altitudes of sea level to 900 m. Its best development occurs in deep fertile soils in valleys and lowlands, and is found with rainforest and eucalyptus species such as *E. grandis, E. maculata, E, pilularis* and *Tristania conferta.*

Physical description of tree: Turpentine attains a height of 40 - 55 m and a diameter of 1 - 1.3 m in good soils. It is of good form and coppices readily. The red-brown bark is thick and fibrous. It persists on the trunk and limbs and appears stringy with deep longitudinal furrows. The ovate adult leaves are opposite pairs grouped in fours with a dark green colour above and pale coloured finely matted hairs underneath. The inflorescences are axillary with 1 or 2 whorls of 4 inflorescences containing 7 flowers each. The petals are hairy and white-cream in colour and appear fused together, creating a large bloom of colour. The fruits are complex with capsules fused together in a mass of 7 hard woody fruits.

Physical description of timber:

colour:	sapwood is cream and heartwood is deep red to brown
grain:	fine to medium texture and wavy, interlocked grain.
density:	900 - 995 kg/m^3
durability:	class 1
wood:	pH of the wood is 3.6 - 3.9. Vessels are small, solitary and uniformly distributed.Tyloses are present and parenchyma are indistinct, while rays are fine but visible. The wood does not splinter and is resistant to wear due to its high silica content (0.33 - 1.24%).

Tristania conferta (now *Lophostemon confertus*)
(Brush box)
Occurrence: This tree is distributed from Atherton in Queensland to Newcastle NSW, in the latitude range of 16 - 33^{o}S. It occurs on the coast in warm humid climates at altitudes of sea level to 800 m and requires an annual rainfall from 900 - 1700 mm. Heavy fertile alluvial soils are best for good development of the tree, especially in valleys and on slopes. It appears in tall open forest alongside rain forest and eucalypt species such as *E. grandis, E. microcorys* and *Syncarpia glomulifera.*

Physical description of tree: Brush box attains a height of 35 - 40 m and a diameter of 1 - 2 m. The tree has good form with grey/brown fibrous or scaly bark persistent on the lower trunk and orange-brown smooth bark on the upper trunk. The crown is dense and is composed of tiers of glossy green foliage clumps. The adult leaves are alternate and grouped in 4 to 5. The inflorescences are axillary with 7 flowers each having 5 broad white petals. The fruits are hemispherical capsules with 3 enclosed valves.

Physical description of timber:

colour:	sapwood is pale and heartwood is pink-brown to red-brown
grain:	fine texture with curly and interlocked grain

density: 880 - 900 kg/m^3
durability: class 3
wood: pH of the wood is 3.9 - 4.6. Vessels are small, solitary and diffuse, while tyloses are common and parenchyma not visible. The rays are fine and there are no gum veins. The wood is slow to dry and distortion will occur if curly grain is present.

Araucaria cunninghamii
(Hoop pine)
Occurrence: Hoop pine occurs along the eastern seaboard from latitude 12 - 31°S. It grows best in warm to hot and humid climates in excess of 750 mm annual rainfall at altitudes of sea level to 1000 m. It can grow on almost any soil that is well drained and well aerated from sand to basaltic coastal soils. As an emergent tree, hoop pine occurs in dry subtropical forest and may be found following disturbance in wetter areas. It is associated with *Flindersia* and *Dysoxylum* spp, *Castanospermum australe, Grevillea robusta* and *Ceratopetalum apetalum*. It is also successfully used as a plantation timber in Queensland and northern NSW, with an average stand age of 60 years. It is most productive on red volcanic soilsof Atherton and Gympie, but does not regenerate readily because the seedlings are shade intolerant.

Physical description of tree: The tree attains a height of 60 m and a diameter of 0.6 - 1.9 m. It has a tall straight trunk with an open crown consisting of branch whorls with long internode length and foliage clumped at various points along its branches. The bark is dark-brown, tough, scaly and hard with horizontal cracks that form 'hoops'. The adult leaves are spirally arranged, straight and sharply pointed. The leaves and small branches are shed as a short single piece. Both male and female strobili are grown on the same tree, with the male being terminal and cylindrical with tightly packed scales and pollen cells on the underside. The female strobili are globular and formed at the ends of shoots. They contain ovule-bearing wedge-shaped scales fused to the upperside of the cone bract.

Physical description of timber:
colour: sapwood is white and heartwood is light yellow brown
grain: growth rings are indistinct and the wood has a fine smooth texture and no figure. Compression and wet wood are common.
density: 530 - 560 kg/m^3
durability: class 4
wood: pH of the wood is 5.2. . Rays are fine and parenchyma are not visible.

Callitris columellaris/glauca
(Coastal/white cypress pine)
Occurrence: Cypress pine is found over a large part of eastern Australia from central-western Queensland to Victoria between latitudes 23 -38°S. However, the most extensive forests are found in southern Queensland and northern NSW. Cypress pine grows best in warm sub-humid to warm sub-arid climates with 220 - 750 mm annual rainfall at an altitude of 90 - 750 m. It is a hardy species and grows well on sandy or loamy soils, but can tolerate infertile or acidic soils. Pure stands of cypress pine favour gently undulating countryside but can be found alongside eucalypt species such as *E. crebra* and *Casuarina* species. In a three tiered forest, the eucalypts and *Angophoras* tower above the cypresses, while the wattles and sheoaks grow underneath.

Physical description of tree: This tree usually grows to a height of 15 - 20 m with a diameter of 0.3 -0.6 m. It has a conical shape crown with a straight trunk. The bark is dark grey, hard and deeply furrowed; it persists to the small branches. Its foliage consists of alternating linear leaves that are sharply pointed or triangular and grow in whorls of 3 to 4. They are grey-green in colour with stomata arranged parallel with the branchlets to minimise evaporation. The male strobuli are ovoid in shape and grow in threes at the end of branchlets. The female strobuli have 2 whorls of three scales that have longitudinal rows of ovules, and develop on thin stalks low on the branch. The mature cone is spherical, with alternating sets of three large and three small scales, containing 18 to 36 seeds. Cypress pine has a deep rooting system that allows it to survive drought conditions well.

Physical description of timber:
colour: sapwood is creamy and pale and wide, heartwood is light yellow to dark brown.
grain: very fine with an even texture and generally straight grained.
density: 680 kg/m^3
durability: class 1

wood:	Dark brown knots are common and the wood has a distinctive resinous odour and a slightly greasy feel. Growth rings and rays are indistinct.

Pinus caribaea var *hondurensis*
(Caribbean pine)
Occurrence: Native to Central America, Cuba and the Bahamas, Caribbean pine is grown in plantations in Queensland and northern NSW, as well as Melville Island in the Northern Territory. Wood density is lower at high altitudes. It grows best in tropical areas north of Maryborough in Queensland, and can tolerate poor soils.

Physical description of tree: Caribbean pine appears very similar in shape and structure to slash pine (*P. elliottii* var *elliottii*). It is finely branched, sensitive to wind damage and stem deformation, and has rapid growth during the first fifteen to twenty years of its growth.

Physical description of wood:

colour:	sapwood is pale yellow brown and heartwood is golden brown
grain:	coarse and uneven texture with straight grain
density:	500 kg/m^3.
durability:	class 4
wood:	high resin content. Growth rings are prominent. Numerous resin canals, and rays are fine but visible.

Pinus radiata
(Radiata pine)
Occurrence: This tree is a native of California but is grown extensively in plantations in southern Australia, in New Zealand and in Chile, because of the tree's adaptability. It has a rapid growth rate in cool moist fertile soils and favours rainfall exceeding 700 mm annually. It grows adequately on sandy soils; and can tolerate some salt spray and light frosts.

Physical description of tree: Radiata pine can grow to 40 - 50 m height and 1m diameter. It generally has good form with large spreading branches in whorls. The bark is red-brown to grey, thick, rough and deeply fissured, and sheds in scales. The foliage grows in fascicles of 3 triangular needles, which are stiff with a waxy cuticle. The male cones form in clusters of 20 or more at the tips of lower branches while the larger female cones are formed higher up the tree. The male cones seldom fertilise female cones from the same tree because they mature at different times.

Physical description of timber:

colour:	sapwood is pale yellow to white, heartwood is red-brown to yellow
grain:	straight grain; non-uniform with distinct early and latewood bands gives figure to backsawn timber
density:	450 - 580 kg/m^3
durability:	class 4
wood:	pH of wood is 4.0 - 4.8. . It has a fine texture and numerous resin canals giving it an pleasant odour. Radiata pine timber may twist because of spiral grain in juvenile wood.

Pinus pinaster
(Maritime pine)
Occurrence: native to SW Europe and NW Africa. Mainly found on Atlantic coast in France , Portugal and Spain, where it copes well with poor sandy soils. The plantations in Western Australia are on poor soils in lower rainfall areas unsuitable for radiata pine.

Physical description of tree: Maritime pine can attain 40 - 50 m height and 1m diameter. Its bark is generally more red-brown than grey, is deeply fissured and sheds in plates. The tree is similar to radiata pine with branches growing in whorls, but with 2 needles per fascicle.

Physical description of timber:

colour:	pale yellow sapwood and reddish brown heartwood
grain:	coarse, uneven texture with straight grain
density:	600 kg/m^3
durability:	class 4
wood:	resinous pockets and knots are common.

Pinus taeda
(Loblolly pine)
Occurrence: Loblolly pine is native to south-eastern USA, and is used as plantation softwood on the North coast of NSW, in Queensland and on the north island of New Zealand. It grows best in a sub humid to warm humid environment and an annual rainfall exceeding 700 mm.

Physical description of tree: Loblolly pine grows rapidly, attaining a height of 30 - 40 m with a 0.9 m diameter in approximately 40 years. It is similar in appearance to slash and Caribbean pine, with fine branching and deeply fissured red-brown to grey bark.

Physical description of timber:

colour:	sapwood light is yellow and heartwood is light reddish brown
grain:	fine and even textured with a straight grain
density:	550 - 630 kg/m^3
durability:	class 4
wood:	growth rings may not be prominent.

P. elliottii **var.** ***hondurensis*** **X** ***P. caribea*** **var** ***hondurensis***
F1 Hybrid
Occurrence: The F1 hybrid is a hybrid between slash and Caribbean pine parents, and is extensively grown in Queensland. It is the major plantation material since 1993.

Physical description of tree: The hybrid has similarities in appearance to both slash and Caribbean pine.

Physical description of timber:
as for the above pinus species

Information was gathered from the following references: *2, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 19, 24, 25, 33, 34, 36, 39, 42.*