



Productivity and Economic Assessment of Hardwood Species for Scrimber Production

**A report for the
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by
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"Productivity and Economic Assessment of Hardwood Species for Scrimber Production"

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Foreword

The project described in this report was designed to investigate early, rapid growth of *Pinus radiata* and of six hardwood species.

The latter were selected for their potential to grow in the region and for their wood properties: straight grained wood of moderate density that has good workability, low durability, and high moduli of rupture and of elasticity.

The seed used to produce *P. radiata* seedlings was that used at the time for plantations in the region around Mount Gambier, that for the hardwood seedlings was the provenance of each species thought most likely to be successful in the region. Seedlings were raised in root trainer pots and planted on the CSIRO campus at Mount Gambier in May 1991 at two spacings, 1.2m and 2.4m with three replicate plots of each.

A half of each plot was fertilised. At the end of the project an economic evaluation was carried out to examine the economic viability of growing these species for firewood or for feedstock for wood chip for the pulp market, or for scrimber production.

Peter Core

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Many people have had a direct input into this project; assisting with ideas, practical help or with enthusiasm, several with a combination of all three. This support has been very gratifying, as has the enthusiasm of visitors to the site, many of whom have been landowners seeking information or comparing notes. To all of these people many thanks. A particular acknowledgment and thanks to Dr Richard Jago, who provided much inspiration and collaboration in developing the concept of this project and in the early gathering of data, and to Mr David Klem who, from its beginning, looked after the tree-growing aspect of the project on a day-to-day basis; producing the seedlings and organising and conducting their planting, care and measurement.

The economic evaluation that is part of this report, and the projections of growth required for this evaluation were produced by Ms M. Wallace and Dr R. Boardman, Primary Industries South Australia, Forestry.

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Executive Summary

This project was designed to evaluate growth, productivity and economic viability of selected tree species found suitable for scrimber production and to compare the growth of several hardwood species with that of *Pinus radiata*, the species grown most commonly in the Mount Gambier region.

Based on general information about how climatic factors affect the growth of different species, several hardwood species were identified as having an expected high growth rate in the Mount Gambier region. Timber was obtained from other sources for those with promising wood characteristics and was scrimmed by Scrimber International. The best six of these species (*Acacia mearnsii*, *Casuarina glauca*, *Eucalyptus fraxinoides*, *E. globulus*, *E. grandis* and *E. saligna*) were grown in a trial on the CSIRO campus in Mount Gambier to produce a short rotation crop of rapidly-grown timber. Seed from the provenances considered most suited to the region's growing conditions was germinated, grown in root trainer pots and planted out at spacings of 1.2m and 2.4m in three replicate blocks. One half of each plot was fertilised according to a split plot design. There are few trials in southern Australia where comparisons of growth have been made between hardwood species and *P. radiata*. Such a comparison is appropriate in the Mount Gambier region where there is a large softwood plantation industry and increasing interest in farm forestry. The opportunity of comparing productivity of the hardwood species with that of *P. radiata* was taken in this project by growing both under the same conditions at the same site.

The seedlings were planted in May 1991 and growth measured biannually for about four years. Generally, *A. mearnsii*, *E. globulus*, *E. grandis* and *P. radiata* grew faster than the other species and the more productive hardwood species grew proportionately faster than *P. radiata* early in the project. Fertilisation and tree spacing had small, interacting effects on growth.

At the end of the project an economic evaluation was carried out to examine the economic viability of growing these species for firewood, for wood chip for the pulp market, or for scrimber production. As growth of the stands had not plateaued at the end of the project, future growth was predicted using mensurational models. These extrapolations were used to predict the time at which the average stem diameter of each species treatment combination would become 17cm, provided this occurred in a reasonable timeframe. A stem diameter of 17cm was a defined requirement for feedstock for scrimber production, and was taken as the end point for all uses considered. The economic evaluation indicated that for a range of indices *P. radiata* offers the best returns, but that some treatments of *E. grandis* could also produce positive returns. Of those species treatment combinations that reached 17cm in diameter, unfertilised *A. mearnsii* and *E. saligna* at 2.4m spacing were the least profitable.

Introduction

This project was started in collaboration with Scrimber International, a company established in Mount Gambier to commercialise the scrimber process for *Pinus radiata* thinnings. Scrimber is a reconstituted timber product based on a CSIRO discovery (Hutchings and Leicester 1985). The project was designed to examine:

- ♦ the potential for producing scrimber from hardwood timbers;
- ♦ potential productivities of fast-grown hardwood timbers suitable for producing scrimber, and comparison of these with *Pinus radiata*, the region's traditional commercial species;
- ♦ the scrimming properties of fast-grown hardwood timbers;
- ♦ the economic feasibility of a fast-grown timber regime for scrimber production.

Trials conducted by Scrimber International had shown that several Australian hardwood species could be used to produce scrimber, with potential for sale in a high - value market. However, these trials had mostly used timber from older trees, which are often in restricted supply, always expensive when of good timber quality.

Australian hardwoods grown under short-rotation regimes could have great potential for producing timber suitable for processing into scrimber, but this possibility had not been examined. Six species of Australian hardwoods were selected and grown at two planting densities. To obtain a valid comparison of productivity of these species with that of *P. radiata*, this was also included in the project. Rates of stem wood production were monitored by measuring stem growth. Short-rotation regimes are especially attractive for farm forestry because an earlier return can be obtained from the crop than in conventional forestry with a high value sawlog regime. Results from this project are, therefore, generally applicable to farm forestry, and the comparison between growth of hardwood species and of *P. radiata*, provides a valuable productivity benchmark.

Scrimber International encountered a period of problems, as a result of which the consortium of owners of the rights to the Scrimber process and their commercial partners decided to close operation of the Scrimber plant in Mount Gambier in 1992. More recently, Georgia Pacific used the facilities previously operated by Scrimber International to further develop the manufacturing process, although they have not commercialised the product to date and have ceased its ongoing development in Australia. This has meant that the aim of producing scrimber from the fast-grown experimental crop could not be realised

At the end of the project an economic evaluation was made of the potential of the seven species to be grown as a commercial crop. Tree growth had to be projected forwards to a size suitable for harvesting as firewood, or to produce woodchip or scrimber. Growth projections and the economic evaluation were undertaken by Primary Industries South Australia (PISA), Forestry under a contractual arrangement.

Methods

Selection of Species

There were two distinct, though interrelated, operations in the selection of species for this project:

- 1) identification of species with a high growth potential in the Mount Gambier region. As there was little local information about growth of most species in the region, selection criteria were based on observations in native stands with similar climates; and where available, growth data obtained from as close as possible to the project site;
- 2) as the final phase of the project was planned to be an investigation of the suitability for scrimber production of trees grown over a short rotation, Scrimber International examined the wood properties of species in the list produced from 1) to ensure their suitability for the scrimber process.

Testing by Scrimber International

A number of hardwood species with good potential for rapid early growth in the region were tested by Scrimber International to examine their suitability for scrimber production. Timber was sourced from sites as close as possible to Mount Gambier. Timber characteristics required for scrimber production were:

- Moderate density - to facilitate further compaction.
- Workability - should be relatively easy to facilitate working operations.
- Durability - should be relatively low (class or 4) to facilitate gluing.
- Modulus of Rupture - should be >120 MPa.
- Modulus of Elasticity - should be high (>18 GPa preferred).
- Grain - straightness important.

The hardwood species selected for the project and the geographic origins of the seed (provenances) are listed in Table 1. The *Eucalyptus* species selected were the best-scrimming species from an initial list of seven. Each selected provenance is from as near as possible to the site from which Scrimber International obtained the best results when scrimming timber of that species. Seed for *Pinus radiata* was obtained from The Southern Tree Breeding Association (based in Mount Gambier), supplied as that then used by commercial forest companies to produce planting stock for the region's plantations.

TABLE 1. Origins of seed for the hardwood species used in the project

Species	CSIRO	Origin		
	Seedlot N ^o	Latitude(S)	Longitude	Altitude
<i>Acacia mearnsii</i>	14926	37 ^o 10'	147 ^o 45'	300 m
<i>Casuarina glauca</i>	14930	35 ^o 08'	150 ^o 38'	1 m
<i>Eucalyptus fraxinoides</i>	15526	36 ^o 29'	149 ^o 19'	1100 m
<i>Eucalyptus globulus</i> <i>ssp pseudoglobulus</i>	15271	37 ^o 30'	149 ^o 11'	140 m
<i>Eucalyptus grandis</i>	16839	30 ^o 15'	152 ^o 58'	450 m
<i>Eucalyptus saligna</i>	13334	31 ^o 40'	151 ^o 49'	540 m

Production of Seedlings

Seedlings of all species were produced under identical conditions. Seeds were germinated at 25° C on a moisture-retaining fine gravel under a 1 kW metal halide lamp (HPI/T 1000W: Philips lighting Industries Australia)* that provided a photon irradiance of about 1 mmol m⁻² s⁻¹ at the gravel surface for 8 h per day. When a suitable size (radical 1-2cm long, cotyledons emerged) each seedling was planted into a 'Rite-Gro' (Yates, Milperra NSW)* root-trainer tube that contained a composted potting mix and slow release 'Osmocote Micro max' (Scotts Australia, Castle Hill, NSW) * fertiliser. *Eucalyptus* seedlings were treated with 'Previcure' (Fertool Distributors, Victoria) * to prevent damping-off.

After potting, seedlings were transferred to a glasshouse maintained within the temperature range 10 □ 30 °C. When a seedling reached a height of about 10cm it was moved to an outdoor nursery area, first under shade cloth and then in an unshaded area for several weeks, during which time they were watered daily. After hardening off in these areas in early 1991 the seedlings received a balanced application of foliar nutrients in April 1991 and were planted in May 1991.

Plantation Establishment and Maintenance

The seedlings were planted out on the CSIRO campus at Mount Gambier. The locality is recognised as a high quality site for commercial *P. radiata* plantations, and produced good growth of many *Eucalyptus* species and provenances in another project located on the campus (Cotterill *et al.* 1985).

* Specifying these instruments does not imply approval by CSIRO to the exclusion of other products

The project site was divided into 48 plots so that each species could be planted at two spacings (1.2m and 2.4m) in three replicate plots of each with 121 trees in each plot. The seedlings were planted out in early May 1991, as soon as possible after opening rains, before

the soil had cooled appreciably. Two spacings were used because 1) there was no silvicultural standard in the district for hardwood regimes and 2) to provide information about the relationship between site productivity and planting density.

To minimise early weed competition the site was sprayed with herbicide prior to planting. Spot spraying with herbicide in August 1991 minimised competition from *Oxalis pes-caprae*. Subsequent weed control was by mowing, continued until the trees had suppressed this competition.

Insect attack was noticed on several occasions. Insecticide was applied in September and December 1991 and in February 1992 and 1993 to control beetles and grasshoppers. Further insecticide applications were considered unnecessary.

The seedlings were drip irrigated to ensure good survival. They received a single application of 8 l per plant each week during the summer of 1991/92, fortnightly applications of 16 l in autumn 1992 and 24 l in summer 1992/93.

Fertiliser was applied to a half of each plot. For this the plots were divided into western and eastern halves, to provide similar exposure to sunlight during the course of a day, and the fertilised half of any plot selected at random. To maximise nutrient uptake from the fertiliser it was applied in three doses, in October 1991, September 1992 and in September 1993. A total of 200 kg ha⁻¹ of nitrogen and 80 kg ha⁻¹ of phosphorus was applied at these times at ratios of 1:2:4.

Tree height was first measured in December 1991, and subsequently at approximately six-monthly intervals. Stem diameters were measured at the same times as heights, but for any species these started at the time stem diameters were large enough to measure with reasonable accuracy.

Economic Evaluation

The inputs to the economic analysis were data for mean diameters, heights and stem volumes and establishment and maintenance costs associated with operating the project for five financial years. To assess the comparative profitability of the seven species and the effects of treatments it was necessary to determine possible market products for the trees as well as the likely costs and yields. Yield and diameter data from the project indicated that growth had not plateaued by the time measurements ceased. To estimate future yield, equations that interrelate stem basal area, height and volume were adopted from other sources, where available for the species. Where these were not available a non-linear (Richards) best fit estimation was used. The forms of these equations, their parameters and guiding models for each species are in Appendix 1, together with the measured and projected data for each treatment. Assumptions made for this analysis are that there were no thinnings or mortalities, a single rotation, costs and prices change at the same rate over time, and merchantable volume was estimated using the following equation (adapted from Shiver and Brister, 1992):

$$\text{Merchantable Volume} = \text{True Volume} (1 - 0.73 (10)^{3.49} (\text{Diameter})^{-3.37})$$

A positive outcome from the economic evaluation requires stems to reach a marketable size, so results of the evaluation are not included in this report for species and treatments that failed to attain a projected 17 cm diameter in a reasonable time frame (*c.* 20 years): *viz* *C. glauca* (all treatments), unfertilised *E. saligna* at a spacing of 2.4m and all species other than *P. radiata* at a spacing of 1.2m. The analysis was calculated in real terms, with three possible markets considered for the grown product - scrimber, firewood and woodchips, the latter limited to species currently used domestically or exported to Japan. As neither firewood nor woodchips have restrictive log specifications, those that apply to Scrimber were used. Information from Georgia Pacific using the scrimber technology at Mount Gambier indicated the specifications to be a stem diameter of 7 to 17cm, stem taper of 3cm and length of 3.6 m. Accordingly, the age of clearfall and sale of the crop was based on the mean diameter at breast height reaching 17cm.

Costs included were for a commercial regime similar to that used for the project reported here, including initial irrigation and maintenance until the trees attain 17cm diameter. However, the main purpose of the project was a comparison of species. Treatment and land costs would be the same for all species, so land purchase was excluded from the analysis.

Best estimates of selling price were used for scrimber production and for firewood, at \$18/m³ and \$12/m³, respectively. Woodchips were priced at their prevailing export price for standing tree if exported to Japan (*E. grandis* at a discount to *E. globulus*) or at the Australian processing price.

Sensitivity Analysis

Several assumptions made for the economic evaluation result in considerable uncertainty associated with the analyses. To examine a likely range of economic results three discount rates: 4%, 7% and 10%, and a variation in the basal area, volume and height indexes by $\pm 15\%$ have been examined.

Results

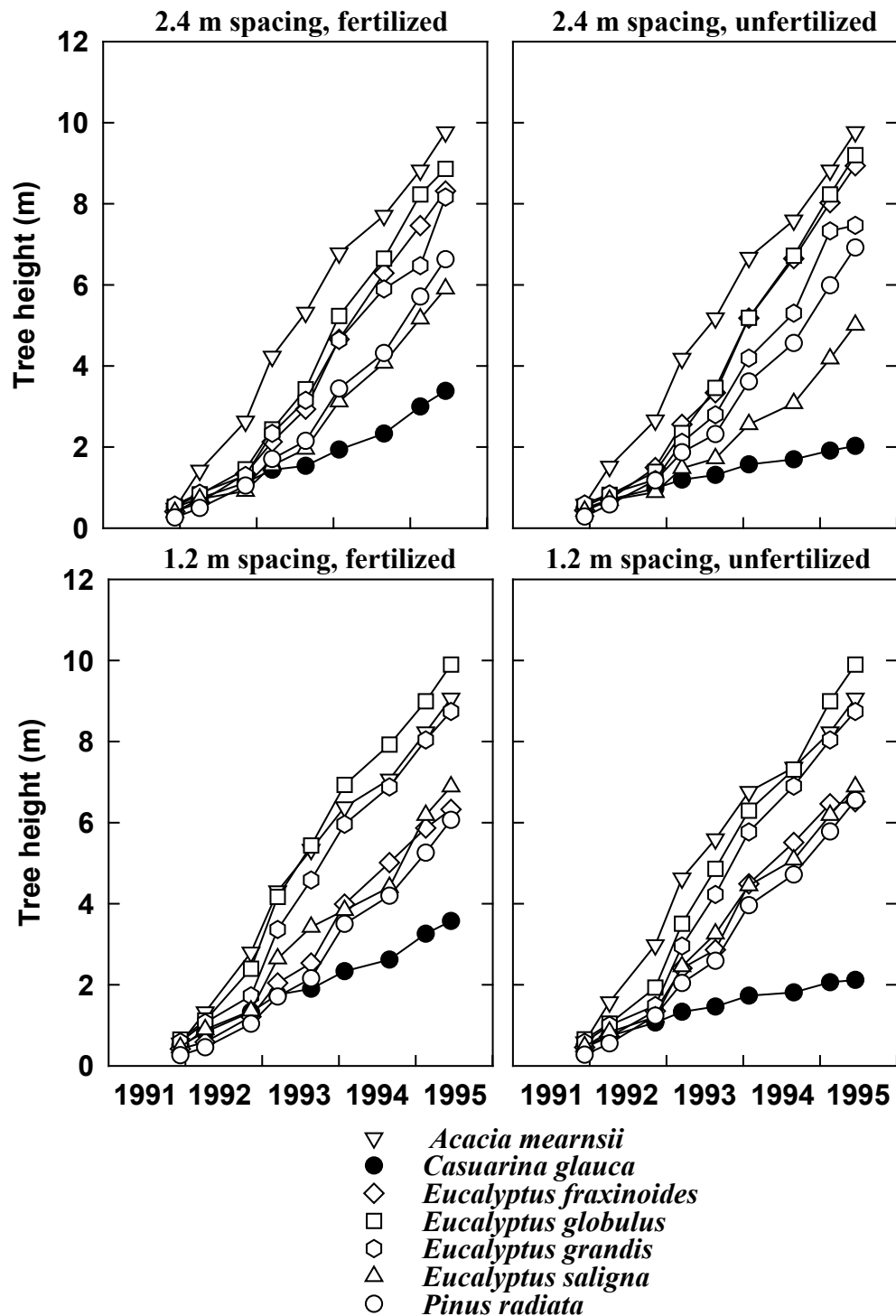


Figure 1. Trends in mean tree height over time for the four treatments and seven species. Variation within a treatment species combination at each measurement time is shown by standard error bars where these extend beyond the symbol.

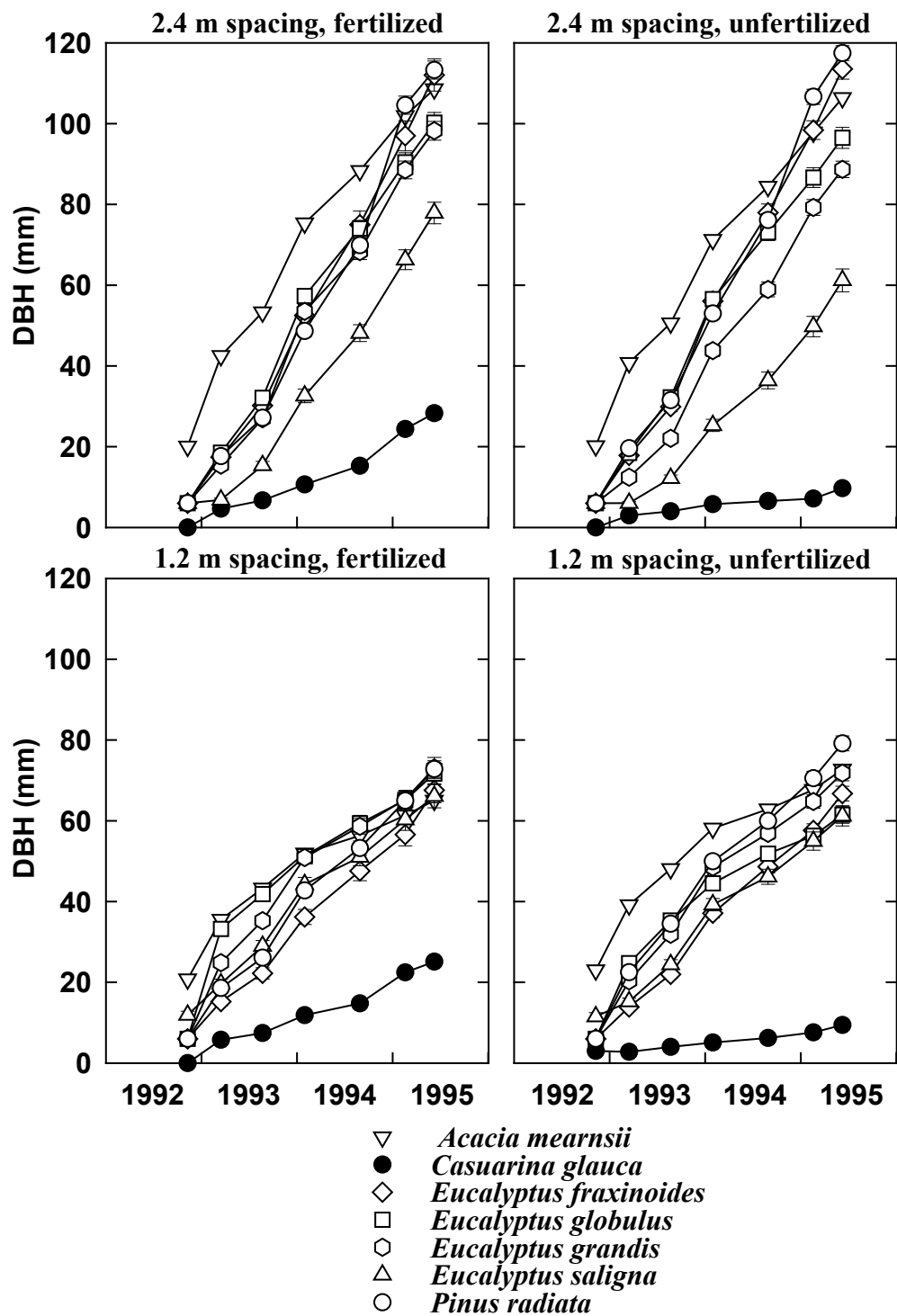


Figure 2. Trends in mean tree diameter at breast height (DBH) over time for the four treatments and seven species. Variation within a treatment species combination at each measurement time is shown by standard error bars where these extend beyond the symbol.

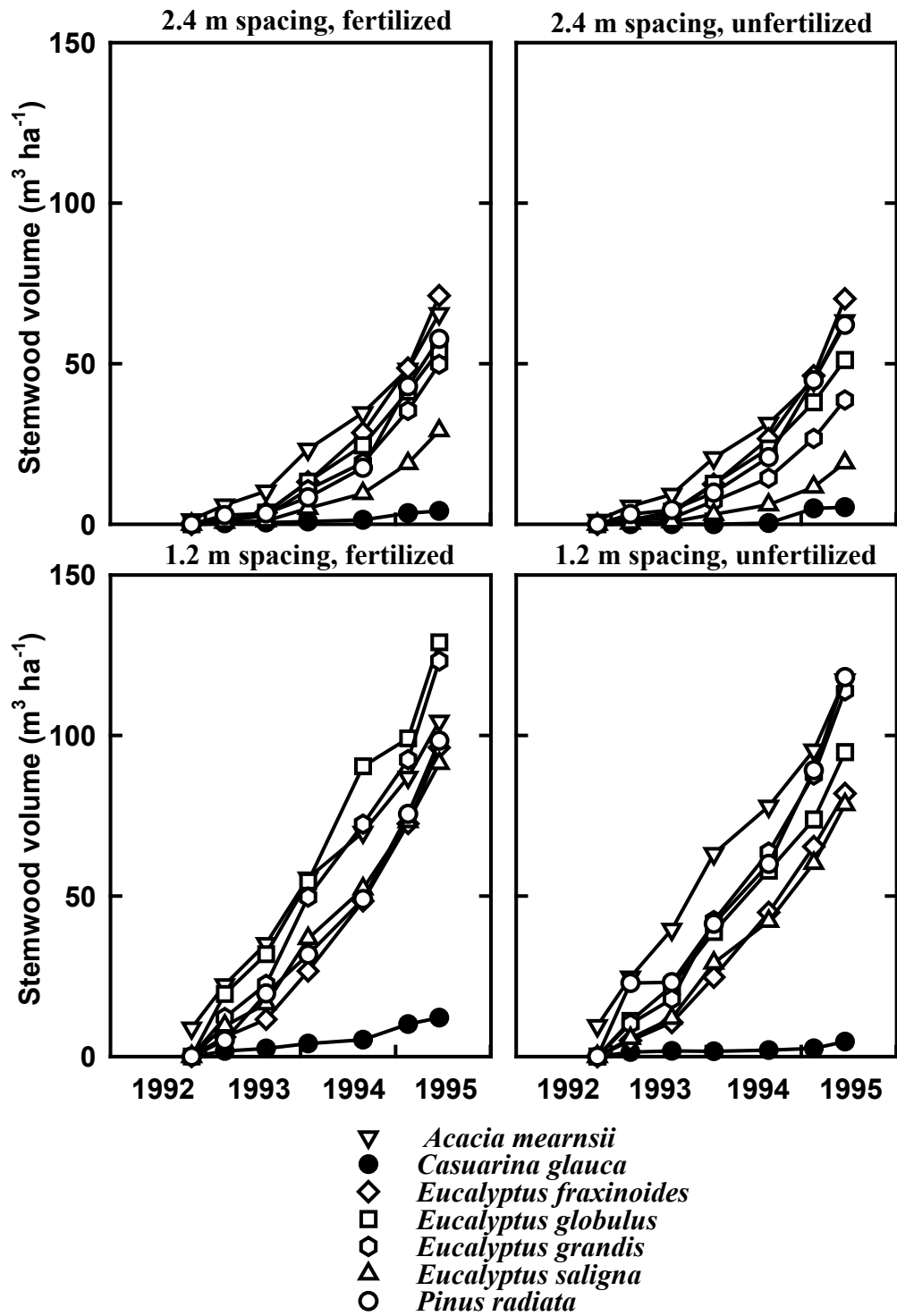


Figure 3. Trends in stem volume; calculated from height, DBH and stocking; over time for the four treatments and seven species. Variation within a treatment species combination at each measurement time is shown by standard error bars where these extend beyond the symbol.

Growth

Generally, all species other than *C. glauca* grew well on the site. Differences in growth of different species varied over time and interacted with spacing and fertilisation. At 2.4m spacing *A. mearnsii* was the tallest species throughout the project (Figure 1) and had the largest stem diameter (DBH) for most of this period (Figure 2), but at 1.2m spacing this species was marginally larger for only a brief period without fertiliser addition. Similarly, height growth separated into three ‘groups’ at 1.2m spacing: (1) *A. mearnsii*, *E. globulus* and *E. grandis*; (2) *E. fraxinoides*, *E. saligna* and *P. radiata*; and (3) *C. glauca* in order of height (Figure 1). At 2.4m spacing such groupings were not readily apparent and ranking was not always the same in fertilised and unfertilised treatments, except that *A. mearnsii* and *C. glauca* grew fastest and slowest, respectively. Differences in ranking of some species with spacing and fertiliser treatment are also apparent in DBH data and in stem volumes, calculated from DBH and height (Figure 3).

Economic Evaluation

Using the assumptions and methodologies given above for projecting future yields, the best proposition on a net present value basis at a discount rate of 7% is unfertilised *P. radiata* at a spacing of 1.2m, irrespective of product (Table 2). The next best was fertilised *P. radiata* at a spacing of 1.2m and the fertilised *E. grandis* at a spacing of 2.4m. A similar ranking is obtained using the internal rate of return to assess viability, except that unfertilised *A. mearnsii* at a spacing of 2.4m is now second to *P. radiata*, and better than *E. grandis* (Table 2).

Sensitivity Analysis

Results for the most optimistic option (discount rate of 4% and 15% higher sizes indices) and the worst option (10% discount rate and 15% lower indices) are in Tables 2 and 3.

As with the ‘standard’ analysis reported above, unfertilised *P. radiata* at the 1.2m spacing and fertilised *E. grandis* were still very highly ranked for both the optimistic and the pessimistic options. *E. saligna* and *A. mearnsii* remain the lower profitability alternatives (Tables 3 and 4).

With the improved yield assumptions of the optimistic option two more species x spacing treatments attain a diameter of 17cm: fertilised *E. grandis* at 1.2m spacing and unfertilised *E. saligna* at 2.4m spacing (Table 3). The former is particularly promising compared to the other species at 2.4m spacing. Under the pessimistic scenario, unfertilised *E. globulus* and unfertilised *A. mearnsii* failed to reach a DBH of 17cm and so are not considered (Table 4).

Projected returns are not large under most of the species x treatment x economic options. Setting up the irrigation system was costed at \$4 200 per hectare, so returns would be considerably larger if similar rates of survival and growth could be obtained without irrigation. Seedlings were costed at \$135 and \$280 per thousand for *P. radiata* and hardwoods, respectively. Savings here would improve economic returns from the crop.

Table 2. Net present value and internal rate of return calculated using the base case for productivity and royalties for all combinations of species and treatments that were projected to reach a DBH of 17cm within a reasonable period. Species and treatments are listed in sequence of net present values.

Species	Spacing/Treatment (m)	17cm DBH Age (y)	NPV at 7% (\$)	IRR (%)
Scrimber Specification				
<i>Pinus radiata</i>	1.2 Unfertilised	17	1,676	8.6
<i>Pinus radiata</i>	1.2 Fertilised	20	-305	6.7
<i>Eucalyptus grandis</i>	2.4 Fertilised	10	-2,913	-1.8
<i>Eucalyptus grandis</i>	2.4 Unfertilised	12	-3,003	-0.8
<i>Eucalyptus fraxinoides</i>	2.4 Unfertilised	8	-3,079	-6.0
<i>Pinus radiata</i>	2.4 Fertilised	7	-3,109	-8.3
<i>Pinus radiata</i>	2.4 Unfertilised	7	-3,142	-8.6
<i>Eucalyptus globulus</i>	2.4 Unfertilised	12	-3,360	-2.2
<i>Eucalyptus globulus</i>	2.4 Fertilised	12	-3,376	-2.9
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	8	-3,403	-7.6
<i>Acacia mearnsii</i>	2.4 Fertilised	13	-3,753	-2.7
<i>Eucalyptus saligna</i>	2.4 Fertilised	14	-4,069	-3.2
<i>Acacia mearnsii</i>	2.4 Unfertilised	23	-5,058	-2.3
Firewood				
<i>Pinus radiata</i>	1.2 Unfertilised	17	-1,124	5.7
<i>Pinus Radiata</i>	1.2 Fertilised	20	-2,685	4.3
<i>Eucalyptus Grandis</i>	2.4 Fertilised	10	-3,855	-6.8
<i>Eucalyptus Fraxinoides</i>	2.4 Unfertilised	9	-3,861	-11.9
<i>Eucalyptus Grandis</i>	2.4 Unfertilised	12	-3,886	-4.9
<i>Pinus radiata</i>	2.4 Fertilised	7	-3,888	-15.2
<i>Pinus radiata</i>	2.4 Unfertilised	7	-3,910	-15.4
<i>Eucalyptus globulus</i>	2.4 Unfertilised	12	-4,124	-6.3
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	8	-4,143	-13.6
<i>Eucalyptus globulus</i>	2.4 Fertilised	12	-4,181	-7.3
<i>Acacia mearnsii</i>	2.4 Fertilised	13	-4,453	-6.5
<i>Eucalyptus saligna</i>	2.4 Fertilised	14	-4,690	-6.8
<i>Acacia mearnsii</i>	2.4 Unfertilised	23	-5,424	-4.7
Woodchips				
<i>Pinus radiata</i>	1.2 Unfertilised	17	1,839	8.7
<i>Pinus radiata</i>	1.2 Fertilised	20	-166	6.9
<i>Eucalyptus grandis</i>	2.4 Fertilised	10	-1,342	3.6
<i>Eucalyptus grandis</i>	2.4 Unfertilised	12	-1,943	2.7
<i>Eucalyptus globulus</i>	2.4 Fertilised	12	-2,035	2.1
<i>Eucalyptus globulus</i>	2.4 Unfertilised	12	-2,086	2.2
<i>Pinus radiata</i>	2.4 Unfertilised	7	-2,902	-7.3
<i>Pinus radiata</i>	2.4 Fertilised	7	-3,064	-8.0

Table 3. Net present value and internal rate of return calculated using the best case for productivity and royalties for all combinations of species and treatments that were projected to reach a DBH of 17cm within a reasonable period. Species and treatments are listed in sequence of net present values.

Species	Spacing/Treatment (m)	17cm DBH Age (y)	NPV at 4% (\$)	IRR (%)
Scrimber Specification				
<i>Pinus radiata</i>	1.2 Unfertilised	14	9,665	11.7
<i>Pinus radiata</i>	1.2 Fertilised	17	7,006	8.6
<i>Eucalyptus grandis</i>	1.2 Fertilised	33	2,177	4.7
<i>Eucalyptus grandis</i>	2.4 Fertilised	9	-599	2.5
<i>Pinus radiata</i>	2.4 Fertilised	7	-1,763	-2.8
<i>Eucalyptus grandis</i>	2.4 Unfertilised	10	-1,932	-1.0
<i>Eucalyptus globulus</i>	2.4 Fertilised	9	-2,092	-2.0
<i>Acacia mearnsii</i>	2.4 Fertilised	10	-2,115	-1.4
<i>Eucalyptus globulus</i>	2.4 Unfertilised	9	-2,123	-2.3
<i>Eucalyptus fraxinoides</i>	2.4 Unfertilised	8	-2,274	-5.3
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	7	-2,696	-7.3
<i>Pinus radiata</i>	2.4 Unfertilised	6	-2,860	-8.6
<i>Acacia mearnsii</i>	2.4 Unfertilised	12	-2,957	-2.8
<i>Eucalyptus saligna</i>	2.4 Unfertilised	24	-4,568	-2.1
<i>Eucalyptus saligna</i>	2.4 Fertilised	7	-4,584	-23.0
Firewood				
<i>Pinus radiata</i>	1.2 Unfertilised	14	4,118	8.1
<i>Pinus radiata</i>	1.2 Fertilised	17	2,049	5.7
<i>Eucalyptus grandis</i>	2.4 Fertilised	9	-2,381	-3.1
<i>Eucalyptus fraxinoides</i>	2.4 Unfertilised	7	-3,373	-12.1
<i>Eucalyptus grandis</i>	2.4 Unfertilised	10	-3,221	-5.8
<i>Pinus radiata</i>	2.4 Fertilised	7	-2,881	-11.4
<i>Pinus radiata</i>	2.4 Unfertilised	6	-3,797	-15.4
<i>Eucalyptus globulus</i>	2.4 Unfertilised	10	-3,323	-7.7
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	7	-3,727	-14.2
<i>Eucalyptus globulus</i>	2.4 Fertilised	9	-3,376	-7.5
<i>Acacia mearnsii</i>	2.4 Fertilised	10	-3,400	-6.2
<i>Eucalyptus saligna</i>	2.4 Fertilised	7	-4,985	-29.5
<i>Acacia mearnsii</i>	2.4 Unfertilised	12	-3,994	-6.9
<i>Eucalyptus grandis</i>	1.2 Fertilised	33	-1,767	3.3
<i>Eucalyptus saligna</i>	2.4 Unfertilised	24	-5,251	-4.4
Woodchips				
<i>Pinus radiata</i>	1.2 Unfertilised	14	9,988	11.9
<i>Pinus radiata</i>	1.2 Fertilised	17	7,295	8.8
<i>Eucalyptus grandis</i>	2.4 Fertilised	9	49	4.1
<i>Eucalyptus grandis</i>	2.4 Unfertilised	10	-384	3.2
<i>Pinus radiata</i>	2.4 Fertilised	6	-1,687	-2.5
<i>Eucalyptus globulus</i>	2.4 Fertilised	12	-2,035	2.1
<i>Eucalyptus globulus</i>	2.4 Unfertilised	12	-2,086	2.2
<i>Pinus radiata</i>	2.4 Unfertilised	7	-3,320	-15.5

Table 4. Net present value and internal rate of return calculated using the worst case for productivity and royalties for all combinations of species and treatments that were projected to reach a DBH of 17cm within a reasonable period. Species and treatments are listed in sequence of net present values.

Species	Spacing/Treatment (m)	17cm DBH Age (y)	NPV at 10% (\$)	IRR (%)
Scrimber Specification				
<i>Pinus radiata</i>	1.2 Unfertilised	14	-3,233	6.0
<i>Eucalyptus grandis</i>	2.4 Fertilised	12	-3,821	-2.0
<i>Eucalyptus fraxinoides</i>	2.4 Unfertilised	9	-3,838	-7.8
<i>Pinus radiata</i>	2.4 Fertilised	7	-3,857	-10.5
<i>Pinus radiata</i>	2.4 Unfertilised	6	-3,877	-10.7
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	8	-3,987	-11.0
<i>Eucalyptus grandis</i>	2.4 Unfertilised	14	-4,027	-1.8
<i>Eucalyptus globulus</i>	2.4 Fertilised	13	-4,243	-3.5
<i>Acacia mearnsii</i>	2.4 Fertilised	13	-4,589	-6.3
<i>Eucalyptus saligna</i>	2.4 Fertilised	18	-4,969	-3.9
<i>Pinus radiata</i>	1.2 Fertilised	17	-5,386	4.1
Firewood				
<i>Pinus radiata</i>	1.2 Unfertilised	14	-4,302	3.6
<i>Eucalyptus fraxinoides</i>	2.4 Unfertilised	9	-4,316	-13.1
<i>Pinus radiata</i>	2.4 Fertilised	7	-4,335	-16.4
<i>Pinus radiata</i>	2.4 Unfertilised	6	-4,348	-16.6
<i>Eucalyptus grandis</i>	2.4 Fertilised	12	-4,405	-6.2
<i>Eucalyptus fraxinoides</i>	2.4 Fertilised	8	-4,458	-16.9
<i>Eucalyptus grandis</i>	2.4 Unfertilised	14	-4,501	-5.4
<i>Eucalyptus globulus</i>	2.4 Fertilised	13	-4,695	-7.4
<i>Acacia mearnsii</i>	2.4 Fertilised	13	-4,921	-10.2
<i>Eucalyptus saligna</i>	2.4 Fertilised	18	-5,226	-6.8
<i>Pinus radiata</i>	1.2 Fertilised	17	-5,953	2.4
Woodchips				
<i>Eucalyptus globulus</i>	2.4 Fertilised	12	-2,035	2.1
<i>Eucalyptus globulus</i>	2.4 Unfertilised	12	-2,086	2.2
<i>Eucalyptus grandis</i>	2.4 Fertilised	12	-3,118	1.4
<i>Pinus radiata</i>	1.2 Unfertilised	14	-3,171	6.1
<i>Eucalyptus grandis</i>	2.4 Unfertilised	14	-3,458	1.1
<i>Pinus radiata</i>	2.4 Fertilised	6	-3,829	-10.2
<i>Pinus radiata</i>	2.4 Unfertilised	7	-3,994	-17.1
<i>Pinus radiata</i>	1.2 Fertilised	17	-5,353	4.1

The growth projections predict that for all species other than *P. radiata*, the wider spacing increased harvestable stem productivity by increasing the potential to reach 17cm diameter breast height (see Appendix). Fertilisation, at the rate used in this project, is estimated to cost \$500 per hectare, so this is the difference in net present value between the fertilised and unfertilised treatments of a species. On the basis of this *A. mearnsii* and *E. saligna* both benefited from fertilisation while *P. radiata* at the 1.2m spacing did not. For the other species x fertiliser treatment combinations there was no significant case for or against fertilisation.

Conclusions

Growth

All species, other than *C. glauca* produced good growth. Stem volume growth was greater or the same for several hardwood species (*A. mearnsii*, *E. fraxinoides*, *E. globulus* and *E. grandis*) as for *P. radiata* in fertilised treatments. This difference was less pronounced in the unfertilised treatments, suggesting that at least some of these species may benefit more from a higher nutrient supply than does *P. radiata*. Faster early growth of some Eucalyptus species than of *P. radiata* is frequently observed. Such differences could be expected to be even greater once these hardwoods have had a similar history of selection and breeding as has the population of *P. radiata* in the region's plantations. The difference in history of selection and breeding may explain the greater variation in stem size within a hardwood plot compared to *P. radiata*. This translates statistically into a one and a half times greater variance in volume of the stems of hardwood species at the time of last measurement than was found for *P. radiata*.

Economic Evaluation

The base case and the sensitivity analysis both indicate *P. radiata* at 1.2m spacing and *E. grandis* are likely to produce the best returns. Of those species and treatments that reached 17cm in diameter, unfertilised *A. mearnsii* at 2.4m spacing and *E. saligna* at 2.4m spacing were the least profitable. Only a few species $\times$ treatment $\times$ economic options were assessed to be profitable. However, if similar productivities could be achieved without irrigation, the smaller expenditure would result in many other options being profitable. Irrigation was used to ensure full survival of planted seedlings, so that strict inter-specific comparisons would be justifiable. In commercial operations development of appropriate site and situation specific silvicultural operations can have considerable impact on the cost of production of wood and on yield.

The economic evaluation relies on several assumptions, which could change with stand management or with the economic opportunities, or with both. It can, therefore, only be used as a guide to the profitability of situations different from those defined for the evaluation. Growth rates may vary with climate and soil characteristics. The growth prediction models used are the best available at the time, but the accuracy of prediction will vary with local conditions and with management regimes.

The information obtained from this project has immediate applicability to forestry in the Mount Gambier region, especially to farm forestry enterprises, which are the major venue for hardwood plantations in the region. However, the information has a wider application because productivity of the hardwood species has been compared to that of *P. radiata*, which is widely grown in commercial plantations in southern Australia. Thus, provided these data are interpreted with care and with some knowledge of the environmental limitations for each species, the benchmark provided by *P. radiata* data is a useful tool to indicate possible potential productivities for the other species. However, before large investments are

committed in other environments, regional, and if possible site - specific information should be obtained for each species to be used. The site where this project was undertaken is generally considered to be of high productivity for the region. This needs to be taken into account in planning operations at other sites.

Greater detail of site conditions and of responses of various species to a range of these is necessary in order to produce a detailed recommendation for region-wide plantings.

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APPENDIX A

PREDICTIONS OF PRODUCTIVITY

<i>Pinus radiata</i>										
Factor	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
<i>Fertilised - 2.4m spacing</i>						<i>Unfertilised - 2.4m spacing</i>				
1.2	1.8	3.9	2.8	1.9	—	2.0	4.1	3.1		—
1.64	2.7	5.3	3.4	4.9	—	3.2	6.7	4.4		—
2.68	5.1	8.2	5.7	20.4	—	5.5	8.4	6.8	19.8	—
3.26	7.2	9.6	14.0	35.2	—	7.8	9.9	17.1	34.1	—
3.73	10.7	10.8	39.4	50.7	13.4	10.8	11.1	42.1	49.2	16.4
4.06	11.6	11.6	53.8	63.6	26.4	11.9	11.9	58.7	61.7	29.0
4.94	13.4	13.5	101.5	105.6	68.8	14.0	13.9	102.6	102.4	70.1
7		17.3		244.8	208.3		17.8		237.5	205.4
17										
20										
<i>Fertilised - 1.2m spacing</i>						<i>Unfertilised - 1.2m spacing</i>				
1.2	1.9	2.3	5.0	2.3	—	2.3	2.5			—
1.64	2.6	3.1	19.7	6.0	—	3.5	3.3	23.1	6.9	—
2.68	4.5	4.8	18.4	24.8	—	5.2	5.1	26.9	28.7	—
3.26	5.6	5.6	33.9	42.7	—	6.2	6.0	45.0	49.4	—
3.73	6.8	6.3	60.9	61.5	—	7.3	6.8	76.2	71.1	—
4.06	7.5	6.7	82.3	77.1	—	8.1	7.2	106.9	89.1	—
4.94	7.8	7.8	135.2	127.8	—	8.4	8.4	153.7	147.7	—
7										
17										
20		17.0		1823.7	1534.9		17.3		1730.7	1474.0

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}
while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Basal Area = Id * (1-e^(b3*Age_x))^{b4}

Guiding Models : South Australian yield tables and South African CCT.

Factor		Basal Area			Volume		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	151	-0.11	2.0	41.5	-0.07	1.2
Unfertilised	2.4	160	-0.11	2.0	38.0	-0.07	1.2
Fertilised	1.2	205	-0.11	2.0	35.0	-0.07	1.2
Unfertilised	1.2	237	-0.11	2.0	35.0	-0.07	1.2

Factor	<i>Eucalyptus grandis</i>									
	Diameter (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Diameter (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
Age										
	<i>Fertilised - 2.4m spacing</i>					<i>Unfertilised - 2.4m spacing</i>				
1.2	1.5	3.5		1.8	—	1.2	3.2		1.5	—
1.64	2.7	4.6		4.5	—	2.2	4.2		3.5	—
2.68	5.6	6.9	9.1	17.4	—	4.6	6.4	5.9	13.6	—
3.26	7.1	8.1	18.4	29.1	—	6.1	7.5	13.2	22.8	—
3.73	9.3	9.0		41.0	—	8.2	8.3	27.2	32.2	—
4.06	10.1	9.7	49.6	50.7	—	9.1	8.9	37.7	39.9	—
4.94	11.2	11.2	80.4	81.7	28.4	10.3	10.3	64.1	64.2	8.2
10		17.5		360.4	308.8					
12						17.6		385.6		331.6
	<i>Fertilised - 1.2m spacing</i>					<i>Unfertilised - 1.2m spacing</i>				
1.2	2.5	2.7				2.0	2.7			
1.64	3.5	3.6				3.2	3.5			
2.68	5.3	5.3	42.9			5.0	5.2	35.6		
3.26	6.2	6.2	67.3			5.9	6.1	58.1		
3.73	7.0	6.8				6.7	6.7			
4.06	7.8	7.2				7.4	7.1			
4.94	8.2	8.3	191.8			8.0	8.1	179.1		
10										
12		(a)					(b)			

(a) Estimated maximum diameter was 16cm, hence volume not presented

(b) Estimated maximum diameter was 15.7cm hence volume not presented.

— Nil merchantable volume

Equations

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Volume based on basal area * height: height = Id * (1-e^(b3*Age_x))^{b4}

Guiding models: South African yield tables for height

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	120	-0.11	1.90	38	-0.09	1.16
Unfertilised	2.4	80	-0.11	1.90	35	-0.09	1.16
Fertilised	1.2	140	-0.14	1.90	40	-0.09	1.16
Unfertilised	1.2	135	-0.14	1.90	39	-0.09	1.16

<i>Eucalyptus globulus</i>										
Factor	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
<i>Fertilised - 2.4m spacing</i>						<i>Unfertilised - 2.4m spacing</i>				
1.2	1.9	3.0	1.2	1.2	—	1.8	2.9	1.3	1.1	—
1.64	3.2	4.2	3.6	3.6	—	3.2	4.1	3.9	3.5	—
2.68	5.9	6.9	11.6	18.6	—	5.9	6.8	11.6	17.7	—
3.26		8.3	23.6	33.3	—		8.1		31.6	—
3.73		8.7		39.3	-19.4		8.5		37.4	—
4.06	9.3	9.3	42.4	48.3	-9.9	9.2	9.1	27.6	45.9	—
4.94	10.3	10.0		60.2	2.6	10.0	9.7	50.8	57.2	—
11		17.0		335.1	282.3					
12						17.0		341.2		286.9
<i>Fertilised - 1.2m spacing</i>						<i>Unfertilised - 1.2m spacing</i>				
1.2	3.3	2.1	19.5			2.5	1.7	11.0		
1.64	4.2	3.0	31.9			3.5	2.5	22.0		
2.68	5.4	5.0	50.1			4.6	4.1	34.6		
3.26		6.0					4.9			
3.73		6.3					5.2			
4.06	7.0	6.7				6.0	5.5			
4.94	7.6	7.2				6.5	5.9			
11										
12		(a)					(b)			

(a) Estimated maximum diameter was 13.5cm, hence volume not presented

(b) Estimated maximum diameter was 11.1cm hence volume not presented.

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Volume based on basal area * height: height = Id * (1-e^(b3*Age_x))^{b4}

Guiding models: Californian yield tables for basal area and height

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	48	-0.2	2.7	22.5	-0.3	1.7
Unfertilised	2.4	46	-0.2	2.7	22.5	-0.3	1.7
Fertilised	1.2	100	-0.2	2.7	22.5	-0.3	1.7
Unfertilised	1.2	68	-0.2	2.7	22.5	-0.3	1.7

	<i>Eucalyptus saligna</i>
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Factor	Diameter (cm)		Volume (m³/ha)		Merch. Volume (m³/ha)	Diameter (cm)		Volume (m³/ha)		Merch. Volume (m³/ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
	Fertilised - 2.4m spacing					Unfertilised - 2.4m spacing				
1.2	0.7	2.7	0.0	0.7	—	0.6	2.2	0.0	0.4	—
1.64	1.5	3.6	0.2	2.0	—	1.2	3.0	0.2	1.1	—
2.68	3.5	5.8	3.0	9.1	—	2.6	4.7	1.6	5.3	—
3.26	5.0	6.9	7.6	16.1	—	3.8	5.6	3.9	9.3	—
3.73	7.0	7.7		23.4	—	5.5	6.3	8.9	13.6	—
4.06	8.1	8.2	24.8	29.4	—	6.6	6.8	15.0	17.0	—
4.94	9.6	9.6	50.4	48.7	—	8.1	7.9	28.0	28.2	—
14		17.2		315.0	266.9					
12						(a)				
	Fertilised - 1.2m spacing					Unfertilised - 1.2m spacing				
1.2					—					—
1.64	2.0	2.0	2.3		—	1.5	1.8	1.4		—
2.68	2.9	2.9	4.7		—	2.4	2.6	4.5		—
3.26	4.6	4.7	26.4		—	4.2	4.2	21.6		—
3.73	5.4	5.5	40.8		—	5.0	5.0	34.2		—
4.06	6.6	6.2			—	6.0	5.6			—
4.94	7.2	6.6			—	6.6	6.0			—
	7.7	7.7	132.4		—	6.9	6.9	112.9		—
14										
12						(c)				
		(b)								

(a) Estimated maximum diameter was 16.5cm hence volume not calculated.

(b) Estimated maximum diameter was 12.3cm hence volume not calculated.

(c) Estimated maximum diameter was 11.7cm hence volume not calculated.

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Volume based on basal area * height: height = Id * (1-e^(b3*Age_x))^{b4}

Guiding models : Kenya and Hawaii stand tables

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	55	-0.15	2.2	22	-0.17	1.5
Unfertilised	2.4	37	-0.15	2.2	19	-0.17	1.5
Fertilised	1.2	83	-0.24	2.6	23	-0.17	1.5
Unfertilised	1.2	68	-0.24	2.6	23	-0.17	1.5

	<i>Eucalyptus fraxinoides</i>
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Factor	Mean Diam (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Mean Diam (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
	Fertilised - 2.4m spacing					Unfertilised - 2.4m spacing				
1.2	1.7	4.0	1.1	2.7		1.8	4.0	1.1	3.2	—
1.64	3.0	5.4	3.6	6.6		3.0	5.4	3.3	7.7	—
2.68	5.8	8.3	10.0	19.7	—	5.8	8.4	11.3	28.0	—
3.26	8.2	9.8	25.4	36.6	—	8.1	9.8	27.3	45.0	0.0
3.73	10.4	10.9	45.7	53.6	15.2	10.1	10.9	50.0	61.4	18.2
4.06	11.8	11.6	62.7	67.1	28.2	11.7	11.6	64.5	74.1	32.0
4.94	13.3	13.3	101.6	103.1	65.4	13.3	13.4	114.0	112.0	71.8
8		17.5			211.8		17.6		261.2	224.1
	Fertilised - 1.2m spacing					Unfertilised - 1.2m spacing				
1.2	1.5	2.5	6.1			1.4	2.4	5.0		
1.64	2.2	3.4	11.6			2.2	3.2	10.6		
2.68	3.9	5.2	17.9			3.8	4.8	17.9		
3.26	5.2	6.1	37.6			5.1	5.6	37.5		
3.73	6.3	6.7	60.7			6.1	6.2	59.8		
4.06	7.3	7.1	0.0			6.9	6.6	0.0		
4.94	8.1	8.1	128.6			7.5	7.5	113.6		
8		(a)					(b)			

(a) Estimated maximum diameter was 12.7cm, hence volume not presented

(b) Estimated maximum diameter was 11.77cm hence volume not presented.

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Volume based on basal area * height: height = Id * (1-e^(b3*Age_x))^{b4}

Guiding Models: Best fit

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	71	-0.19	2.2	21	-0.13	1.0
Unfertilised	2.4	72	-0.19	2.2	21	-0.13	1.0
Fertilised	1.2	88	-0.22	2.2	17	-0.13	1.0
Unfertilised	1.2	76	-0.22	2.2	17	-0.13	1.0

	<i>Acacia mearnsii</i>	
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Factor	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Mean Diam. (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
	Fertilised - 2.4m spacing					Unfertilised - 2.4m spacing				
1.2	1.9	4.0	1.2	2.9	—	0.6	3.9	1.3	2.6	-58.1
1.64	3.2	5.4	3.6	7.3	—	1.8	5.1	3.9	6.6	-52.5
2.68	7.6	8.1	23.8	28.2	—	7.2	7.7	21.1	25.3	-31.8
3.26	9.0	9.3	36.9	45.6	—	8.5	8.9	33.3	40.9	-15.6
3.73	10.3	10.2		61.9	7.7	9.9	9.8		55.6	-0.5
4.06	11.1	10.8		74.3	20.3	10.6	10.4		66.7	10.8
4.94	12.1	12.2	110.5	109.4	55.8	11.7	11.7	97.8	98.2	42.7
13		17.0		334.1	281.1					
23						17.0		344.0		289.0
	Fertilised - 1.2m spacing					Unfertilised - 1.2m spacing				
1.2	3.3	2.5	19.5		—	2.5	2.6	11.0		—
1.64	4.2	3.4	31.9		—	3.5	3.5	22.0		—
2.68	5.5	5.1	50.1		—	5.9	5.2	56.2		—
3.26	6.0	5.9	65.7		—	6.4	6.0	72.2		—
3.73	6.6	6.4			—	7.0	6.6			—
4.06	7.0	6.8			—	7.5	7.0			—
4.94	7.4	7.7	162.0		—	7.8	7.9	160.8		—
13										
23		(a)					(b)			

(a) Estimated maximum diameter was 11.2cm, hence volume not presented

(b) Estimated maximum diameter was 11.5cm hence volume not presented.

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

while basal area = Ig * (1-e^(b1*Age_x))^{b2}

Volume based on basal area * height: height = Id * (1-e^(b3*Age_x))^{b4}

Guiding models: Best fit

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	70	-0.25	2.2	22	-0.24	1.4
Unfertilised	2.4	40	-0.25	2.2	21	-0.24	1.4
Fertilised	1.2	68	-0.25	2.2	20	-0.24	1.4
Unfertilised	1.2	72	-0.25	2.2	20	-0.24	1.4

	<i>Casuarina glauca</i>	
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Factor	Mean Diam (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)	Mean Diam (cm)		Volume (m ³ /ha)		Merch. Volume (m ³ /ha)
Age	Actual	Projected	Actual	Projected	Projected	Actual	Projected	Actual	Projected	Projected
	Fertilised - 2.4m spacing					Unfertilised - 2.4m spacing				
1.2	0.5	0.7	0.0			0.3	0.2	0.0		
1.64	0.7	1.1	0.1			0.4	0.3	0.0		
2.68	1.1	1.9	0.2			0.5	0.6	0.0		
3.26	1.7	2.4	0.5			0.6	0.7	0.1		
3.73	2.7	2.8				0.8	0.9	0.1		
4.06	3.2	3.1	2.5			1.1	0.9	0.2		
4.94	3.8	3.8	4.8			1.2	1.2	0.4		
	(a)					(b)				
	Fertilised - 1.2m spacing					Unfertilised - 1.2m spacing				
1.2	0.6	0.6	0.2			0.3	0.2	0.0		
1.64	0.7	0.9	0.4			0.4	0.3	0.1		
2.68	1.3	1.6	1.1			0.5	0.6	0.1		
3.26	1.6	1.9	1.9			6.0	0.7	0.2		
3.73	2.5	2.3				0.8	0.8			
4.06	2.7	2.5				1.0	0.9			
4.94	3.1	3.1	12.4			1.1	1.1	1.1		
	(c)					(d)				

(a) Estimated maximum diameter was 16.5cm, hence volume not presented

(b) Estimated maximum diameter was 14.1 cm hence volume not presented.

(c) Estimated maximum diameter was 13.3cm, hence volume not presented

(d) Estimated maximum diameter was 6.6cm, hence volume not presented

— Nil merchantable volume

Equations:

Diameter at Age_x = (basal area/number of trees *40,000/PI)^{0.5}

Basal area = Ig * (1-e^(b1*Age_x))^{b2}

When diameter did not attain 17 cm volume was not projected forward.

Guiding Models: Best fit

Factor		Basal Area			Height		
Treatment	Spacing	Ig	b1	b2	Id	b3	b4
Fertilised	2.4	37.0	-0.08	2.6	19.5	-0.10	1.3
Unfertilised	2.4	27.0	-0.03	2.6	19.0	-0.07	1.3
Fertilised	1.2	95.0	-0.08	2.6	19.5	-0.10	1.3
Unfertilised	1.2	23.5	-0.06	2.6	18.0	-0.07	1.3