DROUGHT RISK: HAVE ECONOMIC BENEFITS FROM E. GLOBULUS PLANTATIONS IN SOUTH WEST AUSTRALIA BEEN OVERESTIMATED?

Tym Duncanson & Steven Schilizzi

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by Tym Duncanson and Steven Schilizzi[1]

Introduction

The *Eucalyptus globulus* (*Eucalyptus globulus* Labill. *subsp globulus*) plantation industry in south west Australia has grown from a small developing industry to the State's most active plantation establishment industry in less than two decades. During this period, plantation management in Western Australia has changed from a mostly government managed and owned plantation estate to one which is almost exclusively managed and owned by private companies and plantation growers. The majority of the increase in plantation establishment has more recently come from companies operating Managed Investment Schemes on behalf of often high net worth individuals utilising the tax effective nature on investing in plantations. Five major Managed Investment Scheme companies are now active in south west Australia with combined capital in excess of AUS$1 billion. The increased cost of land and the sustained demand for new land for plantation establishment indicate that, to obtain sufficient land to meet the demand for plantation establishment, Managed Investment Scheme companies will be forced to consider the inclusion of less productive land in their annual planting programs.

To attract funding and government support for the industry, the social benefits of establishing broadscale plantation industry in south west Australia has been well promoted by government and non-government organisations (see CALM undated, Shea, 1998, ITC 1999 and CALM 1999,). Reported social benefits include the amelioration of land degradation, (Macar, 1995, Agriculture Western Australia *et al*, 1996 and Farrington and Salama, 1996) removal of carbon from the atmosphere (Shea *et al*, 1998), and the possible substitution of plantation derived timber and timber products of native forest produce (Western Australian South-West Regional Forest Agreement, 1998).

During an extended rain-free period in the summer and autumn of 1993 and 1994, significant areas of young plantations died due to drought stress. This lead to more concentrated research into climatic and site conditions that impact on plantation growth and survival in periods of drought. *E. globulus* is not recognised for its tolerance to drought (White, 1999). The key determinants of a productive plantation identified as described in Edwards and Harper (1996) and McGrath (1999) are:-

- soil type, depth and water storativity;
- rainfall and seasonality of rainfall;
- evaporation; and
- plantation density and configuration.

Research effort culminated in a plantation management workshop "*Balancing Productivity and Drought Risk in E. globulus Plantations*" in November 1999. At the workshop scientists expressed concern of reduced productivity over time of sites selected for the establishment of *E. globulus* plantations (Crombie and McGrath, 1999). It was inferred that in the lower rainfall area of *E. globulus*

[1] Agricultural & Resource Economics, The University of Western Australia (Steven.Schilizzi@uwa.edu.au). Summary of work done for the degree of MSc in Natural Resource Management (Tym Duncanson: tymd@wantree.com.au).

plantations receiving 600mm to 800mm optimistic estimations of productivity and the possible failure of *E. globulus* root systems to access and use deeper ground water stores may result in reduced returns to plantation growers. It was argued that plantation managers may underestimate this effect and their risk management planning does not sufficiently allow for this possibility.

The purpose of this study is to investigate potential impacts of reduced plantation productivity. The possibility of reduced investment and the impact on the reported social benefits is of interest to the *E. globulus* industry and the broader community. The hypothesis to be tested in this study is:

"Lower than expected plantation productivity of E. globulus plantations is likely to result in unacceptable returns (less than 10%) to a hypothetical Managed Investment Scheme investor. This will reduce investment and in turn have negative impacts on the reported social benefits of E. globulus plantations."

Methodology and Data

Two economic models have been developed to generate expected values for return on investment; one for a hypothetical investor selling into the export chip market (Scenario A) and one for a hypothetical investor selling into a domestic log market (Scenario B). Generation of outputs of the models allows sensitivity analyses to be performed. Sensitivity analysis techniques were selected from those summarised in Pannell (1997) and (NCEDR, 2000) as follows:-

1. *Variable by Variable Analysis:*. From this analysis it can be possible to compare the significance plantation productivity in determining an investor's return on investment.
2. *Slopes and elasticity*: Described as the rate of change of the objective function with respect to changes in a parameter. This analysis allows a change of scale when compared to Spider diagrams and gives a better indication of which parameter causes the greatest change to investor returns.
3. *Break-even Values:* The value of a parameter that results in the achievement of a threshold or limit can be useful in understanding how much a parameter need to change before an objective is not met.

As a means of qualitatively analysing the probability of occurrence of drought and its impact on investor return, the relationship between probability of drought and fall in investor return will be developed. Without some discussion of the probabilities, the models and sensitivity analyses rely on the decision maker applying weights to each scenario (Pannell, 1997). Some analysis, even a simplistic method will allow some discussion of this important issue.

Information obtained from Peter Eckersly by Smith *et al* (1998) and information appearing in CALM (undated) produced in the early 1990's allowed the compilation of 'ballpark' figures for analysis. Spreadsheet models, using the assumptions shown in Appendix 1, was developed to perform sensitivity analyses. The key indicator of the profitability of a plantation chosen was Internal Rates of Return (IRR) for a hypothetical investor purchasing woodlots from a Managed Investment Scheme company. IRR is described as the time-adjusted rate of return where present value revenues equal present value costs (Friedlob and Plewa, 1996) and allows costs and revenues occurring over may years to be compared. IRR, rather than alternative indicators such as Net Present Value, was chosen as an indicator as it is commonly used in the literature for estimating Managed Investment Scheme company return on investment. It also allows investment in plantations to be compared to alternatives such as investing in government bonds or the stock market. The use of IRR as an indicator has several limitations including

1. The use of IRR in investments resulting in an up-front tax deduction may mask the fact that a tax deduction can 'lever' the amount of funds available for investment. Net Present Values

(NPV) is useful in overcoming this masking affect of leverage made possible by investments in plantations being tax deductible. At a 7% discount rate (to be consistent with the discount rate used by Smith *et al*, 1998) the NPV for an investor using their tax deduction to lever their investment is $4,124. An investor not receiving leverage due the tax deductibility of the investment receives an NPV of $1,597 even though all other factors remain unchanged. If the leverage made available by using tax deductions was reflected using NPV, then it is likely that investing in Managed Investment Schemes such as *E. globulus* plantations would seem more attractive than they do using IRR as the key indicator.

2. Steve would you be able to add to these???

The required rate of return is the "*minimum expected return on an asset that an investor requires before investing*" (Jones, 1996) and for the purpose of this analysis it is assumed that the threshold for investment is 10%. This is several percentage points higher than relatively low risk, low return 10 year Government Bonds (6.1% as of July 2000).

Results and Discussion

Plantation productivity would have to be reduced by more than 50.8% (or less than 12.3 cubic metres per hectare per annum) for both rotations before IRR fell below 10% (Table 1). A 40% reduction in the second rotation only reduces IRR from 19.6% to 18.7% (Table 2). Even if plantation productivity in the second rotation only is reduced to 0 cubic metres per hectare per annum then IRR would still be 17.0%. Using the threshold of 10%, reduced plantation productivity due to drought of less then 50% in both rotations and less than total death in second rotation only, still results in a suitable return on investment if chips are sold into the export market.

Table 1: Effect of haul distance and growth rate on IRR for E. globulus sold into international chip market

Distance to port (kilometres)	Growth rate (cubic metre/hectare/year)					
	10	15	20	***25***	30	35
50	8.9%	**14.4%**	**18.2%**	**21.3%**	**23.8%**	**25.9%**
75	8.1%	**13.5%**	**17.4%**	**20.4%**	**22.9%**	**25.1%**
100	7.2%	**12.7%**	**16.5%**	**19.6%**	**22.0%**	**24.2%**
125	6.3%	**11.7%**	**15.6%**	**18.6%**	**21.1%**	**23.2%**
150	5.2%	**10.7%**	**14.6%**	**17.6%**	**20.1%**	**22.2%**
175	4.1%	9.7%	**13.5%**	**16.5%**	**19.0%**	**21.1%**
200	2.9%	8.5%	**12.4%**	**15.3%**	**17.8%**	**19.9%**

Note: The base case is shown in ***bold and italic*** type

Table 2: Effect of reduced growth rates in the second rotation on IRR for E. globulus sold into international chip market

Reduction in growth rate of second rotation (cubic metres/ hectare/year)	Growth rate of first rotation (cubic metre/hectare/year)					
	10	15	20	***25***	30	35
No reduction	7.2%	**12.7%**	**16.5%**	**19.6%**	**22.0%**	**24.2%**
-5	4.1%	**11.5%**	**15.9%**	**19.1%**	**21.8%**	**24.0%**
-10		9.9%	**15.1%**	**18.7%**	**21.5%**	**23.7%**
-15			**14.2%**	**18.2%**	**21.1%**	**23.5%**

Note: The base case is shown in ***bold and italic*** type

The outcome of this analysis reflects the fact that the base case results in a high IRR (19.6%) which is well above the threshold of 10%. There would have to be large changes in parameters, possibly implying a low probability of occurrence, to approach the break-even situation (Table 3). Reducing 'MAI in the second rotation only' or 'tax rate' to 0 did not result in an IRR less than 10%. IRR was most sensitive to basic density and chip price changes.

***Table 3:* Break-even changes in parameter values for *E. globulus* plantation investor receiving export chip price**

Parameter	Break-even Parameter Change
MAI for both rotations	-50.8%
Export chip price	-23.4%
Plantation costs	+104%
MAI for second rotation only	IRR is 17.0% if MAI for second rotation is zero.
Distance to port	+190%
Tax rate	IRR is 10.6% if tax rate is 0%.
Basic density	-23.5%

The effect of reduced plantation productivity on returns for an investor using the domestic sale model was greater (Table 4). A plantation 100 Km from the port, which is expected to grow at 25 cubic metres per hectare per year was selected as the base case in this study. For the domestic sale model the effect of drought would have to reduce plantation productivity by 22% (or less than 19.5 cubic metres per hectare per annum) for both rotations before IRR fell below 10%. This greater impact is due to the base case 'mill door price' selected corresponded to a low export chip price (Table 5). This suggests that if a Managed Investment Scheme company can sell into the international market and obtain current export prices, then large reductions in expected plantation productivity due to the effects of drought can still result in attractive returns for an hypothetical investor. Therefore the hypothesis was not supported by this analysis if, and only if, export parity prices are achieved.

Table 4: Effect of haul distance and growth rate on IRR for E. globulus for sold domestically.

Distance to mill (kilometres)	Growth rate (cubic metre/hectare/year)					
	10	15	20	***25***	30	35
50	3.4%	9.0%	**12.9%**	**15.9%**	**18.3%**	**20.4%**
75	2.1%	7.8%	**11.7%**	**14.6%**	**17.1%**	**19.2%**
100	0.7%	6.4%	**10.3%**	**13.3%**	**15.7%**	**17.8%**
125	-1.0%	4.8%	8.8%	**11.8%**	**14.2%**	**16.3%**
150	-3.0%	3.1%	7.1%	**10.1%**	**12.5%**	**14.6%**
175	-5.4%	1.0%	5.1%	8.1%	**10.6%**	**12.6%**
200	-8.5%	-1.6%	2.7%	5.8%	8.3%	**10.4%**

Note: The base case is shown in ***bold and italic*** type

Table 5: Comparison of E. globulus export chip and mill door price and the effect on IRR

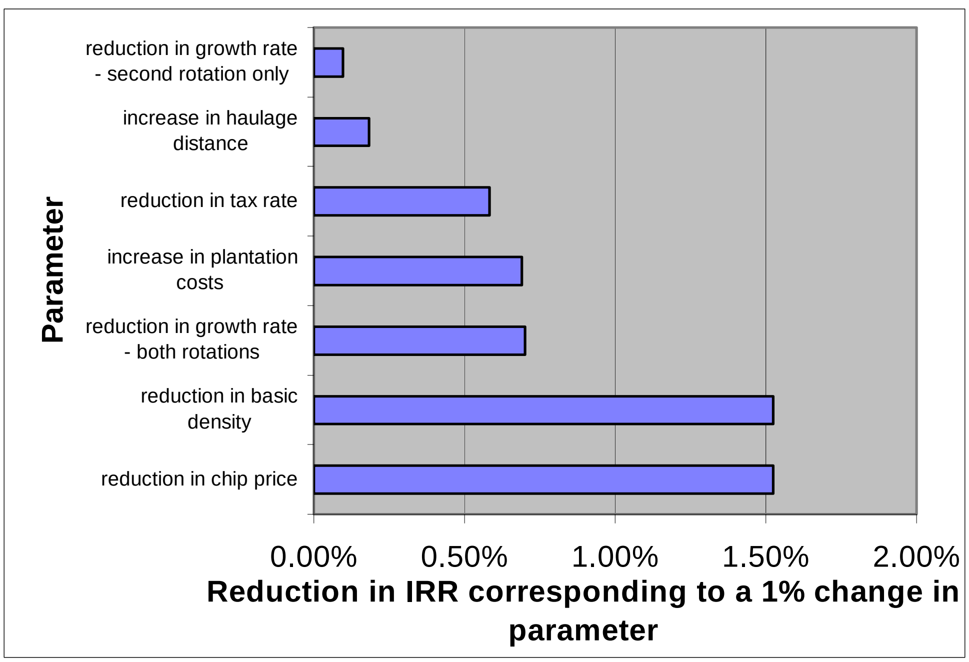
Mill door price ($/m3)	**$15**	**$35***	**$50#**	$50.83	$63.89	$76.95
Chip price ($/bone dry tonne)	$61.43	$99.72	$128.42	**$130**	**$155#**	**$180**
IRR	NA	-0.8%	13.3%	13.8%	19.6%	23.7%

NA results from no positive cashflow in any period of the two plantation rotations.
* base case used by Smith *et al* (1998)
# base case used by CALM (undated) and for this analysis

It was evident that, subject to the assumptions and the limitations of the models, export chip price (and corresponding mill door price) and plantation costs were the factors causing the most impact on investor IRR. The effect of plantation productivity was important but not as significant.

Ranking of elasticities of IRR due to changes in parameters is shown in Figure 1. It is clearly evident that variations in chip price had the most effect. Variations in basic density mirrored the variations in chip price because a greater density of chips results in more dry matter and consequently a higher price per cubic metre of wood. However it could be argued that the natural range of basic density of wood is not as great as the potential range of variability of chip price so the latter has the largest impact on investor IRR.

FIGURE 1: COMPARATIVE HISTOGRAM OF ELASTICITY OF IRR FOR AN INVESTOR RECEIVING EXPORT CHIP PRICE

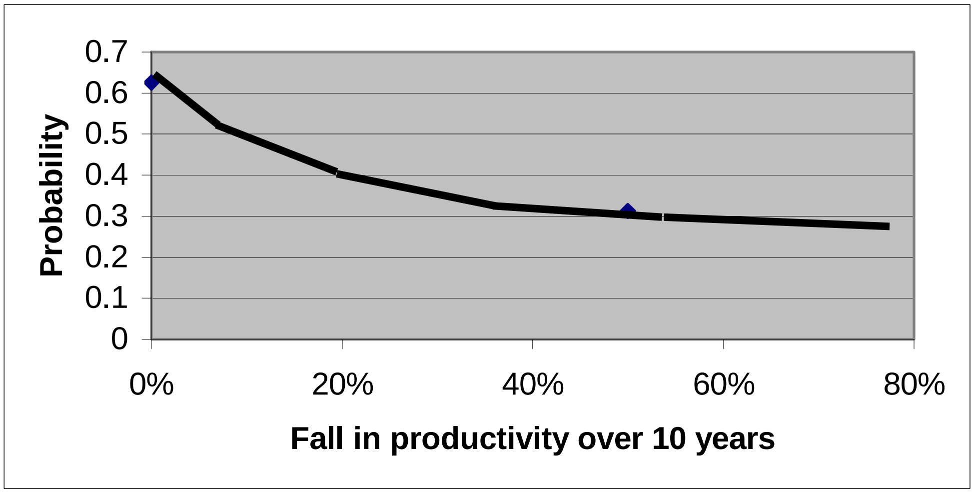


Probability of Occurrence

The preceding analyses of the impact of individual variables on the return to an investor selling into the export and domestic markets was performed by testing the robustness to changes in individual parameters rather than the likelihood of occurrence. For this reason, it is intended to address the impact of the likelihood of drought, or drought risk, in a conceptual form to give qualitative indications of the impacts of drought risk on plantation productivity and financial returns to an hypothetical investor in a Managed Investment Scheme.

Figure 2 was developed after discussions with Dr John McGrath and Dr Stuart Crombie (Research Scientists, WA State Government of Department of Conservation and Land Management) and indicates the possible relationship between the likelihood of drought events and its possible impact on plantation productivity. The curve is very much an indication only and does not represent an accurate determination of the relationship between drought probability and reduced plantation productivity.

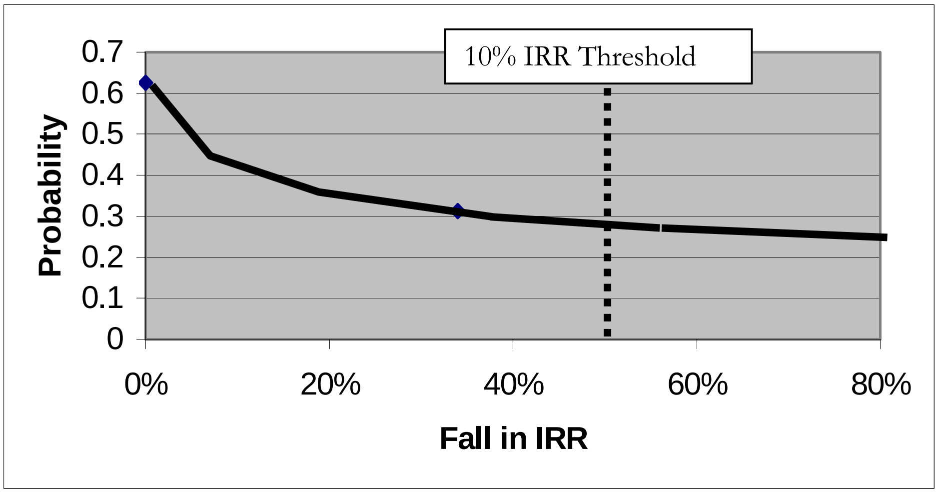
FIGURE 2: INDICATION OF THE PROBABILITY OF REDUCED PRODUCTIVITY IN *E GLOBULUS* PLANTATION DUE TO DROUGHT



It is likely that the due to the physiological strategies, which enable the rapid growth of *E globulus*, plantation productivity would be sensitive to drought events.

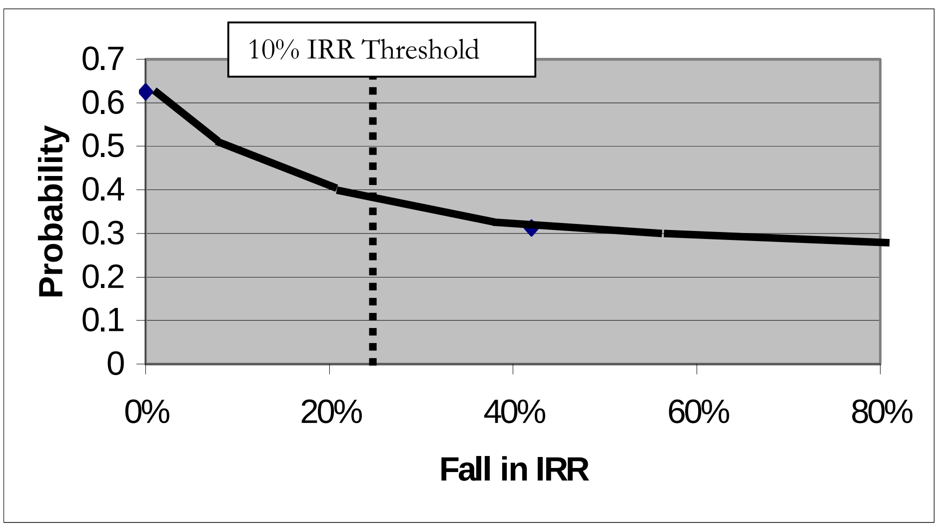
Figures 3 and 4 show how changes in plantation productivity from the base case translate into IRR for an investor selling into the export market and domestic market respectively. The 'robustness' of the investment is reflected in the less flat curve of Figure 3 and for any probability of occurrence the percentage fall in IRR is not as great as for plantation productivity. The location of the 10% IRR threshold also indicates that that the chance of a hypothetical investor receiving less than 10% IRR is unlikely if selling into the export market but more likely if selling into the domestic market.

FIGURE 3: INDICATION OF THE PROBABILITY OF REDUCED IRR OF AN *E GLOBULUS* PLANTATION DUE TO DROUGHT – EXPORT SALE



Note: Fall in IRR is the result of a fall of plantation productivity in the first rotation only.

FIGURE 4: INDICATION OF THE PROBABILITY OF REDUCED IRR OF AN *E GLOBULUS* PLANTATION DUE TO DROUGHT – DOMESTIC SALE



Note: Fall in IRR is the result of a fall of plantation productivity in the first rotation only.

The models and sensitivity analyses indicated that an investment was reasonably 'robust' as large changes in parameters were possible before IRR was reduced to below threshold levels. The likelihood of plantation productivity being reduced due to drought was analysed using fairly ambitious assumptions due to the lack of information available. This qualitative analysis showed that the probability of an investor receiving less than 10% was very approximately between 0.2 and 0.3 for export (indicating a low probability) and very approximately 0.4 if selling into the domestic market (indicating a slightly higher probability).

Although the analysis allows conceptual analysis of the relationship between drought risk and return to the investor the analyses has several limitations, which are:

1. *Effect of Subsequent Rotation*: Any reduction in stored soil water by the first rotation would most likely exaggerate the effect of drought.

2. *10 Year Growing Cycles*: As final harvest volumes are related to growing conditions over approximately 10 years for each crop, the risk of drought and its implications on plantation productivity are further complicated by when the drought occurs within the cropping cycle. In successive years of periods there may be little opportunity to increase ground water stores.
3. *Climate Change*: There is evidence to suggest that average annual and decadal rainfall is decreasing in south west Australia and isohyets are moving in a south west direction (Mr Morten Nilsson CALM Sharefarms, Department of Conservation and Land Management pers comm).
4. *Increase in Productivity*: The analysis did not consider increases in plantation productivity resulting from better than anticipated climatic factors.
5. *Non Homogenous Nature of Plantation Productivity.*
6. *Investors' Understanding and Management of Drought Risk*

As with all models and analyses, there are limitations to which the export sale and domestic sale models reflect the actual situation. Some issues of relevance that are not included in the models and analyses are as follows:

1. *Irrationality of Tax Minimisation*

   Although not discussed in this study or reflected in the models, it appears that there is a large demand for legitimate investments that result in an early tax refund, even if future earnings of that investment are uncertain.

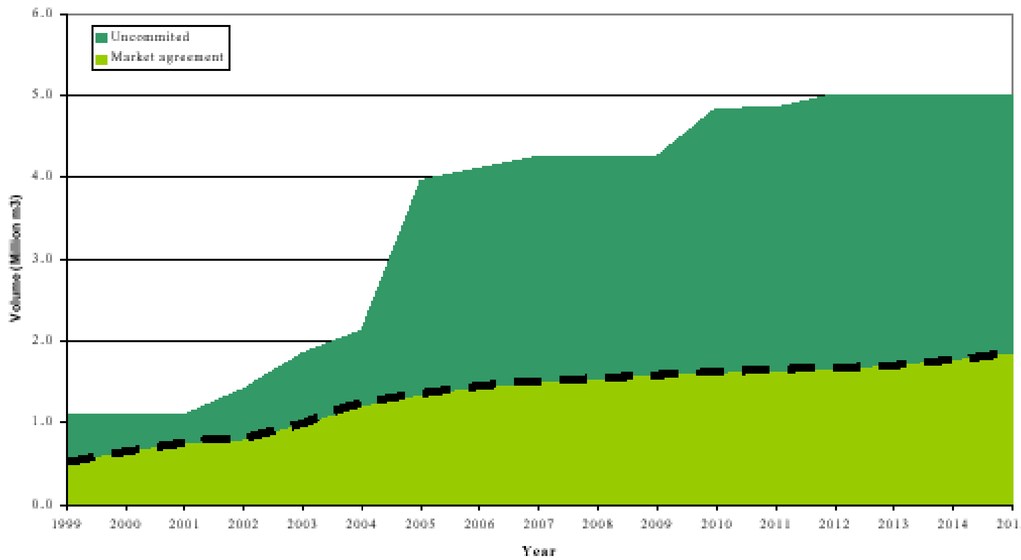
2. *Probability of Achieving Predicted Plantation Productivity*

   The 'variable by variable' risk analysis does not take into account the relative probabilities of changes in each parameter tested. For example, it may be more likely that plantation productivity would reduce by 10% of a predicted outcome than the likelihood of chip price increasing by 10%. Therefore the analysis ignores relative importance or "weight". It would be of great assistance to the industry if probability distributions for key parameters such as plantation productivity (especially in those areas susceptible to drought), basic density and price of wood could be determined.

3. *Barrier to Entry*

   The export chip model makes the assumption that a Managed Investment Scheme company can obtain export parity price for its woodchips. In reality, the international trade of woodchips is dominated by a small number of buyers, mostly Japanese pulp and paper companies, who have their own plantation resources around the world.. Dames and Moore Group (2000) summarised this issue by identifying committed (resource subject to a "market agreement" with a paper manufacturer or similar resource user) and uncommitted timber (resource with no known market agreement for future sale or use) in south west Australia (see Figure 5). The summary demonstrates that uncommitted wood is the highest proportion. Therefore there is no certainty that there will be buyers of woodchips or wood which is not already the subject of sales arrangements.

FIGURE 5: COMMITTED AND UNCOMMITTED *E. GLOBULUS* TIMBER IN SOUTH WEST AUSTRALIA



Source: Dames and Moore Group (2000)

Access to chipping and vessel loading infrastructure may be another barrier to obtaining export parity prices. An existing facility in Bunbury Port and a proposed facility in the Albany Port are and will be both owned and operated wholly or in part by Japanese trading houses and pulp and paper companies. Unless these facilities are replicated, regional monopolies of chipping and vessel loading facilities may remain.

The international trade of woodchips requires specialised vessels. Woodchips have a relatively low basic density requiring large, high volume purpose built ships. The majority of the world's fleet are owned and controlled by a small number of large pulp and paper companies with large economies of scale.

4. *Managed Investment Scheme Plantation Costs*

The costs to establish and maintain the plantation, the cost of land, insurance against damage such as fire and the costs of the Managed Investment Scheme company to the hypothetical investor may have been underestimated in this study. All plantation costs, according to the assumptions made, total $5,212 using a 7% discount rate for two rotations. However, Norgard Clohessy (1999) indicated that the costs per hectare for an investor in the major Managed Investment Scheme companies ranged from $5,827 to $9,091 for one rotation only. These costs did not include insurance (NPV of $149) and in some cases excluded the cost of land (NPV of $1,855). Where land was not included in the costs, the Managed Investment Scheme deducts a proportion of harvest revenue as deferred land leasing costs. This underestimation of plantation costs in this study may have resulted in a higher IRR than is possible in reality.

Conclusion

The study identified that:

1. the models based on export chip price and domestic sale of logs and the assumptions made, indicate that IRR above the threshold 10% were achievable for most of the cases tested;
2. sensitivity analysis indicated that IRR in excess of 10% was achievable, even if drought caused plantation productivity to reduce by up to half in both rotations or anything less than total plantation death in the second rotation only. IRR was most sensitive to wood price and basic density of wood if it was sold into the export chip market. Thus the hypothesis was not supported by this study;
3. a crude analysis of the probability of occurrence of drought and it impact on plantation productivity was performed and indicated that it was reasonable unlikely that drought would cause IRR to fall below the 10% threshold if selling into the export market. Drought was more likely to result in an IRR below 10% if selling into the domestic market;
4. the lack of information predicting plantation productivity in second and subsequent plantation rotations should also be of significant concern to the industry. It is apparent that second and subsequent rotations would be more susceptible to drought due the first plantation established on previously cleared farmland depleting ground water stores; and
5. as the hypothesis was not supported the social benefits would not be affected by the probability of reduced plantation productivity as returns to investors were not sufficient to discourage investment using a simple 10% threshold. **The major assumption being that investors could sell into the current international chip market and prices in the market are sustained.**

The study was limited in its evaluation of social benefit and did not discuss issues such as social benefits to local communities of investment in broadscale *E. globulus* plantations. Possible social costs such as displaced agricultural production and reduction in people living on the land was not discussed in this study, was not well documented in the available literature and would benefit from further studies. Another area identified for future studies is determining the likelihood and therefore probability distributions of key parameters, most importantly plantation productivity estimates being achieved especially in lower rainfall areas and areas prone to drought.

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Appendix 1:

Assumptions used in Financial Analysis of E. globulus for Export and Sold Domestically

Variable	Assumption	Source or Explanation
Plantation plan, prepare, and plant; weed control; fertiliser; and annual firebreak maintenance.	$930, $100, $100 and $10 respectively.	Smith *et al* (1998).
Overheads and annual maintenance.	$150 and $10	CALM (undated)
Annual insurance	Variable depending on age of plantation.	Jardine Lloyd Thompson – insurers recommended by Australian Forest Growers. Maximum no claim bonus and 'loyalty' discounts.
Cost of land	$160 per hectare of plantation per annum.	Estimated as bank interest (8%) of estimated cost of land ($2,000 per planted hectare). Cost does not include associated costs such as rates and taxes.
Responsible entity cost. This is the cost of a project manager in issuing a prospectus and managing investment.	$500 in first year and $50 per annum thereafter.	Difficult to obtain due to the commercial nature of the information. However it is estimated that this figure is conservative.
Harvest and chipping costs	$16.50 and $8.00 per green tonne.	CALM (undated).
Transport	10c per tonne per kilometre.	CALM (undated).
Responsible entity marketing fee for sale of plantation produce.	5% of harvest proceeds.	Typical proportion of proceeds appearing in a summary of prospectus costs by Norgard Clohessy Equity Pty Ltd (1999).
Physical losses during chipping.	5%.	CALM (undated) suggested 5-7%.
Costs per hectare.	Do not vary for varying scale of plantation project size.	
Costs to load onto ship.	$8 per tonne.	CALM (undated).
Pulpwood basic density.	550 kilograms per cubic metre.	CALM (undated).
Pulpwood green density	1 tonne per cubic metre.	Smith *et al* (1998).
Distance from plantation to Port	100 kilometres.	Mid range distance of resource in the Bunbury Port catchment.
Growth rate of plantations (mean annual increment).	25 cubic metres per annum	Most common estimation of productivity in Norgard Clohessy Equity Pty Ltd (1999).
Crop rotation.	10 years	Smith *et al* (1998).
Number of crops.	2	Smith *et al* (1998).
Chip price	$155 per bone dry tonne free on board the ship in Bunbury.	Highest value in ABARE (2000).
Marginal tax rate of investor.	48.5% and assumes all expenses are tax deductible in the same year as expense was incurred.	Top long term rate.
Chipping facility location effect on price of chipping and transport.	Constant regardless of whether the chipping operation occurs 'in forest', in close proximity to the Port or somewhere in between necessitating two transport phases.	

Additional assumptions used in Financial Analysis of E. globulus Sold Domestically

Variable	Assumption	Source or Explanation
Physical losses during harvesting and transport.	0%.	Assumes all merchantable volume is harvested.
Wood green density	1 tonne per cubic metre.	Smith *et al* (1998).
Distance from plantation to mill	100 kilometres.	Smith *et al* (1998).
Mill door price	$50 per green metric tonne.	Assumes investors can benefit from the marketing of the resource by the Managed Investment Scheme company to achieve a good price from the mill.