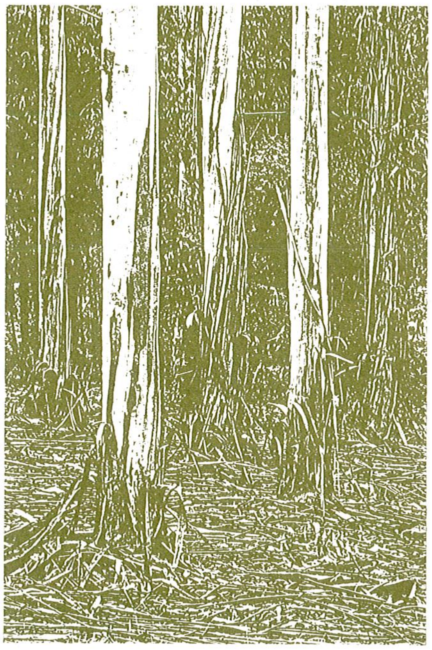
OUT OF THE WOODS



Concluding Report on the Small Eucalypt Processing Study

Wood Utilisation Research Centre

Department of Conservation and Land Management, Western Australia

EXECUTIVE SUMMARY

For the W.A. Department of Conservation and Land Management (CALM), the major goals of the Small Eucalypt Processing Study were:

- to establish markets for the thinnings from overcrowded regrowth eucalypt forests;
- to increase the supply of high-quality wood for furniture manufacture.

CALM believes it has achieved these purposes, on time and within budget.

CALM's Wood Utilisation Research Centre (WURC) first had to overcome a number of problems in converting small eucalypts into value-added products. The physical properties of the logs, including their small dimensions, make them more difficult to process than mature logs. At the same time, WURC decided that a resource-driven study was likely to prove fruitless, and took market demand as the basis of its work.

Research found that drying problems decrease sharply when board thickness is reduced, which resulted in WURC developing edge and face jointing of thin laminae into laminated panels. Market research supported the viability of such products.

There were three major commercial products of the Study:

1. VALWOOD®: Waste-reducing techniques were developed in each of the processing steps, resulting in efficiencies in log handling, sawing, drying and dimensioning. The whole process was registered as VALWOOD®, a name devised to represent the value-added nature of the new product. The name VALWOOD® was also registered to cover products of the process. Several of these have been developed, notably a range of furniture blanks, crossarms for transmission poles, and wide signboards. A business plan, prepared for a commercial VALWOOD® plant, indicated commercial viability.

2. CALM Drying System: As part of the research and development, a new concept of timber driers was developed. This CALM Drying System uses solar energy in low-cost driers suited to efficient low-volume operations. Research suggested a potential market of some 800 sawmills within Australia.

3. GUMTREE®: This is the name of a computer model, designed to demonstrate the integration of forest products industry sectors and thereby to highlight the areas in greatest need of research and development. Using GUMTREE®, the CALM Drying System was shown to be cost-effective for many small sawmills which would find conventional kiln drying uneconomical. The potential for adding value to additional wood resource is significant.

Apart from VALWOOD®, the CALM Drying System and GUMTREE®, the Study has developed other knowledge, techniques and facilities of value to industry:

- log-handling and stockpiling techniques to minimise damage
- experimental drying kilns to establish schedules for regrowth timbers
- several prototype facilities for monitoring moisture content at different processing stages (using gamma-rays, ultrasonics and microwave technology)
- modified processing techniques resulting in significant reductions in wastage
- 'feature' grade wood (offering great potential for opening new export furniture markets)
- establishment of some basic causes of wood decay
- establishment of many physical properties of regrowth timbers.

Using the market-driven strategy detailed in this report, we have successfully resolved many of the problems that face the forest products industry as the supply and nature of those resources change.

One of CALM's goals is to help the timber industry serve the Australian public by using forest resources more efficiently. To this end, WURC has shared knowledge resulting from the Study with industry and other research institutions (via papers, workshops, media coverage, lectures, etc.). The reactions have been most encouraging.

INTRODUCTION

In 1984 the Western Australian Department of Conservation and Land Management (CALM) established a Wood Utilisation Research Centre (WURC) based on a small sawmill and processing complex at Harvey, a rural town 140 km south of Perth. WURC is a Registered Research Agency, in the fields of:

- timber sawmilling technology
- timber seasoning and treatment processes
- forest resource studies
- application of timber residues, and
- development of value-added wood products.

The desire to improve the value-added processing of small eucalypts was stimulated by two factors:

- limited markets for thinnings from overcrowded regrowth forests, and
- chronic shortage of quality dry hardwood for furniture manufacture.

The need for such research and development work was reinforced by a Timber Utilisation and Marketing Task Force in its report to the Western Australian Government in 1984.

In 1985, the Forest Production Council, a joint private/government committee established under the CALM Act to advise the Minister, lodged an application with the Commonwealth Government for Public Interest Project funds for study to establish techniques and develop equipment to process commercially small eucalypt regrowth logs.

All Australian states were facing the crisis of diminishing supplies of mature hardwood, threatening to escalate the country's massive import bill, which already approached $2000 million annually. Predictions of global timber shortages, particularly in hardwoods, made the utilisation of regrowth forests an urgent necessity.

In Western Australia it was necessary to reduce the quantity of logs cut from mature native forests for the next 50-70 years in accordance with the Government's policy of achieving sustained yields. The timber industry, as a result, faced significant reductions in its traditional log resource (1987 Timber Strategy). Similar action was required in other states.

Because of their overstocked condition, many regrowth, or new generation forests, were growing slower than they could. To redress this situation there was a need to establish techniques for commercial processing of small logs.

The Small Eucalypt Processing Study (SEPS) was approved, and, under the terms of agreement with the Commonwealth, the State conducted the $4,631,000 four-year study. Funding came from three sources - one third from the Commonwealth, one third from the State and one third from separate arrangements between the State and organisations involved in the Western Australian timber industry.

The Australian Industrial Research and Development Board monitored the study through the State office of the Department of Industry, Technology and Commerce (DITAC). A Review Group comprising representatives from DITAC, CSIRO Division of Forestry and Forest Products, the Australian Timber Research Institute (ATRI), CALM, Curtin University of Technology and the Furniture Industry Association met every three months. The group considered technical and financial progress reports, and provided guidance and public relations support.

In a number of fields where expertise was not available within the study team, research and development was commissioned to outside research institutes and individuals.

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1: THE ACHIEVEMENTS

1. **Commercial Successes**
2. **Improvements to Techniques**
3. **Current Projects**

Timber research in the W.A. Department of Conservation and Land Management has one overriding purpose: to help the timber industry serve the Australian public while maintaining its adherence to principles of conservation. With the Small Eucalypt Processing Study, CALM believes it has achieved this.

The major goals of the Study were:

- to establish commercially viable markets for the thinnings from overcrowded regrowth eucalypt forests;
- to increase the supply of high-quality wood for furniture manufacture.

1. COMMERCIAL SUCCESSES

There are a number of achievements, two of which are ready for commercialisation. These are the CALM Drying System and the VALWOOD® process.

CALM DRYING SYSTEM

For an estimated 800 small hardwood mills in Australia, conventional drying kilns are not commercially viable, and in Western Australia less than 20 per cent of the hardwood produced is dried and used for higher value products. These are the sawmills to which the CALM Drying System is directed.

The CALM Drying System is a low-cost, low-energy timber-drying system run by solar power. It is backed by scientifically developed and practically tested drying schedules and control systems, and is custom-built to meet specific requirements.

The drying chambers are clad with double-skinned ultra violet (UV) resistant plastic, which is inflated to provide insulation without restricting the collection of radiated heat from the sun. Inside the chamber, the air circulates through timber stacks and is controlled by a patented system using a plastic blanket. Temperature, humidity and air speed are automatically adjusted to meet the requirements of the timber being dried.

It is proposed to manufacture the CALM Drying System in kit form and develop a DIY Manual for installation.

VALWOOD®

The name VALWOOD® has been registered as the trade mark for a sequence of timber conversion processing steps and for the resulting products.

In all Australian states except South Australia, stands of small eucalypts have regenerated following earlier harvesting of native forests. These regrowth stands may stagnate due to overcrowding and must be thinned out if the forest is to reach its maximum productivity. (A video entitled *An Investment in Timber* has been prepared to further illustrate the benefits of thinning and sound forest management.)

The VALWOOD® process uses these small eucalypt thinnings which presently have little or no commercial value. The VALWOOD® products are high-value panels custom-built to provide manufacturers with raw material which will improve the efficiency of their operations.

The VALWOOD® process uses thin boards laminated together on the edges and faces to build up panels. The panels are custom-built to suit single components, such as table tops, or for resawing to multiples of curved components.

Licences to produce VALWOOD® products will commit licencees to meeting strict quality control standards during the production.

CALM received a Gold Award for VALWOOD® at the 1990 Government Technology Event.

GUMTREE©

Another achievement is being used to provide commercial information, although it is not yet available as a commercial package.

This is the GUMTREE© computer model. GUMTREE© is an economic model of the sawmilling sector of the forest products industry. If refined for user-friendly operation and supplied with a user manual, GUMTREE© could be made available commercially. In the interim it is being used to study the economic benefits to sawmills of a range of timber drying options. Used in this manner, it is a valuable marketing tool for the CALM Drying System.

2. IMPROVEMENTS TO TECHNIQUES

A range of commercial processing techniques has been developed for converting small eucalypt logs into value-added products. The following is a summary of techniques which have been promulgated as recommendations to industrial users of regrowth eucalypts:

- Logs are best transported to sawmills with bark on and in tree lengths.
- Logs should be taken to sawmills within five days of felling.
- Sawmill log stockpiles need to be properly constructed and equipped with water spray facilities.
- Options for design of stockpile yards, water spray facilities and watering schedules have been developed.
- Advice is available on the efficient use and maintenance of sawmilling equipment when converting small eucalypt logs into value-added products.
- Schedules have been developed for drying a range of eucalypts (particularly regrowth eucalypts, which are more difficult to dry than mature wood). They include schedules to meet the stringent requirements of wood for furniture manufacturing.

- A 'feature' grade specification for furniture wood has been developed and demonstrated in a range of furniture items. This specification highlights the aesthetic benefits of natural wood features and at the same time provides a fourfold increase in the available supplies.

- The benefits of an enclosed humidified area for strip-stacking green boards were demonstrated and low-cost equipment developed for establishing these areas commercially.

- Improved recovery of value-added timber by the taper resawing of dry boards was demonstrated.

- Significant improvements in volume recovery by using a straightening planer in place of the conventional four-sider were demonstrated.

- The use of regrowth core wood for exposed-face furniture components was pioneered.

- Physical properties for a number of regrowth eucalypts were assessed.

- Recommendations for the commercial use of adhesives were made following a review and extensive testing.

- The rate of change in wood moisture content under different climatic conditions was assessed.

- A successful experimental kiln was developed.

- A sampling assessment technique for increasing the capacity of experimental kilns was developed.

- The use of high-pressure fogging equipment as a valuable technique in the initial stages of drying hardwoods was pioneered. This technique was established in a laboratory and later applied to a prototype commercial drying chamber.

- The design and construction of a gamma-ray densitometer was commissioned. This unit is used for non-destructive measurement of wood densities and moisture profiles in sample boards up to 150 mm thick. This is a laboratory instrument for use in wood drying research.

3. CURRENT PROJECTS

A number of unfinished projects show great potential for commercial development:

- Several species of fungi, including a number of basidiomycetes capable of destroying cellulose, have been isolated from discoloured wood in karri. When introduced to fresh wounds in healthy trees, some of these fungi cause decay in heartwood and/or sapwood in less than a year.

- In response to furniture makers' requests for improved quality control, the development of a low-cost, non-destructive, hand-held moisture meter was commissioned. The nearly completed prototype uses specific microwave frequencies.

- As a production quality control aid, CSIRO Division of Building, Construction and Engineering were commissioned to develop an instrument to detect variations in moisture content and density. The prototype, which measures microwave attenuation at high speeds, is completed. Its operation now depends on the construction of a transport mechanism and the development of specific algorithms.

- Work commissioned at the University of W.A. has demonstrated that measuring the velocity of ultrasonic waves could provide a reliable method of monitoring the moisture content of boards during the critical early stages of drying. The laboratory work is being tested in a drying kiln. Until now, the accurate measurement of moisture contents in timber above 30 per cent has been difficult.

- The development and quality assurance testing of a decorative and structural VALWOOD® beam has begun at the Curtin University of Technology. The beam is light and provides a service duct for electrical cabling.

- Successful strength testing of VALWOOD® crossarms for utility poles has been conducted. Accelerated weathering tests of crossarms are in progress at the Australian National University in Canberra.

A market-driven strategy was adopted for the Small Eucalypt Processing Study. This approach meant first finding out what furniture makers wanted, then setting out to meet this demand from available resources. This strategy was responsible for the high success rate achieved.

2: THE PROBLEMS

1. **Resource Characteristics**
2. **Logging Methods**
3. **Log Storage**
4. **Sawmilling**
5. **Drying**
6. **Processing**
7. **Manufacturing**
8. **Marketing**

The regeneration which followed the logging of virgin Australian hardwood forests resulted in surplus regrowth trees of many different species of eucalypts. The species used for much of the research and development work in the SEPS study was jarrah (*Eucalyptus marginata*). Most of the problems encountered resulted from the small size and young age of the trees, not from the choice of species, and are considered to be common to regrowth eucalypts around Australia.

This chapter summarises those problems addressed while developing a strategy for the study as a whole.

1. RESOURCE CHARACTERISTICS

JUVENILE WOOD

Most eucalypts are characterised by defective centre cores. The juvenile wood fibres and vessels laid down during the first 15-20 years of tree growth are smaller and have thinner walls than in the mature wood produced in later years. The juvenile wood has low strength properties, is brittle, and is subject to excessive collapse during drying. It is therefore unsuitable for most traditional solid wood uses and presently only commands markets for fuel, pulp and reconstituted wood products.

KNOTS

The juvenile core is also characterised by numerous knots. Traditional markets for appearance-grade hardwoods, unlike softwood markets, treat knots as defects rather than features.

SAPWOOD

The sapwood of many eucalypts, when dry, is subject to attack from the powder post borer (*Lyctus brunneus*). In others, the colour contrasts unfavourably with the heartwood. Sapwood therefore makes the wood less desirable for quality furniture.

GROWTH STRESSES

As with all hardwoods, the stability of eucalypt trees depends on the development of wood in tension around the perimeter of the trunk. When sawn lengthwise, tension is released and the resulting planks distort outwards. Boards which are backsawn (sawn tangentially) are said to 'bow' and those which are quartersawn (sawn radially) are said to 'spring' in response to this release of growth stresses. Eucalypts generally have high levels of stress and young trees more than mature ones.

DURABILITY

The resistance of heartwood to decay and insect attack is related to the type and quantity of chemical extractives in the wood. Although quantitative data is not yet available, the lower extractive levels of regrowth eucalypts (indicated by paler colour) may result in lower durability than established for mature wood of the same species.

DIMENSIONS

The small size of regrowth logs creates significant problems when using conventional logging and processing equipment, and it particularly accentuates the other problems of regrowth log characteristics discussed above.

DISCOLOURATION AND DECAY

The occurrence of discoloured wood is common in regrowth eucalypts. The effect of discoloured wood on wood strength, permeability and durability is not properly understood. There is evidence to suggest, however, that it may lead to decay. The problems are to identify any decay fungi involved, how they are introduced into young trees, and what control options are available. For high value appearance products, discoloured wood is undesirable.

INSECT ATTACK

Insects which attack living trees cause downgrading of the timber because of unsightly borer holes, introduction of fungi which can cause discolouration and decay, and, as a response to injury, the formation of kino deposits.

The powder post borer (*Lyctus brunneus*) is an insect which destroys the dry sapwood of some eucalypts. The greatly increased proportion of sapwood in small regrowth logs increases the risk that this insect may cause significant structural damage to timber products from susceptible species.

2. LOGGING METHODS

A reduction in log diameter is the most obvious problem faced when harvesting regrowth logs. Silvicultural needs, however, often require the removal of suppressed and deformed trees which will only produce short lengths of marketable quality logs. Small-diameter short logs significantly increase the costs of felling, log preparation, loading and haulage. Consequently the affordable royalty is greatly reduced.

3. LOG STORAGE

Environmental protection and disease control requirements in the forest frequently force sawmillers to stockpile logs. Small-diameter regrowth logs with high growth stresses are prone to damage from exposure in dry conditions, and splitting (particularly on the ends) is common. As the sapwood can also be attacked by borers, the stockpiling of regrowth logs compounds two major problems associated with eucalypts.

4. SAWMILLING

DEBARKING

This becomes more difficult and costly as the log diameter reduces. For protection of logs required for value-added products, it is desirable to leave the bark on, until processing can be started. This means debarking is best carried out at the sawmill rather than in the forest. The volume of bark on small eucalypts can be 30 per cent of the wood volume, which involves costly disposal.

SAWING

All aspects of conventional sawing are made more difficult by reduced log diameters and lengths. Sawn recovery, productivity and ability to meet the dimensions required by the market are all adversely affected. These problems are compounded by the increased growth stresses of young eucalypts. The release of growth stresses during the milling of flitches with circular saws often results in inaccurate sizing and excessive wear on saw spindles.

5. DRYING

STRIP STACKING

Excessive spring and bow makes it difficult to build square, stable stacks and results in warped boards.

WOOD PROPERTIES

When wide and/or thick boards are cut from small-diameter logs, they include a range of wood types such as juvenile, outer heartwood and sapwood. The small radius of the logs also means boards mostly contain some backsawn and some quartersawn material. All of these variations make shrinkage and drying rates more variable, and result in distortion which increases the need for weight restraint.

Wood from regrowth eucalypts is more prone to surface and internal splitting than wood from mature trees of the same species. This means longer, milder and more costly drying schedules.
Mechanical properties for eucalypts accepted for Australian Standards were established by sampling mature trees. It is not known whether these properties hold good for regrowth eucalypts.

MOISTURE CONTENT MONITORING

Mackay (1970) established that it is necessary to carefully regulate the drying rate of green eucalypt boards in the initial drying process if severe surface splitting is to be avoided. Brennan, Glossop and Hanks (1990) demonstrated that drying rates for regrowth jarrah and karri needed to be slower than for mature wood of the same species and that the most critical period occurred when the boards were wettest.

Conventional electrical resistance moisture meters are inaccurate when moisture contents are above fibre saturation point (about 30 per cent). Determining moisture contents by the oven-dried method is reliable, but impractical as a means of monitoring early drying because it takes at least 24 hours and is a destructive testing method. Alternative methods were obviously required.

6. PROCESSING

Most of the difficulties in dressing, gluing, resawing and sanding from regrowth eucalypts relate to the piece size and not to the wood property variations. Colour matching, when required, is adversely affected by the often wide range of colours within a single board of regrowth wood. Processing costs are adversely affected by small piece sizes.

7. MANUFACTURING

Small piece size and colour variation create the major problems for a manufacturer using wood from regrowth eucalypts.

8. MARKETING

Markets have not been established to absorb large quantities of furniture and other high-value goods manufactured from regrowth eucalypts. Indeed, in some markets where appearance quality counts, there is resistance to laminated products.

Some eucalypt species are considered unsuitable for value-added manufacturing, while others are not suited for pulp production. Where the product requires resistance to decay and insect attack, it may be necessary to increase the natural durability of regrowth wood by chemical treatment.

3: THE STRATEGY

1. **GUMTREE©**
2. **Market-Driven Study**
3. **Strategy Stages**

1. GUMTREE©

GUMTREE© is an acronym for General Utilisation Model of Timber Resource Economic Evaluation. It was developed to provide a perspective of the vertical and horizontal integration of the existing forest products industry. The attached table shows the relationship between production functions and research needs.

2. MARKET-DRIVEN STUDY

Using the GUMTREE© model, and in the belief that resource-driven studies are frequently protracted and fruitless, it was decided that market demand should be the driving force of the strategy. This fundamental marketing approach was considered to offer the best prospects for reaching a positive and commercial result within the constraints of time and funds available.

The SEPS strategy can be stated as: the adapted use of regrowth eucalypts to meet perceived market demands for value-added wooden products.

3. STRATEGY STAGES

STAGE 1: ESTABLISH THE GOALS

Identify target markets
Establish specific demands
Assess processing methods
Conduct literature reviews

RELATIONSHIP BETWEEN PRODUCTION FUNCTIONS AND RESEARCH

	MARKETS										MANUFACTURING						PROCESSING										LOG PRODUCTION			
	Fencing	Furniture	Fuel	Structural	Paper	Rounds	Packaging and Pallets	Panels	Seasoned Mill Products	Sleepers and Crossings	Housing	Furniture	Dimensioning	Panelling	Plywood	Paper	Fuel	Reconstituted Wood	Paper Pulping	Veneer Slicing	Veneer Peeling	Laminating	Sawmilling	Preservation - Sawn	Preservation - Round	Structural Rounds	Product 3 Logging	Product 2 Logging	Product 1 Logging	Integrated Logging
Dimensions																											●	●	●	●
Logging																											●	●	●	●
Log Storage																				●	●				●	●	●	●	●	●
Insects and Fungi	●			●		●				●													●	●	●	●				
Wood Properties			●									●			●	●			●				●							
Juvenile Wood		●		●				●	●																					
Knots		●		●				●	●						●					●	●		●							
Sapwood	●	●		●		●		●	●											●	●		●	●	●	●				
Growth Stresses	●	●		●		●		●	●											●	●		●	●		●				
Durability	●			●		●	●			●													●	●	●	●				
Weathering	●			●		●				●													●	●	●	●				
Permeability																								●	●	●				
Strength	●	●		●		●	●		●	●																●				
Debarking																		●	●	●	●									
Sawing															●								●							
Strip Stacking																							●							
Initial Drying																	●						●	●	●	●				
Final Drying												●			●							●	●	●	●	●				
Grading		●		●				●	●	●	●	●								●	●		●			●	●	●	●	●
Processing		●						●	●						●					●	●		●							
Manufacturing		●									●	●	●	●		●														
Solid Panel Production								●														●	●							
Stability				●								●										●	●							
Pulping Properties		●			●										●				●											
Slicing																				●										
Extractives						●		●				●							●											
Gluability		●						●				●			●	●		●				●								
Furniture Testing		●										●			●	●														
Market Surveys		●						●				●			●	●														

STAGE 2: ASSEMBLE RESOURCES AND DETERMINE STANDARDS

Equipment
Install R & D equipment
Commission R & D equipment
Staffing
Recruitment
Training
Wood Processing
Establish parameters for:
log storage
sawmilling
drying
dressing
gluing
wood quality

STAGE 3: RESEARCH AND DEVELOPMENT

Processing
Test promising options
Refine techniques
Produce prototype products
Equipment
Develop commercial prototypes
Resource
Quality evaluation
Quantity inventory
Marketing
Test prototype products - structurally
Establish market acceptance
Prepare a prototype commercial model

STAGE 4: SEEKING COMMERCIAL REALITY

Commercial development
Prepare business plan
Establish quality control specifications
Examine the impact on the environment
Market physical and intellectual property
Technological and scientific exchange
Meet the commitments of the Public Interest Project.

4: IMPLEMENTING THE STRATEGY

1. **Marketing**
2. **Processing**
3. **Eucalyptus Species Tested**

This chapter summarises results obtained by a variety of specific studies which have been published as separate reports. These are listed in full in Appendix 1. To simplify the presentation, the four stages of each of the separate processing topics are discussed. In practice there was a great deal of interaction between topics as the study progressed.

1. MARKETING

IDENTIFYING TARGET MARKETS

In 1983 Glass & Shedley conducted a comprehensive market survey of wood manufacturing in Western Australia. This survey revealed that about half of the 53,000 m^3 of solid wood used per annum was imported. Many manufacturers indicated a preference for the local timber, jarrah, but were not satisfied with the spasmodic supply, unsuitable dimensions and quality of timber from local suppliers.

A Timber Utilisation and Marketing Task Force set up by the W.A. Government in 1984 reported a long history of dispute between sawmillers and furniture manufacturers. The Task Force report (1984) recommended that expansion into export manufacturing would be desirable, resource permitting.

In the initial stages of the Small Eucalypt Processing Study, detailed discussions were held with the W.A. Guild of Furniture Manufacturers, and in May 1987 the SEPS Manager joined a study tour to Europe organised by the Guild. The study group found that potential for substantial markets for solid wood furniture existed overseas (Shedley 1990). In quantity, market preference was for light-coloured woods, but niche markets at high prices were opening up for dark red woods resulting from a world scarcity of the traditional timbers such as mahoganies and cherry.

EXPORT FURNITURE

These findings, and the need for expansion of manufacturing industries in Australia, were instrumental in setting the principal target as export furniture. The large-volume markets for light-coloured wooden furniture can be targeted with many eastern Australian species, while niche markets for the red cabinet woods are suited to jarrah and karri from Western Australia and some species on the east coast such as red mahogany (*E. resinifera*) and river red gum (*E.camaldulensis*).

The Guild then set up a Furniture Export Committee, which included representatives from CALM and the Department of Trade Development. This committee organised an exhibition of W.A. manufactured furniture in the 1988 Interzum Furniture Fair in Milan, Italy. This biennial trade fair is recognised as the most important in the furniture world. It attracts some 100,000 visitors, including buyers from most countries. Responses from exhibitors at Milan confirmed the findings of the 1987 study tour and highlighted the need for professional design standards.

When VALWOOD® (laminated furniture-blank material) was developed, several furniture manufacturers were approached to assist with a four-stage marketing strategy. It was proposed that different items of established popular designs be tested as follows:

1. Test the suitability of VALWOOD® panels for manufacturing.
2. Test the manufactured articles to international standards.
3. If the first two steps were successful, manufacture sufficient numbers to test local market acceptance.
4. Test interstate and overseas market acceptance.

Although time did not permit the completion of the program, a report by Lim (1989) describes the successful testing of a settee, built from jarrah VALWOOD® panels.

ESTABLISH SPECIFIC DEMANDS

The Glass and Shedley report (1983) had already established general market trends for requirements in wood manufacturing. A procedure given by Araman *et al.* (1982) was followed by the SEPS study in conducting a detailed survey of some major manufacturers. Complete details of the requirements for the most popular designs of furniture were obtained. The results given by Challis (1989) indicated that 84 per cent of demand is for lengths of less than 1 m, 95 per cent for thicknesses of less than 35 mm, and 76 per cent for widths of less than 100 mm.

These findings led the SEPS team to consider converting small short logs into wide blanks or furniture components. Cutting curved furniture components singly from individual boards involves excessive waste which can be avoided when several components are cut from wide panels.

LAMINATED FURNITURE BLANKS

The first edge-and-face-glued panels designed for furniture blanks were built up using 20 mm thick boards. Arrangements were made with several manufacturers to construct different items of furniture from the panels.

Although green boards of nominal 25 mm thickness from mature logs are relatively easy to dry, they show greater instability when cut from small regrowth logs. Some of the furniture built from the earlier panels showed a tendency towards this instability, although extensive stability testing of the whole panels produced satisfactory results.

Subsequent laminated panels using 10 mm laminae showed greater stability (see VALWOOD® Properties).

STRUCTURAL PRODUCTS

To provide outlets for value-added timber products other than furniture, it was also decided to target aesthetic structural beams. A recent increase in market preference for exposed beams in domestic and public buildings was seen as evidence that a potential market existed here too.

A project for a final-year structural engineering student at Curtin University developed the concept of a VALWOOD® box beam. The features and characteristics of the beam are described by Karpinski (1989) and include:

- aesthetic appearance
- light-weight
- central cavity to carry electrical and other services
- modulus of rupture and elasticity sufficient to meet the requirements of Australian Standards.

Further development and testing is required to establish working loads for these beams.

Crossarms for electrical transmission poles and wide signboards were two other structural products tested. The development of VALWOOD® crossarms involved rigorous quality assurance testing. Curtin University tested the strengths of 30 jarrah and 30 karri VALWOOD® crossarms. Siemon (1990a) determined the modulus of rupture and modulus of elasticity for these tests. He found the performance of 100 x 100 mm cross-section karri VALWOOD® crossarms exceeded the design criteria specified by SECWA for 125 x 100 transmission line crossarms, while half the jarrah crossarms achieved these criteria.

Accelerated exposure tests have been established at the Australian National University on sections of VALWOOD® and solid wood crossarms in an Atlas Weatherometer to simulate 10 years of weathering. Resorcinol, which gives a type A bond, was used as the adhesive and two species (jarrah and karri) are involved. Jarrah has a durability of class 2 and is comparatively easy to glue, while karri is class 3 minus and has variable gluability. These tests are not finished.

The testing of VALWOOD® signboards was carried out by practical field application. A range of board dimensions was constructed and tested at sites throughout Western Australia. The routed and painted signs were 30 mm thick for single-sided signs and 40 mm for double-sided. Although performance standards will take some years to evaluate, the results of the Weatherometer tests for crossarms can be assumed to relate to the signboards.

VALWOOD® PROPERTIES

When 10 mm laminae were used to build up furniture blanks, the product showed improved stability. This is thought to be due to easier drying resulting in uniformly dry, stress-free boards. The resulting VALWOOD® products were tested for stability by alternating between 20 per cent and 6 per cent equilibrium moisture contents each week for several months. Further international tests for strength and design were conducted on furniture carcasses at Curtin University, and accreditation certificates were issued.

Public acceptance of the laminated VALWOOD® furniture was gauged by exhibiting at the 1990 W.A. Furniture Fair, the Public Service Expo and several country exhibitions in 1989. This exposure was to some 70 000 people and the responses were overwhelmingly positive.

A display was also well received at the 1990 Government Technology Event in Canberra, at which a Gold Award was presented to the department for the VALWOOD® process.

VALWOOD® BUSINESS PLAN

A detailed business plan was prepared by Mr D. Gray of Scott Gray Pty. Ltd. for a VALWOOD® manufacturing process. As part of the marketing study, on which the business plan was based, Gray conducted 20 face-to-face interviews with furniture manufacturers. A wide range of furniture types was represented, and from the responses, Gray concluded that the process had high potential for commercial success.

2. PROCESSING

In examining successful results in other industries, it was apparent that vertical integration of the various sectors (tree growing, sawmilling, processing and manufacturing) would be of significant importance if regrowth eucalypts were to be marketed successfully. Accordingly, a range of industry advisory committees was established to assist in determining the R & D priorities, and to provide a wider expertise in all likely aspects of processing.

Previous research and industry experience interstate in processing regrowth eucalypts had indicated that recovery of value-added products was likely to be low. Accordingly, the need to look at residue utilisation needed close attention.

In all processing phases (sawmilling, drying, dressing, gluing and finishing) it was decided to establish equipment which would offer the greatest flexibility of approach.

New technology for drying timber without excessive internal or surface splitting appeared to be essential if value-adding was to succeed. Eucalypt timbers are notoriously difficult to dry and a great deal of effort by Australian research institutes was, and is, being made to establish economic drying schedules. It was therefore decided to contribute to this Australia-wide program, and invitations to participate in the Joint Timber Seasoning Committee established by the Forest Products Conference and the *ad hoc* seasoning committee established by the Australian Timber Research Institute were accepted.

A series of trials was initiated to determine the parameters necessary to minimise the degrade and productivity problems of the various steps in processing. The log dimensions for the study were mostly 150 to 300 mm small-end diameter under bark, and so generally smaller than normally utilised by industry.

LITERATURE REVIEWS

Of research conducted at other institutions around the world, that of Araman *et al.* (1982) on furniture blanks was selected as the most promising. The concept of 'dimension manufacturing' by experts in drying, dressing and gluing had particular appeal as most other research on small hardwoods was directed to producing structural products.

LOG STORAGE

Stockpiling evaluation was carried out by comparing the distortion, splitting and borer damage of sawn products converted from freshly cut and stockpiled logs. These initial trials showed conclusively that log degrade due to release of growth stresses, drying degrade and insect attack, is totally prevented by continual high-volume water spraying (Brennan,Glossop and Mathews 1990).

The studies then progressed to determining minimum water spraying requirements so that recommendations could be made for commercial schedules, showing that 15 minutes' high-volume water spraying in every three hours provided as much protection as continual spraying, without any adverse effects on log quality.

White (1990a) assessed high-pressure and low-pressure water spray systems for stockpiling.

SAWMILLING

Debarking

Because sapwood is a significant component of the wood volume of small regrowth eucalypts, a means of debarking was sought which causes minimum damage to the sapwood. Industry experience had indicated that processing debarked logs provides significant benefits in recovery and productivity in the sawmill. A literature review conducted by Amalgamated Mining Consultants (1987) indicated that ultra-high-pressure water jets might be an effective technique to handle a range of species. Offers to conduct trials with equipment developed by Dr A. Krilov were not accepted by the N.S.W. Forestry Commission, and as no other opportunity presented itself, this approach was not pursued. The cost and time limitations were considered too great to undertake direct development work.

Debarking in the forest is cost-efficient, but results in rapid drying and consequent splitting of regrowth logs, as well as increased problems from dirt and stones becoming embedded in the wood. The mechanical debarker assessed for some of the project logs was a modified Rosser head, developed by logging contractors R & N Palmer of Bunbury, W.A. The modification involves the staggering of the teeth on the head and results in an effective debarking with a minimum of damage to the sapwood. However, this method had two major drawbacks. The log must be rotated, making the method unsuitable for crooked logs, and the high cost makes it commercially unattractive.

A relatively low-cost chain flail debarker from South Africa shows considerable promise of a satisfactory unit cost and performance (White 1990b). Tests with this machine conducted by the agents, Bunnings Forest Products Pty Ltd, demonstrated good performance on a number of commercial species except for turpentine (*Syncarpia glomulifera*). To be suitable for regrowth sawlogs, the upper diameter limit of 300 mm of this machine would need to be increased.

Of the methods presently available, hand debarking of small crooked logs proved to be the most cost-effective and gave the minimum of sapwood damage.

Sawing

Early sawmilling studies by White on regrowth jarrah (1989a) and regrowth karri (1989b) using twin log-edger breakdown patterns, confirmed that recovery and value productivity were reduced when milling long logs was attempted. The release of growth stresses and the irregular shapes of many regrowth eucalypts were the main reasons for these results. Reduction in the length of logs improved recovery, but reduced the volume productivity for log-edger breakdown. Sawing trials of structural timber were done on other regrowth eucalypts, including marri (White 1989c), rose gum (Hanks 1990), Tasmanian blue gum (Thomson and Hanks 1990), and red mahogany (Raper 1990). Improved recoveries were obtained when the logs were sawn through and through (sap to sap) using a horizontal band saw. This method, however, resulted in more than half the boards splitting badly because of the release of growth stresses (Mathews 1990a).

The best results were obtained for cutting short logs (up to 2.4 m) using a pattern which produced backsawn boards from opposite sides of the log simultaneously, but totalling not more than 25 per cent of the diameter. The centre cant is then turned down and cut into backsawn boards with a reciprocating gang saw. Donnelly (1990) reported frame saw cutting accuracy is less affected by the relief of growth stresses during multi-ripping than circular saw edgers, and hence thinner gauges can be used. It is also possible to mill short logs without significant loss of productivity. For structural products where longer lengths are required, it is less suitable: the effects of taper when sawing parallel to the pith are adverse.

On logs up to 2.4 m in length, the taper is usually less than 20 mm. If boards are cut as thin as 14 or 15 mm (green size), as in the VALWOOD® system, taper sawing for the initial breakdown is not justified. Also, the crown-cut backsawn boards from parallel sawing produce the 'cathedral' grain pattern which is valued for appearance purposes.

Another important benefit arising from this cutting pattern is the reduced variation in thickness shrinkage which results from the majority of boards being backsawn. Because the thickness shrinkage is radial, green board dimensions can be reduced, improving recovery into dry boards (Mathews 1990a).

A number of green jarrah and karri centre cant flitches were sent to West Germany for cutting into thin boards by three different methods. Donnelly (1990) reported on the use of a reciprocating gang saw, slicing, and double arbor circular edging saws. He concluded the former was the most efficient for the VALWOOD® process.

Drying

Brennan, Glossop and Hanks (1990) showed that wood from regrowth eucalypts is more subject to drying degrade, in the form of surface splitting and warping, than wood from mature trees of the same species. A pilot study demonstrated that the juvenile wood of jarrah (the first 15-20 years of growth) has small cells with thin walls, and is particularly prone to excessive collapse shrinkage. The ratio of twice cell wall thickness to cell diameter was 0.36 for 5 year-old material and 0.59 for 40-year-old material. Wide boards cut from small trees contain significant variations in wood grain and quality. These boards are subject to more distortion during drying than those cut from large mature logs, which have fewer wood variations.

As with mature wood, many problems associated with drying increase significantly with board thickness. The amount of surface and internal checking, and the time required for drying all tend to increase exponentially with increasing thickness.

Brennan, Glossop and Hanks (1990) demonstrated for jarrah and karri regrowth wood that initial drying schedules need to provide milder conditions than for mature wood. Conventional schedules for mature wood, such as those published by CSIRO (Campbell 1980), result in too much surface checking to produce acceptable quality for furniture products. A curing period of high humidity prior to the application of these schedules is required. Even with this preliminary curing period, for regrowth jarrah and karri at least, the schedules are still too severe. Reducing board thickness from 40 mm to 30 mm will substantially reduce the drying time required to reach fibre saturation point. If board thickness is halved from 30 mm to 15 mm, drying schedules can be more radical and still result in reduced drying degrade. Mathews (1990a) showed that reducing the thickness from 16 mm to 13 mm reduced the time required to dry to fibre saturation point by 13 per cent.

High Temperature Drying

Hardwoods can be dried rapidly, from below fibre saturation point (around 25 per cent) to a final moisture content (around 10 per cent) using high temperatures. Research has confirmed that hardwood timber can only withstand wood temperatures exceeding 100 °C (termed high temperature drying) without severe internal checking, if it has first been dried at lower temperatures to moisture contents below the fibre saturation point. Drying schedules must ensure that no part of the wood is above these levels prior to commencing high temperature drying (Hanks 1989).

Collapse

The abnormal shrinkage resulting from cell collapse is common in juvenile wood of regrowth eucalypts, even in species for which the mature wood is not collapse-susceptible. In a pilot study, regrowth jarrah collapse was recovered by steaming when moisture contents were below fibre saturation point. Thomson (1989) demonstrated that maximum collapse recovery in 140 x 40 mm jarrah was achieved by steaming at wood moisture contents between 11 per cent and 16 per cent.

Drying VALWOOD®

Boards for the VALWOOD® process are cut green at 15 mm or less in thickness. Mathews (1990b) showed that these boards could be dried at far greater rates than 25 mm thick boards and with far less splitting. To capitalise on these advantages, a jet impingement drier was designed and constructed by two final-year mechanical engineering students at Curtin University (Burgess and Ellery 1989). The drier was installed as a research facility at the Wood Utilisation Research Centre. Parameters for the drier are:

- take boards singly (i.e. without strip stacking)
- apply continuous and variable weight restraint
- transport boards continuously
- apply hot air jets with velocities up to 25 m/s and temperatures to 150 °C
- provide reconditioning water sprays.

The design incorporates a reciprocal motion to simulate a long tunnel. Commissioning and testing is not completed.

CALM Drying System

The bulk of timber drying in Australia is carried out by large sawmillers with production capacities in excess of 10,000 m^3. Smaller sawmillers producing lesser quantities have found it financially unattractive to establish drying kilns, often because conventional kilns lose efficiency when scaled down. A survey of the major hardwood-producing states showed that there are more than 1000 hardwood sawmills in Australia. Of these an estimated 80 per cent have outputs of less than 10,000 m^3pa.

Increasing pressure for adding value to hardwoods implies a need for a low-volume, low-cost, low-energy drying system. The application to regrowth eucalypts is particularly significant due to the relative difficulty in drying this wood without excessive splitting, and the need to increase its use for furniture supplies.

The CALM Drying System specifically targets the perceived needs of small sawmillers and those with regrowth eucalypt resources. McDonald (1990) described the features of the CALM Drying System:

- Two layers of transparent UV-resistant plastic membrane are supported on a tubular steel framework to provide an airtight chamber.
- The two layers of plastic are kept apart by air blown between them. This creates an air-insulated solar collector outer cover.
- Inside the drier, one or two charges of timber stacks are covered by opaque plastic 'blankets' which efficiently baffle the stacks and direct the airflow through them.
- Air speed in the chamber is controlled by turning on or off one or more of several low-cost fans.
- Air speed through the charges is further controlled with different mesh screens attached to the open end of the blankets. This allows for different air speeds for two charges in the one chamber, if required.
- For drying below fibre saturation point, an additional fibre-insulated chamber is provided. When full of wood, this has high thermal inertia to store auxiliary heat provided by wood residue combustion.
- Control through a relatively low-cost programmable logic controller (P.L.C.) provides optimum drying conditions.
- Flexibility in capacity is provided by the blankets, which can accommodate differing dimensions and numbers of stacks within a charge. In addition, each chamber will handle one or two charges with equal efficiency.

Dressing

In Western Australia, skip-dressing of boards is specified for furniture grade hardwood (Forest Products Association (WA) 1986) . This process is required so that the major defect of surface splits can be readily identified. Industry practice to skip-dress with conventional four-sided planers has the disadvantage that boards are not straightened in the process. The Guilliet straightening planer used for the study at Harvey, by straightening and skip-dressing simultaneously, simplifies the process of grading for dimensional specifications. This type of planer, which has the first set of drive rollers situated after the bottom face cutter head, is recommended as offering the best recovery as well as more uniform dimensions.

Trials with a modern rotary planer were conducted in Yugoslavia and demonstrated that, although the technology is capable of reducing the amount of wood required to plane the board adequate for effective gluing, it has not been developed sufficiently for commercial production (Donnelly 1990).

Gluing

Using experience gained by many sectors of the forest products industry, it was decided to test the suitability and performance of commercially available adhesives. Two distinct product lines for regrowth eucalypts were considered. These are furniture components and structural applications.

a) Furniture Components

As many of the furniture components are exposed, the adhesive properties for these products were nominated as:

- colourless
- strength at least equal to the wood
- durable in internal situations
- not subject to creep
- moisture resistant as for type C plywood bonds.

b) Structural Applications

For these products the adhesive properties required were:

- waterproof as for type A plywood bonds
- strength greater than the wood
- durable in external situations
- not subject to creep.

In a review of current industry adhesive practice, Hillis (1990) recommended urea formaldehyde as meeting the requirements for furniture components, and resorcinol, phenol or tannin formaldehyde for structural applications.

A series of performance tests were carried out on two species, jarrah and karri, which are rated for gluability by Bootle (1983) as satisfactory and variable respectively. Newby and Siemon (1989) reported on a range of commercially available adhesives tested to Australian Standard cleavage tests and confirmed the recommendations of Hillis (1990) for jarrah. Early indications are that karri's variable gluability will be overcome by reducing the moisture content to 8 per cent or less. This agrees with results conducted by the Plywood Association of Australia (Lyngcoln personal communication) for some hardwoods in N.S.W. that are difficult to glue.

Accelerated long-term stability was simulated by weekly cycling between high humidity (20 per cent e.m.c.) and low humidity (6 per cent e.m.c.) environmental chambers (Newby 1990). Significant dimensional changes in the glued panels were observed but the recommended adhesives maintained their structural integrity.

A laminated settee of regrowth jarrah using urea formaldehyde was successfully tested to international standards by Curtin University (Lim 1989).

Sections from 12 utility pole crossarms (six jarrah and six karri), laminated using resorcinol formaldehyde, were exposed to accelerated weathering by the Australian National University in Canberra. At 1000 hours' exposure in an Atlas Weatherometer, it was apparent that surface defects in either solid or laminated wood must be avoided or coated. The trials are continuing.

Thirty jarrah and thirty karri crossarms were strength-tested at Curtin University with no glue line failure in either species when tested to failure. Siemon (1990a) established that the MOR and MOE exceeded those for solid mature wood and with a considerably lower spread of results.

Waterproof glues (resorcinol, phenol or resin formaldehydes) were used for outdoor products where the appearance of dark glue lines is unimportant.

Wood Quality: Grading for Value-Added Products

As a starting point, the specification for Furniture grade 1 of the W.A. industry specifications TASG4 (Forest Products Association (WA) 1986) was used. This specification had been drawn up a few years earlier as a joint exercise by CALM, the Forest Products Association and the W.A. Guild of Furniture Manufacturers. The SEPS team set about amending these grade rules in several key areas:

- Restrictions on sapwood were particularly harsh on the recovery from regrowth logs. The restrictions had been established on appearance grounds only, and considering that most manufacturers stain their products to a uniform colour, it seemed reasonable to relax the requirement.
- Moisture contents of 12 per cent were shown to be too high to produce stable wood, particularly for some major overseas markets. Guided by recommendations from the United States, it was decided to adopt a target of 8 per cent for all glued furniture components.
- The tightening of moisture content requirements then made it possible to relax a number of restrictive specifications on other characteristics such as tight knots and birds-eyes, which are stable when dried to 8 per cent.

Draft amended grade rules were drawn up and submitted to an industry workshop with a wide representation from sawmillers and furniture manufacturers. This workshop elected a committee of CALM and industry people to refine the amended specifications.
Several items of furniture were then constructed using the draft specifications, to test market reaction to the modified grade. This strategy has not been completed.

Mechanical Properties

To confirm that wood from regrowth eucalypts could be substituted for that from mature trees and meet the requirements of Australian Standards, a series of strength tests was conducted at Curtin University.

The tests were conducted on three Western Australian eucalypts, jarrah, karri and marri. Samples of green and dry wood from mature and regrowth trees were tested.

The results reported by Siemon (1990b) confirmed the published strength properties (Modulus of Rupture, Modulus of Elasticity, Maximum Crushing Strength) for the mature wood and indicated that these properties in regrowth wood samples were similar.

Biodegradation

Discoloured wood is common in natural regrowth and plantation grown eucalypts. Davison (1990), in a search for causes and control, isolated some eighteen fungi from brown wood in karri. A number of these are basidiomycetes with the ability to cause wood decay.

3. EUCALYPTUS SPECIES TESTED

Most of the research and development work was conducted on jarrah (*E. marginata*). Other species tested to varying extents were:

- karri (*E. diversicolor*)
- marri (*E. calophylla*)
- wandoo (*E. wandoo*)
- Tasmanian blue gum (*E. globulus*)
- mountain ash (*E. regnans*)
- brown mallet (*E. astringens*)
- rose gum (*E. grandis*)

5: INFORMATION EXCHANGE

1. **Publications**
2. **Technical Groups**
3. **Liaison with Research Institutions**
4. **Workshops and Seminars**
5. **Educational Tours**
6. **Media Coverage**
7. **Guest Lectures**
8. **Videos**
9. **Exhibitions**
10. **Technology Exchange Events**

To meet the undertakings of the Public Interest Project, action was taken to transfer acquired technology to industry, research and other Government bodies, educational institutions, politicians, crafts people and the general public.

The two-way information exchange which resulted from the feedback proved valuable in determining the needs of consumers and was used to modify research procedures.

Information exchange for the project was achieved by written, spoken and visual means.

1. PUBLICATIONS

WURC NEWS

This was published irregularly as a low-cost newsletter which summarised other published reports. It had a widespread distribution and proved popular with industry people.

WURC REPORTS

These detailed reports covered significant R & D programs by WURC staff. The distribution included industry associations and the libraries of educational and research institutions.

WURC TECHNICAL REPORTS

Pilot studies and prospects of slightly lower scientific standard were given a more limited distribution. Readers were advised of the titles and synopses in *WURC News*.

Consultants' Reports

Where applicable, these reports were published as WURC Reports under the authorship of the consultant concerned.

Progress Reports to the Commonwealth Review Group

Quarterly reports on the technical and financial progress were made to the Commonwealth Review Group. This group comprised representatives from the Department of Industry, Technology and Commerce (DITAC), CSIRO (Division of Forestry and Forest Products), Australian Timber Research Institute (ATRI), Curtin University of Technology, the Furniture Industry Association, and the Department of Conservation and Land Management (CALM).

Magazine Publications

Several articles were published in *Landscope* (CALM's conservation and wildlife magazine) and in the *Australian Forest Industries Journal.*

2. TECHNICAL GROUPS

Small groups of industry people were invited to advise in a number of specialised fields. They met with management and research staff in the early planning part of the Project. Groups covered the fields of:

- stockpiling
- sawmilling
- drying
- small kiln development
- processing
- marketing
- computer modelling
- promotion.

These groups provided valuable guidance in determining priorities when planning specific research working programs.

3. LIAISON WITH RESEARCH INSTITUTIONS

The CSIRO Division of Forestry and Forest Products was very helpful in sending different specialists to represent it at the three-monthly Commonwealth Review Group meetings held throughout the Project. This Division and the Division of Building Construction and Engineering were commissioned to carry out some of the R & D in which they specialised. Opportunities were taken on several occasions to visit these and other eastern states' research laboratories to discuss aspects of the project's work.

Joint Timber Seasoning Committee meetings were attended in Melbourne, Gympie, Hobart, Sydney and Rotorua, New Zealand, during the project's duration. These provided excellent forums for exchange of timber drying technologies and opportunities for discussion with experts in other fields of timber technology in Government and industry.

A seminar on Western Australia's wood resources and commercial opportunities was jointly arranged by CSIRO Division of Forestry and Forestry Products, CALM and the Forest Products Association (WA). The Gottstein Trust arranged for a Fellowship tour and a Fellowship report. Each of these functions provided opportunities for visiting experts to inspect the project's operations and give valuable advice.

Staff of the University of W.A., Murdoch University, Curtin University, the Australian National University, Melbourne University and Chisholm Institute of Technology were commissioned to conduct certain specialised research and development work. The resulting interchange of ideas was invaluable.

The necessary understanding of the manufacture and marketing of wooden furniture was obtained by commissioning a number of furniture manufacturers to construct quality items, and by frequent liaison with the Furniture Industry Association, the Department of Trade Development, the Technology and Industry Development Authority, Austrade, Technical and Further Education colleges, and the Forest Products Association (WA).

4. WORKSHOPS AND SEMINARS

Workshops and seminars were conducted on a range of subjects covered by the project. These included small log harvesting, log stockpiling, sawmilling, drying, small kiln design, dry processing, moisture profiling, utility pole testing and feature timber grading.

In some cases these events resulted in industry adopting techniques which had been developed. All were well attended and provided the project team with excellent feedback.

5. EDUCATIONAL TOURS

Frequent tours of the Wood Utilisation Research Centre were conducted during the project. Visiting groups included schools, technical college students and staff, wood turners, fine wood crafts persons, furniture manufacturers, State and Commonwealth officers, politicians, scientists, conservationists, overseas delegations and the Resources Commission.

6. MEDIA COVERAGE

Several radio and TV interviews were undertaken, and a number of press releases and feature articles were published.

7. GUEST LECTURES

Guest lectures were given to schools, technical colleges, wood turners, wood carvers, crafts groups, conservation groups and social clubs.

8. VIDEOS

Two 'Timber Talk' videos were made. These showed an outline of the project and the environmental case for utilising thinnings from regrowth forests.

9. EXHIBITIONS

In the third and fourth years of the project, it was possible to make public exhibitions of the VALWOOD® process and products.

Major displays were made in 1989 to the W.A. Furniture Exhibition, the Public Service Expo, and to the Fine Woodcrafts Exhibitions in 1989 and 1990. Surveys were conducted which showed a favourable reaction from the estimated 70,000 viewers.

A display was exhibited at the 1990 'Technology in Government Event' in Canberra. A special Gold Award was received in recognition of the environmental benefits of the VALWOOD® process.

Semi-permanent displays were placed in the Manjimup Timber Museum and at some CALM offices.

10. TECHNOLOGY EXCHANGE WORKSHOPS

An afternoon/evening function was held for sawmillers and furniture manufacturers in Perth at the end of March 1990. This technology exchange offered a full coverage of the Small Eucalypt Processing Study to the Western Australian forest products industry. It included Gottstein reports on related subjects by Dr. Barbara Ozarska and Mr Andrew Rozsa.

Similar workshops featuring opportunities for industry to benefit from the technologies are being held in Adelaide, Melbourne, Sydney, Brisbane and Launceston.

The presentation of scientific papers is planned for the Forest Products Research Conference in Melbourne in November 1990.

6: FINANCE

Funding for the S.E.P. Study of $4,631,000 was shared equally between the Commonwealth, the State and the Australian timber industry over a period of four years.

Under the terms of the agreement the State maintained:

(i) proper accounting records facilitating authorised officers reasonable access to the records.

(ii) quarterly financial statements.

(iii) records of property acquired or constructed during the period of the grant.

(iv) statement of liabilities.

To maximise control, both budgets and expenditure were broken into easily identifiable components.

Budget was controlled under three main subdivisions:

(i) capital works on construction - this included site improvements, major equipment modifications and new equipment purchases.

(ii) labour - to control expenditure the labour components were assessed and separated from the main budget to facilitate easier control, and

(iii) materials - this group included all other expenditure not directly related to labour or capital works.

A detailed budget was prepared at the start of the project to conform with the approved grant.

Expenditure - was broken into the major functions of:

Log handling
Sawmilling
Wood drying
Processing
Wood qualities and properties
Promotion, marketing and administration
Capital construction

This is demonstrated in the following cost statement and graphed expenditure.

Some departure from the budgeted program occurred due to delays in material supply and sub-contract work. These did not affect the final outcome.

General

Overall, the S.E.P. Study achieved its objectives within the required time frame and within budget.

Finances were managed and matched to a staged programme to ensure that no overrun would be incurred, and consequently some programmes were deferred and some carried by CALM.

S.E.P. STUDY - ORIGINAL BUDGET PROPOSAL

The costs involved with this phase cover labour, consumables and contract costs.

The labour requirements in year one during the construction phase were estimated to be three salaried staff and five wages. As the additional facilities became available for the research operations, the salaried staff needs were estimated to increase to five and the wages employees to eight.

	Year 1	Year 2	Year 3	Year 4	Total
LABOUR					
Salaries	135 000	243 000	262 000	284 000	924 000
Wages	150 000	259 000	280 000	302 000	991 000
Total	285 000	502 000	542 000	586 000	1 915 000
MATERIALS					
Fuel, power & water	30 000	70 000	77 000	86 000	263 000
Mobile plant	35 000	65 000	70 000	77 000	247 000
Sundries	5 000	15 000	17 000	20 000	57 000
Total	70 000	150 000	164 000	183 000	567 000
CONTRACTS					
Logging	60 000	160 000	175 000	190 000	585 000
Strength & durability testing	15 000	22 000	25 000	35 000	97 000
Publications & Sundries	5 000	58 000	64 000	95 000	222 000
Total	80 000	240 000	264 000	320 000	904 000
Research total	435 000	892 000	970 000	1 089 000	3 338 000
Construction total	1 245 000				1 245 000
GRAND TOTAL	**1 680 000**	**892 000**	**970 000**	**1 089 000**	**4 631 000**

SUMMARY OF TOTAL S.E.P.S. EXPENDITURE

Log handling	245736
Sawmilling	409794
Wood drying	583310
Processing	737781
Wood qualities and properties	313669
Promotion marketing and administration	1285421
Capital construction	1317277
Sub total	4892988
Balance expenditure carried by CALM	261 177
TOTAL	**4631811**

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APPENDIX 1: FACILITIES & STAFF

1. **WURC Equipment**
2. **External Resources**
3. **WURC Staff**

1. WURC EQUIPMENT

Most of the existing equipment at the Wood Utilisation Research Centre was retained, modified or refurbished as required, while some was replaced with new items more suited to converting small logs. Having equipment suited to testing a range of processing options under controlled conditions was considered more important than obtaining high production rates.

The principal items of equipment at the Wood Utilisation Research Centre which were available for the study.

Stockpiling

- Clay-lined water storage dam of approximately 750 m3 capacity. Remote auxiliary water supply pump. Direct coupled centrifugal 50 mm inlet, 50 mm outlet.
- Electric motors 7.5 kW 2880 RPM.
- Emergency float valve scheme water supply. Pump house with three in-line 50 mm centrifugal pumps.
- Aluminium irrigation mains (125 mm) and spurt pipes (75 mm).
- Oscillating sprinklers on stands complete with hoses.
- Reticulation controller with solenoids, valves and cables.
- Hard surfaced 100 m x 50 m log storage area. Water run-off return half drain and settling pond.
- Caterpillar log loader with fork and bucket attachment.

Sawmilling

- Forestor 150 horizontal bandsaw. 18 Gauge 150 mm wide band.
- Overhead pillar and boom crane (two tonne).
- Eilbeck overhead beam twin circular saw log-edger suitable for logs from 100 mm to 400 mm dia, from 1.2 m to 5.4 m length.
- Jonsered vertical band resaw with face-cutting facilities, suitable for maximum depth of 205 mm, maximum width of 800 mm, minimum thickness of 15 mm. 18 gauge 150 mm wide band.
- Bruks four blade chipper and storage bunker. Model 1300M with Varitron solid state motor controller and Detec electric metal detector model HFE .06.
- Pendulum air docker. 700 mm dia. blade.
- Enclosed insulated evaporation air conditioned docking and stripping room.
- 20 m3 capacity curing tent with fogging and ventilation for green timber storage.
- Circular saw breast bench. 1020 mm dia. Eight gauge 54 teeth saw.
- Nolex docker S/N 2369.
- A VALWOOD® Taper Trimmer

Research Drying

- Tunnel kiln, eight bay (2.2 long x 1.2 x .800 high) with recirculated air flow, evaporative air conditioning and platform scales.
- Tunnel kiln, 10 bay (2.2 long x 1.2 x 800 high) with straight through air flow with staged fogging and platform scales.
- Batch kiln 0.5 m3 with electronic data logging and control of heating (ambient to 100°C) - fogging, steaming and airspeed (0.2 to 3.0 m.p.s.).
- Experimental high temperature kiln 0.5 m3 with P.L.C. control of heating and venting (ambient to 150°C) steaming and variable reversible air speed to 5 m.p.s.
- Steaming chamber - 0.5 m3.

Commercial Kilns

- A-frame steaming chamber (20 m3 capacity) with controls and a return flame, oil-fired, steam generator.
- High temperature ferro-cement kiln chamber (20 m3 capacity) with Radco oil-fired thermal oil coil heat exchanger and controls.
- Prototype Mark I CALM Drying System (20 m3 capacity) Solar/blanket design with L.P.G. gas booster to 60°C. PLC controller.
- Prototype Mark II CALM Drying System - three chambers (each 80 or 160 m3 capacity) (Ambient to 70°C) Solar/blanket design with solid fuel water heating booster. PLC controller and data logger.

Drying Instruments and Support Facilities

- Two Electric element ovens
- One Microwave oven
- Micromac 5000 kiln controller, data logger with PC and monitor
- Insulated, air conditioned drying progress inspection room
- Simons co electric boiler (80kw) for research kilns
- MEE 1000 fogging generator and 1000 p.s.i. reticulation
- Vertical wood worker sample preparation bandsaw
- Wood sampling/slicing guillotine
- Two Precision electronic balances
- Platform scales (1.5 tonne) (additional to those in tunnel kilns)
- Large precision calipers
- Small precision calipers
- Bollman electrical resistance moisture meter (temperature compensating)
- Portable ultrasonic transmission and moisture content measuring equipment
- Custom-built wet and dry bulb hygrometers
- Viva 20 capacitance moisture meter
- Anemometer
- Gamma ray densitometer
- Fork lift four to five tonne
- Gann temp compensations moisture metre

Wood Quality

- Video camera recorder and monitor with log table and remote controlled overhead scanning track.

Dry Processing

- Mida P4E conventional four sider planer
- Guilliet straightening, random width, four sider planer
- Radial arm docker saw
- Robinson air docker
- Cadet rip-saw bench
- Bag type portable dust extraction system
- Fixed fully ducted dust extraction system
- Two stability testing chambers (six per cent and 20 per cent e.m.c.)
- Hilleng proofgrader
- RPPA Static bending tester
- Hombak buzzer/edger with power feed
- "Kambro Panel saw
- "Kambro" thicknesser (800 mm)
- World-Max Wide belt sander (800 mm)
- Electronic balance for glue mixing
- Glue applicator
- Manual clamp glue press
- Orma universal hot oil press (2.4 m)
- Prototype in-line moisture detection meter and PC controller
- Prototype hand-held microware moisture meter
- Bollman needle/hammer moisture meter

Management

- Four personal computers and work stations
- Olivetti typewriter
- Facsimile machine
- Commander telephone system
- Two Printers

2. EXTERNAL RESOURCES

The broad field of the strategy meant that in many areas the necessary disciplines and expertise were not available 'in house'. Consequently the following organisations and specialists were commissioned to conduct some specialised areas of research and/or development.

Amalgamated Mining
ARANDA & Associates
Australian National University
Chisholm Institute of Technology
CSIRO - Division of Building Construction and Engineering
CSIRO - Division of Forestry and Forest Products
Curtin University of Technology
Forest Commission of NSW - Division of Wood Technology & Forest Research
Hillis, Dr W.E.
Leederville College of TAFE
McKenzie, Dr W.M.
Melbourne University
Murdoch University
Scott Gray Pty Ltd
University of W.A.
Vibrasound
Whittakers Ltd

3. STAFFING

RECRUITMENT

At the commencement of the SEP Study, the following staff were available for a significant direct involvement.

Manager: Phil Shedley, BSc (For.), Dip. For., MIFA, AIWS
Principal Research Scientist: Graeme Siemon, PhD BSc (For) (Hons) MIFA AIWS

Gary Brennan BSc (For) MIFA MIWS	
Des Donnelly MIWS	
Brett Glossop BSc	replaced by Judy Pitcher
Kevin White MIWS	
Lex Mathews	
Trevor McDonald B App Sc (Mech Eng)	
Don Challis BA	replaced by T. Jones
Alan Thomson BSc (For)	replaced by B Glossop BSc
Vic Combs	replaced by J. Dorlandt
Elaine Davison PhD BSc	
Francis Tay BSc (Hons)	
Trevor Bamess	(mill crew)
Des Robins	" "
Ian Charchallis	" "
Keith Wallam	" "

To meet the time constraints associated with funding, the following additional staff positions were established:

Diane Gibson BSc Dip Comp	replaced by G. Godfrey
Cecil Scott PhD	replaced by M. Tucek BAg.Sc (Hons)
Wayne Hanks	
Steve Raper BSc (For)	replaced by
Steve Ward B.App.Sc. (Biol)	
Amelia Oberthur	replaced by C. Summerell
Peter Newby	
Rodney O'Keefe	(mill crew)
Danny Lee	" "

TRAINING

Various programs were undertaken to equip the staff for efficient research and development for the Small Eucalypt Processing Study. These included literature reviews, courses in statistics, scientific writing, wood science and various aspects of word processing and marketing.