From: The future of eucalypts for wood products: proceedings. Launceston, Tas. 2000

PRODUCTIVITY, SAWN RECOVERY AND POTENTIAL RATES OF RETURN FROM EUCALYPT PLANTATIONS IN QUEENSLAND

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Abstract

This paper reviews the results of stand mensuration and wood quality studies undertaken on various eucalypt plantations in Queensland as part of the State Government's Private Plantation Initiative. The paper discusses the productivity, wood properties and sawn product recovery of the plantations evaluated. Commercial returns have been calculated based on current cost/product data and estimates provided of the potential returns to both the grower and processor, when assuming improvements in genetics, forest management, harvesting systems, processing technology and also markets.

The analyses conducted demonstrated that the 21 to 41-year-old plantations evaluated yielded poor returns. Key factors limiting economic viability included low productivity, a high incidence of defects including end splitting and distortion of sawn timber, knots, kino veins and insect damage. These factors can be mainly attributed to the use of un-improved planting stock, inappropriate silviculture and limitations in processing technology. However, further analyses performed suggested that hardwood plantations can become a viable economic proposition if reasonable targets in productivity and wood quality can be achieved through research and development in genetics, silviculture and processing. The enhancement of the economics of hardwood sawlog plantations between now and the first significant clearfell harvests is likely to be predominantly brought about by:

- at least 20 years of technological advancement in wood processing and harvesting systems;
- at least 20 years improvement in markets and
- at least 20 years for some silvicultural and genetic improvements to be imposed.

Introduction

In support of the development of private plantations in Queensland, the Wood Products Program of the Queensland Forestry Research Institute (QFRI) has conducted studies on various hardwood plantations since 1996. The objective of these studies has been to evaluate the processing properties and wood quality of these resources with the aim of establishing their utilisation potential and value. This information is vital to supporting species selection, the development of genetic resources, and to optimising silviculture and processing practices.

As timber is increasingly sourced from plantations and the transition is made away from natural hardwood forests, a number of wood quality issues emerge as significant challenges. Existing wood properties knowledge on hardwoods is based predominantly on natural forest grown trees. The wood properties and sawn recovery of plantation grown hardwoods can be expected to differ from the natural forest resource that the industry is currently used to. This is largely because plantation grown trees will be grown faster, harvested younger and the log size will generally be smaller. Studies conducted in Australia and overseas have demonstrated considerable differences between the wood quality and processing attributes of plantation and natural forest grown hardwoods (Hillis and Brown,1978; Bhat, 1986; Di Villiers, 1973; Kauman *et al.* 1995; Kromhout and Bosman, 1981; Waugh and Yang, 1994;Yang and Waugh, 1996; Waugh, 1997; Northway and Blakemore,1997). The negative features of plantation hardwoods highlighted in the above mentioned studies included processing problems and reduced sawn recoveries due to high levels of growth stress and also a high incidence of defects such as knots, kino veins, insect damage, collapse and checking.

Another issue confronting the emerging plantation hardwood industry is the transition in markets that is occurring concomitantly with the changing nature of the hardwood resource. The appearance and feature attributes of native eucalypt hardwood timbers have been recognised and there is a growing tendency towards shifting these timbers into value-added products such as furniture and joinery components, flooring, panelling and mouldings. This trend has been reinforced by the declining supplies of hardwood cabinet timbers from tropical rainforests. However, the trend towards value-adding native hardwoods and converting them into appearance, instead of the more traditional structural products, produces numerous technical challenges especially as the industry moves into a regrowth and plantation resource characterised generally by young wood and poorer log quality (at least in the first rotation).

There is also an urgent need to augment the negligible database on the economics of growing and converting plantation hardwoods into solid wood and panel products. This information is critical to attracting private sector investment. This paper attempts to address this shortfall in economics information on hardwood plantation forestry by examining the information derived from comprehensive stand mensuration and wood quality studies undertaken on selected hardwood plantation stands in Queensland. Furthermore, the paper suggests significant, yet realistic assumptions about the improvements likely to be made and which could help achieve economic viability (with acceptable Internal Rates of Return). These improvements could be achieved in the time between now and when any significant new solid-wood plantation resource reaches the market.

Method

Site and stand details are given in Table 1. Tree measurements[1] and site assessments were undertaken on stands selected for study and where possible, information was gathered on silvicultural history. Sawing studies were undertaken at the QFRI research mill in Brisbane, with the exception of the 21-year-old blackbutt (*Eucalyptus pilularis*), which was sawn on a twin edger at a commercial sawmill. The emphasis was on the production of timber to be used in appearance applications and therefore most boards were cut to a nominal 25 mm thickness prior to planing. Following seasoning and dressing, the timber was graded in accordance with *Australian Standard DR 97207-97208 Timber-Hardwood-Sawn and Milled Products* (the Draft Revision of AS2796). At the time the timber was graded this was the current Australian/New Zealand draft specification for seasoned and milled hardwood products such as joinery, mouldings, lining and flooring.

Shrinkage blocks were cut from the outer heartwood of each log. These blocks were cut to a standard size (100 mm X 25 mm X 25 mm) having truly tangential and radial faces with length parallel to the grain (Kelsey and Kingston, 1957). The method of testing was similar to that described by Kingston and Risdon (1961), except that no reconditioning was applied at 12% moisture content.

Discs taken from the top and bottom of each log were used to determine sapwood width and also to provide samples for basic density determination. The discs were stained with 0.2% di-methyl orange to determine sapwood area. Two radial wedges (on opposite sides and on the shortest axis) were extracted from each disc. These wedges were 90 mm wide

[1] Tree measurements were not undertaken on the Eucalyptus argophloia

at the cambial surface and 12 mm thick. Basic density was determined for each wedge using the water displacement method.

Table 1. Site data for each plantation

Species	*Eucalyptus. cloeziana*	*Eucalyptus cloeziana*	*Eucalyptus pilularis*	*Eucalyptus microcorys*	*Eucalyptus grandis*	*Corymbia citriodora*	*Eucalyptus argophloia*
Standard trade name	Gympie messmate	Gympie messmate	blackbutt	tallowwood	rose gum	spotted gum	western white gum
Age (years)	32	35	21	28	28	41	32
Source	Pomona (SEQ[a])	Pomona (SEQ)	Bellthorpe (SEQ)	Ravenshoe (NQ[b])	Ravenshoe (NQ)	Gatton (SWQ)	Dalby (SWQ[c])
Annual Rainfall (mm)	1500	1500	1688	1669	1669	800	690
Latitude (00°00'S)	26 22	26 22	26 50	17 20	17 20	27 30	27 10
Longitude (00°00'E)	152 54	152 54	152 40	145 30	145 30	152 20	151 10
Soil Type	Coarse grey sand with brown loam on slopes.	Coarse grey sand with brown loam on slopes.	Red brown to dark brown clay loam.	Rhyolite derivative.	Rhyolite derivative.	Red Podsolic (upper slopes). Yellow Podsolic (lower slopes).	Greyish, black light clays.

[a]SEQ = South-East Queensland [b]NQ = North Qeensland [c]SWQ = South West Queensland

Results and Discussion

Table 2. Productivity and sawn recovery data for each plantation

Species	*Eucalyptus. cloeziana*	*Eucalyptus cloeziana*	*Eucalyptus pilularis*	*Eucalyptus microcorys*	*Eucalyptus grandis*	*Corymbia citriodora*	*Eucalyptus argophloia*
Stems per hectare (total stand pre-harvest)	Na	250	190	741	801	903	Na
DBHOB (cm, total stand)	38.3	40.9	39.2	25.5	26.7	20.6	Na
Stems per hectare (merchantable trees only)	Na	240	185	432	216	258	Na
DBHOB (cm, merchantable trees only)	42.2	41.6	39.2	34.8	43.0	30.9	Na
Average merchantable volume per stem[2] (m^3)	1.17	1.16	0.94	0.718	1.26	0.37	Na
Merchantable volume per hectare (m^3/ha)	Na	278.4	177.6	310.2	272.7	96.5	Na
Merchantable MAI[3] (m^3/ha/yr)	Na	8.0	8.5	11.1	9.8	2.4	Na
Merchantable ht (m)	19.8	20.1	13.5	15.4	13.8	6	Na
Total ht (m, merchantable trees)	34.6	41.2	31.7	36.4	36.2	26.7	Na
No of trees selected for wood quality studies	15	17	40	22	11	22	3
GOS Recovery[4] (%)	42.9	40.1	36.5	34.0	37.4	36.3	32.3
DGR Recovery[5] (%) –flooring, mouldings	15.3	15.9	15.3	15.0	12.7	18.8	7.9
DGR Recovery (%) -lining	13.8	14.5	15.0	12.7	12.0	18.1	7.9
DGR Recovery (%) -joinery	3.2	3.3	7.7	5.7	6.9	6.9	1.8

Plantation Productivity

The merchantable MAI figures of 2.4 to 11.1 m^3/ha/yr given in Table 2 would be regarded as low relative to what has been reported or predicted elsewhere in Australia and overseas for plantation eucalypts. Recent work by Ryan (1993a) summarised in Table 3 shows that standing merchantable volume MAI[6] for four eucalypt species in old growth trials on moist sites in South-East Queensland have ranged from 6.6 to 29.3 m^3/ha/yr.

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[2] sawlog merchantable volume; 20cm sed or where form limited log length
[3] Mean annual sawlog standing merchantable volume increment; 20cm sed or where form limited log length
[4] Recovery (as a percentage of log volume) of sawn timber in nominal dimensions after docking out want and wane
[5] Recovery (as a percentage of log volume) of appearance grade sawn products in nominal dimensions after drying, dressing and grading in accordance with DR97207-DR97208
[6] Standing merchantable volume (40cm dbh to 20cm top diameter)

Table 3. Merchantable volume mean annual increment (MAI) of four eucalypt species in old trials in Queensland (Ryan, 1993a)

	Moist		Dry
	SEQ	NQ	SEQ
E. resinifera	6.6-13.2	Na	>2.5-6.2
E. microcorys	10.1-15.1	11.6-27.8	5.1-8.8
E. cloeziana	7.8-19.7	Na	Na
E.grandis	10.6-29.3	Na	Na

The Joint Venture Scheme of DPI Forestry (1997) suggests that yields in the order of 15 to 25 m^3/ha/yr net merchantable volume should be achievable. Over a plantation rotation of 40 years, this would result in total harvesting volumes of 600 to 1000 m^3 per ha. These assumptions specify a moderate to high site index. Rose gum plantations in Uruguay are achieving a DBHOB of 50 cm and a merchantable sawlog MAI of 25 m^3/ha/yr at the age of 18 (Gough[7], pers comm,1998,) Ryan (1993a) highlighted the importance of matching species to sites for which they are most suited, of providing good early weed control, adequate nutrition and appropriate thinning regimes and of the potential to improve productivity through genetic selection and breeding. The merchantable MAI figures shown in Table 2 were derived from measurements on stands where there had been very little silvicultural input and no genetic improvement.

Processing and Sawn Recovery

The dried, graded and dressed recoveries (DGR) for the various plantation stands are considerably lower than that expected in the conversion of mixed hardwood species from natural forest in Queensland to structural and appearance products. Hardwood sawmills in Queensland typically recover 85% to 90% of the GOS volume (in nominal dimensions) after drying, dressing and grading boards for flooring and other appearance grade board products (Evans[8], pers comm,1999) This means that commercial mills would on average currently recover around 30% of the log volume as 'saleable' appearance grade board products. Whereas, the results in Table 2 reveal that in the case of flooring, the DGR ranged from 8% to 19%, well below the average DGR of 30% expected for current "compulsory" hardwood log conversion in Qld.

The reasons for downgrade varied between species. However, the major reasons included knot defects (tight, loose and bark encased), gum vein, end splits, distortion (spring and bow), wane (run-off), decay and insect damage. Insect damage due to mainly longicorn beetles, pinhole borer and giant wood moth was the principal reason for downgrade of the 28-year-old rose gum timber from north Queensland.

The DGR results are given for three different product categories: flooring/mouldings, lining and joinery. Distortion limits are different for the three product categories with the permissible distortion for joinery being considerably less than that allowed for lining and flooring/moulding products. The effect of growth stresses on sawn recovery is clearly illustrated by the low recovery of timber suitable for joinery (Table 2) and also by Figure 1 below which shows the number of boards out of grade due to spring or bow in the QFRI studies.

[7] D. Gough, Forester/Timber Technologist, Queensland
[8] T. Evans, Woodford Timbers and Queensland Timber Board Hardwood Division

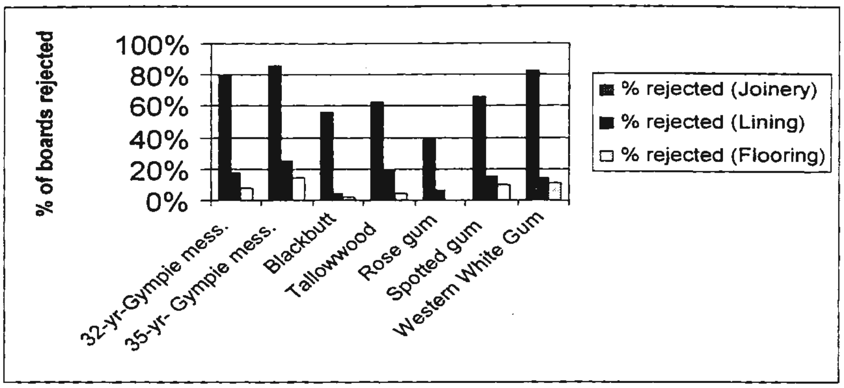

Figure 1: *The percentage of boards rejected due to spring or bow in accordance with DR97207-DR97208 for each species and for each product category.*

Studies by QFRI (Muneri *et al.* 1999) on 10-year-old Gympie messmate revealed that larger trees had lower growth stress levels. Other studies have also shown negative relationships between tree size and growth stresses (Wilkins and Kitahara, 1991; Waugh, 1977). This could mean that growing trees faster via genetic or silvicultural manipulation to achieve a larger log size at a given age could help to reduce end-splitting and distortion of timber due to growth stresses. However, the results from these studies contrast with those of Chafe (1985,1995) who found a significant and positive relationship between strain and diameter in 8-year-old shining gum (*E. nitens*) and mature mountain ash (*E. regnans*).

Some of the issues exposed by QFRI in the conversion studies undertaken on plantation grown hardwoods have also been highlighted in other studies. Northway and Blakemore (1997) in studies conducted on young (18-27 years old) plantation eucalypt species, including rose gum (*E. grandis*), Sydney blue gum (*E. saligna*), southern blue gum (*E .globulus*) and spotted gum (*C. maculata*) report that between 13 and 55% of the sawn volume did not make appearance grade. This was principally due to defects such as unacceptable knots, distortion, collapse, want and insect attack.

Waugh and Yang (1994) in a study on Tasmanian plantation eucalypts reported that there appeared to be little commercial opportunity for sawn appearance products from trees grown on rotations of less than 30 years. In studies with plantation grown mountain ash (*E. regnans*), southern blue gum (*E. globulus*), and shining gum (*E. nitens*), less than seven percent of total product out-turn met appearance grade specifications at select grade or higher. The major reason for downgrade was knot characteristics.

Washusen (1999) reports that during the past 10 years there have been a number of projects investigating the potential of southern blue gum to produce high quality engineering and appearance products. Washusen (1999) explains that the results have generally been disappointing due to knots, kino, decay, drying degrade and inconsistent drying. However, one positive result was reported by Moore *et al.* (1996) where it was concluded that 13-year-old southern blue gum grown in Busselton,WA produced marketable sawlogs and a high proportion of appearance grade timber.

Sawn recoveries from plantation eucalypts should markedly improve in the future, given:

- Focus on the production of small clear/select grade markets, including glue-laminated and finger jointed products, parquetry, components and end matched flooring; thin sawing and veneer wrapped products. Defect docking down to very short lengths (300 mm) is practiced already in some current commercial operations exporting tongue and groove overlay flooring. Docking down to short lengths can only be justified if the extra costs of production can be recovered through the development of high value markets as well as consumer acceptance.
- Genetic and silviculture improvement producing larger logs, with a higher proportion of clear wood and a reduced tendency to distort and end split due to growth stresses (Malan, 1991; Marsh and Burgers, 1967).
- New processing solutions such as heating logs with combustion gases (Tejada, *et al.*1997); log storage treatments (Turnbull, 1965; Nicholson, 1973) and improved sawing strategies eg 'balanced sawing' (Kauman *et al.* 1995); double edging saws (Turnbull, 1965); Saw Dry Rip systems (Campbell and Hartley, 1978); radial sawing (RADCON (undated)); high temperature softening (Arima and Grossman, 1978), and improved drying schedules, radio frequency vacuum drying and microwave drying.
- More appropriate marketing facilitating the acceptance of natural features.

Table 4: Comparisons of wood property values between plantation and mature[9] trees of the nominated species.

Species	Age (years)	Basic Density[10] (kg/m³)	Sapwood Width (cm)	Tangential [11]Shrinkage (from green to 12%) (%)	Radial Shrinkage (from green to 12%) (%)	Unit Shrinkage[12] Tangential (from 12% to 5%) (%)	Unit Shrinkage Radial (from 12% to 5%) (%)
E. cloeziana	32	769 (810)	1.9 (1.5 – 2.5)	6.96 (6.2)	5.12 (3.4)	NA	NA
E. cloeziana	35	782 (810)	1.8 (1.5 – 2.5)	5.89 (6.2)	4.23 (3.4)	0.39 (0.37)	0.30 (0.21)
E. pilularis	21	567 (710)	2.2 (1.5 – 2.5)	NA	NA	NA	NA
E. microcorys	28	729 (800)	2.3 (1.5-2.5)	5.56 (6.1)	3.54 (3.7)	0.38 (0.37)	0.31 (0.28)
E. grandis	28	566 (510)	2.6 (1.5-2.5)	5.90 (7.2)	3.44 (4.0)	0.31 (0.34)	0.23 (0.25)
C. citriodora	41	802 (740)	2.9 (1.5 – 2.5)	5.78 (6.1)	3.43 (4.3)	0.43 (0.38)	0.34 (0.32)
E. argophloia	32	815 (NA)	1.8 (1.5 – 2.5)	4.87 (NA)	2.78 (NA)	0.40 (NA)	0.31 (NA)

Sources: Bootle, K.R., 1983. Wood in Australia: types, properties and uses.
Kynaston, W.T. *et al.*, 1994. Timber Species Notes. Second edition, Department of Primary Industries Forest Service
Hillis and Brown, 1978. Eucalypts for wood production. CSIRO

Wood Properties

Basic density was less than that expected for mature wood of the species in Gympie messmate, blackbutt and tallowwood (Table 4). The density expressed as a percentage of mature wood was 96%, 80% and 91% for Gympie messmate, blackbutt and tallowwood respectively. For the other species the basic density of the plantation logs was higher than that expected for mature logs[13].

No significant relationship between growth rate and density was found when regression analyses were performed between DBHOB (diameter at breast height over bark) and tree density in all species. This is encouraging from the geneticist and silviculturist's perspective, because it implies that wood quality is not necessarily impaired with faster growth. Density is more influenced by age than growth rate in the eucalypts (Zobel and van Buijtenen, 1989). Generally, the younger the age of harvest the lower the density of

[9] Mature value in brackets
[10] Basic density is a measure of the amount of actual wood substance present and is calculated as the oven-dry mass of a specimen divided by its green volume.
[11] A change in dimensions occurring as the timber dries from a "green" to a seasoned condition. Shrinkage was measured in the tangential and radial directions.
[12] Percentage change in dimensions with each one percent change in moisture content (below about 25 percent moisture content), measured in the tangential and radial directions.
[13] In the case of western white gum, no mature value was available for comparison

the wood. The influence of growth rate on density can only be regarded as indirect in that it results in trees reaching a merchantable size earlier, resulting in a younger age of harvest. However, this indirect effect of growth rate on density is important in that it means trees grown faster to a merchantable size may contain a higher proportion of juvenile wood which may be more problematic with traditional processing and seasoning methods. On the other hand, this material may be more successfully utilised in processes such as gluing and jointing where lower density material is advantageous.

The sapwood width values given in Table 4 for the various plantation species are generally within the range of 1.5 to 2.5 cm expected for mature trees of these species (Hillis and Brown, 1978). Plantation trees however are generally smaller in diameter than native forest logs, therefore sapwood, although similar in width, constitutes a higher proportion of log volume compared to mature trees.

Generally, the shrinkage values given in Table 4, from green to 12% moisture content correspond fairly closely with data published in the literature for the various species. Likewise, the unit shrinkage values from 12% to 5% moisture content also correspond fairly closely with published values for each species. In some cases the plantation timbers displayed less shrinkage than that published for the species by Kynaston *et al.* (1994). However, the 32 and 35-year-old plantation Gympie messmate displayed a much higher radial shrinkage than that reported by Kynaston *et al.* (1994).

Economics

Growing Economics -Status-quo scenario

An economic analysis of the available data from mensuration and sawing studies was undertaken to determine the viability of growing and processing the various eucalypts under study. A realistic assumption of all costs and revenues was entered into a spreadsheet to give a statement on the net present value per hectare (NPV, using a discount rate of 10% nominal, therefore including inflation at 2.5%) and internal rate of return (IRR) of the plantations. Figure 2 details the results of the analysis on the various plantations[14].

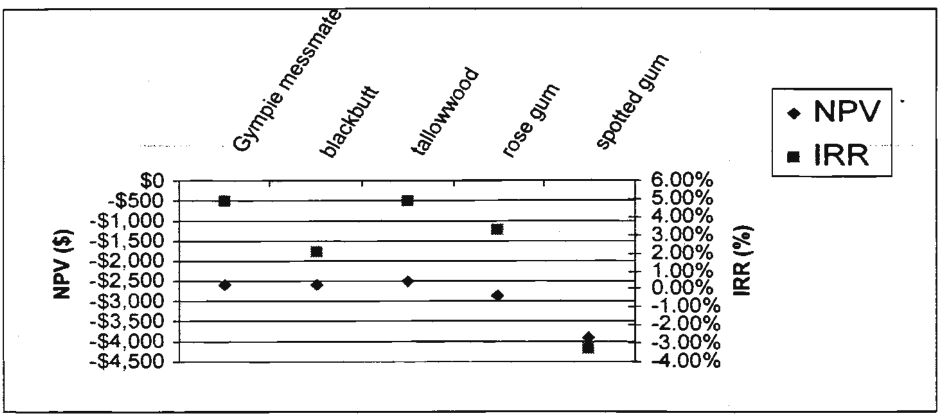

Figure 2: *Net Present value and Internal Rate of Return for the plantations*

The analysis result depicted in Figure 2 shows that all plantations yielded poor IRR's and negative NPV's. The IRR's are less than the 10% IRR (nominal) that DPI Forestry nominates as an acceptable IRR when assessing the profitability of its plantations in Queensland (Blake[15]; pers.comm, 2000). Hardwood pulpwood plantation prospectuses

[14] The figures given for Gympie messmate are based on the 35-year-old plantation, not the 32-year-old plantation. No economic analysis was performed on the Western white gum plantation due to insufficient data.
[15] G.Blake, DPI Forestry, Qld

throughout 1997 and 1998 nominated IRR's of 9.9% (Timbercorp), 8.6% (WA Blue Gums) and 10% (Forestry Tasmania). ANZ 10-year bonds are currently paying at a fixed rate of 6.6% per annum (ANZ Investment Bank, December, 1999).

Growing Economics -Enhanced Scenario

When interpreting and extrapolating from these results presented in Figure 2 it must be noted that the stands evaluated cannot be considered representative of future hardwood plantations. The limitations associated with these stands which were planted more then 20 years ago have been described by Ryan (1993b) as inadequate weed control; high degree of genetic variability; inadequate spacing/thinning treatments; no pruning; inadequate site preparation; inadequate nutrition and no pest control. Additionally, the log royalties used in the analysis are based on current average log royalties for natural forest grown hardwoods, whereas future plantation log harvests are likely to occur in a vastly different and potentially improved supply and demand climate.

Therefore, given the limitations associated with the analysis conducted above, it was considered necessary to revise some of the key parameters. The real potential IRR's of the plantations were then calculated after accounting for increases in productivity, log royalties, reductions in rotation length and increased costs of growing. Figure 3 illustrates the improvements in IRR for the Gympie messmate plantation only. Rotation length is assumed to be 25 years.

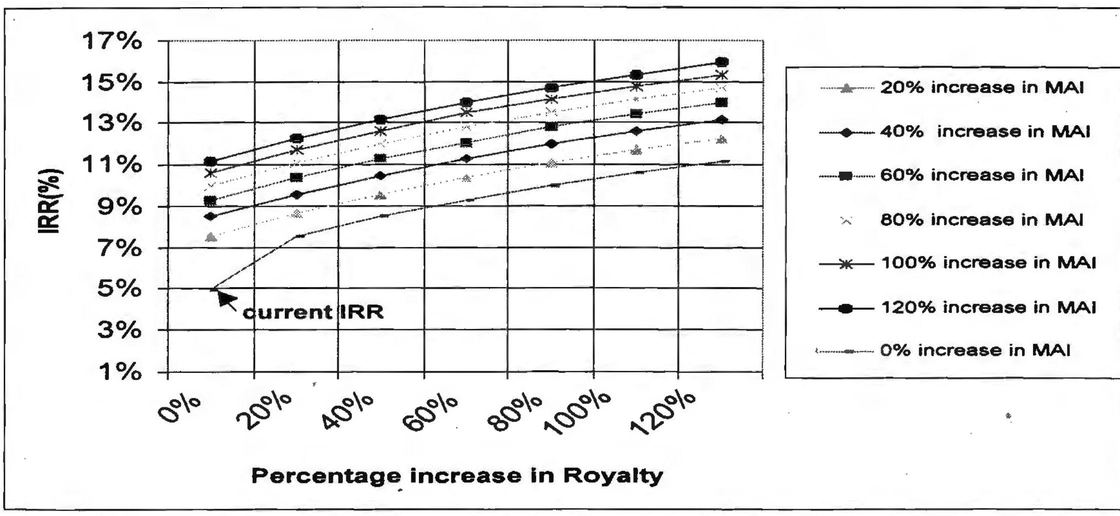

Figure 3: *Internal Rate of Return for the Gympie messmate plantation, after reducing rotation length and assuming increases in royalty, productivity and growing costs.*

The justification for assuming considerable increases in productivity in future hardwood plantations is based on the gains demonstrated from tree breeding and improved silvicultural practices. For example, the realised gain for radiata pine (*Pinus radiata*) from silvicultural and breeding developments in the early 1970's, has on average, and across soil types been 51% in MAI. (Whiteman *et al*, 1993). Use of cultivation, chemical weed control and fertiliser increased volume MAI at age 30 months of *Acacia mangium* planted in South Kalimantan, Indonesia from about 10 to 26 m^3/ha/yr (Turvey, 1996). Through phenotypic selection of fast growing trees of rose gum in Australia an increase in volume to the extent of 54% has been realised (Ades and Burgess, 1982). In Brazil (Aracruz) and the Congo (Point Noire), the growth rate of plantations established in the 1980's from cuttings was about double that of plantations established from the unimproved seed available before 1975, even allowing for improvements in establishment practices (Eldridge *et al.* 1994). It is also important to note that the *status quo* merchantable MAI's recorded in this current study (Table 2) are generally lower than that reported elsewhere and in some cases hardwood plantations of similar ages to those studied here have yielded more than double the merchantable volume.

The assumption of considerable improvements in royalty over the current average crown sawlog stumpages used in the status quo regime is believed to be justified given that most analyses predict real increases in log royalties. Dyason and Lovell (1998) in a paper on the economics of small plantation forestry suggest that log royalties will increase by 100% in real terms in the medium term (10 years). In the long term (30 to 50 years) they expect royalty rates will increase at a rate of 3 percent greater than the rate of inflation. Russell *et al.* (1993) suggests a possible increase of up to 1.3% per annum in cabinet timber prices. Bhati (1999) refers to projections in a recent FAO study which imply that sawnwood prices in the world market could rise in real terms at an average rate of 0.36 per cent a year till 2010. Bhati (1999) also refers to data published by the Australian Bureau of Statistics which shows that both softwood and hardwood timber prices in Australia have generally increased in real terms from 1993 to 1999.

Processing Economics

The economics of plantation hardwood forestry cannot be examined without some consideration of the economics of converting logs to a saleable product. The enhanced regimes illustrated in Figure 3, all assume that logs harvested at age 25 can be successfully processed into saleable wood products. Ultimately, wood quality and costs of log conversion will influence the ability of the processor to pay a certain royalty for the logs. Figure 4 details the results of an economic analysis on the conversion of logs from the plantations being studied, to primarily appearance products. The following parameters were used in the analysis:

- 1000 m^3 log volume;
- 50 km haulage distance to mill (this reflects a plantation situation as opposed to typical haulage distances with the native forest sector);
- Stumpage @ \$30/m^3 (current average "compulsory" hardwood sawlog residual price in Qld) (Walls[16], pers comm,1999);
- Cut and snig costs @ \$20.21/m^3 log (NFSPWG,1997);
- Haulage costs @\$0.30/m^3/km log (NFSPWG,1997);
- GOS conversion costs @\$237/m^3 sawn timber (NFSPWG,1997);
- Dried/Dressed conversion @\$230/m^3 sawn timber (NFSPWG,1997);
- Sawn recoveries as given in Table 2; residue recovery (chips – landscaping) @ 50% of log volume;
- Revenues @\$864/m^3 (wholesale) for appearance (flooring) products (NFSPWG,1997) and \$557/m^3 (wholesale) for framing (NFSPWG,1997) and \$5/m^3 for residues (Evans[17], pers comm, 1999)
- The analysis performed is based on all known quantifiable costs and does not account for additional costs such as depreciation on capital items, other mill overheads and financing arrangements.

[16] J. Walls, DPI Forestry, Qld
[17] T. Evans, Woodford Timbers and Queensland Timber Board Hardwood Division

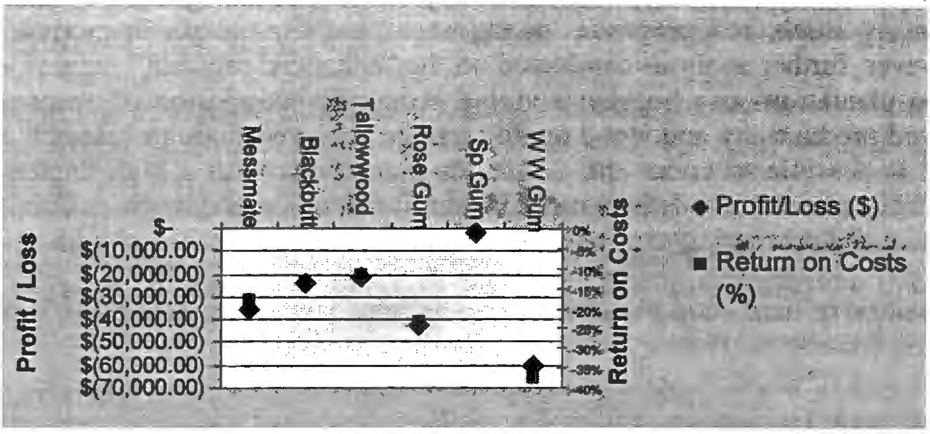

Figure 4: *The economics of processing, given status quo situation*

The analysis reveals that in all cases the plantation hardwood logs were not economically viable to process into appearance products such as flooring, using the assumptions of costs, recoveries and revenues that were made. The quality of the wood has a marked effect on the profitability of the processor and the range of products that are recoverable. In this instance the main reason for the poor economics of processing the plantation logs to appearance products relates to the very low recovery of good quality wood from these particular sample logs as explained earlier and the high costs of sawing, drying and dressing that are associated with conversion to these products.

Figure 5 provides another set of financial information which is probably a more likely prediction for the future. Here royalties and recoveries for high quality wood have been increased to match the improved growing and processing conditions of the enhanced regime. Log and timber royalties have been increased by 100% over the *status quo* case, appearance grade product recovery has been increased by 10 percent of log volume and the costs of production have been decreased by 10% to reflect improved uniformity of log form and quality and to also account for improvements in processing technology. The analysis has shown that higher log royalties can be supported if wood quality is improved, enabling the manufacture and marketing of high value products.

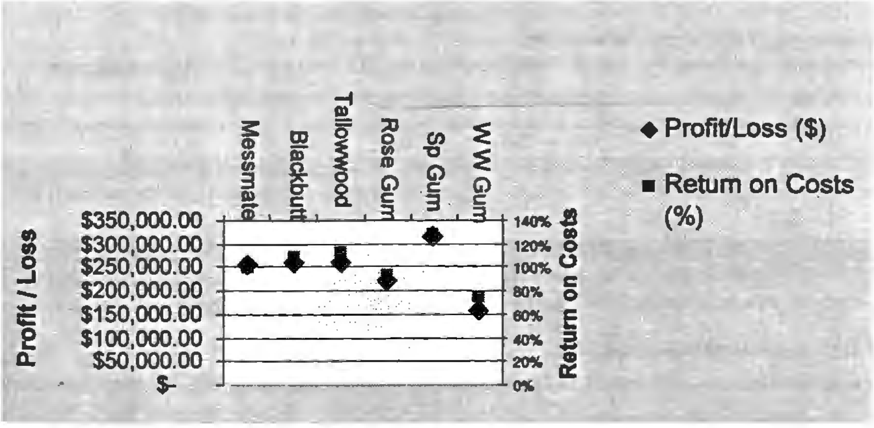

Figure 5: *The economics of processing, given enhanced situation*

Conclusions

Currently, the economic viability pertaining to the existing, limited plantation hardwood resource in Queensland, established between 20 and 40 years ago is not very favourable.

This is due mainly to low productivity and poor wood quality resulting from the use of unimproved planting stock, inappropriate management and limitations in processing technology. However, further analyses conducted on the "enhanced regimes" suggest that hardwood sawlog plantations can become a viable economic proposition if reasonable targets in improved productivity and wood quality can be achieved through research and development. It is possible to create the future for plantations with a high degree of certainty by ongoing research and development. A similar situation originally confronted the now competitive and prospering exotic softwood plantation industry in Australia.

The economic position of hardwood plantations will be greatly strengthened in the future, given the following factors:

- genetic and silviculture improvement producing larger logs, with a higher proportion of clear wood and a reduced tendency to distort and end split due to growth stresses;
- improvements in harvesting, processing and manufacturing technology which will facilitate the conversion of smaller logs allowing shorter rotations;
- focus on the production of small clear/select grade markets, including glue-laminated and finger jointed products, parquetry, components and end matched flooring; thin sawing and veneer wrapped products;
- improvements in log and timber royalties, given a burgeoning demand for medium to high density, durable hardwood timber and also timber's status as a renewable resource, characterised by low embodied energy relative to other alternative products such as steel, plastic and concrete.

Additionally, Queensland hardwood timbers as a group, even when plantation grown, offer a variety of colour and figure. They are generally hard, strong, durable and produce a good finish. These features confer a diverse array of product opportunities which should augur well for the future marketing of hardwood timbers from the region.

Acknowledgments

The authors would like to gratefully acknowledge the assistance of the following people:

- The QFRI Salisbury Research Centre staff;
- Miss Katherine Whittaker and Mr Mark Leet from the QFRI Wood Products Program for assistance with data analysis;
- Woodford Timbers for the sawing and drying of the 21-year-old blackbutt;
- Mr Justin Spanner (Business Development Consultant) and Adnan Cokic, Geoff Blake (DPI Forestry, QLD) for assistance with the commercial analyses.

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