



The Cost Benefits of Small Log Processing

Laminated Three-ply Flooring

- A Case Study in WA

**A report for
the RIRDC/Land & Water Australia/FWPRDC
Joint Venture Agroforestry Program
and
*The Wood and Paper Industry Strategy
- Industry Development Program***

By Phil Shedley

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Foreword

While the Federal Government's agroforestry programs typically aim to integrate sustainable and productive agroforestry within Australian farming systems, the aim of the Wood and Paper Industries Strategy - Industry Development Program is to make commercial use of agroforestry products. This project successfully coordinates the aims of both programs.

The project was funded by the Joint Venture Agroforestry Program (JVAP), the Wood and Paper Industries Strategy (WAPIS), Western Australian Government instrumentalities and forest products industry private sector participants.

Eight year-old southern blue gum in 600 mm rainfall zone
(This photograph is reproduced in colour at the back of this publication)



Acknowledgments

The following industry and Western Australian Government participants carried out all the activities of the project and provided 55% of the funding by way of in-kind contributions.

Access to facilities and contributions are gratefully acknowledged.

Primary Researcher and Project Manager:

Valuwood International Pty Ltd - Developed project concept, conducted all primary research activities, undertook overall project management and group coordination, recording of data and preparation of project reports.

Major Participants:

Forest Products Commission of WA – Timber Technology Centre - for log harvesting, portable saw cant production, lamellae drying, technical and scientific advice, product testing and market analysis.

West Australian Department of Conservation and Land Management – Farm Forestry Unit - for providing plantation costs and silvicultural advice.

Inglewood Products Group - for lamination, polishing and marketing advice.

Pinetec - for log conversion and lamellae production.

D & L Jamieson - for the development of a computerised cost modeling system.

Water and Rivers Commission - for the supply of logs.

Australasian Furniture Research and Development Corporation (Furntech) - for product testing.

Other Participants:

Hamilton Sawmills - for market advice.

Forest Industries Federation of WA - for market testing.

Macquarrie Corporation - for the provision of a portable sawmill.

Boral Brickworks - for the use of an autoclave.

Smorgan ARC - for the development of lamellae racking sheets.

Peter Eckersley of AgWA - for advice on farm forestry modeling.

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Abbreviations

ABS	Australian Bureau of Statistics
AFRDI	Australasian Furniture Research and Development Corporation (Furntech)
CALM	Conservation and Land Management - Western Australia
EWf	Engineered Wood Flooring
FPC	Forest Products Commission - Western Australia
FWPRDC	Forest and Wood Products Research and Development Corporation
ITTO	International Tropical Timber Organisation
MAI	Mean Annual Increment
MDF	Medium Density Fibreboard
SEDUB	Small End Diameter Under Bark
SWOT	Strengths, Weaknesses, Opportunities and Threats

1 Executive Summary

Hardwood plantations in the last two decades have expanded rapidly in Australia, largely in response to a demand for pulpwood and partly as a means of lowering the water table in salt affected agricultural land.

The 1997 FWPRDC report entitled "Adding Value to Small Eucalypt Logs" concluded that juvenile eucalypt wood is technically suitable for laminating into value added products. It identified laminated flooring as having the best potential as a market for the juvenile wood, additional to that of pulpwood.

To test the finding of the previous FWPRDC study, this project conducted a case study for the manufacture and testing of laminated three-ply flooring from the common pulpwood species southern blue gum (*E.globulus*). In order to apply the results to other species and growth situations it developed VALUFLOOR®, to model all the commercial cost parameters from establishing plantations through log processing and manufacturing to the laying of floors.

Trees from plantations of 6, 8 and 10 year-old southern blue gum (*Eucalyptus globulus*, Labill.) and 12 year-old Maritime pine (*Pinus pinaster*, Aiton.) were harvested for the manufacture of 150 square metres of pre-finished three-ply laminated floating-floor panels.

Laboratory testing to international standards was conducted on the panels and demonstration floors were laid to assess the market acceptability of the finished product.

A detailed and comprehensive VALUFLOOR® software model was written to analyse the cost parameters of all the processes involved from plantation establishment, through log conversion and manufacturing, to the distribution and laying of floors.

Potential markets for floating floors and other related floor types were evaluated.

The potential for the processes to be applied for commercial utilisation of juvenile eucalypts was assessed.

The conclusions reached are:

2 Introduction

In recent years, southern blue gum (*Eucalyptus globulus*, Labill.) which has the standard trade name of southern blue gum has been extensively planted in Western Australia on cleared farmland as an alternative to traditional agriculture. The primary driving force has been the availability of attractive markets for wood chips for pulp and paper and the taxation benefit entitlement of the investment. This government assistance has been driven by the need to reduce the effects of increasing salinity in many agricultural regions caused by the clearing of native deep rooted perennial vegetation and subsequent rising water tables. The rapid increase in blue gum plantation areas in recent years has led to many economists predicting reduced demand for wood chips and a consequential reduced price to the growers. This prospect has stimulated the search for alternate markets. For this reason and because of its ready availability, blue gum was selected for this study.

Although blue gum is planted in many countries around the world, it is almost exclusively used as furnish for paper pulp and is not considered suitable for sawlogs due to high growth stresses and severe collapse during drying. A FWPRDC 1997 study "Adding Value to Small Eucalypt Logs" (1), however, demonstrated the technical suitability of juvenile blue gum for processing into laminated flooring provided the lamellas are cut green. It also produced evidence of a strong worldwide and expanding market for laminated floating floors.

Maritime pine (*Pinus pinaster*, Aiton) has also been widely planted in Western Australia. It is a species well suited to the Mediterranean climate and tolerates the poor infertile sandy soils of the coastal plain and the lower rainfall zones of much of the salt affected inland wheatbelt. Extensive areas of maritime pine are presently being established in the 400 to 600 mm annual rainfall zones of the wheatbelt as a means of lowering the water table to reduce salination. Due to the difficulty of obtaining reliable adhesive bonding of eucalypt to eucalypt in laminated flooring, it was felt necessary to have a central core lamella of softwood. Also markets will be needed for the early thinnings from these maritime pine plantations and hence the testing of this species as core material for laminated floor panels.

This project uses a computer model to examine all costs from growing trees to the installation of floors and the prices paid by the consumers. Other researchers studying the economics of farm forestry have tended to terminate their review at the point of sale of sawn timber, without following through the further processing to the end products.

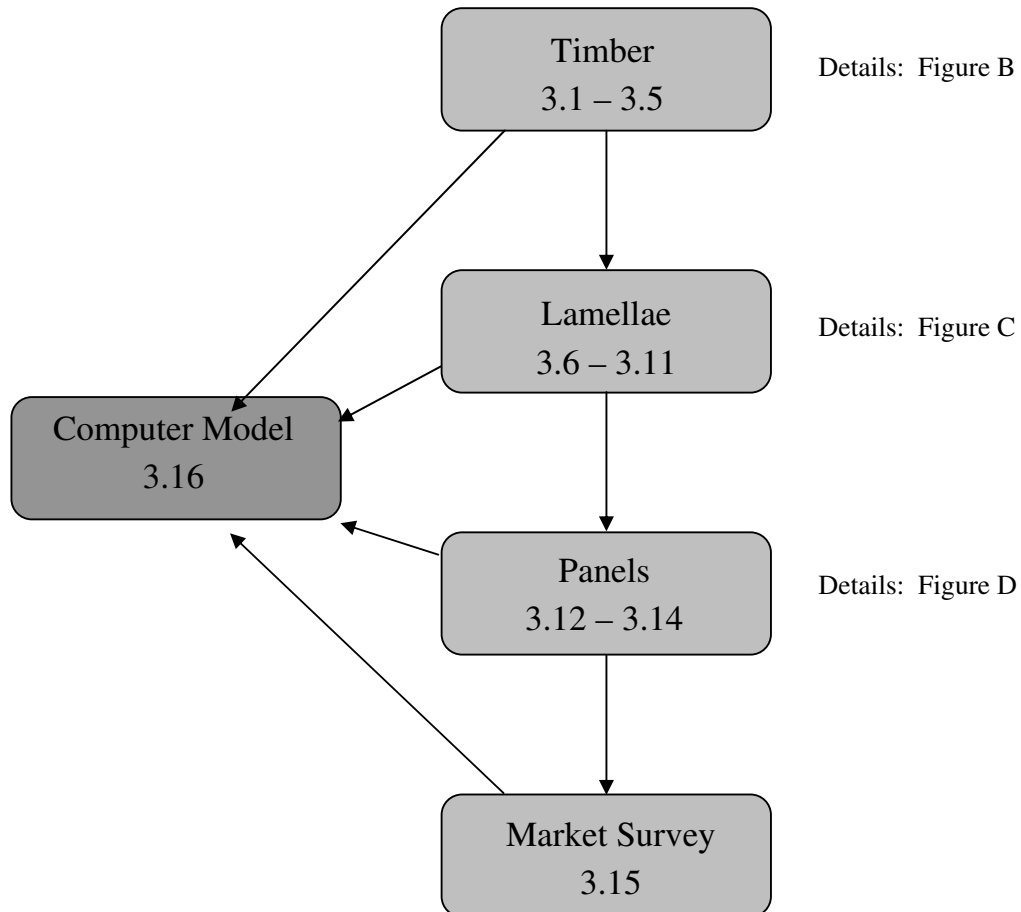
3 Objectives

The research contract states that "**The objective is to stimulate private investment in farm forestry throughout Australia by demonstrating the cost/benefits of processing short rotation timber crops**".

The principal outcomes and deliverables were expected to be:

4 Methodology

Figure A: Major Research Activities



4.1 Costing Plantation Establishment

Based on advice from Agriculture Western Australia for valuing agricultural land for tree plantation establishment, several cost options were considered.

For the silvicultural treatment and to meet the blue gum 'flooring' log specifications, the Farm Forestry Unit of CALM recommended three prescriptions.

1. Produce flooring logs and pulpwood at 6 to 7-years-old, leaving crop trees to grow on to 20+ years old as sawlogs.
2. Produce flooring logs at 6 to 7-years-old and clear fall for pulpwood at 10 years old.
3. Clear fall at 6 to 7 years old for flooring logs and pulpwood. This option will only be possible in plantations with an MAI exceeding 25 m³/ha/yr.

Due to the limited sites available to the project and limited access to commercial harvesting operations, the actual prescriptions adopted were:

- A. Harvest 10% of an 8-year-old plantation with a stocking of 1000 trees/ha in a 600 mm rainfall zone. Thinning from above was required to meet the size specification. A clear falling for pulpwood at age 10 or 11 is anticipated.
- B. Integrated with a commercial clear falling for MDF furnish, select 10% of a 10 year-old plantation with a stocking of 1200 trees/ha on a poor site in a 700 mm rainfall zone.
- C. Select 180 crop trees/ha and harvest 120 trees/ha of flooring logs from 6 year-old plantation with a stocking of 1200 trees/ha in a 700 mm rainfall zone. To meet the size requirements without choosing crop trees, the selection was limited to large 'wolf' trees and those with double leaders resulting from parrot damage.

Details of the operations are given in Section 4.4 and the CALM report in Attachment A.

The pine log specification presented no problems and corresponds to a commercial grade of industrial wood. Most of the requirements were obtained as a 10% thinning of an unthinned, unpruned 12-year-old stand on a poor sandy site in a 1000 mm rainfall zone.

4.4 Harvesting

Two harvesting options were tested:

For prescription B in section 4.3 mechanical harvesting was in a 10-year-old stand in an 800 mm rainfall zone. The plantation was being clear felled for MDF furnish with mechanical harvesters and forwarders, so we were able to test integrated harvesting.

Maritime Pine

The maritime pine flooring log specifications are listed in Table 4.2.

Table 4.2: Maritime Pine Flooring - Log Specifications

Log Parameters	Specification / Description
General condition	All logs to be free of insect and fungal attack, blue stain, abrupt changes in diameter, massive knot whorls and burnt bark.
Length	2.5 metres
Diameter	SEDUB 150 to 250 mm.
Straightness	Sweep not to exceed 20% of the SEDUB along the total length measured from log surface to the chord created by a straight edge.
Branch size	Dead knots to be less than 50-mm diameter on the greatest axis.
Log preparation	Branches to be flush trimmed and the bole to be square docked.

For a small trial thinning of maritime pine, a 12-year-old plantation in a 600 mm rainfall zone was selected. The trees were wide spaced and had been pruned. The results were excellent but it is considered that for core lamellae, pruned and thinned plantations could not be justified. The logs were far higher quality than we needed.

A second small trial in a twelve-year-old unpruned, unthinned plantation on very poor sandy soil in a 1000 mm rainfall zone was selected. Although some difficulty was experienced in meeting the straightness specifications, the resulting veneers easily met our requirements. The specifications for these logs were identical to a commercial product sold by CALM as 'case logs', which are produced by mechanical harvesters along with other grades.

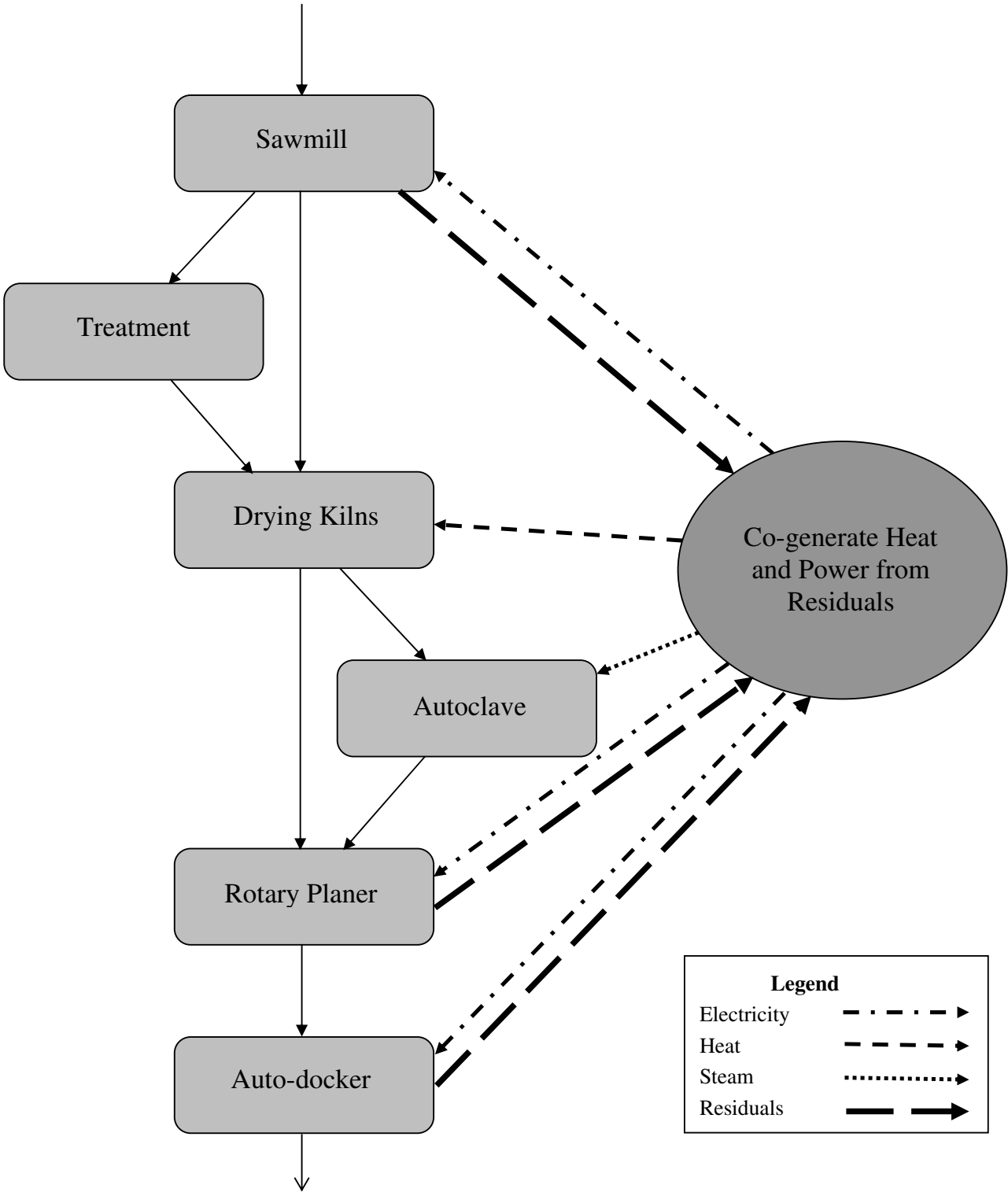
Having established the appropriate log quality, it was decided to pick up some of the time lost due to a delayed start to the project by purchasing a supply of commercially available 'case logs' rather than proceed with a costly and time consuming separate harvest operation.

4.5 Timber Yields

The plantations sampled were all planted at approximately 1200 stems per hectare with actual stocking down to 1000 stems. In order to meet our log specification from trees as young as possible, a system of '*thinning from above*', that is choosing dominant trees (often with double leaders or other damage), was adopted. On this basis we were able to select about 10% of the trees for producing suitable flooring logs. Depending on the age, site quality and stocking at the time of harvest, the yield of flooring logs ranged from 6 m³ to 15 m³ per hectare.

In most cases only a single 2.5 metre flooring log was recovered from any tree, so a significant residual volume suited to pulpwood remained. This pulpwood volume was left in the plantations because the small scale of our operations meant commercial recovery was not possible. The quantity of pulpwood not recovered was roughly equal to the volume of the flooring logs.

Figure C: Research Activites 3.6 to 3.11



4.6 Cant Production

To facilitate the cutting of veneers for flooring lamellae, accurately dimensioned cants are needed. To compare the cost effectiveness of producing squared cants from the blue gum logs using a portable sawmill in the plantation, with the operation of a fixed sawmill located at the processing plant, two methods were used:

4.10 Dimensioning

For Thickness

Unfortunately the Forest Products Commission was unable to meet its contractual obligation to install a state-of-the-art rotary planer. Consequently, a wide belt sander was used for thicknessing,. As the final lamellae thickness was to be 4 mm, the initial dimensioning was to 4.5 mm, leaving 0.5 mm for final sanding. It was found desirable to sand both faces of each lamellae to provide one flat face for gluing and the other to facilitate accurate grading.

For Width

Two panel profiles were tested. One was 180 mm wide with three edge-jointed face lamellae, and the other was 70 mm wide with a single face lamella.

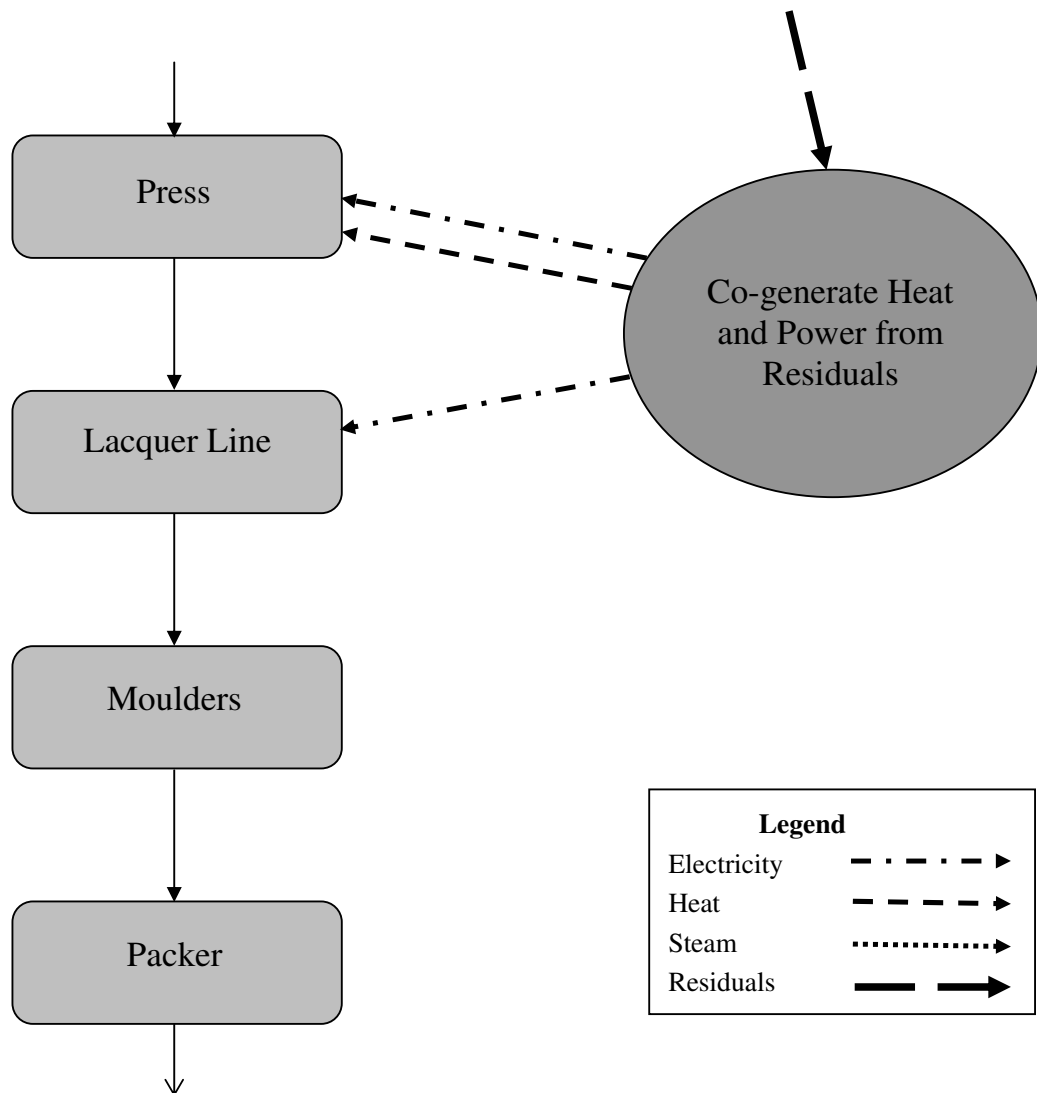
For the wider panels, to obtain good edge jointing, it was necessary to dimension the widths of the lamellae prior to lamination. This was achieved using a copy shaper on bundles of veneers to produce uniform and parallel-sided lamellae. For the narrow panels width dimensioning of the lamellae was not required prior to lamination. Final width of both wide and narrow panels was determined by the tongue and grooving operation on a double-ended tenoner machine.

4.11 Defect Docking

Grade docking to the set lengths of 600 mm, 900 mm, 1200 mm and 1800 mm, was carried out to eliminate defects and to recover the optimum of face lamellae.

No docking of the pine lamellae was required because it was used exclusively for the cross-laminated cores where appearance is not important.

Figure D: Research Activities 3.12 to 3.14



4.12 Laminating

All of the panels were prepared with blue gum face and back lamellae and most had cross-laminated maritime pine cores. Some of the panels were produced with blue gum core lamellae.

The lay-up of panels and the application of urea formaldehyde adhesive were done manually in a metal frame.

An Orma oil heated hot press was used for laminating the panels. A pressure of 100 kPa at 100 C for 3 minutes was applied.

Testing of cross-linked PVA, urea formaldehyde, melamine fortified urea formaldehyde and two types of hot-melt polyurethane adhesives was undertaken.

4.13 Polishing

Two coats of Mirrortone UV - cured lacquer were applied. The first sealing coat was sanded before the application of the top coat.

Small samples were finished with three coats of an imported Beckers lacquer to compare with the Australian Mirrortone product.

4.14 Testing

See Attachment B - Furntech Test Results and Attachment C - FPC Timber Technology Test Results for further details.

Small Ball, Rolling Load and Hardness Tests

Representative samples of the early runs of flooring panels (unfortunately without tongue and grooving on the ends) were sent to Furntech in Launceston for testing to national and international standards. Equipment was purchased or manufactured by Furntech to conduct the following tests:

- a. Resistance to impact by small diameter ball in accordance with BS EN 438 (derived from ISO 4586-2: 1988). This test is to determine the capability of the panels to withstand damage caused by dropped items that have sharp edges or the application of concentrated loads on a small area. This would be applicable to ladies small-heeled shoes on floor panels.
- b. Rolling load test in accordance with ASTM D 2394. This test is designed to assess the capability of the floor panels to withstand damage that may be caused by movement of heavy items of furniture or whitegoods. A prime example of possible damage would be relocation of a piano mounted on small roller wheels.



Because these standards do not provide 'pass / fail' limits, Furntech were asked to compare the results with equivalent flooring products accepted in the market place. However, Furntech claimed it was unable to obtain such products and compared the results with those of melamine coated MDF panels. Because the VALUFLOOR flooring did not compare favourably with the 900 kg/m³ MDF panels, action was taken to apply a hardening treatment in New Zealand and to repeat the tests at Harvey.

This testing by the FPC repeated the Small ball impact and Rolling load tests for the treated and untreated panels and compared the results with those of kapur, jarrah, marri, European oak and nyatoh. In addition Janka hardness tests were conducted. The untreated blue gum panels compared favourably with the nyatoh and European oak and below kapur, jarrah and marri. Results with the hardened samples were inconclusive due to faulty treatment procedures.

Panels with blue gum cores performed better than those with pine cores.

Cleavage Tests

As specified by the Australian Standard for Glue-laminated Structural Timber (AS 1328-1987), the Dry Cleavage Test was applied to the range of adhesives and timbers in the test VALUFLOOR panels. The test specifies that a satisfactory glue joint will show 60% or more wood failure.

Urea formaldehyde and melamine fortified urea formaldehyde adhesives provided satisfactory jointing of blue gum to pine, provided the glue was applied to both faces. But with blue gum to blue gum, 14% of the joints showed less than 60% wood failure.

To address the lower performance, samples of hot-melt polyurethane adhesives used by commercial laminated flooring manufacturers were obtained from Germany and tested.

Commercial application equipment however was not available and difficulty was experienced in applying these adhesives to the manufacturer's specifications. Several variations of wood and press temperatures were tested and results indicated that when the hot-melt glue was applied to cold wood and hot-pressed at 100C there was no subsequent glue failure for either blue gum / pine or blue gum / blue gum joints. Some other temperature variations gave somewhat poorer results, believed to be the result of inappropriate application.

Demonstration Floors

Action was taken to test on-site performance and market responses as follows:

Colour

The colour of the finished floor panels is considerably darker than was expected. The market response to the colour however was positive, with comments like "unique", "pleasing walnut colour" and "although knotty, will not be mistaken for pine".

Three likely causes of the darkened colour have been considered:

- a. The common occurrence of reaction wood because the trees harvested were grown in areas of marginal rainfall. This appeared to be the primary cause of darkening although many of the lamellae were pale when first cut; to the extent that consideration was given to either colour grade the end products or treat the dark ones as rejects to be used as back lamellae.
- b. Rapid drying at temperatures approaching 100 C. This did not appear to cause a measurable darkening.
- c. Collapse recovery using super heated steam at 140 C. After the collapse recovery treatment, the colours were so uniformly dark that colour grading was seen to be unwarranted and rejecting dark lamellae would have resulted in uneconomic recovery losses.

Measurements were taken with a tristimulus colorimeter comparing steamed and unsteamed lamellae. These measurements confirmed that the steaming was responsible for the resulting uniformly darkened colour. See Attachment C.

Dr C N Pandey of the Forest Research Institute, Dehra Dun, in a paper presented to the IUFRO Eucalypt Conference 2000 in Launceston (4), reported on a technique of ammonia fumigation to bring out the latent figure and provide a "walnut" look to *Eucalyptus tereticornis*, making it suitable for high class timber work. The degree of darkening is dependent on the level of tannin present in the timber.

When the market response indicated a preference for the darker wood, consideration was given to applying this treatment to the face lamellae. The darkening by steaming made this unnecessary although preliminary ammonia fumigation trials showed there is sufficient tannin present for this darkening process to be effective with *E. globulus* if found to be desirable.

4.15 Market Evaluation

At the Timber Advisory Centre and the office of CALM in Perth demonstration floors were laid to gauge the public acceptance of the VALUFLOR panels. Responses were assessed by analysing completed questionnaire forms from each location.

VALUFLOR panel samples were displayed as a poster paper for the IUFRO Eucalypt Conference in Launceston and the WA Farm Forestry Expo 2000 in Boyup Brook. Additional market data was collected regarding public acceptance from these displays.

VALUFLOR samples were taken by the principals of Inglewood Products and Hamilton Sawmills to their established overseas clients to gauge the market response to the product.

The Forest Products Commission prepared a detailed analysis of the world-wide timber flooring market environment (Attachment D). This report reviews consumption, pricing and the preferred flooring type in world, Australian and Western Australian markets. (NOTE: The product 'laminated three-ply flooring' is termed Engineered Wood Flooring (EWF) in Attachment D.)

4.16 The VALUFLOR® Software Model

VALUFLOR® was developed to track commercial costs and recoveries for timber tonnes, volumes and square metre areas from the timber stands through every step in production to delivery at a destination. The model may also be used in reverse to backtrack costs and recoveries from a specified destination delivered area of panels and their price per square metre, back through every step in production to the value of the initial logs or timber stands. Costs may be converted from dollars in one year to dollars in a different year by applying Consumer Price Index (CPI) values or estimates.

See Section 6.6 for the Model design and Appendix 3 for notes on the VALUFLOR® model functions.

5 Significant Results

The following findings resulting from the project are considered to be of significance:

6 Discussion of Results

6.1 Plantations Investment

The basis adopted for allocating plantation costs to the thinnings extracted for the manufacture of flooring, was first to establish the of total costs incurred at the time of thinning. Total costs included land costs, plantation establishment and annual maintenance costs, plus GST. These costs were then apportioned according to the number of trees felled, expressed as a percentage of the total number of trees remaining prior to the thinning.

Although the approach adopted of 'thinning from above' meant that none of the trees extracted were suppressed stems, several advantages were likely to accrue to the remaining plantation. Trees forked as a result of parrot damage and not preferred as pulpwood logs often yielded flooring logs. In marginal rainfall zones, the early thinning is expected to delay the onset of drought death. The removal of 'wolf' trees as a thinning assists in developing a more uniform tree size in the final crop.

In plantations destined for the selection of crop trees to grow on as sawlogs, it was possible to harvest 10 % of the crop as flooring logs without taking any crop trees.

Southern blue gum is widely acknowledged as being more difficult to process than other commercially available eucalypts. The positive outcomes of this project, therefore, auger well for successfully applying the techniques developed to other eucalypts. The following are some eucalyptus species, when grown in plantations in Western Australia, are considered to have the potential to produce early thinnings suitable for the manufacture of high quality flooring.

The 10 year-old trees (planted at 1200 trees/hectare on a poor sandy site) displayed an excess of loose knots when processed. The scale of the project operations did not permit a comparison of differing stem spacings, site qualities and rainfall zones.

From previous experience, in converting small logs into squared cants, about half the volume ends up as residue material (round-back wings and sawdust). Because plantations are frequently remote from processing, freight costs can potentially be halved if the initial processing into cants is carried out in the plantation.

Cant Production

The Macquarrie Mini Mill portable sawmill was considered the most efficient available for handling very small logs due to the 45° orientation of the log trough and saw, obviating the need for dogging to secure the logs. The difficulty of securing small logs on a flat horizontal bed was the main limitation of other models considered for these trials.

The trough fed twin circular saw log edger, followed by a vertical band resaw, was selected because cutting both sides off in the first pass produces a parallel sided cant unaffected by the release of growth stresses. This setup was available to us at the same factory as the veneer cutting equipment.

Other options for producing cants include replacing the band resaw with a second pass through an overhead beam feed twin edger or a four-sided chipper canter (either fixed or portable). These may prove to be more efficient but were not available to us.

The productivity of the portable mill was no more than 20% of that of the twin log edger option and the 50% of log volume of off-cuts is more costly to recover for pulpwood when left in the plantation. Full costing of the portable mill option was therefore not pursued.

In producing squared cants the most common log defect encountered and not detected when selecting the logs was too much sweep, particularly in the smaller diameters. This lack of straightness resulted in the maximum length of flooring panels being reduced from 2.4 to 1.8 metres.

6.3 Lamellae

Production

In an FWPRDC report 'Adding Value To Small Eucalypt Logs' (1) cants of three species were taken to the Linck works in Germany for slicing into thick veneers. Veneers up to 10 mm thick produced there performed well as plywood flooring lamellae.

For this project we opted for sawing rather than slicing for veneer production. For some years we had followed the development by Wintersteiger of a thin cutting frame saw which could process green wood and were fortunate to secure the use of the first of these saws in Australia at Pinetec in Perth for our trials. We were encouraged by an earlier successful hardwood trial with the Wintersteiger DSG 200 Thin-cutting Framesaw that is described in Appendix 1.

After drying, collapse recovery and dimensioning, the final production run was made at 6 mm for the blue gum and the pine. In hindsight, an additional 0.5 mm would be desirable for species such as the blue gum with high shrinkage and collapse.

Drying

The FWPRDC report Adding Value To Small Eucalypt Logs (1) tested several methods of restraining thick veneers during the drying process. One successful method used in Europe was the use of expanded metal sheets to replace conventional wooden stickers. The use of these sheets was tested but was found to leave indentations in the wood, requiring additional loss of wood to sand out. The Smorgan ARC company was commissioned to manufacture specifically designed weld-mesh sheets that performed well in providing adequate restraint with a minimum of indentation. Galvanised wires with a diameter of 5.2 mm are spaced laterally at 50 mm spacing and held together by three longitudinal wires, two at the width extremities of the sheet and one centrally. The veneers are laid longitudinally between these three wires so that a laminar air flow is possible across the stack.

An attempt to halt the drying process at around 20% moisture content in order to effect the recovery of the collapse was unsuccessful. The considerable moisture content variation between and within veneers resulted in some veneers being too wet for any recovery and others being too dry for recovery at 100 C. By drying to lower than equilibrium moisture contents, as practiced in the veneer industry, a very uniform moisture content resulted.

Bootle 1983 in - 'Wood in Australia' (5) quotes blue gum mature wood shrinkage after recovery as 4% radial and 7% tangential compared to 6% radial and 12% tangential before collapse recovery. In the FWPRDC report 'Adding Value To Small Eucalypt Logs' (1) Shedley demonstrated a greater than 12% increase in volume for juvenile blue gum veneers which had been dried to 6% moisture content and then treated with super-heated steam at 120 C. It was not possible to apply the conventional collapse recovery treatment of wood at 18-20% moisture content with steam at 100 C because of the difficulty of obtaining a relatively small range of moisture contents when halting the drying process. This left two options, to either considerably slow down the rate of drying or to recover the collapse after final drying. The former was considered to be less cost effective so the latter approach was adopted.

Finished face lamellae thickness of 4 mm was adopted because this is the dimension of the best quality laminated flooring products in the marketplace.

The Rotoles rotary planer is judged to be the most effective machine for dimensioning timber lamellae. Its action of planing parallel to the wood face produces a gauged surface best suited for gluing and not subject to subsequent grain lifting. Material as short as 150 mm and down to 2 mm in thickness can be dimensioned with less wood loss than either sanding or conventional planers. It produces an excellent finish without tearing for the end grain present as knots. The inability of the Forest Products Commission to install this equipment was regrettable and resulted in the use of a wide-belt sander that proved to be a slow and less effective alternative. The differential hardness caused by the end grain of knots resulted in a less than flat surface that often remained apparent in the finished product.

Defects

The juvenile blue gum had a number of defects, notably:

To allow for an option of using hardwood as the cross-laminated core lamellae, a uniform finished thickness of 4 mm was adopted for each of the three lamellae. This resulted in a final floor panel thickness of 12 mm which is common to many of the commercially available products even though the thickness of the three layers varies considerably.

Gluing Trials

Preliminary testing showed a cross-linked PVA adhesive to be unsuitable and urea formaldehyde to be adequate for bonding blue gum to maritime pine but less than consistent for bonding blue gum to blue gum. Testing melamine fortified urea formaldehyde showed less than ideal bonding for both applications. As a result all the panels were bonded with urea formaldehyde, most with blue gum face cores of maritime pine and only a small quantity with cores of blue gum.

When subsequent testing showed improved hardness was obtained with blue gum cores, two types of hot-melt polyurethane adhesives used for laminated flooring in Europe were obtained. Testing of Purmelt 5300 (hard setting) and Purmelt 5305 (soft setting) adhesives showed consistently better results in all situations than any of the other adhesives tested. The cost of these adhesives at around \$2/m² of flooring is several times that for urea formaldehyde but as its application does not involve heating the wood, the additional cost is not likely to be prohibitive. For more details see Attachment C - FPC Timber Technology Test Results.

Testing

See Attachment B and Attachment C for further details on the conduct and results of tests.

The results of Furntech tests (Attachment B) casting doubt on the hardness compared with a hardened MDF product were almost 12 months overdue. Furntech did not make comparative tests with other laminated solid wood products that are readily available in the marketplace as requested and it had not been commissioned to conduct a comparison with the hardened MDF board - a dissimilar flooring product. Never-the-less, an additional hardening processes was conducted in New Zealand and comparative testing was carried out by the Forest Products Commission Timber Technology centre (Attachment C) with other commercially available laminated flooring samples manufactured in Europe and Asia.

Pacific Hardwoods in New Zealand hardened a small sample of blue gum veneers using the Vydex process. The samples were then returned and laminated into panels for the additional Small Ball and Rolling Load tests. When investigating a disappointingly small increase in hardness and density of these samples it was discovered that the treatment had been applied to wood with moisture contents that were too low to allow optimum penetration. Repeating the hardening treatment with the NZ Forest Research product Indurite would have been desirable but the delay in delivery of the Furntech test results meant that insufficient time was left to complete this function. It is understood that the FPC Timber Technology intends to follow up this activity.

6.5 Market Evaluation

From the responses from the public, distributors and the market evaluation report it is concluded that:

green veneers with a low percentage of face grade veneers but with a relatively high volume recovery.

Simulation Data

Simulation data consists of the following worksheets:

7 Implications

7.1 Commercial Opportunities

Static snapshots were prepared from the VALUFLOR© model for several scenarios using costs derived during the project study. Some examples are shown in Appendix 4.

Analysis of these revealed:

8 Recommendations

8.1 Action For Funding A Feasibility Study

Funding a feasibility study for a commercial flooring plant in Australia, including the generation of electricity and heat from residues, should be considered by Federal and State Governments as a means of assisting the transition from harvesting old-growth forests to harvesting plantations and regrowth forests. The study should investigate:

9 Bibliography / References

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2. Shedley, P.N., Korecki, S. and Hill, P. (1998). Wintersteiger Thin-Cutting Framesaw – Green Hardwood Trial. CALM Timber Technology. Internal report.
3. VALUFLOR© Model (2001). Cost and Production Software Model. Research Agreement PN99.2007
4. Pandey, C.N. (2000). Potential of Plantation Grown Eucalypts as Source of Raw Material to Wood Based Industry in India. Proceedings of IUFRO Conference 'The Future of Eucalypts for Wood Products'. Launceston, Tasmania. March 2000.
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Appendix 1

Wintersteiger Thin Cutting Framesaw

Prior to commencing the project, Valuwood International in association with Wintersteiger, Pinetec, Inglewood Products, Hamilton Sawmills and CALM Timber Technology (now FPC Timber Technology), conducted a preliminary study with the Wintersteiger DSG 200 Thin Cutting Frame Saw to determine its capacity and efficiency in processing six Western Australian hardwoods.

The study (2) entitled "Wintersteiger Thin-cutting Framesaw. - Green Hardwood Trial" - Shedley *et al* 1998, demonstrated that the Wintersteiger DSG 200 satisfactorily processed green hardwoods, with green densities up to 1280 kg/m³, into veneers with significantly greater accuracy than produced by a conventional band saw. At a feed speed of 1 metre per minute and a saw kerf thickness of 1.5 mm, the Wintersteiger DSG 200 produced thirty accurately sawn 4.5 mm veneers each 150 mm deep. The species tested were jarrah (*E. marginata*), karri (*E. diversicolor*), wandoo (*E. wandoo*), southern blue gum (*E. globulus*), marri (*Corymbia calophylla*), and WA sheoak (*Allocasuarina fraseriana*).



Appendix 2

4S Racking Sheets

The "Smorgan/Shedley Steel Stripping" sheets (4S sheets) were custom designed in welded galvanised steel for drying 6-7 mm thick green lamellae produced from very small diameter logs.

A wire diameter of 5.2 mm (less than the final dry thickness of the lamellae) was used to fabricate the 4S sheets. Cross wires at 50 mm spacing are held in place by three longitudinal wires, one on either side of the sheet and one in the centre.

The 2.4 metres x 1 metre sheets weigh less than 12 kg, are stable and easily placed in position by one person. Timber stacks built with the 4S sheets were stable and provided accurately aligned restraint. They were used many times without damage.

A layer of green lamellae is placed longitudinally along the sheet, but not on the longitudinal wires, before placing another sheet and more timber etc.

The Smorgan-ARC contribution to the development of the 4S sheets is gratefully acknowledged.



Appendix 3

VALUFLOR© Model Notes

A3.1 Correlating S_to_D_Model with D_to_S_Model

The two models produce similar figures to each other but operate in different directions. The S_to_D_Model starts at the stands and does all appropriate calculations through to the destination. The D_to_S_Model starts at the destination and works back to the stands.

When an S_to_D_Model is first setup it may result in a lot of leftover veneers. For example a model of three-ply with southern blue gum top and bottom and Pinus radiata in the middle may have leftover pine or Blue Gum veneers. This will effect the apparent costs because all costs are monitored and accumulated in the model.

To avoid the model showing excess veneers, and hence additional costs, it is possible to use the S_to_D_Model and D_to_S_Model as a pair. The following steps are recommended:

A3.4 Modelling Of Large Or Small Scale Production

Because of the richness of data fields available in the simulation it is possible to model large or small-scale productions. The following examples illustrate the principles:

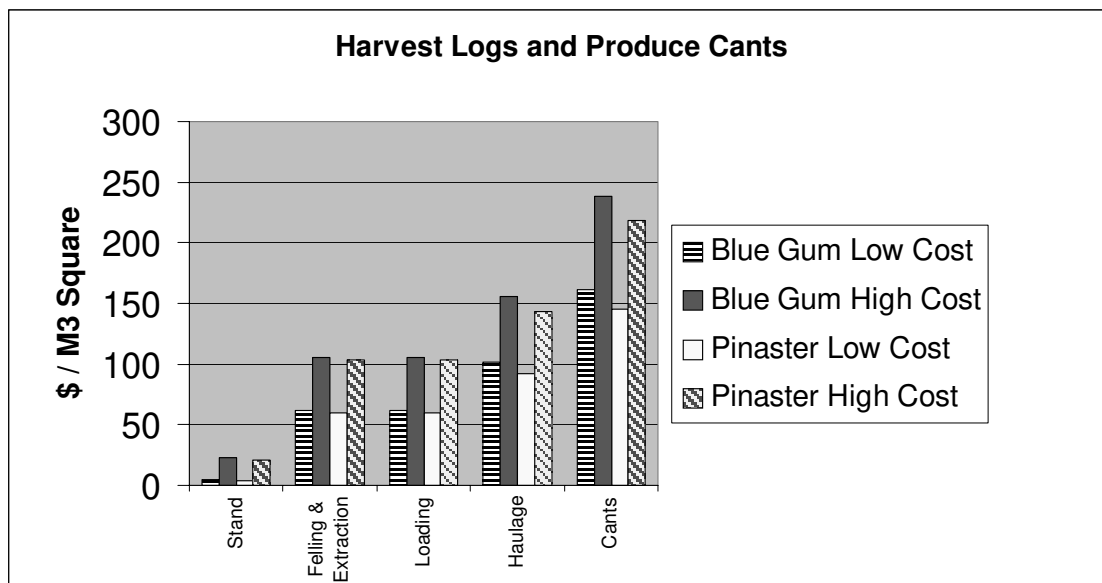
Appendix 4

VALUFLOR© Model Examples

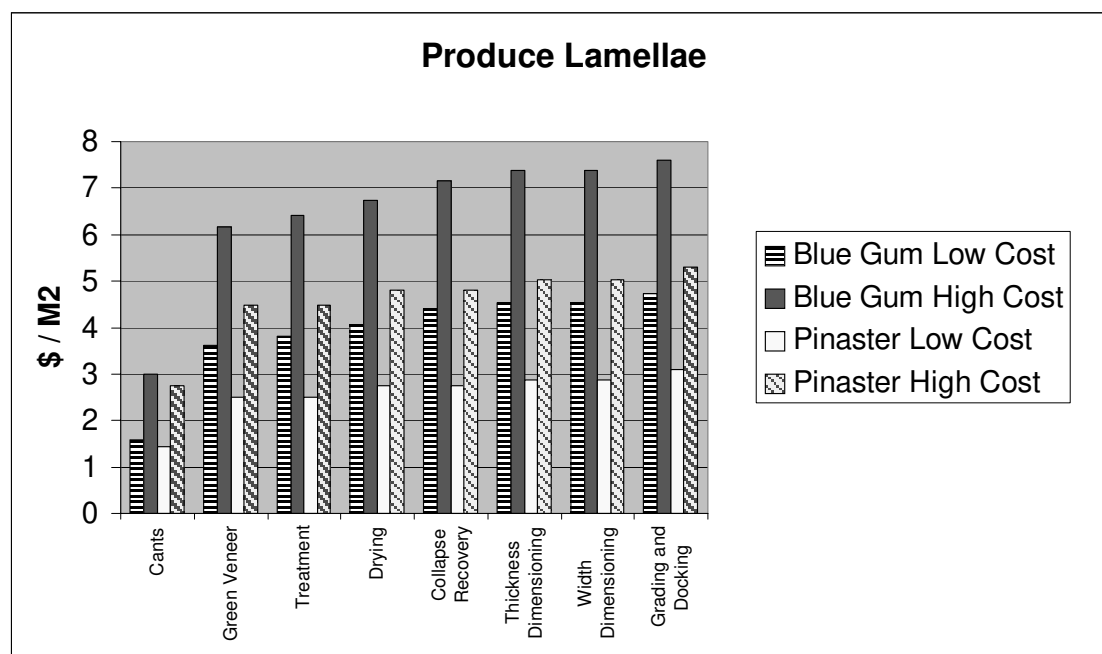
Example 1: Stand to Destination Comparison of Direct Costs

This sequence of static snapshots displays the various stages involved in the manufacture of laminated flooring. In order to highlight the critical direct cost areas, this sequence omits all price markup values.

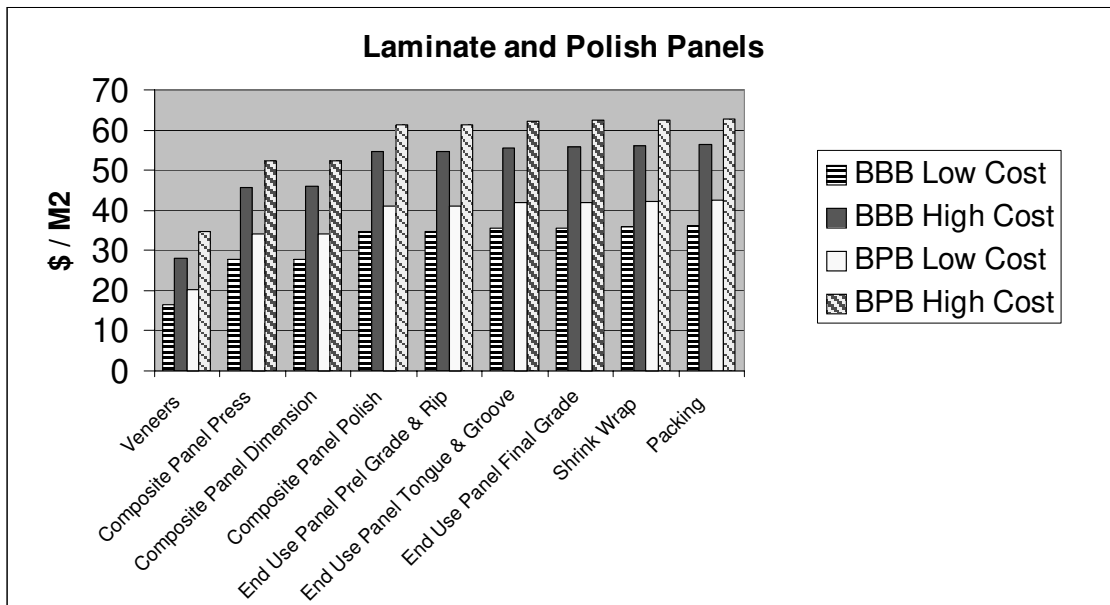
Displayed are:



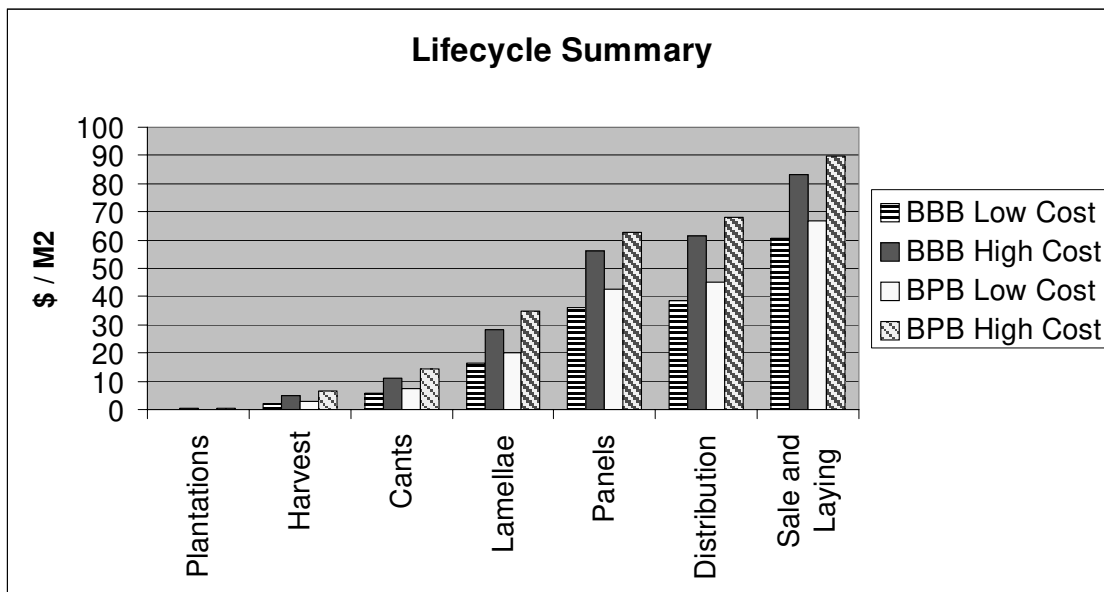
VALUFLOR© predictions of cumulative direct costs for harvesting logs and producing cants at a fixed sawmill, including costs for plantations and GST, expressed in year 2001 Australian dollars.



VALUFLOR© predictions of cumulative direct costs for producing dry dimensioned, including costs for plantations, harvests, cants and GST, expressed in year 2001 Australian dollars.



VALUFLOR© predictions of cumulative direct costs for producing the composite panels, including costs for plantations, harvests, cants, lamellae and GST, expressed in year 2001 Australian dollars.



Summary of VALUFLOR© predictions of cumulative direct costs from plantation establishment through to floor laying and GST, expressed in year 2001 Australian dollars.

Summary of VALUFLOOR© predictions of cumulative direct costs from plantation establishment through to floor laying and GST, expressed as a percentage of total cost.

The conclusions from example 1 are:

Example 2: VALUFLOR© Predictions for a London Destination

The conclusions from example 2 are:

Example 3: VALUFLOR Predictions for a Sydney Destination

Example 4: VALUFLOR© Predictions From Destination back to the Plantations

Stage	Model 1	Model 2	Model 3
Price Laid in London (£ / m2)	£32.00	£33.00	£34.00
Price in London (£ / m2)	£22.00	£23.00	£24.00
Markup FOB Fremantle (\$ / m2)	\$52.27	\$54.73	\$57.20
Price Ex Factory (\$ / m2)	\$34.29	\$35.93	\$37.57
Cost + Markup on trees (\$ / m3 round)	-\$20.07 (loss)	\$3.62	\$27.31
Cost of growing (\$ / m3 round)	\$2.52	\$2.52	\$2.52
Return in five years (\$ / hectare)	-\$1540 (loss)	\$74.97	\$1690

The conclusion from example 4 is:

Appendix 5

VALUFLOR Floor Panel Questionnaire

QUESTIONNAIRE

(PLEASE CIRCLE AS APPROPRIATE)

Q. 1: HOW DO YOU RATE THE GENERAL APPEARANCE OF THE FLOORING?

Like very much don't like at all

1 2 3 4 5 6 7

Q. 2: WHAT IS YOUR OPINION OF THE COLOUR?

Like very much don't like at all

1 2 3 4 5 6 7

Q. 3: WE HAVE AIMED TO FEATURE THE NATURAL CHARACTERISTICS OF THE WOOD.
WHAT IS YOUR OPINION OF THIS LOOK?

Like very much don't like at all

1 2 3 4 5 6 7

Q. 4: IF IT WAS AVAILABLE, WOULD YOU LIKE TO INSTAL THIS FLOORING IN YOUR HOME?

Price range \$80-\$120/M2 laid?	YES	NO
If it was cheaper?	YES	NO
If it was dearer?	YES	NO

Q. 5: DO YOU HAVE ANY OTHER COMMENTS?

Q.6: WHAT AGE GROUP ARE YOU IN?

under 20 20-30 31-40 41-50 51-60 over 60

Q.7: WHAT IS YOUR POST CODE? _____

Thank you for your assistance.

ATTACHMENT A

Silviculture and Growing Costs CALM Farm Forestry Unit

R.A.Hingston and R.W.Moore
CALM, Farm Forestry Unit, Busselton

Introduction

This report addresses Task 1 and 2 of the Laminated Three-ply Flooring Project. Task 1 was to recommend silvicultural prescriptions for the production of southern blue gum (*Eucalyptus globulus*) and maritime pine (*Pinus pinaster*) logs suitable for the flooring product. It was also to provide estimates of cost for establishing and managing plantations for the production of the specified logs. Task 2 was to provide estimates of the cost of harvesting the logs.

The overall aim of the Project was to demonstrate the commercial feasibility of producing three-ply flooring from small logs grown on a short rotation.

Method

Undertaking Tasks 1 and 2 involved:

1. Referring to log specifications
2. Developing silvicultural prescriptions (with costs of production)
3. Verifying silvicultural prescriptions by field checking.

Log Specifications

The development of silvicultural prescriptions was dependent on having firm specifications for “flooring logs”. Two small milling trials (Tasks 4 to 7) enabled log specifications for “flooring logs” to be firmed up. The flooring product is sawn from squared cants 100 x 100 mm. Therefore blue gum and maritime pine logs must be large enough to produce cants of this size.

Specifications for bluegum “flooring logs” are described in Table 1 and for Maritime pine flooring logs in Table 2.

Table 1: Specifications for blue gum logs for the flooring product.

Log parameter	Specification/description
Length	2.5 metres
Diameter	small end diameter under bark (s.e.d.u.b.) 150 to 250 mm
Straightness	sweep shall not exceed 10% of s.e.d.u.b. along the total length measured from log surface to the chord created by a straight edge
Branch size	not to exceed 25 mm, but some can be up to 40 mm
Branch condition	to minimise the age of dry encased knots, crown recession should not exceed 5 metres
Bark	bark must be left on during the harvesting operation
General condition	all logs to be free from insect or fungal attack
Log preparation	branches to be flush trimmed and bole to be square docked
Log delivery	logs to be delivered to water spray stockpile or covered storage within 48 hours of felling

Table 2: Specifications for Maritime pine logs for the flooring product.

Log parameter	Specification/description
Length	2.5 metres
Diameter	small end diameter under bark (s.e.d.u.b.) 150 to 250 mm
Straightness	sweep shall not exceed 20% of s.e.d.u.b. along the total length measured from log surface to the chord created by a straight edge
Branch size	dead knots to be less than 50 mm diameter on the greatest axis
General condition	all logs to be free from insect and fungal attack, blue stain, abrupt changes in diameter, massive knot whorls and burnt bark
Log preparation	branches to be flush trimmed and bole to be square docked

Silvicultural Prescriptions

Silvicultural prescriptions for the production of blue gum and maritime pine logs suitable for the flooring product were developed.

Southern Blue Gum

Option 1 – Regime To Produce “Flooring Logs” + Pulpwood + Sawlogs (20 Year Rotation)

Silvicultural option No 1 for blue gum involves thinning for “flooring logs” and pulpwood at 6 to 7 years and clearfelling for sawlogs at 20 years. Details of the regime are set out in Table 3 below; ie. timing of operations, likely costs and the expected range in log volumes produced.

Table 3: Silvicultural prescription for southern blue gum (*E. globulus*) to produce “flooring logs” and pulpwood at 6 to 7 years and sawlogs at 20 years.

Year	Operation	Cost (\$/ha) & (\$/m ³)	Log volume (m ³ /ha)
0	Prepare site and plant 1250 trees/ha	\$1245 to \$1500	
3	Select and low prune 300 trees/ha (50°/tree)	\$150	
6	Select and mark 180 crop trees/ha (for sawlogs) Select and mark 120 flooring log trees/ha	\$40	
6 to 7	Harvest 120 trees/ha for flooring logs Harvest 900 trees/ha for pulpwood Transport flooring logs & pulpwood (80km) Prune 180 crop trees/ha to 6m (\$1.50/tree)	\$24 to \$28 \$14 to \$16 \$10 \$270	6 to 15 80 to 130
6.5 to 7.5	Spray coppice	\$100	
8	Fertilise with super/potash @ 400kg/ha (optional)	\$0 to \$340	
15	Fertilise with super/potash @ 400kg/ha (optional)	\$0 to \$340	
20	Clearfell for sawlogs & pulpwood (180 trees/ha) Transport sawlogs (80km)	\$30 \$10	270 (sawlog) 162 (pulpwood)
	Total costs (establishment & management) Total costs (harvesting and transport)	\$1805 to \$2740/ha \$88 to \$94/m³	

Note:

1. Some of the 300 crop tree selected for low pruning will become “flooring logs”. 300 trees were selected to provide choice in selecting crop trees for sawlogs at 6 to 7 years.
2. Age of harvest of “flooring logs” depends on site quality. On high quality sites, trees can be harvested at 5½ years. On low quality sites, trees may be 7 years or older before 120 trees/ha are large enough.

3. If “flooring logs” require bark to be kept on, the logging operation at 6 to 7 years may need to be a two phase operation; one for pulpwood and one for “flooring logs”. The “flooring log” operation would possibly involve hand falling and extraction with small machine (e.g. Bell logger). This aspect requires further investigation.
4. Volume data of “flooring logs” and pulpwood logs are derived from data presented in Appendix 1.
5. A risk with this regime is wind-throw after thinning at 6 to 7 years.
6. Fertilizing is to boost crop tree growth (i.e. reduce rotation length for sawlogs) and is optional.

Option 2 – Regime To Produce Flooring Logs + Pulpwood (10 Year Rotation)

Silvicultural option No. 2 for blue gum involves thinning for “flooring logs” at 6 to 7 years and clearfelling for pulpwood at 10 years. Table 4 below presents information on the regime, lists likely costs and gives a range of expected yields of “flooring logs” and pulpwood.

Table 4: Silvicultural prescription for Tasmanian bluegum to produce flooring logs at 6 to 7 years and pulpwood at 10 years on an average quality site (i.e. MAI = 20 m³/ha/yr).

Year	Operation	Cost (\$/ha) & (\$/m ³)	Volume of logs (m ³ /ha)
0	Prepare site and plant 1250 trees/ha	\$1245 to \$1500	
6	Mark 120 “flooring log” trees/ha	\$40	
6 to 7	Harvest 120 trees/ha for flooring logs Transport flooring logs (80km)	\$24 to \$28 \$10	6 to 15
10	Clearfell for pulpwood (approx 900 trees/ha) Transport pulpwood (80km)	\$14 to \$16 \$10	200
	Total costs (establishment & management)	\$1285 to \$1540	
	Total costs (harvesting & transport)	\$58 to \$64	

Note:

1. Age of harvest depends on site quality. On high quality sites, trees can be harvested at 5½ years. On low quality sites, trees may be 7 years or older before 120 trees/ha are large enough (see Appendix 4/1).
2. As with silvicultural option No. 1, logging “flooring logs” at 6 to 7 years is may involve hand falling and extraction with small machine (e.g. Bell logger) to keep the bark on the logs.

Option 3 – Regime To Produce Flooring Logs + Pulpwood (6 To 7 Year Rotation)

Silvicultural option No. 3 involves clearfelling for “flooring logs” and pulpwood at 6 to 7 years. There will be a reduced volume of pulpwood compared with harvesting at 10 years but cost of logging will also be reduced because logging is carried out at the one time. Table 5 presents information on the regime, lists likely costs and gives a range of expected yields of “flooring logs” and pulpwood.

Table 5: Silvicultural prescription for southern blue gum to produce “flooring logs” and pulpwood at 6 to 7 years.

Year	Operation	Cost (\$/ha) & (\$/m ³)	Volume of logs (m ³ /ha)
0	Prepare site and plant 1250 trees/ha	\$1245 to \$1500	
6	Select and mark 120 “flooring log” trees/ha	\$40	
6 to 7	Clearfell stand for: “Flooring logs” (120 trees/ha) Pulpwood logs (1100 trees/ha) Transport logs (80km)	\$24 to \$28 \$14 to \$16 \$10	6 to 15 90 to 200
	Total costs (establishment & management)	\$1285 to \$1540	
	Total costs (harvesting & transport)	\$48 to \$54	

Note:

1. This regime is likely to be most feasible on high quality sites (MAI of 25 to 30 m³/ha/yr).
2. Age of harvest depends on site quality. On high quality sites, trees can be harvested at 5¹/₂ years. On low quality sites, trees may be 7 years or older before 120 trees/ha are large enough.
3. As with silvicultural option No. 1, logging “flooring logs” may involve hand falling and extraction with small machine (e.g. Bell logger) to keep the bark on the logs.

Field Verification Of Blue Gum Regimes

Plots were established at six blue gum sites to verify silvicultural prescriptions for a range of ages and site qualities. Trees were categorised into “flooring log” trees, pulpwood trees and crop trees, depending on their form and size. Tree diameter (D.B.H.O.B) and height were measured. Volume was calculated for each log type. Data is presented in Appendix 1.

The data showed:

1. “Flooring logs” can be produced in plantations of southern blue gum by 5¹/₂ to 7 years of age, depending on the site quality. On high quality sites (e.g. Males) trees were large enough by 5¹/₂ years. On low quality sites trees (e.g. Stammers) trees were 7-years-old before they were large enough.
2. There were about 120 “flooring log” trees/ha on most sites. Where it was not possible to select 120 trees/ha stands were either low in stocking (e.g. Stenes and Stammers) or too young (e.g. Coolangatta).
3. It was possible to select 180 crop trees/ha on all sites, in addition to the 120 “flooring log” trees per hectare.

Maritime Pine

Small sawlogs produced from conventional regimes for plantations of maritime pine meet the specifications for “flooring logs” (CALM 1999 – “*Manual of Management Guidelines for Timber Harvesting*”). Conventional regimes produce small sawlogs at the first and second thinning as well as at clearfelling. Table 6 outlines the regime, presents likely costs and gives estimates of volume of small sawlogs (and other logs) produced.

Table 6: A conventional regime for a plantation of maritime pine for the production of small sawlogs, and industrial wood and sawlogs. Small sawlogs meet the specifications for “flooring logs”.

Year	Operation	Cost (\$/ha) & (\$/m ³)	Volume of small sawlogs (m ³ /ha)	Volume of industrial wood ¹ & sawlogs ² (m ³ /ha)
0	Prepare site and establish 1666 trees/ha	\$700 to \$1100		
1	Control weeds in 2 nd year	\$50 to \$100		
12 to 15	Thin from 1600 to 450 trees/ha	\$16 to \$18	5	75 ¹
20 to 22	Thin from 450 to 150 trees/ha	\$16 to \$18	20	35 ¹ , 25 ²
30 to 35	Clearfell	\$16 to \$18	15	15 ¹ , 60 ²
	Totals		40	125¹, 85²

Notes

Yields are based on an MAI of 8m³/ha/yr

“1” designates industrial wood

“2” designates sawlogs

Field verification for maritime pine was not necessary because the data is based on yields from existing plantations.

Appendix A1

Data from 7 sites used for field verification of silviculture prescriptions for blue gum “flooring logs”.

Site	Rainfall (mm)	Tree age (years)	Flooring logs			Sawlogs			Pulpwood logs			Total volume	Total stocking
			m dbhob (cm)	Vol o.b.* (m3/ha)	trees/ha	m dbhob (cm)	Tree vol ** (m3/ha)	trees/ha	m dbhob (cm)	Tree vol ** (m3/ha)	trees/ha	(m3/ha)	trees/ha
Rylington Park	660	5.9	18.35	8.26	125	18.35	32.2	180	15.7	87.6	825	128	1130
Rylington Park	660	5.9	20.25	12.88	159	20.7	27.9	182	16.8	109.4	795	150	1136
Stenes	700	6.9	25.8	13.72	83	19.9	32.4	183	16.1	51.5	467	98	733
Males	1000	5.4	21	9.72	112	19.9	43.6	180	16.3	108.5	694	162	986
Coolangatta.	850	5.9	19.65	6.54	71	19.65	40.3	190	15.9	104	786	151	1047
Watson	1000	6.7	22.2	15.27	157	22.5	59.6	196	17.1	129.6	784	204	1137
Stammers	950	7.2	19.8	6.86	89	20.6	43.1	178	12.9	53	592	103	859

Note

* Volume calculated using Huber's formula

** Total volume

ATTACHMENT B

Furntech Test Results

Australasian Furniture Research and Development Corporation

Summary

Report on the simulated service testing of laminated three-ply flooring manufactured as part of a research project into the processing of small logs into high value products.

Introduction

Following an approach from Valuwood International Pty Ltd who were preparing proposals for a research project entitled “The Economics of Farm Forestry in Australia – Laminated Three-Ply Flooring, a Case Study in Western Australia” agreement was reached to carry out certain mechanical testing to published Standards on both softwood and hardwood cored laminated flooring panels.

The agreed tests to be carried out were -

- (a) Resistance to impact by small diameter ball in accordance with BS EN 438 (derived from ISO 4586-2: 1988); and
- (b) Rolling load test in accordance with ASTM D 2394.

Purchase or manufacture of equipment was necessary to carry out each of the above tests.

Objective

The testing was carried out to determine the level of success of the attempts to produce a marketable veneered floor panel from small log harvesting practices.

The results of the testing process give figures which are used for comparative purposes and are not applied as a pass/fail judgement of the product, although BS EN 438 Part 1 does provide expected small ball impact figures for decorative high pressure laminates when utilised in various applications.

Theory

- (a) The small diameter ball impact test is to determine the capability of the subject material to withstand damage caused by dropped items that have sharp edges or the application of concentrated loads on a small area. This would be applicable to ladies small-heeled shoes on floor panels.
- (b) The rolling load test is designed to assess the capability of the floor panels to withstand damage that may be caused by movement of heavy items of furniture or whitegoods. A prime example of possible damage cause would be relocation of a piano mounted on small roller wheels.

Experimental Method

(a) Small Ball Impact Test (BS EN 438-2)

The apparatus used in this test is shown in the diagrams in Appendix A. It consists of an impact bolt with a 5 mm diameter steel ball mounted at one end, this being projected once against the surface under test by the release of a compression spring.

The spring compression force can be adjusted before release from 0 to 90 N by means of a force-setting housing barrel, the compression spring having a constant of 1,962 N/m.

During testing, the specimen of board under test was secured to a steel backing plate to avoid any possible deflection effects of the blow applied by the impact tester bolt to the surface.

BS EN 438-2 suggests preliminary tests are started with a spring force of 10 N and increased by 5 N on each occasion to determine the minimum spring force at which the material surface shows damage due to impact stress. The Standard however is concerned with the testing of decorative high-pressure laminates and the sheets are to be bonded to high quality fine-faced wood chipboard of 18 to 20 mm thickness with a density of 650 to 700 kg/m³, supported on a 50 mm thick steel plate. Although the Valuwood products had a density of between 540 and 630 kg/ m³, (depending on whether the infill was hard or softwood) the thickness was only 11.9 mm.

The impact tester was mounted in the support fixture, placed on the first specimen board, and the bolt released at a preliminary setting of 12 N. Five impacts were carried out at this setting with a minimum of 20 mm between each impact point. The impact points were then carefully examined for damage to the surface of the material, damage being defined by the presence of fine hairline cracks (frequently concentric), continuous cracks, or flaking of the surface. Indentations to the surface without cracks are not classified as damage.

In our first test there was damage sustained to each of the impact points and the impact tester was reset to give an 11 N force and the tests repeated, again maintaining a distance of at least 20 mm between each impact point. This series of impacts revealed damage to three of the points.

Further reductions in the applied impact force in 1 N steps resulted in the maximum value of the spring force, for which no damage occurred in a series of five impacts, as being 8 N.

In tests on the second panel, impact forces commenced at 15 N and were reduced in steps of 1 N down to 8 N, at which level damage was still being sustained at every impact point.

As an additional check, five further impacts at 8 N were completed on an area on the same panel but remote from the earlier series and these resulted in five impacts with no damage, suggesting that there is considerable variation in the material density of the upper layer of these panels.

The third, fourth, fifth, and sixth series of tests carried out on different panels resulted in no-damage impact values of 8 N, 11 N, 8 N, and 9 N respectively. As expected at this low level of impact force, there appeared to be no differentiation between those panels with the hardwood centre ply and those with the softwood centre ply.

Comparative tests were carried out on 12 mm thick veneered MDF board, which had a material density of 900 kg/m³. The two boards tested gave no-damage impact strength figures of 9 N and 16 N, which is not a quantum leap ahead of the Valuwood figures and also demonstrated some inconsistency at these low values.

(b)Rolling Load Tests (ASTM D 2394)

The basic requirement for this series of tests is the application of a downwards force, on the item under test, of 890 N through a rolling wheel having a diameter of 30 mm and a width of 14.3 mm with rounded edges so that the flat surface is 13mm wide. This rolling load is to be guided so that each pass of the load traverses the same path. The photographs in Appendix B show the arrangement and application of this apparatus.

Measurements of the resulting indentations in the panel surfaces were made using a specially constructed bridge beam to which was attached a dial gauge having measuring increments of 0.01 mm. (See Appendix D)

For each test set-up a number of the supplied panels were assembled at an angle of 45 degrees to the line of the weighted roller frame on a 19 mm double-faced chipboard. A thin foam rubber cushion was interposed between the chipboard and the test panels, as this system was to be the recommended application arrangement. Provision was made during the mounting to ensure that the loaded roller would traverse both plain joints and also three-face joints. The panels were secured from lateral movement by nails driven into the base mounting surface but not sufficiently driven to provide vertical restraint.

The path of the loaded roller over the panels was then plotted and a number of points along this path selected for measurement purposes. Additional points were also selected away from the roller path to provide control measurements to be able to counter any vertical panel movement.

Run-on and run-off panels were situated at each end of the rolling load pass to avoid parking on a test panel.

The rolling load trolley was positioned and the previously determined load placed on it in such a manner to produce the necessary downwards force of 890 N at the application roller.

Measurements were taken at each of the selected points and the trolley then propelled across the panel assembly for a total of ten passes (one return journey equals two passes) and measurements again recorded at the selected points.

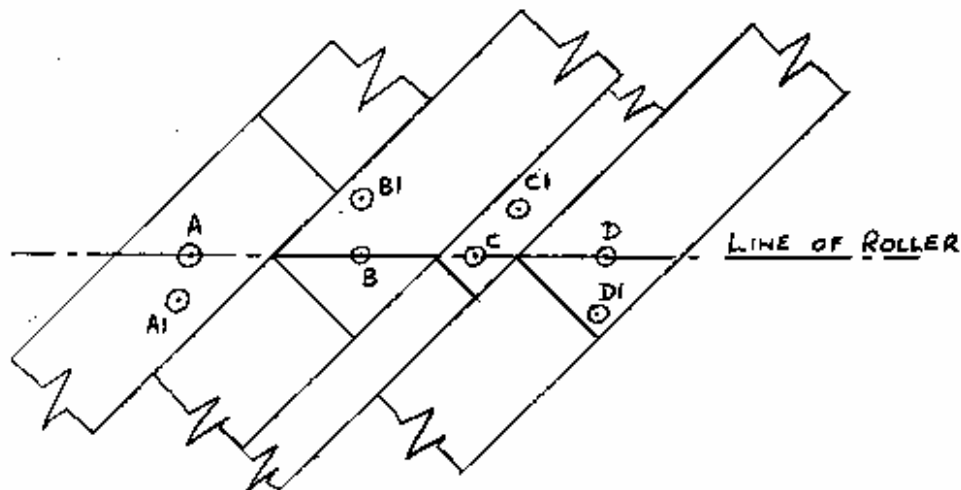
If the indentation produced by the roller after the first ten passes is found to be less than 0.25 mm a further sixteen passes of the rolling load are carried out and the resulting indentation measurements repeated and recorded. This procedure is again repeated up to a total of fifty passes if after the twenty-six passes there is still less than 0.25 mm resulting indentation.

Test No.1

The first tests were carried out on a mixture of hard and soft wood centre ply panels and after the second rolling load pass it was observed that a piece of hardened sapwood had broken out of one of the softwood centre ply boards. As there were no other signs of material failure the testing was allowed to continue for the nominated ten passes. At this stage the trolley started to become unstable as it passed over a three point junction and inspection revealed surface failure at this point, with a measured indentation of 0.65 mm.

It is considered that the lack of tongue and groove location at the ends of the panels contributed to the movement at this point and the subsequent failure.

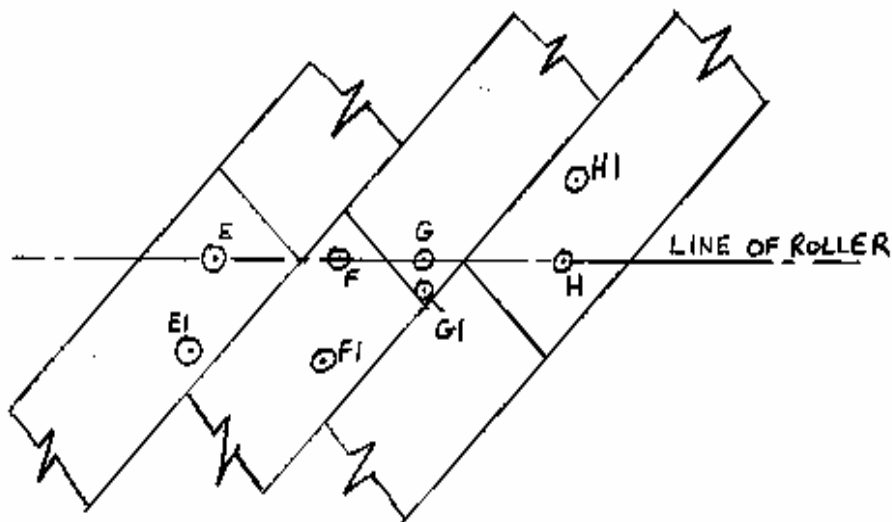
Reading at	Number of Rolling Passes		Deformation
	0	10	
A	15.28 mm	15.07 mm	0.22 mm
A1	15.42	15.43	
B	15.49	15.44	0.10 mm
B1	15.41	15.46	
C	15.63	14.85	0.65 mm
C1	15.64	15.51	
D	15.65	15.21	0.26 mm
D1	15.40	15.22	
Average deformation			0.31 mm



Test No.2

A second batch of panels were then assembled using only those panels with hardwood centre ply and a further series of tests commenced. This second series of rolling load passes did not result in any structural failures and as the average indentation after twenty-six passes at 22.75 mm was less than the 0.25 mm level the maximum fifty passes were made. The fifty passes resulted in an average indentation level of 27.25 mm with a maximum single measurement of 0.38 mm.

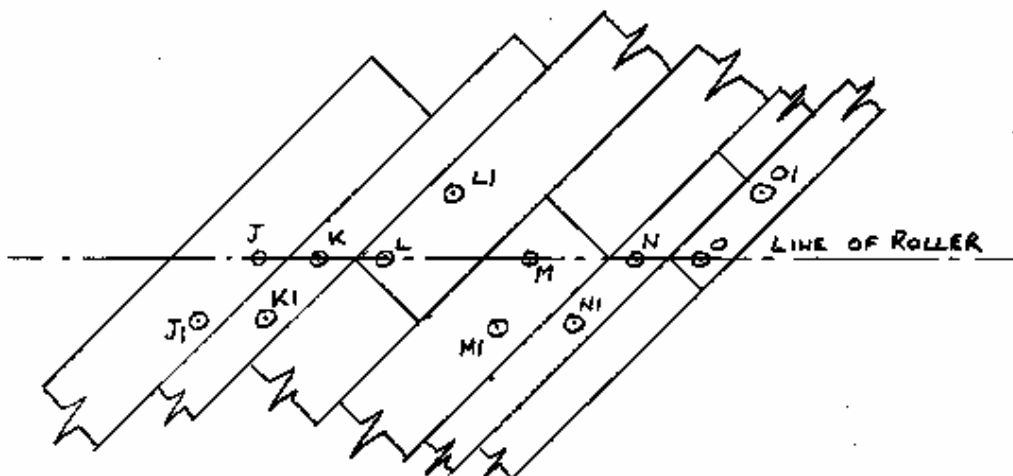
Reading at	Number of Rolling Passes				Deformation after	
	0	10	26	50	26 passes	50 passes
E	15.43 mm	15.12 mm	15.05 mm	15.01 mm	0.32 mm	0.38 mm
E1	15.31	15.28	15.25	15.27		
F	15.95	15.84	15.81	15.78	0.15 mm	0.20 mm
F1	15.43	15.47	15.44	15.46		
G	15.48	15.32	15.21	15.19	0.23 mm	0.25 mm
G1	15.55	15.54	15.51	15.51		
H	15.29	15.19	15.00	15.05	0.21 mm	0.26 mm
H1	15.29	15.37	15.21	15.31		
Average deformation					0.23 mm	0.27 mm



Test No.3

A third batch of panels were next assembled using only those panels with softwood centre ply prior to commencement of another series of tests. Again there were no major structural failures evident in the panels under test and although the average indentation figure after only ten passes exceeded 0.25 mm (0.33 mm) the exercise was continued through twenty-six passes up to fifty passes resulting in average indentation figures of 0.43 mm (25 passes) and 0.46 mm (50 passes).

Reading at	Number of Rolling Passes				Deformation after		
	0	10	26	50	10 passes	26 passes	50 passes
J	15.41 mm	14.86 mm	14.73 mm	14.62 mm	0.45 mm	0.59 mm	0.67 mm
J1	15.47	15.37	15.38	15.35			
K	15.60	15.00	14.88	14.78	0.47 mm	0.60 mm	0.68 mm
K1	15.52	15.39	15.40	15.38			
L	16.09	15.84	15.78	15.72	0.20 mm	0.20 mm	0.16 mm
L1	16.00	15.95	15.89	15.79			
M	15.72	15.46	15.33	15.29	0.26 mm	0.37mm	0.39 mm
M1	15.68	15.68	15.66	15.64			
N	15.94	15.57	15.46	15.39	0.28 mm	0.37 mm	0.40 mm
N1	15.98	15.89	15.87	15.83			
O	15.61	15.15	15.00	14.94	0.30 mm	0.45 mm	0.45 mm
O1	15.45	15.29	15.29	15.23			
Average deformation					0.33 mm	0.43 mm	0.46 mm



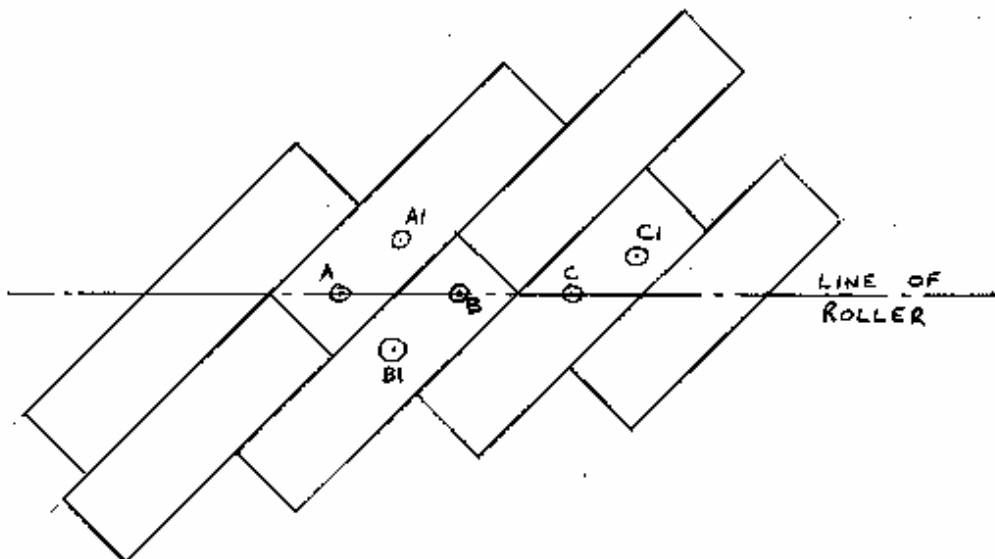
Examination of the test panels after application of the rolling loads revealed undulations occurring in the indented surface that appeared to match the differences wood density normally experienced (See Appendix C). This demonstrated that the maximum indentation to the

surface does not necessarily occur at the points selected for measurement. It is also evident from the control point measurements that there was movement of, or within, the panels which would make it difficult to carry out a meaningful continuous line measurement along the path of the roller. The variation in the control point figures are taken into account when determining the final roller indentation figures.

Test No. 4 on Veneered MDF Board.

Comparison tests were carried out on the veneered MDF board previously used in the small ball impact tests which gave average indentation measurements of 0.04 mm after fifty passes of the rolling load.

Reading at	Number of Rolling Passes				Deformation after		
	0	10	26	50	10 passes	26 passes	50 passes
A	1.55 mm	1.51 mm	1.49 mm	1.51 mm	0.04 mm	0.04 mm	0.02 mm
A1	1.53	1.53	1.51	1.51			
B	1.39	1.33	1.32	1.32	0.03 mm	0.03 mm	0.04 mm
B1	1.43	1.40	1.39	1.40			
C	1.41	1.32	1.30	1.31	0.05 mm	0.06 mm	0.05 mm
C1	1.26	1.22	1.21	1.21			
Average deformation					0.04 mm	0.04 mm	0.04 mm



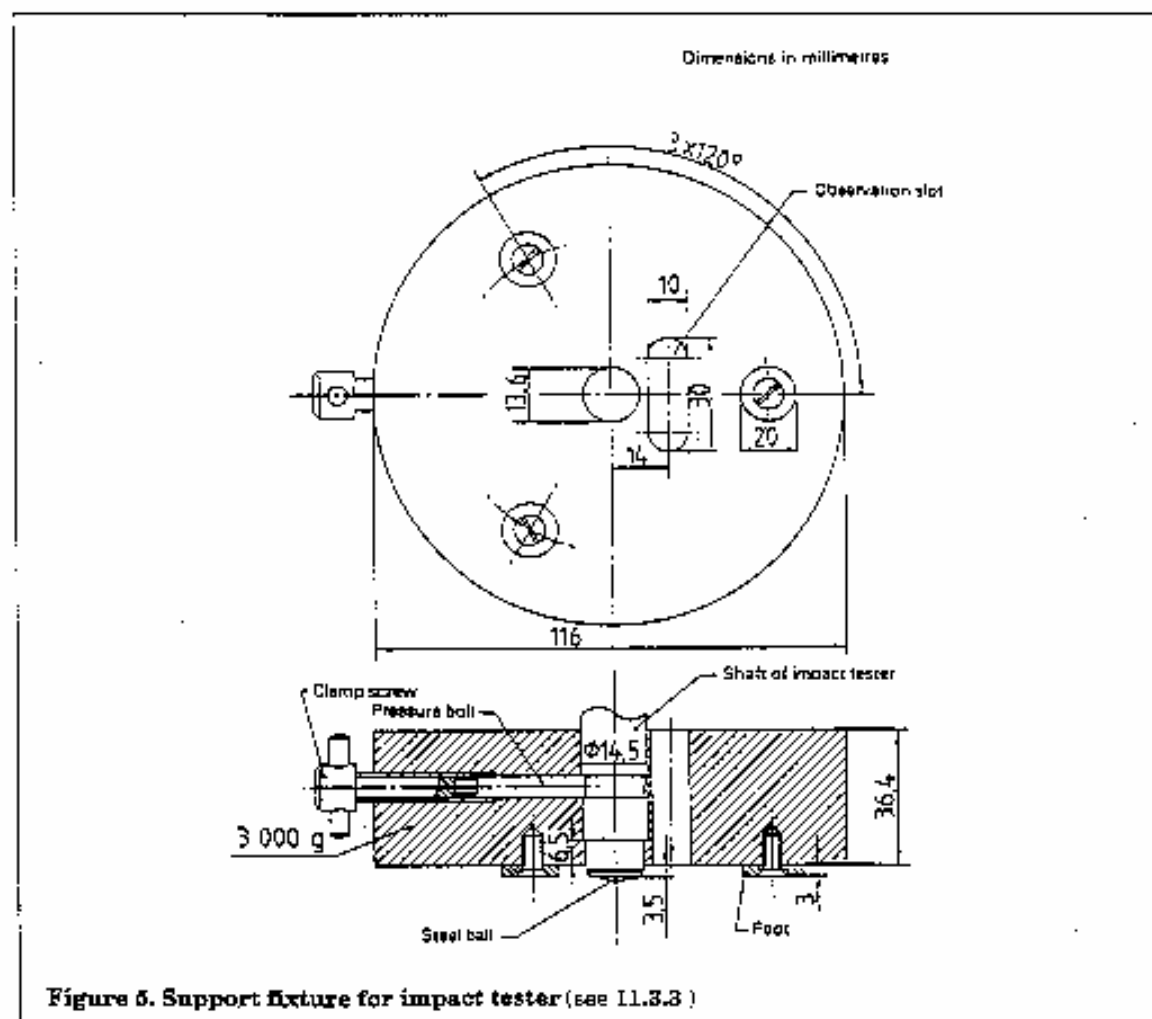
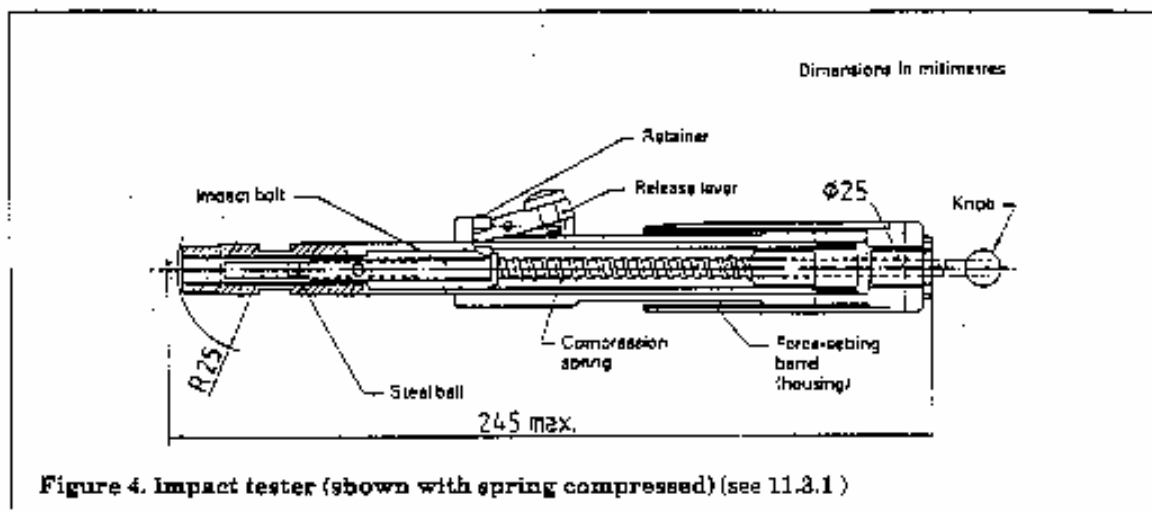
Conclusions

The results of the small ball impact tests bring into question the suitability of the supplied panels for use in flooring applications. BS EN 438 requires a resistance to impact figure of at least 20 N for compliance when used for flooring on special substrates. The best figure attained during testing was only 11 N, which did not appear to be influenced by the centre ply material. If the resistance to impact had achieved a higher level the centre ply material may have contributed to the result.

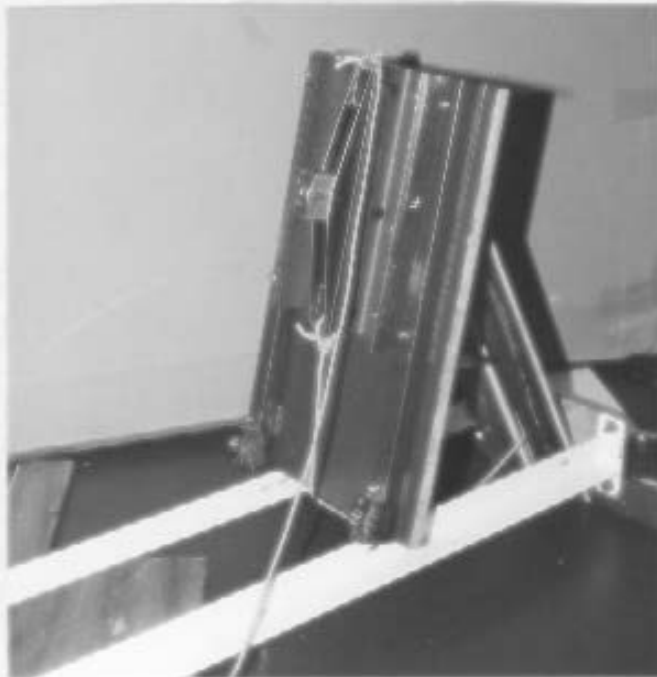
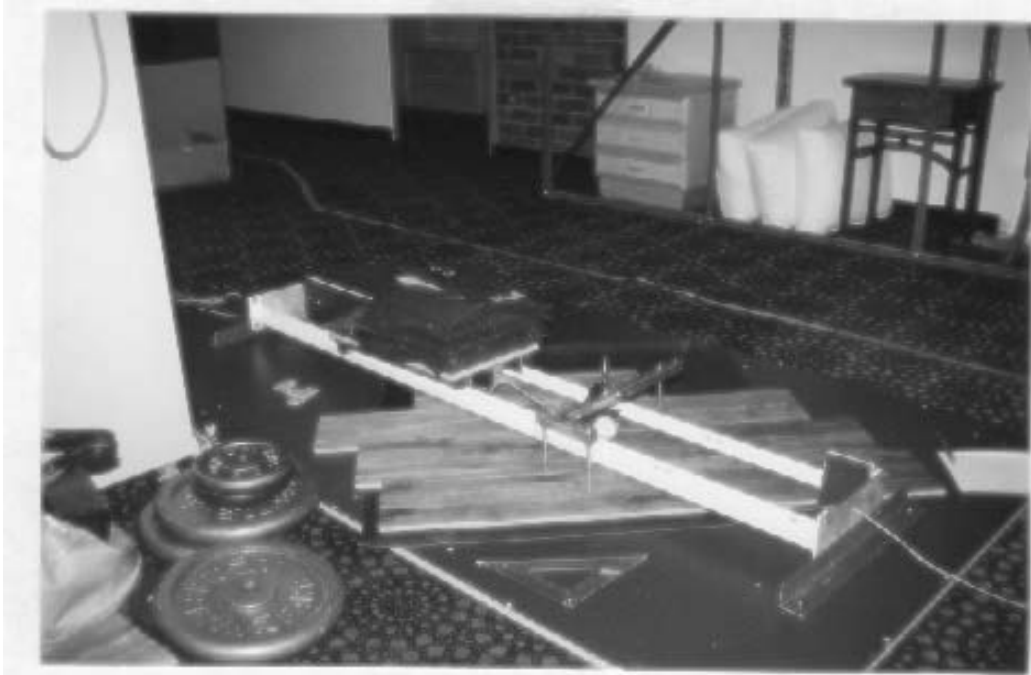
The results of the rolling load tests did demonstrate the superiority of those boards with a hardwood centre ply over those with softwood. However, the tests did indicate that both forms of panel would be expected to sustain considerable damage if used as decorative flooring in any but the most controlled areas of application

As we had no access to any comparative figures for the rolling load tests from any other source, tests were also carried out on commercially available veneered MDF boards resulting in a most unfavourable comparison with the Valuwood products.

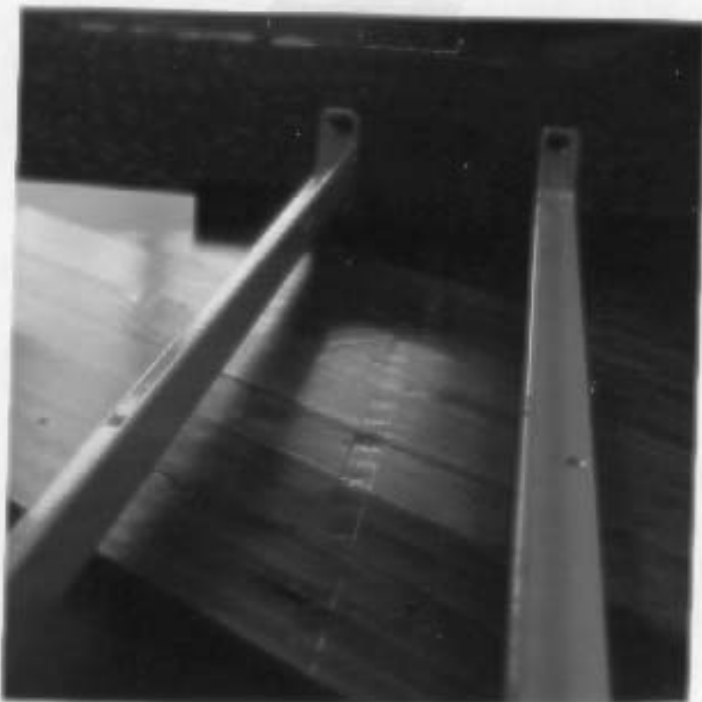
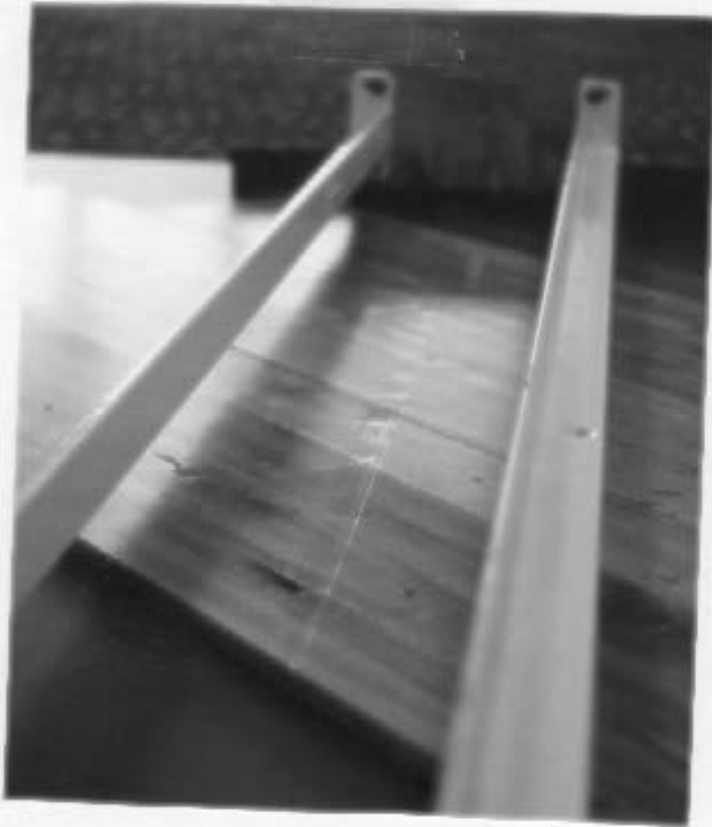
Appendix A



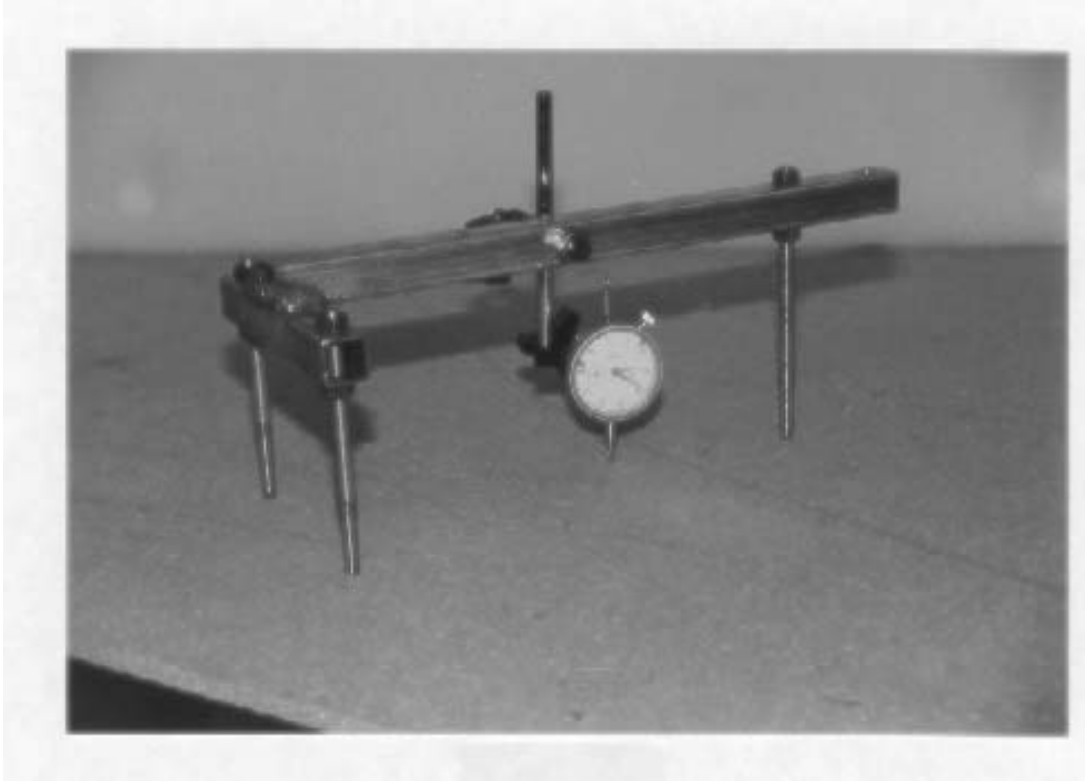
Appendix B



Appendix C



Appendix D



ATTACHMENT C

Forest Products Commission Timber Technology Test Results

EVALUATION OF WA GROWN BLUE GUM (*Eucalyptus globulus*) FOR USE IN LAMINATED 3-PLY FLOORING

BACKGROUND

In May 1999, under the auspices of Forest and Wood Products Research and Development Corporation (FWPRDC), the Department of Conservation and Land Management (CALM) agreed to provide in-kind support and paid services to Valuwood International to undertake FWPRDC Project 99.2007 - *The cost benefits of small log processing - Laminated 3-ply flooring: A case study in WA*. The summarised results of the tests carried out for Valuwood International by FPC Timber Technology (previously CALM Timber Technology) follow. Detailed results and research notes are attached.

COLOUR DIFFERENCE

The colours of end-matched samples that had been either dried without a reconditioning treatment or dried and reconditioned at 140 °C were measured in CIELAB units using a tristimulus colorimeter. The colorimeter was hired from TechRentals and was provided with a current calibration certificate. Five separate measurements were recorded from each sample, avoiding knots. The raw data were used to calculate within sample differences in ΔE_{ab} units using the CIELAB colour difference equation. Average CIELAB coordinates ($n=5$) for each sample were used to calculate the colour differences both within and between the steamed and unsteamed treatments (Table 1).

Table 1. CIELAB colour differences within and between end-matched samples

Sample number	CIELAB colour difference units ([*] _{ab})				Difference between end-matched samples
	Unsteamed		Steamed		
	Within sample	Between sample	Within sample	Between sample	
1	10.0	1.2	5.5	0*	8.1
2	4.7	5.3	10.2	2.8	5.9
3	6.7	6.1	3.4	3.4	5.8
4	6.6	1.0	2.6	2.9	5.3
5	11.2	1.4	2.8	1.2	8.4
6	6.6	7.5	1.8	5.1	4.2
7	6.1	0*	5.2	3.0	6.6
8	4.4	5.7	5.2	4.0	4.6
9	3.7	6.3	5.0	4.4	4.3
Average	6.6	4.3	4.6	3.4	5.9

*Note: * Sample is the reference sample for calculation of between sample differences*

One CIELAB colour difference unit represents a just noticeable difference in colour matching, while six units represents a just tolerable difference. The average colour difference between the steamed and unsteamed end-matched samples was $\Delta E_{ab}:5.9$, suggesting a small but noticeable difference. There were smaller within sample colour differences for the steamed samples than the unsteamed samples, possibly because colour contrast was reduced by darkening. Between sample colour differences for the steamed samples were also smaller, probably because of darkening.

JANKA HARDNESS TEST

The resistance to indentation of the blue gum flooring product developed by Valuwood International in comparison to similar commercial products was measured using a modified Janka method. The Janka method given in ASTM D143 requires incremental measurement of the force required to embed a 0.444" steel hemisphere into the face, edge and end grain of a 2 x 2x 6" test block at a strain rate of 0.25 inches per minute.

Timber Technology used a vice with a modified screw to embed the 0.444" steel hemisphere into the 12 mm thick, 3-ply flooring samples. The maximum load required to embed the hemisphere was determined from the maximum torque applied at the screw using a torque wrench. The rate of indentation was controlled manually by the speed of rotation of the wrench handle to achieve approximately 0.25 inches per minute movement at the jaws. The depth of indentation was measured at the jaws using a Vernier calliper. The results of the tests are given in Table 2.

Table 2. Hardness values for flooring samples based on the Janka indentation test method

Face species	Air-dry density (kg/m ³)	Core species	No. of boards	Face thickness (mm)	Sawing pattern*	Hardness (kN)**
Marri	850	marri	7	4	qs	>13 _(n=14)
Blue gum	650	blue gum	5	4	bs	6.9 _(n=15)
30 yo karri	860	pine	4	2 - 3	qs	6.6 _(n=3)
Blue gum	650	pine	8	4	bs	6.1 _(n=24)
18 yo jarrah	800	pine	1	5	bs	5.8 _(n=4)
European beech	675	pine	2	3	bs	4.8 _(n=5)
Bird's eye maple	730	pine	1	3	bs	3.6 _(n=4)
18 yo. jarrah	800	pine	1	3	bs	3.2 _(n=5)
European oak	690	pine	1	3	bs	3.1 _(n=6)
European beech	675	pine	1	3	qs	2.9 _(n=3)
Nyatoth	650	hardwood	3	3	bs	2.8 _(n=20)

Notes: * bs = *backsawn*, qs = *quartersawn*

** n = *number of measurements used to calculate the average*

The instrument was calibrated by applying torque at the screw using a torque wrench, and measuring the reaction at the jaws using a load cell. An equation relating torque with load over the usable range of the instrument was derived, allowing Nm readings to be converted to kN.

The precision of the test was assessed by repeat measurement of the hardness of three nyatoth boards in a panel. The coefficients of variation within boards varied from 6 to 9 per cent, while the coefficient between boards was 19 per cent, indicating that the differences between boards were significant.

On the basis of air-dry densities of the face laminae, the order of hardness from best to worst should have been karri, marri, jarrah, maple, oak, beech and blue gum. The Janka hardness test ranked the products differently, indicating that the results were influenced by other factors, including the

thickness and sawn pattern of the face laminae, hardness of the core and gaps between the core segments, number of boards tested, and the number of measurements taken.

The results of the tests should be interpreted with an understanding of its limitations. With some boards the sample sizes were small and the hardness figures therefore lacked statistical significance. The extent to which the Janka hardness test replicates the *in-situ* performance of laminated flooring is questionable and a smaller hemisphere may have better replicated the effect of loads imparted by shoes and furniture feet.

Taking uncertainty into account, it can be concluded with some caution that:

- (a) blue gum flooring should be able to meet market expectations for hardness given that European oak, beech and maple are accepted in the market;
- (b) core hardness significantly affected the performance of the product and dense cores should improve overall Janka hardness; and,
- (c) marri will produce a flooring product that is highly resistant to indentation.

ROLLING LOAD TEST

The resistance to rolling indentation of the blue gum flooring samples and similar commercial products was measured using the test method given in ASTM D 2394-83. The method involved repeatedly rolling a heavy three wheeled carriage across assembled sections of floor panel and measuring the depths of indentation caused by the front castor.

The test is intended to replicate the damage caused to timber flooring by moving heavy furniture on castors - a piano being a good example. The variability of the test results was assessed by repeating the test on the same panel three times with the tracks made by the castor separated by one centimetre. After ten passes of the carriage the indentation was measured in 17 positions, avoiding joints, and an average indentation was determined. The coefficient of variation for the three trials was 7 per cent and the coefficient of variation between the panels was 38 per cent, indicating that the differences between the panels were significant.

To achieve this level of precision, it was necessary to ensure that the carriage was moved at a slow uniform speed, joints were not included in the assessment, the carriage traversed the same path (i.e. guiding rails were stiff), and readings were taken in the same places using a three legged instrument to avoid lips at the side of the indentation. The results of the test are given in Table 3.

Table 3. Results of the rolling load test carried out in accordance with ASTM D 2394-83

Species	No. of readings	Indentation (mm)		
		10 passes	25 passes	50 passes
Marri (trial 2)	4	0.02	0.07	0.12
Marri (trial 1)	4	0.07	0.08	0.11
Kapur	8	0.07	0.08	0.12
Jarrah	8	0.18	0.19	0.28
European oak	8	0.15	0.21	0.25
Blue gum wide boards (trial 1)	9	0.17	0.25	-
Blue gum wide boards (trial 2)	9	0.04	0.26	-
Blue gum 'Beckers' coating (trial 2)	10	0.19	0.27	-
Blue gum initial set-up (trial 1)	8	0.18	0.30	-
Blue gum narrow boards (trial 2 qs*)	5	0.36	0.30	-
Blue gum initial set-up (trial 2)	8	0.26	0.33	-
Blue gum narrow boards (trial 1 qs*)	5	0.26	0.34	-
Blue gum 'Beckers' coating (trial 1)	10	0.27	0.34	-
Nyatoh	8	0.21	0.40	-
Blue gum narrow boards (trial 2 bs*)	6	0.42	0.41	-
Blue gum narrow boards (trial 1 bs*)	6	0.33	0.42	-

*qs = quartersawn, bs = backsawn.

The sample size was small and the results must therefore be interpreted with some caution. However, it can be concluded with caution that:

- (a) performance of the blue gum flooring was similar to the lower density imported products because differences in indentation were very small;
- (b) coating the blue gum with three coats of 'Beckers' does not appear to have improved its performance using this test;
- (c) marri will produce a flooring product that is highly resistant to indentation, and;
- (d) use of quartersawn blue gum appears to have marginally improved product performance using this test.

FALLING-BALL INDENTATION

The resistance to impact indentation of a number of the blue gum flooring samples compared to similar products developed elsewhere was measured using the test method given in ASTM D 2394-83.

The test involved dropping a 51 mm diameter steel ball from varying heights onto a test panel and measuring indentation. A straight line was then fitted to the plot of height vs indentation and the indentation at 1800 mm was interpolated. The test is intended to replicate the effect of dropping objects on timber floors

The variability of the test was assessed by repeating the test three times on the same sample. The coefficient of variability for the three tests was 3 per cent and the coefficient of variability of all tests was 23 per cent, indicating that differences between the products were significant. The results of the tests are given in Table 4.

Table 4. Results of the falling ball test carried out in accordance with ASTM D 2394-83.

Species	Indentation from 1800 mm drop height (mm)		
	knots	clear wood	joints
Jarrah		0.34	
Kapur		0.41	
Marri		0.41	
Blue gum + Blue gum core		0.56	
European oak		0.57	
Blue gum + pine core		0.62	
Nyatoh		0.63	
Blue gum wide boards	0.48	0.64	0.66
Blue gum 'Beckers' coated		0.69	

Problems associated with testing such a variable product using a small sample size have already been discussed. The results indicated that:

- (a) performance of blue gum flooring is better with a blue gum core than with a pine core; (b) the performance of blue gum is comparable with nyatoh and European oak, but inferior to jarrah, kapur and marri;
- (c) coating the blue gum with three coats of 'Beckers' does not appear to have improved the performance of the product using this test, and;
- (d) marri will produce a flooring product that is highly resistant to indentation.

TABER ABRASION

The Taber abrasion test was carried out on duplicate samples of the blue gum flooring in comparison with similar products from other manufacturers using the test method given in ASTM 4060. The test involved simultaneously rotating two discs of flooring against rotating abrasive wheels and measuring mass loss and wear after 500 and 1000 cycles. Periodically, the samples were swapped to ensure both were subject to the same abrasive treatment.

The Taber abrader could not accommodate the thickness of the flooring, and the samples were sanded to reduce their thickness' to 10 mm. Removal of the backing caused some of the samples to cup and wear patterns indicated that more material was removed from high spots than low spots during the test. In addition, measurement of wear was subject to significant uncertainty, because thickness measurements were taken in different positions each time and the thickness of the samples was non-uniform.

Although it was not a test requirement, the first sign of apparent wear was noted during the test, and this may be the best indicator of the performance of the flooring *in-situ*, given the uncertainties associated with the other indices. The results of the tests are given in Table 5.

Table 5. Results of the Taber abrasion test carried out in accordance with ASTM 4060.

Species	1st sign of wear	Mass loss (grams)		Wear (mm)	
		500 cycles	1000 cycles	500 cycles	1000 cycles
Nyatoh	150	0.0089	0.0325	0.025	0.035
Jarrah	100	0.0119	0.0347	0.015	0.03
Blue gum 'Mirotone' coated	300	0.0094	0.0347	0.025	0.04
European oak	100	0.0209	0.0454	0.025	0.05
Kapur	150	0.1656	0.0469	0.01	0.025
Blue gum 'Beckers' coated	100	0.0250	0.0530	0.02	0.045

Regardless of the index used for assessment, it can be concluded that the blue gum flooring treated with the 'Beckers' finish did not perform well compared with the other products. If the 1st sign of wear is used as the best means of assessment, the 'Mirotone' coated blue gum performed significantly better than the other products.

GLUE STRENGTH

A range of adhesives was assessed for strength using the cleavage test outlined in AS1328:1986. The test involved preparing notched samples that were split along the glue line using a bolster and masonry hammer. The separated surfaces were then visually assessed and the percentage of wood failure was determined and stated in 5 per cent increments on a scale ranging from 0 to 100 per cent.

Two types of adhesives were evaluated - a melamine urea formaldehyde (MUF) composition and moisture curing hot melt polyurethane (PU) thermoplastic compositions. The test panels were pressed in an Orma glue press with hydraulically actuated vertical and horizontal rams and heated upper and lower platens. In the case of the thermoplastic adhesives, wood and press temperatures were varied to optimise performance. The results are the assessments are given in Table 6.

Table 6. Results of gluing trials carried out using a MUF thermosetting adhesive

Sample	No. of replicates	Per cent that exceeded 60% wood failure
blue gum/blue gum	149	76
blue gum/pinaster pine	153	65

Table 7. Results of gluing trials carried out using hot melt PU thermoplastic adhesives

Sample	No. of replicates	Per cent that exceeded 60% wood failure
Purmelt 5300 (Hard setting)	30	93
Purmelt 5305 (Soft setting)	29	90

The cross-linking thermoplastic compositions were sensitive to moisture absorption and designed for use in an air tight applicator. For the purpose of evaluation, the moisture resistant wrapping protecting the 200 mm diameter by 300 mm length adhesive block was peeled back to expose the end of the sample and the block was placed face down in a non-stick frypan on low heat.

When sufficient adhesive had melted the remaining solid portion of the block was removed from the pan and re-wrapped in its protective barrier. The liquid adhesive was then applied to the wood surface using a spatula. Leftover adhesive was disposed of. After the second trial a rind developed around the adhesive block due to moisture induced cross-linking. Adhesive from the rind did not melt and therefore was not included in the test.

The test results for the untreated blue gum samples indicate that the hard setting hot melt PU adhesive performed significantly better than the MUF adhesive in terms of percentage wood failure. Given the difficulties encountered applying the holt melt adhesives, it is considered probable the hot melt PU adhesives would have performed better if they had been applied using purpose made equipment.

HARDNESS TREATMENT

After treating some samples by the hardening process Vydex, it was discovered that the treatment had been incorrectly applied. Consequently, data from the Vydex treated samples were discarded. Further assessments of the efficacy of hardening treatment processes on blue gum may be undertaken by FPC Timber Technology to clarify the situation.

ATTACHMENT D

**MARKET EVALUATION
TIMBER FLOORING SYSTEMS**

For
Valuwood International Pty Ltd

SEPTEMBER 2001

Terry Jones



Executive Summary

Practical manufacturing products and opportunities need to be identified for high value alternative uses for the developing Australian hardwood and softwood plantation industries. From previous work undertaken engineered wood flooring (EWF) was identified as one such product and market.

Wood flooring markets world wide are extremely large and represent a value of about US\$ 5.4 billion and more than 300 million m² (RWS figures 1996).

In Europe wood flooring accounts for about 20% of the total flooring market, while pre finished EWF has more than 70% of the wood flooring market. Western European production of parquet and EWF increased by almost 4% for 2000 to around 90 million m² with consumption increasing by 8.7% (FEP). Average prices per m² for parquet and EWF in 2000 had imports at an average value of 15.10 euros and exports at 19.50 euros (FEP).

Germany (18%), France (11%), Italy and Spain (8%) were the biggest producing countries in Europe while Germany (31%), Italy (14%) and Spain (13%) were the biggest consumers in during 2000 (FEP).

The US wood flooring industry was valued at US\$ 1.8 billion at manufacturers cost in 2000 and accounts for 7% (70 million m²) of the total flooring market (Catalina Reports 2001). New opportunities are arising in North America due to the increased usage of concrete slabs (now about 40%) in house building, particularly in the eastern parts of the US.

Australia's wood flooring market was around 2.5 million m² with a value of more than A\$21 million in imports for 1999/2000 (Source ABS).

To develop an EWF plant in Australia producing either a two or three layer panel for which an average plant size would be capable of producing 500 000-600 000 m² annually on a two shift basis, international markets need to be found and evaluated.

Bluegum hardwood and softwood plantations can supply furnish to manufacture EWF using either all bluegum or a combination of bluegum as the top or wear layer and softwood as the core and/or the back or bottom layer.

There are limited EWF products in the market in niche areas that have a similar knotty appearance like that of the current bluegum resource which has been grown for chip and pulp production. It has been evident however during the market research that there are more products being put on the market that carry significantly more features and supplement existing production.

There are various raw material suppliers existing in native hardwoods within Australia that could supply furnish as face material for an EWF plant. During a market visit to the east coast of Australia during the latter part of 2001 several native hardwood sawmillers expressed interest in becoming a raw material supplier, which would significantly increase the area of square metres the raw material could be placed in as opposed to traditional solid tongue and grooved flooring.

Other companies are currently sending kiln dried and sawn hardwoods overseas to Asia and Europe, and having EWF produced and then sold in those markets or having it returned to Australia for local sales. This in part would contribute to the increase in imports of pre assembled wood flooring.

Exports to Europe and the US should be reasonably attractive due to the currently favourable exchange rates.

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General Overview

The world supply and use of timber resources are coming under increasing pressure for a range of reasons. Most use is in the most basic form such as fuel in third world countries for cooking and heating, however, in high value, high quality products such as veneers, hand-crafted furniture or multi layered engineered wood flooring, there is always a new product or market to develop and refine.

Whether the wood fibre we use comes from native forests, plantations or farm forestry it is essential that it comes from an ecologically sustainable resource, and while we must resolve environmental issues and problems we also need to obtain the best return from this great renewable resource.

Resource figures relating to flooring use are quoted from various sources around the world. Figures for the total Western European flooring market in 1996 are around 1 724 million m², with statistics from North America quoting manufacturers sales of US \$20 billion and using more than 3 billion m² in 2000.

Sales in the US were slower due to a decline in new home construction and a leveling of in existing home sales. Manufacturers and marketers are looking to more favourable demographics and an increasing size and floor area of the average new single family built home.

Wood flooring consumption has steadily grown in Europe and the US during the 1990s. Information gathered for this report and on markets generally for timber flooring indicates that it has been evident for some time that this is an expanding market and that it is at the same time coming under more intense competition. The competition is not only from “whether”, a German term referring to solid floating or glue-down flooring, but also from high production, low cost hardened laminates and many other types of floor coverings.

Processing and conversion of timber resources for manufactured products is a very efficient way of utilizing as much of the available wood fibre as possible while extending the use of that fibre by extending it two-four times or more depending on the final thickness of the surface layer.

Wood flooring is a natural product and as a result has regained an improved status as a floor covering material. Engineered Wood Flooring (EWF), also known as multi-layer flooring, is such a product. Basically EWF can be produced using two or three layers, although there are products on the market in five layers or multiple layers in a plywood type of construction. For two and three layer products the most common thickness used in face layers is about 4.5-6 mm.

New EWF plants that manufacture either two or three layer flooring are capable of producing about 1000m² per shift. Overall capacity for a plant when working two shifts produce around 500.000-600.000 m² annually, while larger plants could have up to 3.000.000 m² annually on a three shift basis. For this volume of production an Australian based plant would perhaps have to export at least half of its capacity.

Typically EWF can now be produced in many styles, patterns and finishes. Many companies are supplying product with between five to ten coats of finish. New finishes are also on the market providing for a harder wearing surface with products containing aluminium oxide or ceramic and offering up to 25 year guarantees.

The writer has been able to visit several markets and trade show events over the previous 12 months aligned to flooring, wood manufacturing, furniture, equipment and machinery suppliers and end of line manufacturing businesses in Europe and the US.

Such visits included the INTERZUM and LIGNA trade and industry fairs in Germany during May 2001, the Milan International Furniture Fair, Italian Study Tour in April 2001 and visits to major furniture and timber processing exhibitions in North America during mid-late 2000.

The most relevant trade exhibition attended relative to the flooring industry was INTERZUM in Cologne, Germany in May 2001. This show concentrates on materials, fixtures and fittings for the flooring, furniture and domestic/commercial use areas.

At INTERZUM wood was the main material on display from veneers to solid wood, engineered and manufactured products for use in floors, interiors and furniture.

Trends for timber materials are still dominated by locally sourced European timbers in lighter colours, such as beech, maple, pine and alder. Oak was regaining previously lost ground and was being bleached or steamed to lighten its colour while Cherry was entering the market with a much stronger focus. There appeared to be a slight trend upwards in some of the other darker timbers in wenge, merbau, iroko, and coconut. Bamboo was displayed very prominently.

Rustic or characteristic styled floor boards are in fashion and are supplied as wide as possible and in long lengths. There was one Spanish company displaying maritime or pinaster pine flooring, which was milling over 100 000 m³ annually. Samples of jarrah were shown and discussed with several exhibitors and they thought that reddish toned timber had considerable potential because there is little available worldwide.

Another trend evidenced was the introduction of “click joints” for flooring products. This is a profiling style that is used on the tongue and the groove on flooring and helps eliminate the need for glue or adhesive to be applied to flooring joints, while being engineered to maintain or increase the structural integrity of the floor.

Further trends in the development of specialized underlays for floating floors has improved. This includes new products and sealants to reduce sound transmission and/or “drumming”, to the feel and ergonomics underfoot.

New applications for sealing edges on tongue and groove joints with waxes and the appropriate equipment for mechanical application were being introduced. This equipment and processing need to keep pace with the manufacturing outputs, and to be competitively priced.

Flooring producers are introducing new lines displaying these characteristics and are “niche” marketing them. They are complementary to their existing range and production while attracting marginally higher value. Parquet Marty of France has recently introduced a rustic laminated parquet in oak with knots.

While there have been few timber flooring products similar in appearance to plantation grown Tasmanian bluegum, products are currently in the marketplace, including Australian cypress pine with

its knotty appearance. There should be potential to develop a flooring export market using timber of this species. Photo examples of some of these floors are to be found within this report. A SWOT analysis is reported.

It is suggested to best match the characteristics of the resource to the product in flooring, the following should be noted;

Market opportunities are best directed at the flooring retailer and home centres in Europe, North America and Australia. Individually they represent the greatest proportion of the market and have a closer trading relationship between seller and buyer.

Production can be targeted to meet their needs that require short length materials for ease of handling and transport. Length ranges of manufactured EWF panels could be between 600 mm-2200 mm, but could be reduced to say 900 mm, 1200 mm and 1800 mm.

Panel widths could be supplied in single (60-85 mm), double (120-180 mm) or triple board (18-220 mm) widths. Because of the nature of the existing bluegum resource it would be advantageous to produce the smallest widths and lengths possible while meeting the market needs.

A total package not only for EWF panels needs to be implemented but the “package” needs to include all ancillary and complimentary mouldings, fittings, installation information, refinishing guidelines, warranty timing and after sales service back up.

Distribution, packaging and promotional strategies need to be identified to ensure success in the marketplace. Company information in brochures and on web sites have raised the standard for what is required by the seller and the consumer.

Market surveys were conducted in Perth Western Australia with the installation of two floors in prominent positions. One is a permanent floor in the main reception area at the Operational Offices for the Department of Conservation (previously the Department of Conservation and Land Management, CALM) in Kensington. The second floor was temporally displayed at the Timber Advisory Centre at Homebase, Wembley, which is a timber exhibition centre. Information was also gathered from participating at field events and trade shows within Western Australia.

Information was displayed at both centres and surveys were conducted by staff on hand at both locations. Indications show that more than 400 people have filled in the survey forms or requested further information and have generally shown considerable interest and acceptance for the product.

As background to the current production, use and potential for flooring, this report provides data on the overall world production in timber products, and then Australian production. The major emphasis of the report is on flooring products, and the corresponding data for world, Australian and Western Australian production are shown. The current pricing structures by continent and country are also shown.

World Forest Products Production And Trends

World round wood production (1996 figures) 3 358 million m³

Industrial round wood 1 498 million m³

Fuel wood/charcoal 1 860 million m³



Source: State of the Worlds Forests 1999, FAO

The FAO's latest information indicates that developed countries account for 70% of total world production and consumption of industrial wood products. Developing countries however produce and consume 90% of the world's fuelwood and charcoal. World wide more fuel wood and charcoal are used each year than industrial roundwood. The demand for industrial round wood is expected to grow at 1.7% annually between now and 2010, while fuel wood is expected to increase by 1.1% annually over the same period.

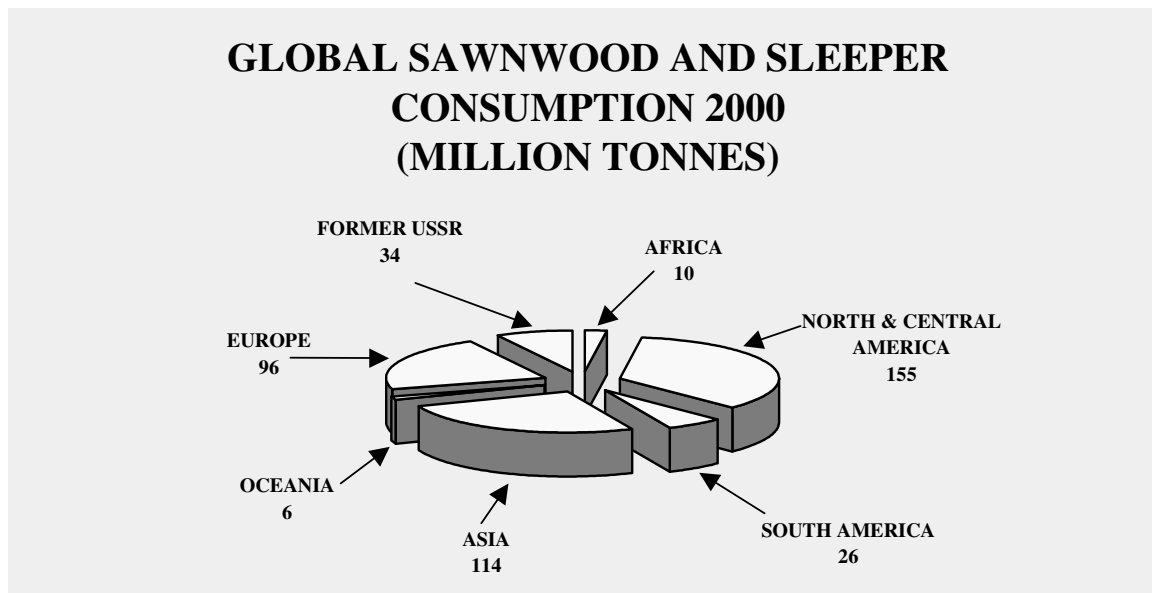
The production of sawn wood and sleepers for 2000 was 441 000 000 million tonnes. This was broken into various geographical regions as; Africa 10 M tonnes, North and Central America 155 M tonnes, South America 26 M tonnes, Asia 114 M tonnes, Oceania 6 M tonnes, Europe 96 M tonnes and the former USSR 34 M tonnes.

Overall trade in logs, sawn wood, veneer and plywood is declining. However the trend is that the value added content and value of the manufactured product are increasing. Most countries are now value adding to their forest resources rather than exporting raw logs or green sawn timber.

Of major current consequence is the trading and consumption of timber in China. With the "westernization" of China and now that that country is hosting the next Olympic Games, the usage

and consumption of timber products is anticipated to increase significantly. It is predicted that Beijing's GDP alone will increase by 10 billion yuan or approximately US\$1.2 billion per annum to 2008. For the first half of 2001 China imported 7.99 million m³ of logs at a value of US \$878.3 million (Source ITTO). Sawn wood imports for the same period were 1.807 million m³ at a value of US \$451.4 million.

*NB: Fuelwood and charcoal use represent more than 50% of total round wood production.



Source: Miller Freeman UK Ltd/Key Note Ltd 1999

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The major use of consumption at present is for construction and housing development, while Olympic Games construction will become a major user. While the average global consumption of timber per capita is 0.68 m³, China's current usage is only 0.12 m³ per capita, or less than 1/5th of the world average. Other major cities in China are experiencing rapid growth and the use of timber in Shanghai and Guangzhou is increasing over other major Chinese cities or regions.

Japan was still the largest importer in the year 2000 with tropical timber imports of about 15 million m³, China was the second largest with 11 million m³, while the European Union imported about 10 million m³ of tropical hardwoods, with Italy, France, UK and Belgium being the major importers in that order.

In the Asia/Pacific region most countries are net exporters of processed wood, and the major exception is India, which is a net importer.

The Malaysian Timber Council quotes that Malaysia for example annually produces around 5.5 million m³ of sawn timber plus 3.4 million m³ of plywood. There were 25 parquet flooring plants, 1128 sawmills, 184 plywood/veneer mills and 257 kiln drying plants in that country.

Malaysia is pursuing other wood processing opportunities such as reconstituted wood-based panel boards or products, solid doors and windows, multi-ply pre finished parquet and wooden furniture and components.

Australian Sawn Timber Production

To get a better appreciation of the comparative importance of flooring in relation to the overall sawn timber production in Australia, the overall trends of production and consumption of both hardwood and softwood (000 m³) are given.

	95/96	98/99	00/01 (March quarter 2001 provisional)
Hardwood			
Production	1604	1267	1218
Consumption	1472	1350	1302
Softwood			
Production	2054	2338	2364
Consumption	2676	2980	3092
Total			
Production	3658	3605	3582
Consumption	4148	4330	4394

The above figures show that from 1995/96 to 2000/01 hardwood production has consistently fallen, especially in the late 1990s, partially due to native hardwood cutbacks and changes to government forest production policies. The implementation of Regional Forest Agreements (RFA) further impacted hardwood production. For 1995/96 though there was a higher production of hardwood than the apparent consumption.

Both production and consumption of softwood has increased during the previous five years. Several factors have changed during this period, namely a shifting focus from hardwoods being used for roof construction with softwood being used more and a higher emphasis being placed on value adding and downstream processing/manufacturing for hardwoods.

The implication for the housing and construction industries of the GST being introduced on July 1 2000 saw increased demand for basic timber construction with a higher than usual consumption figure.

Woodchip production and sales

Woodchip production relies heavily on sawmill residue as well as forest thinnings and residue logs, and therefore data on woodchip production and sales are reported. Generally the processing and sale of native hardwood chips have declined while the sale of plantation eucalypt has steadily increased. Further decline in native hardwoods is anticipated while plantation hardwood will further increase its market share. For example in Western Australia a new chip installation in the lower southwest at Albany had its first delivery of bluegum

chip logs delivered in September 2001. Within a few years it is expected exports from this facility will be around 2.5 million tonnes annually.

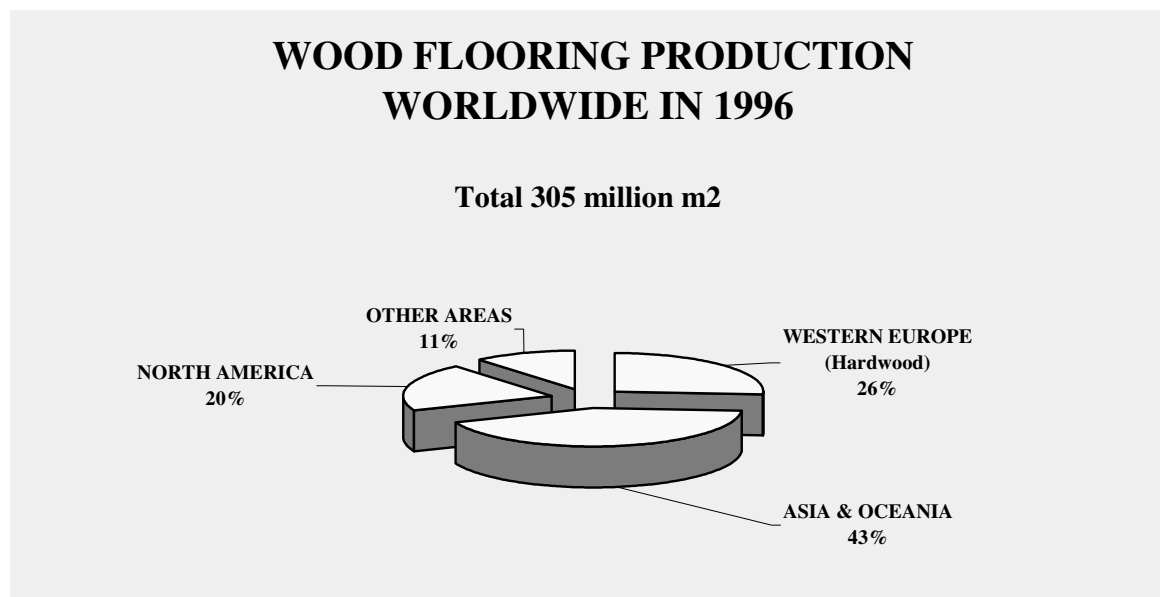
Australian Woodchip Exports ('000 tonnes bone dry units)

Year	98/99	99/00	Dec 99/Sept 00	(Four quarters)
Quantity		3885	4628	4863
Value (A\$M)		585.9	646.1	686.2

World Flooring Trends

This market report addresses the use for flooring but particularly engineered wood flooring (EWF) which includes pre-finished multi layer or laminated flooring.

The RWS-Engineering OY report of 1998 indicated that the 1996 figure for the production of flooring worldwide was 305 million (M) m2, which was divided into four main geographical areas. Of the 305 M m2, Oceania and Asia produced 130 M m2, North America 60 M m2, Western Europe 80 M m2 (hardwood species), and “Other”, which includes Eastern Europe and South America was 35 M m2.



Source:RWS-Databank 1998

The total sales value for flooring was US \$5.4 billion. Production was estimated to be Oceania and Asia US\$1.6 billion, North America US\$1 billion, Western Europe US\$2.1 billion and “other” areas US\$0.7 billion.

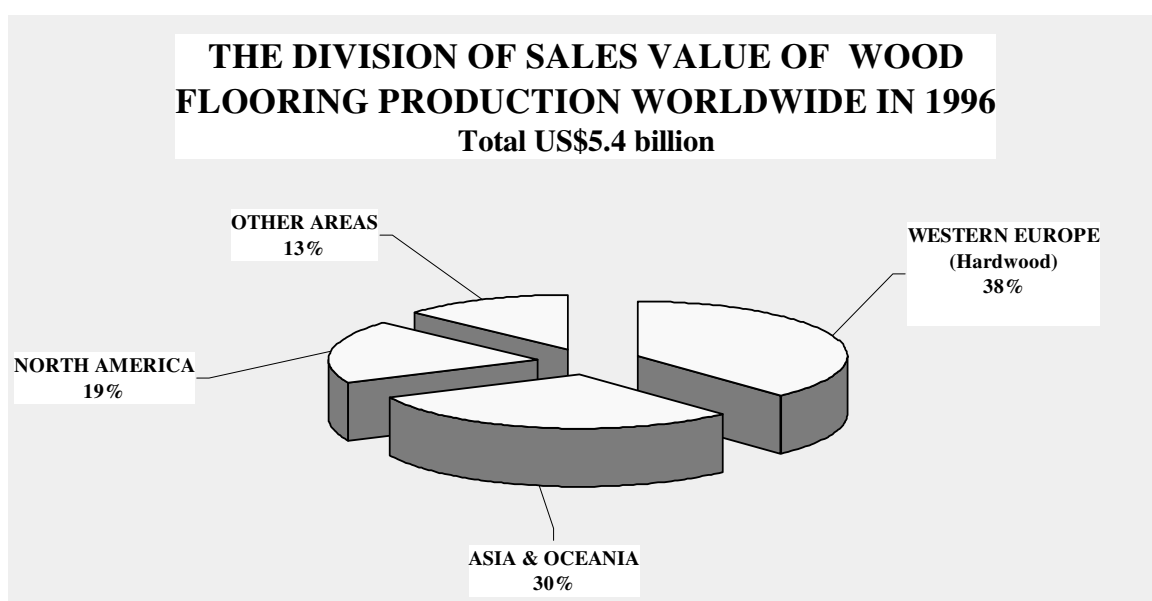
The RWS suggested the future of flooring would be about 360 million m2 by 2010 with laminated parquet making up 145 million m2 or 40% of the total wooden flooring market. This represents an increase of 1.5% annually. Hardwood flooring in Europe represents almost 5% of the total flooring materials used.

Flooring Production And Sales

World production and sales of wooden laminated flooring (in million m2) has been as follows:

World Laminated Flooring Production

<u>Year</u>	<u>Europe</u>	<u>North America</u>	<u>Asia/Other</u>	<u>Total</u>
1995	53	1	1	55
2000	300	28	36	354



Source:RWS-Databank 1998

World Laminated Flooring Sales

1995	50	3	2	0.5	55.5
2000	245	57	50	13	365

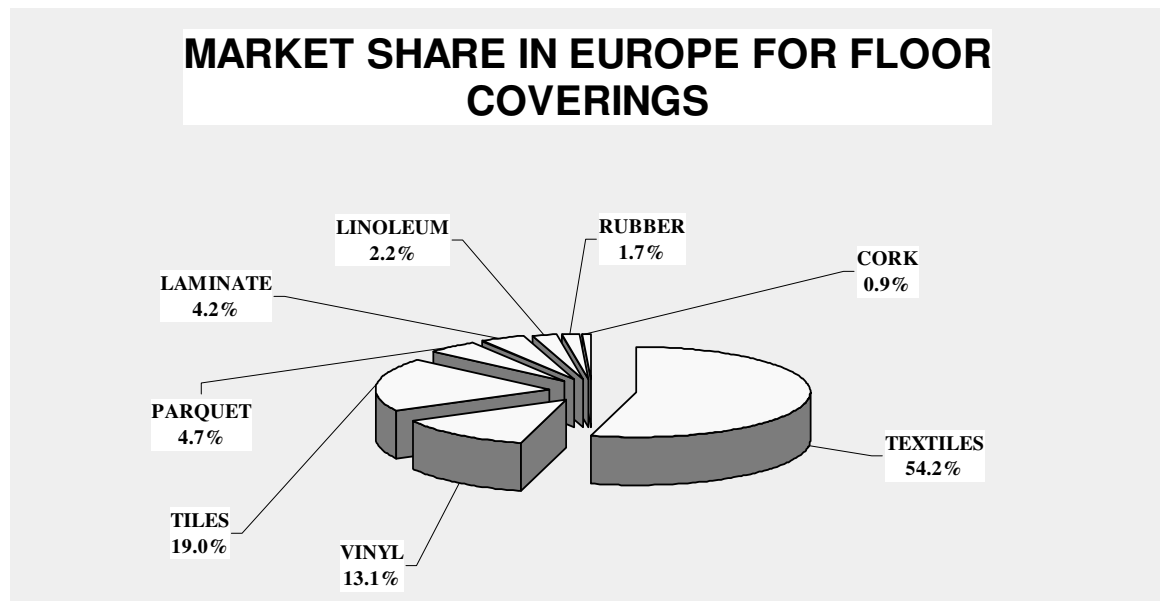
Europe

The total flooring market in Europe for 2000/2001 included 300 million m2 of wooden flooring, representing about 20% of the total flooring market.

Sales distribution for wooden flooring in Europe was:

Flooring wholesaler	20%
Do it yourself (DIY)	45%

Wood and Board wholesaler	10%
Specialised trade/flooring retailers	25%



Source: RWS-Data Bank 1998

North America

The US wood flooring industry was valued at US\$1.8 billion based on manufacturers cost in 2000. Hardwood floors account for 7% of the flooring market. Sales of wooden flooring in North America for 2000/2001 were 70 million m², a dramatic increase in just a few years from 18 million m² in 1997. Distribution was as follows:

Flooring retailers	71%
Home centres	26%
Others	3%

Areas of main use are:

Residential / renovation	92%
New constructions	5%
Commercial	3%

Imports from Europe to North America account for about 50% of the volume.

Asia

By far the largest market in Asia is China, whose flooring sales volume is about 50 million m² and this figure is expected to double by 2002 to around 100 million m².

Oceania

Australia imported about 500 000 m² during the year 2000 from Europe, while our national sales were about 2.5 M m².

Hardwood Laminate Flooring

It is estimated that around 470 million m² of laminated flooring was produced in 2000. The ten biggest producers account for 70% of the market.

There are approximately 37 major plants in Europe, 16 in Asia and only two in America. These plants generally have a larger production capacity over traditional wooden flooring plants with annual plant production capacity of 600 000 m² – 3 000 000 m² being common.

Engineered Wood Flooring – Western Europe

Reports suggest that Western Europe produced about 90 million m² during 2000. The European Federation of the Parquet Industry (FEP) is the biggest flooring association in Europe, representing 46 parquet manufacturers, six national associations and accounts for 80% of total flooring production in Europe.

Production by FEP members during 2000 increased by 3.6% to 63 million m² while consumption increased by 8.7% when compared to 1999. This increase in production came mainly from countries like Finland, Germany, Spain and the Netherlands. If production from other countries like Ireland and Portugal were to be included, then about 91 million m² was produced during 2000.

Traditional parquet sales fell by 16% to 3.3 million m² and now only represent 5% of the total wooden flooring market. Multi layer flooring increased its market share by 6% to 45 million m².

Imports into the European Union during 2000 increased by 14% in value and by 26% in volume to around 21 400 000 m².

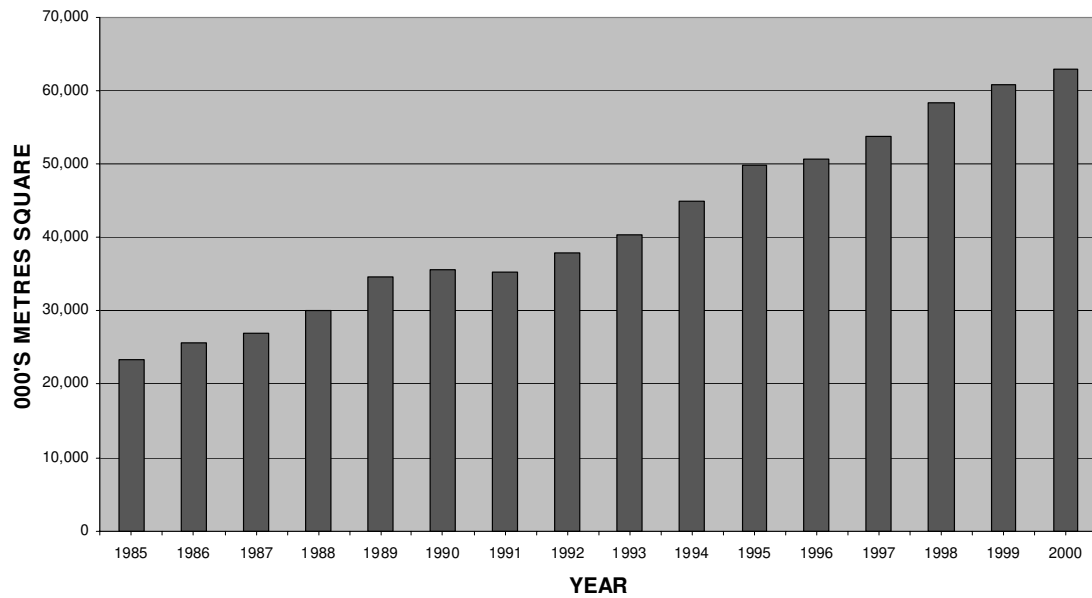
The average price per m² at import level was 15.10 euros and for export was 19.50 euros. Both imports and exports saw an approximate 10% increase from 1999 to 2000.

In Europe wood parquet flooring has re established itself as a traditional flooring material. The Europeans consider that with new product and material enhancements such as;

- Glue free installation systems for multi layer floors
- Improved surface finishes (Which improves resistance to marking and scratching and improving general performance)
- Increased variety of products

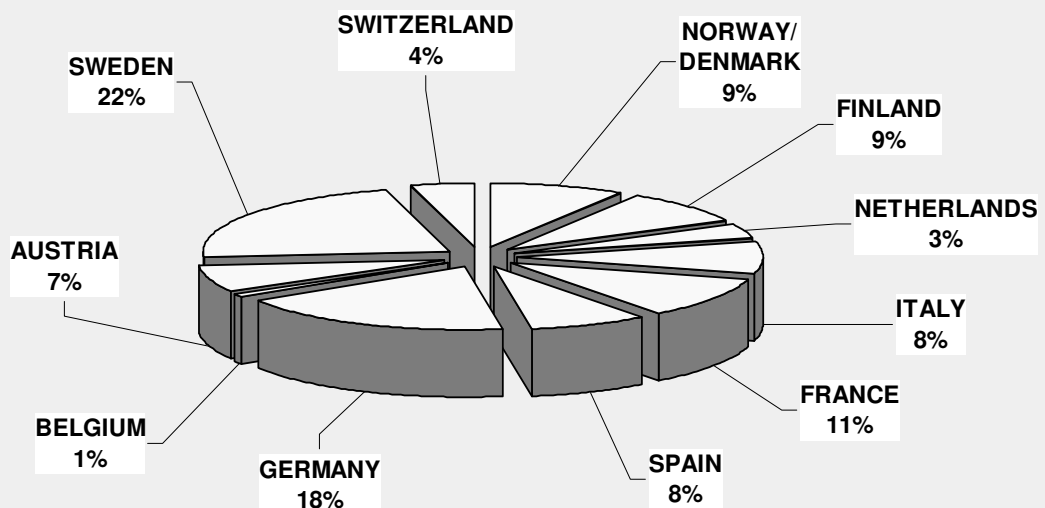
A number of European flooring manufacturers import face layer material in red and white oak from the US. In recent times the cost of these materials has become to expensive and are looking towards the eastern block countries for resource. Labour costs within Europe have also risen making competition tougher.

EUROPEAN FEDERATION OF THE PARQUET INDUSTRY (FEP) **FEP PRODUCTION 1985-2000**



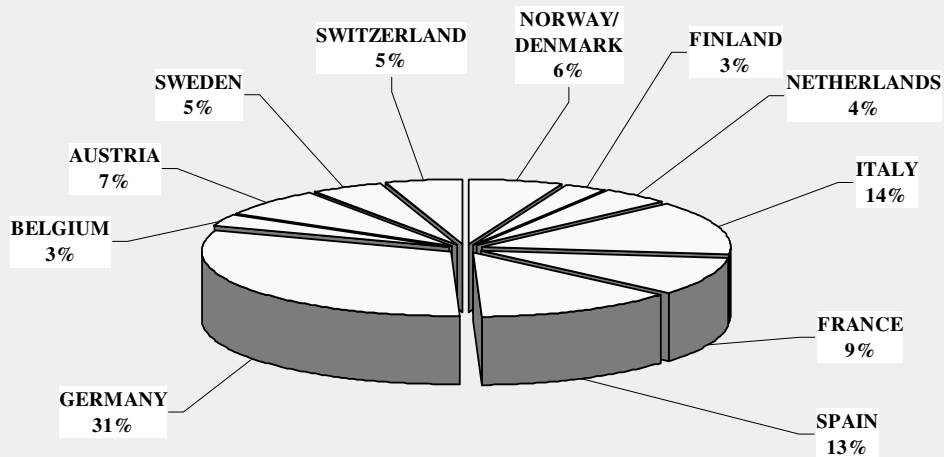
Source: European Federation of The Parquet Industry

FEP PRODUCTION PER MEMBER COUNTRY



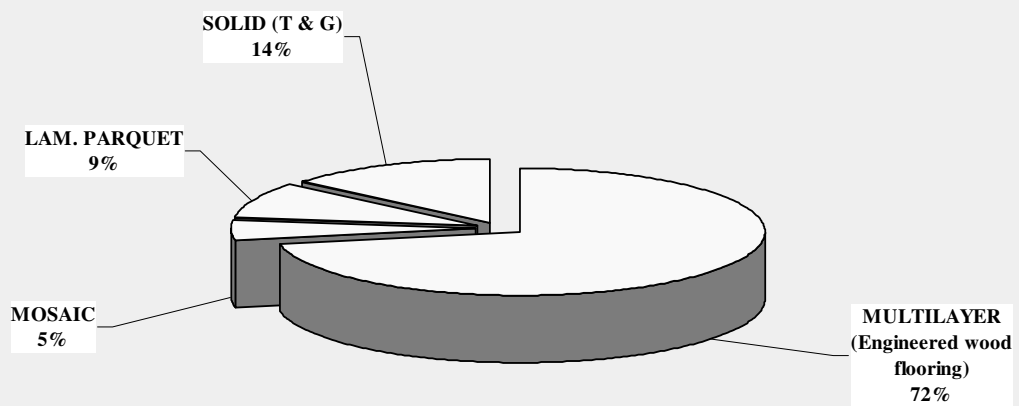
Source: European Federation of The Parquet Industry

FEP 2000 CONSUMPTION BY MEMBER COUNTRIES



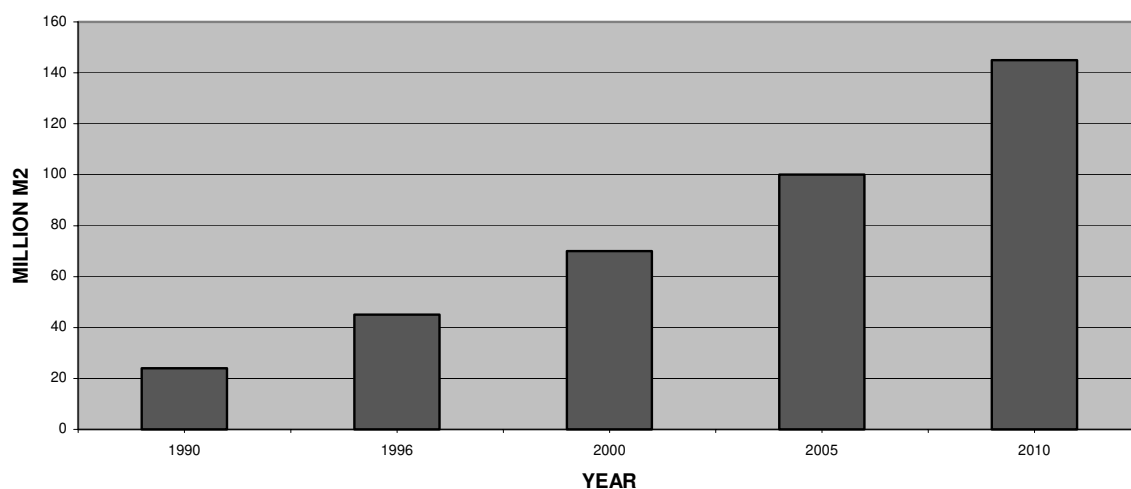
Source: European Federation of The Parquet Industry

FEP PRODUCTION PER FLOORING TYPE - PERCENTAGE OF MARKET



Source: European Federation of The Parquet Industry

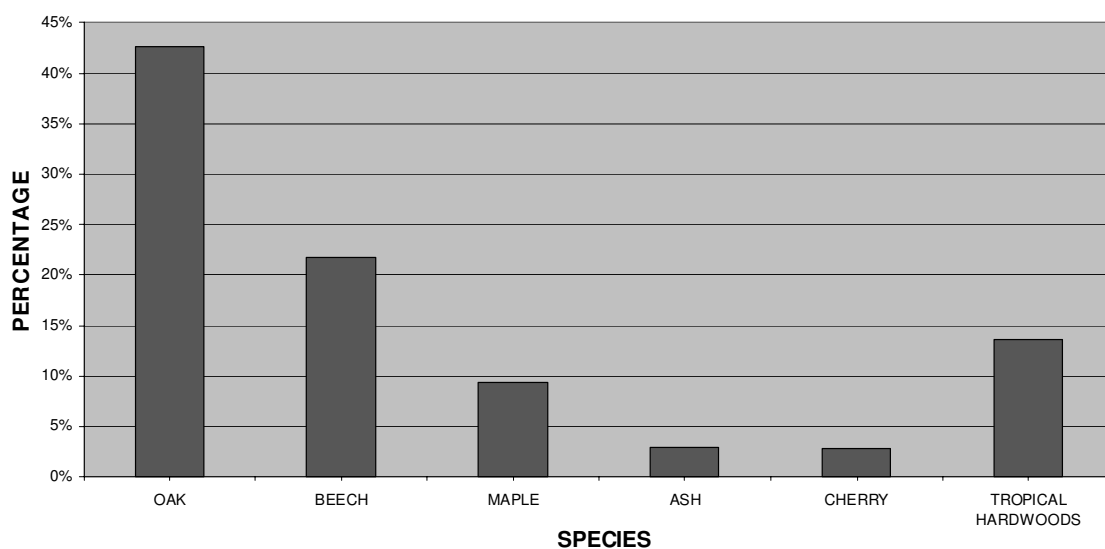
ESTIMATED DEVELOPMENT IN CONSUMPTION OF LAMINATED PARQUET WORLDWIDE UP TO 2010 (MILLION M2)



Source: European Federation of The Parquet Industry

As can be seen by the following graph, the most commonly used wood species are European oak 43%, beech 23% and tropical hardwoods 14%.

TOP SIX WOOD SPECIES USED IN THE PRODUCTION OF PARQUET IN 2000 BY FEP COUNTRIES



Source: Federation of The European Parquet Industry

Major Players In The European Market

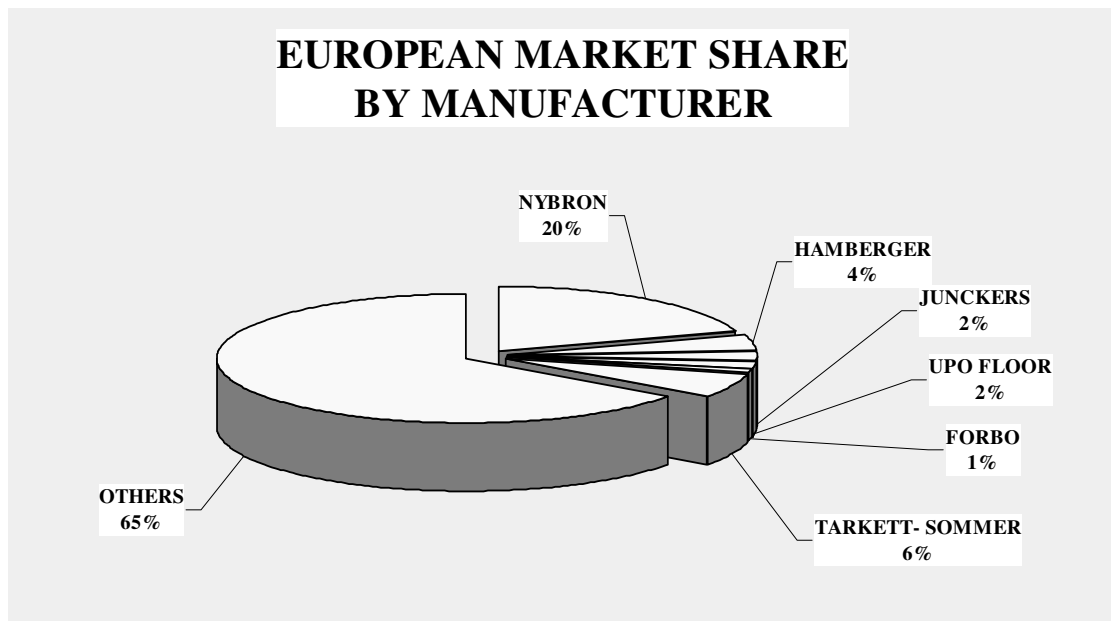
During the latter part of 2000 the Swiss wood products COMPANY HIAG and Swedish venture capital company NORDIC CAPITAL acquired the NYBRON GROUP, now known as NYBRON FLOORING INTERNATIONAL.

Nybron has become the market leader in Europe with sales in 2000 of krona four billion or almost US \$400 million, which represents about 20% of the wood flooring market in Europe. The next five largest companies collectively only account for 15% of the market. Nybron has 13 wood flooring factories and seven sawmills in Europe and with several market outlets employ around 3 700 staff. These operations include well known companies and brands such as BAUWERK, KAHS AND MARTY.

Sales for 2000 by business has KAHS the largest at 49%, BAUWERK 35% and MARTY at 16%. Sales for 2000 by country are – SWITZERLAND 20%, GERMANY 18%, FRANCE 13%, SWEDEN 9%, USA 8%, NETHERLANDS, SPAIN, UK, NORWAY and AUSTRIA with 4% each, and other countries represent 12%.

The three companies have separate responsibilities in the market:

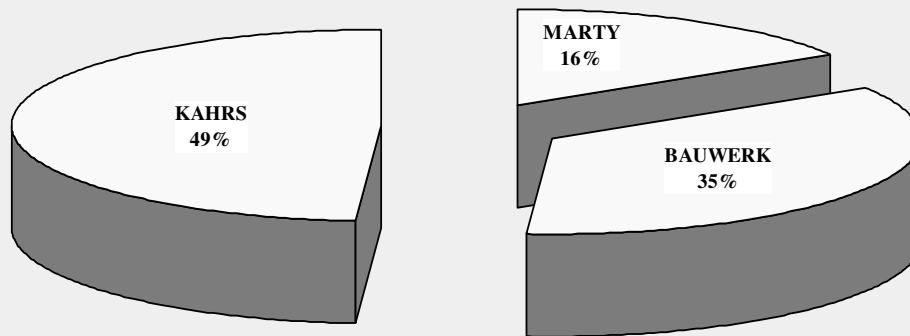
- | | |
|---------|--|
| BAUWERK | - products sold to skilled floor buyers or professional users. |
| KAHS | - private consumers. |
| MARTY | - home centres. |



Source: Nybron Flooring International 2001-10-05

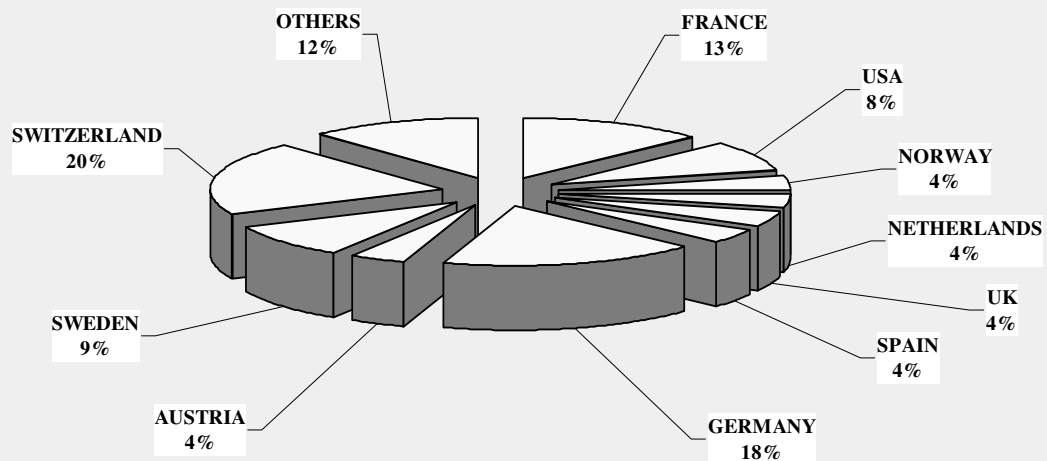
The CEO of Nybron, Mr Ola Wilhelmsson suggested that in his business “the patterns for purchase and distribution play an important role. In the current trend more and more flooring is sold through low price outlets for the DIY at home centres”.

NYBRON - SALES BY BUSINESS AREA



Source: Nybron Flooring International 2001-10-05

NYBRON - SALES BY COUNTRY



Source: Nybron Flooring International 2001-10-05

Engineered Wood Flooring and Installation – USA

The eastern area of the US represents over 60% of the total flooring market. Reports put the total US wooden flooring market at US \$1.8 billion, at manufacturers cost. Wooden flooring remains the strongest sector in the overall flooring market and has been for the past decade. More competitive costs in manufacturing are assisting this, as well as installation costs trending downward which is mainly due to the introduction of pre finished wood flooring products.

Floor costs are as low as US \$3.00/ft² (US \$32 m²) for solid T&G flooring and are usually manufactured and supplied in lengths of 7 ft and 78 inches. Pre finished red oak plank (T&G) can sell for around US \$4.80-\$6.80 ft² (US \$52.00-\$75.00 m²) in 3, 4 and 5 inch widths.

More than 40% of all new homes are constructed now on concrete slabs, so there are new and increasing opportunities. The USA will continue as a significant target for exporters, due to consumer demand for variety and selection. This consumer demand for quality choices and a population of 270 million, will increase overall demand for hardwood flooring.

Solid hardwood T&G floors are manufactured in a variety of widths included 2 1/4, 3, 5, and 7 inch. The most common pre and un finished plank flooring has a 3 inch width but is also available in 3 1/4, 4, 5, 6 and 7 inch widths.

Some of the main manufactured brands include Bruce Hardwood Floors which is suggested it is the biggest producer and seller of timber flooring in the US. Mannington, Mirage, Somerset and Hartco are other manufacturers and sellers that are the more popular. One difficulty you constantly encounter is the use of British, European and American English for different words for the same product.

Reports suggest that there are more than 750 flooring web sites in the USA. Streaming videos have become common on many sites demonstrating how to install your floor which is supplied by the various manufacturers and covers the type of floor covering. B2B exchanges are becoming more common.

Some flooring web sites in the US are quoting hits of between 6.5-9.0 million hits from January to September 2001. Discounted flooring sales are common showing weekly and/or monthly specials.

There are four main types of wooden floor types in the USA:

Nail Down: Nails are typically used with 3/4 inch solid wood flooring products.

Staple Down: Staples are used in place of nails to attach solid wood flooring to a sub floor (Similar to our plank on sub floor) This type of flooring method is considered easier than the nail down installation for the DIY installer.

Glue Down: Engineered wood floors and parquets can be glued down where an adhesive is applied by a notched trowel to adhere the wood flooring to a sub floor. These floors can be installed over existing wooden floors or concrete sub floors.

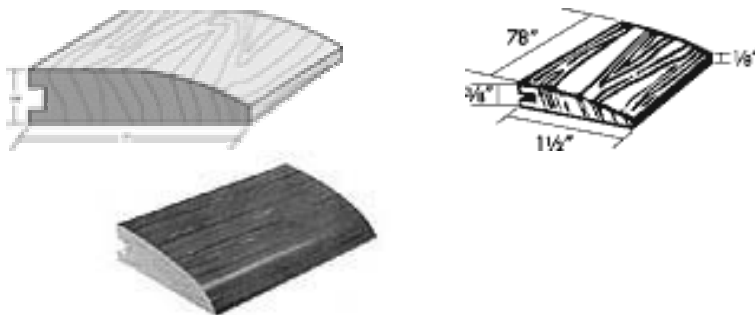
Floating: Some engineered floors and all Longstrip floors can be floated. This is a fast and clean method of installation and is generally easy for the DIY market. Floating floors refer to floors that are not directly attached to any sub floor. An underlay of cork, rubber or foam is laid between the sub floor and the new flooring layer. Alternatively a rubber pad or strips of foam are spaced and placed between the sub floor and the new floor. The padding or underlay protects against moisture, reduces noise and is softer underfoot. Adhesive may be applied to the tongue and groove of each board to hold the boards together or one of the new interlocking floor systems may be used.

Trims And Mouldings

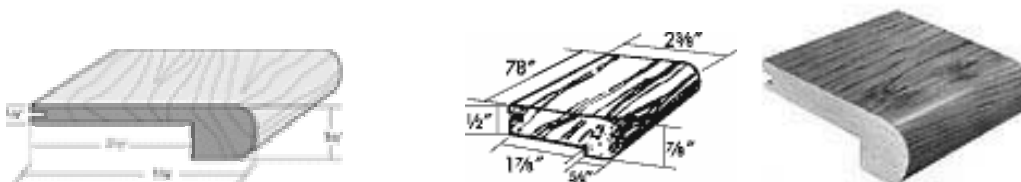
For floating, multi layer or EWF there are a number of trims and mouldings that can be used to assist in the proper installation and appearance of the floor. While timber mouldings are in demand and are “fit to purpose” products, new aluminum profiles and extrusions are increasing market share. The combined use of both timber and aluminum to manufacture profiles is also increasing.

Examples of mouldings as used in the US are as follows:

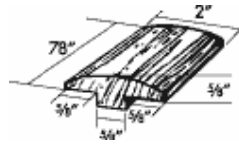
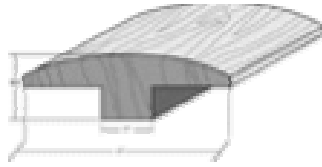
Reducer Strip: Designed to create a perfect transition between floors of different heights.



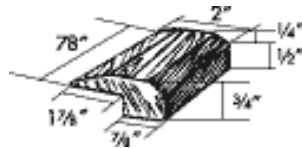
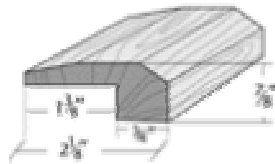
Stair Nosing: Adds a finishing touch to stairs and steps. This protective strip along the edge will protect the tread from constant floor traffic while enhancing the overall appearance.



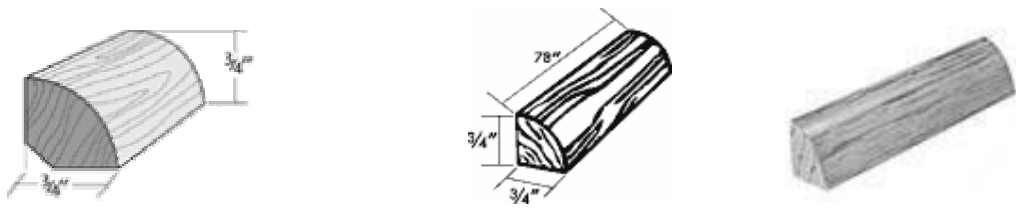
T Moulding: Used in doorways when joining rooms have the same floor levels and surfaces and ensures a good looking floor between rooms.



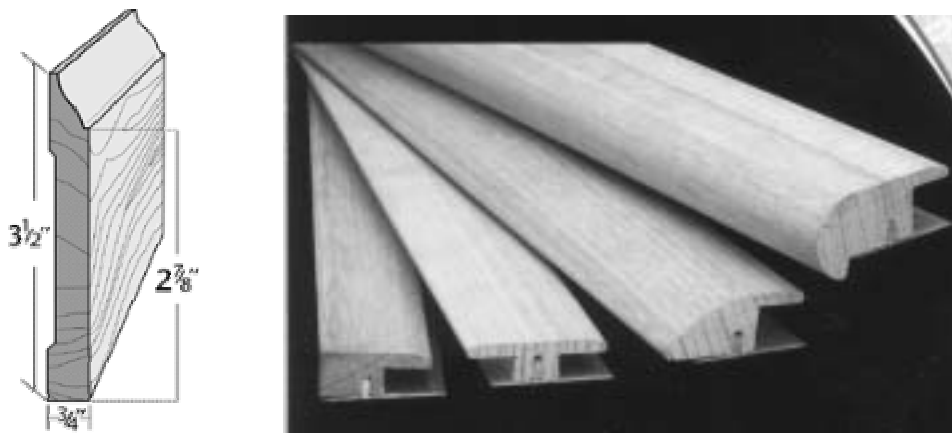
Threshold: Provides a smooth transition between a wood floor and the floor covering from an adjacent room.



Quarter Round: Creates a subtle blend between the floor and the wall.



Wall Base or Skirtings To finish off against the wall and concealing the edge expansion gaps. Can be selected from a standard profile range or specially moulded.



Example of profiles using timber and Aluminum

Flooring Grades

Appearance alone determines the grades of hardwood flooring used in the US. All hard wood flooring grades are equally strong and serviceable, with several main grades.

Clear

Flooring is practically free of defects, containing mostly heartwood though it may still contain minor imperfections. Examples are ash and oak.

Select

Timber is almost clear but contains more of the natural characteristics such as knots and colour variations. Species include:

- American cherry
- American walnut
- Brazilian cherry
- Mahogany

#1 Common

Flooring contains prominent variations in colour and varying grain patterns. Examples include ash and oak.

#2 Common

Ash and oak may contain variations of the product and manufacturing imperfections. This grade is suitable for homes and general utility use, or where character marks and contrasting appearance is desired.

First Grade

Beech has the face practically free of defects, but the natural colour of the wood should not be considered a defect. Beech and maple have the highest standard grade, combining appearance and durability.

Second Grade

Floors have varying wood characteristics and colours to include distinct colour variations, numerous streaks, stained sapwood, sound knots and checks. Examples are beech, birch and maple.

Third Grade

May contain all the defects of every character common to the species. The wood is firm and serviceable. Examples are beech, birch and maple.

Examples of Flooring Grades are shown below (these photographs are reproduced in colour at the back of this publication):



First Grade Maple



Second Grade Maple



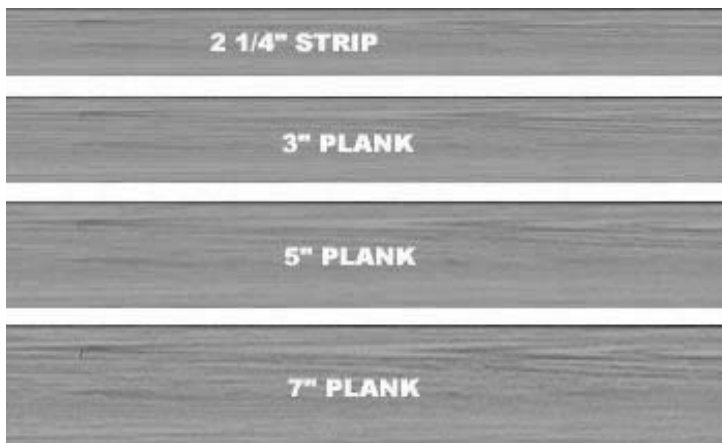
Third Grade Maple

Wood Flooring Types

Solid or strip T & G

(Typically 19 mm or ¾" and are mostly supplied unfinished although more pre finished material is entering the market)

(Board widths are available from 3" – 8")



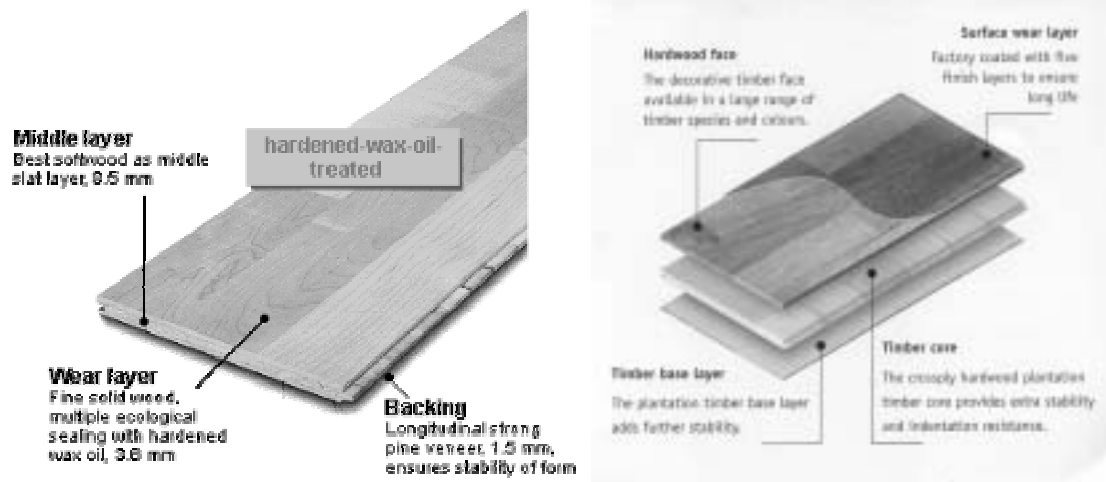
Laminated/engineered wood flooring

(unfinished or pre-finished, however most manufacturers are now supplying pre finished)

2, 3, 5 or more layers

During the Italian Study Tour it became evident that previously traditional producers of T&G solid wood flooring that had gone into production of pre finished EWF were now increasing their business by supplying pre-finished T&G wood flooring and making extra margins.

Can be sanded three times, with a life expectancy of between 30-60 years.



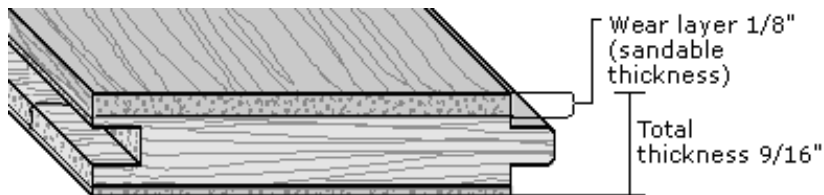
Examples of the construction of an Engineered Wood Floor

Long Strip Plank
(17-35 pieces per panel)

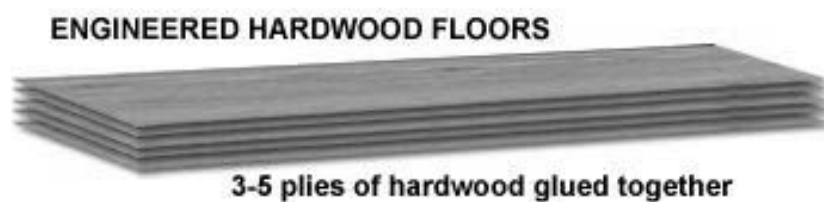
(pre-finished) 7.5" – 95.5"
Brick bond appearance

Parquet

(unfinished or pre-finished)



An example of an EWF



An example of 3-5 layer EWF

Attachment methods for each grade are as follows:

<u>Grades</u>	<u>Installation method</u>
Clear	Nail down
Select	Glue down

STD/Better	Engineered, glued, nailed.
Floating	Not attached
Parquet	Glue down

Accessories include:

- Borders
- Feature Strips (inlay)
- Crests/Medallions
- Joining Strips
- Mouldings
- Stair nosings and covers.

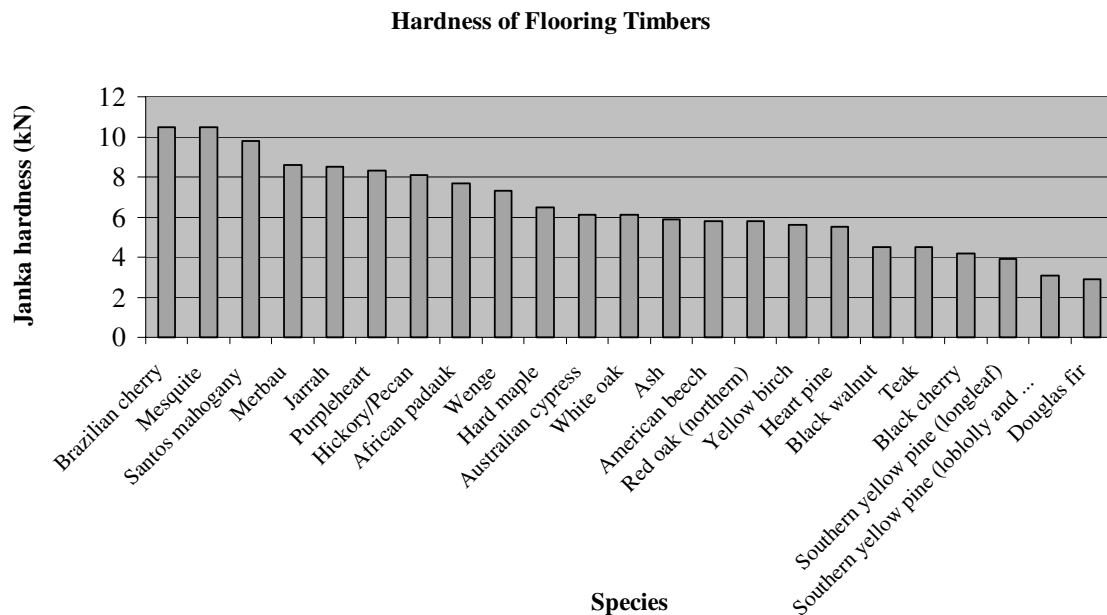
Timber finishes

These include the following treatments:

- Oil modified urethanes (Polyurethane)
- Water added
- UV-cured urethane
- Waxes/Oil
- New Products
 - Alumide (25 year warranty)
 - Ceramic (“ ”)
 - Acrylic impregnated

Timber Hardness

The hardness of the timber (e.g. measured by the Janka hardness test) provides an indication of the likelihood of damage and therefore a reasonable indication of the service life. It is one of the best means of testing the ability of a wood species to withstand denting and wear characteristics, and is also a good indicator of how difficult or easy a species is to work.



Source: Wood as an Engineering Material

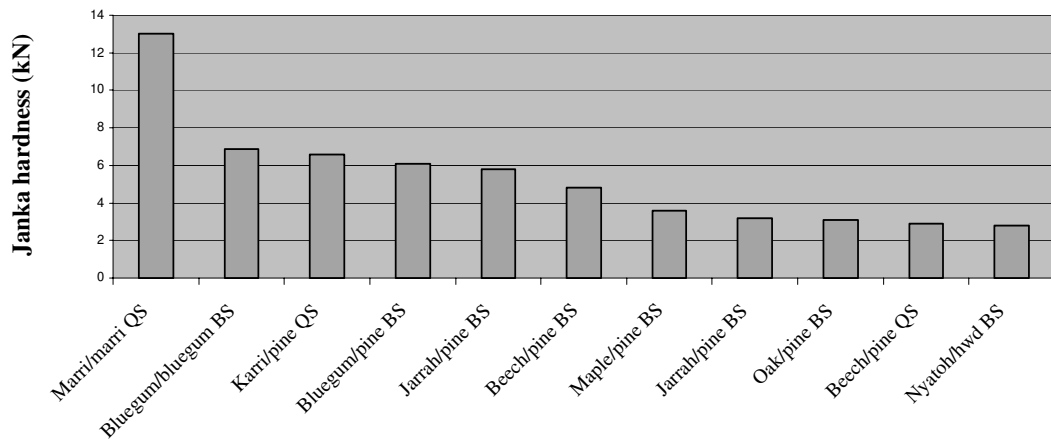
The flooring hardness tests conducted at the Forest Products Commission's Timber Technology at Harvey in Western Australia provide comparative figures for the species and combinations conducted in trials at the centre (see figure next page).

Marri provided the best results, but the above results do not reflect the properties of a two or three layer composition. With superior finishes and treatments such as the alumide and ceramic finishes being available, it is suggested the Timber technology trial results would improve. Other products and processes are constantly being trialled and introduced to the market which could enhance the performance of bluegum EWF.

The hardness testing indicates that a multi layer flooring panel with all layers of bluegum will perform better for indentation and wear and tear than that with a bluegum face and softwood core and/or back.

Another consideration when utilising bluegum is the occurrence of knots from the current available resource, where the knots will be of higher density than the surrounding wood. This problem consistently arises with softwood flooring and as a result you end up with an uneven floor after some time in service. Although a heavy re-sanding will bring the floor back to a safe and aesthetic surface finish, this is another reason why hardening and finishing treatments may be an essential consideration in marketing a flooring product.

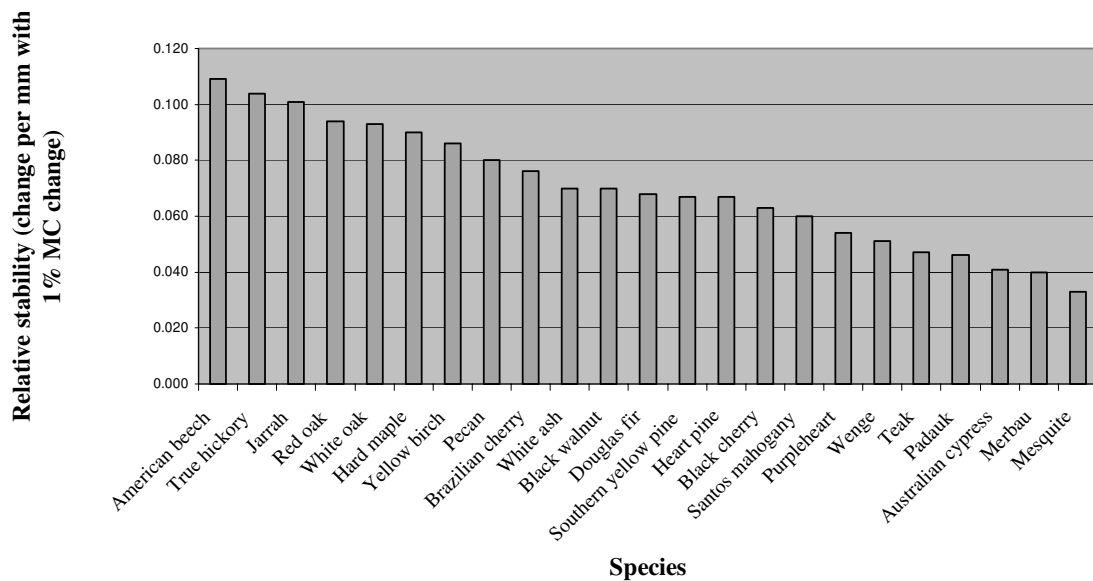
Flooring hardness tests at Timber Technology



Face and core species, sawing pattern

Source: Timber Technology-Forest Products Commission

Relative Stability of Flooring Timbers



Source: Wood as an Engineering Material

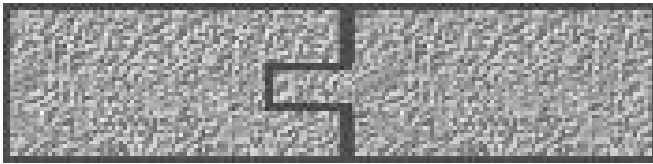
The above figure refers to the stability of solid timber. It is well recognised that with EWF systems, the relative stability is of lesser importance due to the thin veneers used and the method of composing alternative layers for a floor panel.

In some colder climates and countries EWF is laid on a floor heating system. Stability within the EWF panel needs to be able to withstand these heating and cooling changes.

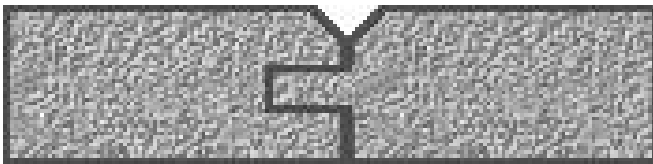
Edge Styles

The following styles are available:

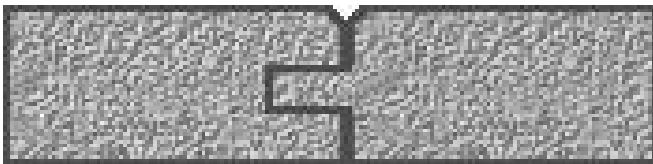
Square edge



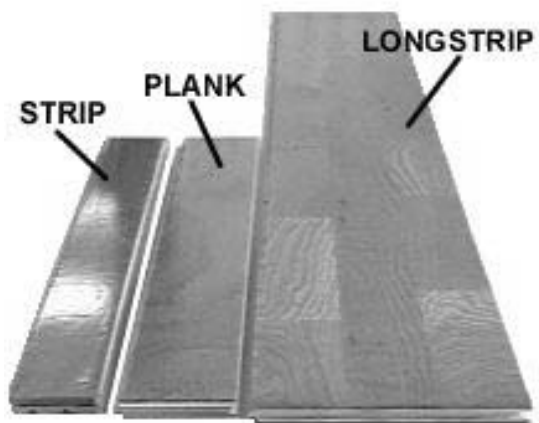
Bevelled edge



Eased edge (Micro)



Wood Floor Styles



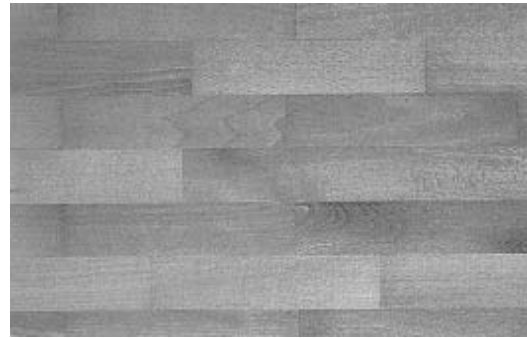
USA style type floors

Timber Species Used In Different Continents Or Countries

The following examples are given of the different species used for flooring in the USA, Europe, Asia and Australia. (These photographs are reproduced in colour at the back of this publication)

USA:

- Red Oak
- White Oak
- Cherry
- Maple
- Hickory
- Pecan



Afrormosia

Europe:

- European oak
- Beech
- Teak
- Maple
- Doussie
- Merbau
- Afrormosia
- Olive
- Iroko
- Wenge
- Mahogany
- Ash
- Cherry



Natural Oak

Asia:

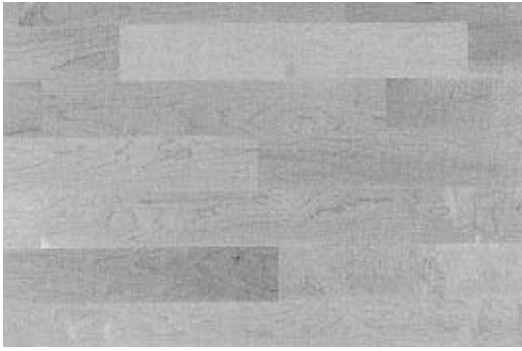
- Merbau
- Teak
- Kempas
- Rubber wood



Iroko

Australia:

- Tasmanian oak
- Jarra
- Victorian ash
- Sydney bluegum
- White cypress pine



Maple



Merbau

European Flooring Standards

The FEP advises that steps have been made towards introducing a European standard for activities in parquet and wood flooring. The European Committee for Standardization (CEN) has approved the development of six draft European standards for parquet flooring as below.

prEN 13226 “Wood flooring – Solid element with grooves and/or tongues”

prEN 13227 “Wood flooring – Solid parquet products”

prEN 13228 “Wood flooring – Solid wood overlay flooring including blocks with an interlocking system”

prEN 13488 “Wood and parquet flooring – Mosaic parquet”

prEN 13489 “Wood and parquet flooring – Multilayer parquet”

prEN 13629 “Wood flooring – Solid pre-assembled hardwood boards”

This may cause some concern to exporters from other countries in being able to meet and conform to these standards once they are introduced.

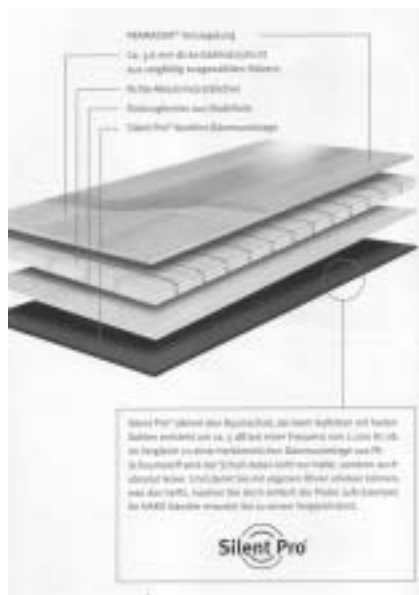
New Products

Robbins Hardwood Flooring

EWF – North American Exotics-With feature

Pecan, Walnut, Cherry

Rubber and sound backing (As pictured below)



Examples of new EWF products using rubber or other underlays and the no glue “click” systems.

Tariffs And Potential Markets In The USA

There is potential for new tariffs to be introduced on Hardwood Flooring Products of 5 – 8% on products not previously taxed by the US Government. The suggested pass on effect could be more than 10% to the customer. Canadian producers are on higher prices than equivalent US products and may not be targeted for these punitive duties.

If mixed species are used in the construction where a softwood core or back is used, it would be likely this would create less impact on taxes and pricing.

Hardwood flooring sales had grown by double digit figures each year from 1996 to 1999. The year 2000 only rose by between 5 – 7%. Hardwood flooring sales for 2000 were approximately US\$1.8 billion, or about 820 million sq ft (76 million m2).

Triangle Pacific Flooring Group represents about 42% of the domestic hardwood flooring market.

There is an increasingly strong demand for natural materials, and each one per cent increase means an additional US \$170 million for hardwood flooring. High end use categories like hardwood will sustain drastic market fluctuations.

The factory finished market continues to grow simply because more choices are being offered than ever before. More colours, styles, designs and wood species are available, and also new finish warranties of up to 25 years are having great effect and give increased confidence for builders and consumers. Seasonally adjusted figures for new construction starts in July 2001 was US \$470 billion.

Details Of Flooring Materials In Selected Countries

USA TYPICAL FLOORING COSTS

Typical costs at a retail level in the USA for flooring using a range of products in (i) kitchen and bathroom (ii) living rooms (iii) bedrooms, are given in the Tables below.

Kitchens and bathrooms

<u>Type:</u>	<u>Material costs</u>	
	<u>(US \$/ft²)</u>	<u>(US \$/m²)</u>
Vinyl	1 – 5	11 - 54
Linoleum	4	43
Cork	5 +	54 +
Ceramic	1 – 6	11 - 65
Natural stone	3 – 10 +	32 – 105+
Concrete	Varies	Varies
Wood	4 – 10	43 - 105
Laminate	2 – 7	21 - 75

Living Rooms

<u>Type:</u>	<u>Material costs</u>	
	<u>(US \$/ft²)</u>	<u>(US \$/m²)</u>
Carpet	1 – 5	11 - 54
Wood	4 – 10	43 - 105

Bedrooms

<u>Type:</u>	<u>Material costs</u>
Wool	Expensive
Acrylic	Moderate
Nylon	Moderate
Polyester	Less than wool or nylon carpet
Olefin	Moderate

CANADA

Species	Finish	Warranty	Sizes (Width)
Birch	4 types	10 years 9 - 25 years	50 & 80mm
Red Oak			
Maple			
Ash			
Cherry			
Walnut			
22 x 127 x 2,200			7.0 mm face, 8 mm core and back
14 x 180 x 2,200			3.4
14 x 195 x 2,200			3.4
14 x 127 x 2,200			3.4
15 x 127 x 2,200			5.0 mm face, 5mm core and back
10 x 127 x 2,200			2.0 mm
14 x 90 x 1,090			5.4
10 x 75 x 525			3.4
15	140 (Maxi)	700 / 1,800	4mm core and back
14	90 (Medium)	600 / 1,200	
10	90 (Mini)	600 / 1,200	

GERMAN TRADE PRICES FOR VARIOUS EWF TYPES AND SPECIES (HARO)

	Thickness (mm)	Width (mm)	Length (mm)		Trade price (DM)
Oak	10.5	180	2,200	2.5 mm	60.93
	10.5	173	2,200	2.5 mm	95 – 120
	13	180	2,200	3.6 mm	67 – 106
	19	180	2,200	5.0 mm	112
	13	173	1,095	3.6	108
Merbau	10.5	180	2,200	2.5	86

Species	Style & Size	Price (DM/M2 Supply Only (Trade) May 2001)
	(11 x 70 x 500 mm)	
Hard Maple	Elegant	103.20
	Natural	91.50
	Market	78.95
Beech	Elegant	81.40
	Natural	69.90
	Market	62.50
Doussie		89.95
Oak	Natural	73.40
	Market	64.20
Esche	Natural	75.30
Black Cherry	Elegant	111.90
Wenge		102.50
Afrormosia		92.70
Iroko		85.80
Teak		114.50
	12.5 x 68 x 476	
Hard Maple	Natural	101.90
Beech	Natural	74.80
Oak	Natural	
	10 x 68 x 476	
Hard Maple	Natural	87.70
Beech	Natural	65.60
Oak	Natural	62.95
Black Cherry	Elegant	102.85
Afromosia		88.10
Iroko		82.30
Merbau		85.60

	10 x 90 x 900	
Hard Maple	Elegant	115.50
Beech	Elegant	94.50
Oak	Elegant	94.50
Haro	Clic Connect ®	13 x 180 x 2,000
	Silent Pro	16 x 180 x 2,200
	Clic	Clic / Silent
Beech	76 – 105	103
Oak	85	102
Maple	85 – 127	125

Floor Market Pricing – Australia

A survey of Australian hardwood producers in August 2001 provided the following information on pricing of timber and flooring products.

15mm Hardwood Plywood with face layer for flooring

Delivered metro area - wholesale > \$70/m²

Supplied and installed > \$140/m²

Finishing cost on site > \$35/m²

T & G Strip Flooring (Supply only for 80 x 19 mm)

Brush box	\$4.50/Lineal metre	\$1800/m ³
Sydney bluegum	\$2.85-\$3.70/LM	\$1140-\$1480/m ³
Spotted gum	\$2.80/LM	\$1120/m ³

Overlay (85 mm wide)

(Supplied as square dressed plank, T&G or micro T&G)

10-12 mm \$35/m²

11 mm \$28/m².

Laying and finishing, > \$105/m²

Full size dry sawn boards supplied then split or re-sawn into thin profiles for flooring > \$800/m³

Engineered wood flooring/multi-layer, at retail (\$/m²)

<u>Species</u>	<u>Single plank</u>	<u>Double plank</u>	<u>3 Strip</u>
----------------	---------------------	---------------------	----------------

Kempas	\$109	95	N/A
African Golden Wood			75
Jarra			109
Oak Active (feature)			79
Rubberwood (<i>Hevea</i> spp)			55

Underlay	\$2.50 - \$5.00 /m2	
Laying	\$25.00 /m2	
Average price for multi-layer flooring:		Range \$70-\$130/m2

Parquet flooring imports into Australia (value assembled) (A\$'000)

1996/97	1997/98	1998/99	1999/2000	March Qtr 2001 only
7474	12 701	14 001	21 671	3 762

The import of assembled parquet panels has increased from almost \$7.5 million in 1996/97 to more than \$21 million within three years. This represents a dramatic threefold increase in less than four years.

Exports of assembled parquet floor from Australia (A\$'000)

1996/97	1997/98	1998/99	1999/2000	March Qtr 2001
156	306	220	18	34

The export of assembled parquet panels has reduced, but was only minimal in the first instance.

Floor Market Pricing – Western Australia (Jan – Sept 2001)

A survey of the current pricing structure in Western Australia is given in the following Tables.

85 x 10 mm square dressed plank or micro T&G

<u>Species</u>	<u>Grade</u>	<u>Price</u>
Jarra	Standard & better	\$47.30 - \$69.00/m2
Victorian ash	“ “	\$47.30 - \$70.00/m2
Marri	“ “	\$42.00 - \$65.00/m2
Karri	“ “	\$45.00/m2 (average)
Rose gum	Select	\$55.00/m2
Tasmanian oak	“ “	\$35.00/m2

<u>Species</u>	<u>80 x 19 mm T&G</u>	<u>120 x 19mm T&G</u>
American white oak	\$91.30/m2	\$127.60/m2

WA blackbutt	\$89.10/m2	N/A
Jarrah	\$57.20/	\$72.60/m2
Karri	\$57.20/m2	\$72.60/m2
Victorian ash	\$63.80/m2	\$75.90/m2

Floating / Engineered wood floors

<u>Species</u>	<u>Double Plank</u>	<u>One Strip</u>	<u>Three Strip</u>
<i>Hevea</i>	\$52.90-\$65.90/m2		\$39.90-\$57.50/m2
Kempas	\$79.00-\$89.90/m2		\$49.90/m2
Tasmanian oak	\$72.90/m2	> \$112.00/m2	\$52.90-\$72.90/m2
Merbau	\$89.90-\$112.00/m2	> \$112.00/m2	\$112.00/m2
Other species	From \$59.00/m2		
Rose gum			\$59.90-\$89.00/m2
American oak			\$49.90-\$72.90/m2

9.1 Block parquetry

Blackbutt	< \$39.90/m2
Tasmanian oak	< \$25.00/m2
Jarrah	\$39.00-\$52.00/m2
Black Forest oak	< \$34.00/m2

Hard Board Laminates (Paper overlay)

<u>Brand</u>	<u>Supply Only</u>	<u>Installed</u>
Domino	\$23.50/m2	\$39.50/m2
Hornitex	\$24.50/m2	\$44.90/m2
Steps "Clickin"	\$29.95-\$34.95	\$47.90/m2
Others	From \$19.00/m2	

Cost of underlay \$2.00-\$5.00/m2

10 Valuwood Questionnaire – Results

In total more than 400 people viewed the two flooring displays and trade events. The Valuwood questionnaire asked respondents to grade on a one to seven basis, with one “liked very much” to seven “don’t like at all”. The replies were as follows:

1: How do you rate the general appearance of the floor?

	Like very much						Don’t like at all
Ranking	1	2	3	4	5	6	7
Reply		26	20	14	3	2	

2: What is your opinion of the colour?

	Like very much						Don’t like at all
Ranking	1	2	3	4	5	6	7
Reply		23	19	15	4	3	1

3: We have aimed to feature the natural characteristics of the wood.
What is your opinion of this look?

	Like very much						Don’t like at all
Ranking	1	2	3	4	5	6	7
Reply		25	22	9	5	2	2

4: This question asked for preferred board widths, but there were only several replies so they are not reported here.

5: If it was available, would you like to install this flooring in you home if the price was;

Laid for \$80-\$120 per m2	31 said yes
If it was cheaper	35 said yes
If it was dearer	2 said yes
Would you lay it at all	4 said no

6: Do you have any other comments?

Of those that responded, some of the positive comments included:

The floor looks nice, it's good it can be laid over an existing floor, ideal for small areas of 12-20 m2, value adding to be encouraged and clear wood is boring.

Of those that responded too the negative comments included:

Too noisy, didn't like the spotted appearance, too many knots, would prefer wider planks and the appearance doesn't fit the décor.

7: What age group are you in?

	Under 20	20-30	31-40	41-50	51-60	Over 60
Reply	0	3	12	25	9	12

The survey has provided some encouraging feedback.

The question on general appearance gave better than 90% acceptance for the appearance of the floor.

The question on opinion of colour suggested that almost 90% like it.

The question in relationship to the feature of the wood in the floor had an approval rating of more than 85%.

The question on price showed that more than 40% said it was well priced (\$80-\$120 per m2 range) while almost 50% would purchase if it was available more competitively. Less than 6% said they wouldn't purchase it at all, but this could partially be due to some respondents suggesting that the floor may not match their existing décor.

Respondents age groups of those that provided information on this question were ranked as more than 40% in the 41-50 age group, less than 20% each in the 31-40 and 60 and over age groups respectively, less than 15% in the 51-60 age group, less than 5% in the 20-30 age group, and none in the under 20 age group.



Examples of a Bluegum Floor produced during the project

Potential For Other Products

Considering the volume of resource potentially available for other manufactured products from regrowth forests and hardwood and softwood plantations a broader range of products and market opportunities is briefly discussed. The list is reasonably comprehensive.

Large Scale Plants-Wood Fibre Consumers

- Particleboard (P/B)
- Hardboard
- Medium Density Fibreboard (MDF)
- High Density Fibreboard (HDF)
- Plywood
- Oriented Strand Board (OSB)
- Parallel Strand Lumber (PSL)
- Construction Strand Lumber (CSL)
- Laminated Veneer Lumber (LVL)
- Glue Laminated Beams (GLULAM)
- Wood I Joists

Manufactured Products

- Furniture
- Joinery*
- Bench Tops
- Flooring Accessories**
- Decorative Panels

Small Production Manufacturing

- Tool Handles
- Specialty uses like paint brushes
- Promotional items
- Corporate and giftware-Tourist Trade

Other areas that should be considered is the use of the wood fibre and residues for biomass in energy production, firing drying kilns, briquette manufacture and oil extraction for cleaning and pharmaceutical use.

* Joinery

Europe and the US have introduced new joinery products into the market. In particular window frames are using aluminium components for the external sections exposed to the elements and show the timber on the inside of the frame and sash. This enhances timbers

ability to perform and look attractive without major upkeep and stretches the use because less material is required in the manufacture of the joinery.

**** Flooring accessories**

Timber mouldings such as skirtings, architraves, stair treads and nosings should be packaged as a total flooring concept to add to the aesthetics of a finished floor.

Bluegum Faced Flooring SWOT Analysis And Potential For Western Australian Products

STRENGTHS

Flooring becoming a major and important user of timber resources
Large potential supply of plantation eucalypt hardwood and softwood
Potential to resource and utilize regrowth thinnings
Some resource species unique to Australia
Eucalypt qualities have some advantages over other species
Engineered wood products/flooring can utilise thinnings
Land available
International appeal for natural timber products
Increasing demand for species range and style
Low energy user
Renewable
Short rotations
Most of the wood fibre can be utilized
Can be easily finished to protect and enhance the product
Good natural insulation values
Carbon sink capability
Fit to purpose
Create new employment opportunities

keep up with new CAD/CAM technologies
Increasing need for higher standards in Health/Safety and Emission control
Potential lack of consistent quality resource
Volatility in pricing and exchange rates
Lack of knowledge
Volatility in availability of timber products
Difficulty in processing
Cheap labour in Asia

WEAKNESSES

Most plantation eucalypts not currently grown as sawlogs
Large number of knots in bluegum
Continual cost of upgrading plant to

WEAKNESSES (Continued)

- Asian infrastructure already in place
- Lack of government support for start up
- Lack of marketing initiatives
- Probable high maintenance cost
- Fluctuating wood prices

OPPORTUNITIES

- Solid wood becoming more expensive
- Improvements in technical know how
- Ability to shift more quickly against big companies to supply niche markets/products
- New consumer markets developing
- Capacity to increase wood flows
- International acceptance to develop new products and markets
- Some equipment and facilities available
- Timber is a cash crop
- Helps in improving the environment and salinity
- Carbon trading potential
- Laminating can stretch the resource by 2 to 4 times because low quality timber can be core or face
- Increasing concrete floor construction

THREATS

- Threat of remaining native forest regrowth areas being locked up
- Use of some resins/adhesives/finishes with harmful effects
- Availability of suitable resource
- Protection by some countries with tariffs and duties
- High transport and shipping costs
- Distance to world markets
- Ability to meet other countries standards
- Reduction in R&D efforts
- Substitution from alternative products
- Fast changing markets
- Producing single market products
- Capacity to supply resource
- Access to some markets limited

Examples Of Flooring Products



Flooring showroom in Germany



Feature flooring showing inlays



Scerri heart pine floor showing knots and features



Coastal hardwood oak floor



Oak floor with inlay in a commercial application



Scerri plank floor plugged



Golden brown Iroko



Mahogany floor

Examples Of Three And Two Layer Products As Seen In Europe

Three layer panels



New two layer flooring panels



References

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European Federation of the Parquet Industry	2001 Journals
Nybron Flooring International	Bulletin 1/2001
CSIL Milan, Italy	1999
Floor Covering Weekly USA	2001
Hardwood Manufacturers Association USA	2001
National Oak Flooring Manufactures Association USA	2001
National Wood Flooring Association USA	2001
International Tropical Timber Organisation 2001	(ITTO)-Market Information 1-15 August
Food and Agriculture Organisation of the (UN)	(FAO) State of The Worlds Forests 1999
Wood Mac Asia 2001	International Conference September 2001
Keynote	The Global Timber Report 2000
Hardwood Direct USA	2001
Forest Products Commission	Timber Technology Report for Valuwood International

Internet References

Bauwerk
World Floor Covering Association USA
National Association of Floor Covering Distributors USA
Floorcovering Installation Contractors Association USA

Major Exhibitions And Trade Shows

DOMOTEX	Hannover Germany 12-15 January 2002
SURFACES	Nevada USA 30/1-1/2 2002
DOMOTEX ASIA/Chinafloor	Shanghai China 26-28 March 2002
National Wood Flooring Association conference	California USA April 2002
BAU	Munich Germany April 2002

Useful Websites

www.parquet.net

www.FastFloors.com

www.hardwoodfloorsmag.com

www.ifloor.com

www.boa-franc.com

www.floorfacts.com

www.wfca.org

www.nafcd.org

www.floorcoveringweekly.com

www.originalparquet.com

www.andersonfloors.com

www.harris-tarkett.com

www.pamino.de

www.woodfloorsonline.com

www.woodfloors.org

www.fcica.com

Colour Photographs

**Eight year-old southern blue gum in 600 mm rainfall zone
(see page iv)**



A demonstration VALUFLOR floor (see page 14)



Examples of Flooring Grades (see pp. 97-98)



First Grade Maple



Second Grade Maple



Third Grade Maple

**Examples of the different species used for flooring in the USA,
Europe, Asia and Australia (see pp 105-106)**



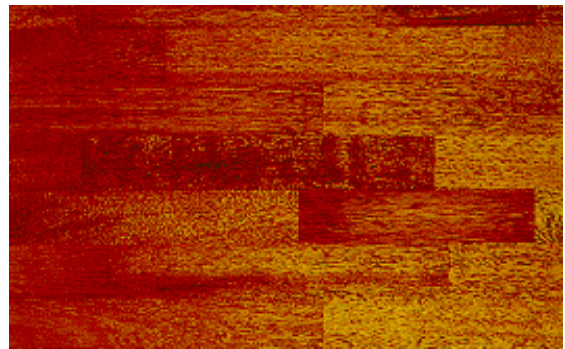
Afromosia



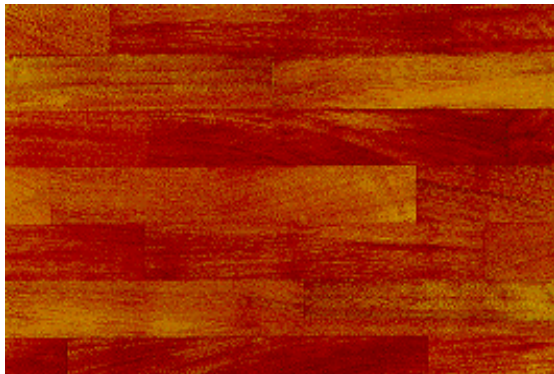
Maple



Natural Oak



Merba



Iroko