A Financial Evaluation of Eucalypt Plantations in Tasmania

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Abstract

An analysis of eucalypt plantations in Tasmania is presented, using a discounted cash flow technique to estimate their financial viability. The resulting Nett Present Values (NPVs) are presented showing the maximum establishment and land costs at which eucalypt plantations will be financially viable for a given location, site quality and management regime over one rotation. Four management regimes were considered: a short-rotation pulpwood-only regime, a longer rotation clearwood or direct sawlog regime, a variation of the clearwood regime which included possible veneer logs, and a commercial-thinning sawlog regime. The impact of discount rate on the management regimes is presented. For most realistic discount rates, the maximum return was gained from a short-rotation pulpwood regime on a high quality site where the plantation was situated close to the processing plant. The longer sawlog regimes were less attractive, with the commercial-thinning regime being the only one that had NPVs likely to cover establishment and land costs. However, the NPV was very sensitive to the interaction between site quality and distance to the mill, with lower quality sites being unlikely to show a positive return at current establishment costs even close to a mill site. A clearwood-type direct sawlog regime did not allow a positive return for eucalypts under any reasonable royalty or establishment costs.

Careful siting of plantations together with the minimisation of establishment costs are two of the major factors determining financial viability. Under the assumptions used, the analysis indicates that sawlog production would only be financially viable on very high quality sites managed under a commercial-thinning sawlog regime but that lower quality sites should be profitable when managed for pulpwood production if establishment costs are carefully controlled.

A map of Tasmania is presented to assist in assessing future plantation developments to determine whether they have the potential to show positive returns for four site qualities managed under a pulpwood regime.

Introduction

There has been a rapid expansion of the area of eucalypt plantations in Tasmania over the past 15 years, primarily for pulp production by large industrial paper companies (Tibbits 1986). The establishment of this resource has been accompanied by calls for plantations to replace almost all the hardwood products currently supplied from native forest (Cameron and Penna 1988; Clark 1990). However, this plan is at odds with that envisaged by industry (FAFPIC 1987) and there is still considerable uncertainty about the feasibility and financial viability of producing sawn timber from eucalypt plantations. Initial concerns were caused by some early failures and slow growth on some sites, although significant progress has been made in the knowledge of appropriate establishment techniques of eucalypt plantations to ensure good survival and growth (Neilsen and Wilkinson 1990). Increasing attention is now being placed on site suitability to enable productivity to be more accurately assessed from site and soil characteristics (Laffan 1993). However, financial analysis of a plantation project before establishment is often overlooked by the forest manager, done too late in the rotation, or considered too difficult and not done at all.

This paper presents a financial analysis of eucalypt plantations in Tasmania using a discounted cash flow technique to calculate Nett Present Values (NPVs). It attempts to simplify the results by presenting a map which enables an estimation to be made of the maximum establishment and land costs that can be incurred in order to show positive returns at a proposed pulpwood plantation site. This should assist managers to easily undertake a simple financial evaluation of one or more sites and ensure that the decision to plant is made with a clear appreciation of the financial viability of the plantations.

Methods

In the following analysis, it has been assumed that the main factors influencing the financial outcome of eucalypt plantations are:

- management regime;
- site quality or site index;
- discount rate;
- royalties;
- distance to market;
- level of establishment and maintenance costs;
- treatment of land costs.

The interrelationship between these factors determines whether or not, on purely financial grounds, eucalypt plantations will be successful.

The analysis was done on an IBM compatible personal computer using the spreadsheet package Microsoft EXCEL version 4. The detailed equations used to determine the NPV can be obtained in written form or on disc from the senior author.

Management regime

The management regime can be described by the main product which the plantation is intended to produce. This may be sawlogs, pulpwood or some combination of the two. Clearly, the desired size and product mix will determine the rotation length, with a sawlog regime requiring a significantly longer rotation length than a pulpwood-only regime.

There is an almost infinite number of possible management regimes for a eucalypt plantation. To simplify the comparisons for this study we chose four regimes: pulpwood only, sawlogs through a commercial-thinning regime, sawlogs through a direct clearwood regime and a variation of the clearwood regime which included possible veneer-log sales. It is also possible that the commercial-thinning sawlog regime could produce some short veneer logs. However, without pruning, the high incidence of knots makes the wood currently unsuitable for appearance-grade products (Mc Kimm *et al.* 1988) and so this variation was not included in our analysis.

The model developed by the Victorian Forestry Commission (now the Department of Conservation and Natural Resources) called STANDSIM was used to simulate the stand growth. Various versions of STANDSIM have been reported (Opie 1972; Campbell *et al.* 1979), with the most recent upgrade by Coleman (1989) for an IBM compatible PC computer being used for this study. The '*E. regnans*' function was considered the most appropriate of the available species within STANDSIM to simulate the fast growth of plantations.

STANDSIM's reliability under various regimes and site indices has been criticised elsewhere (West 1991; Goodwin and Thompson 1989) but it was considered the best model currently available. The criticisms relate, in particular, to STANDSIM's over-estimation of mortality at high stockings. The resulting positive bias in diameter distributions of the remaining trees leads to a subsequent large over-estimation of sawlog proportion (West 1991). Thus, in this analysis, the diameter outputs from STANDSIM were treated with scepticism and the method below was used to determine the rotation length for sawlogs where diameter was critical. For plantations, STANDSIM's high mortality was not considered to have much effect at the generally low plantation stockings considered in this analysis. To avoid the high early mortality inherent in the model from native forest stands, simulations were started at age five, assuming initial stockings of 1000 stems/ha.

Despite these criticisms, STANDSIM's estimates of total volume production are considered reasonable by West (1991) and were used here with the following minor modifications. Given standard Forestry Commission smallwood recovery specifications down to a small-end diameter of 10 cm, it was assumed that 80% of STANDSIM's entire stem volume is merchantable (R. Rich, pers. comm.). These volumes were rounded down to intervals of 50 m^3/ha, and minor adjustments made to make them consistent across site indices and ages. The volume predictions were used to determine the rotation age, directly for the pulpwood regime aiming for 300 m^3/ha and indirectly for the sawlog regimes where the aim was to produce an average log size of 60 cm. The average tree volume was determined by dividing the final figure for volume per hectare by the final stocking (usually between 150 and 200 stems/ha) to get a volume per tree. As the height is also known from the site index and age, the average diameter could be calculated from height and volume using the Opie (1976) equation. The diameters determined in this way were consistently smaller than the STANDSIM outputs.

Rotation ages given here are approximate estimates only and for the longer sawlog regimes are given only to the nearest five-year figure.

The pulpwood regime. The pulpwood simulations were assumed to have no thinning, and rotation lengths were set to obtain around 300 m^3/ha at harvest. This is based on aiming for an average piece size of 0.3 m as indicated by the *Young Eucalypt Program Report* (Roberts and McCormack 1991).

The sawlog regimes. All sawlog regimes were set to produce an anticipated average diameter at breast height (dbh) of around 60 cm at final harvest. This gives a small-end diameter of about 45 cm which is considered the minimum to enable both quarter sawing and back sawing (Waugh and Rozsa 1991). Higher site qualities have taller trees and hence have higher volumes per hectare at a similar average diameter.

The clearwood, direct sawlog regime. The main aim of this regime was to produce high quality logs in the shortest possible time. To encourage rapid diameter growth, the stands were simulated with heavy early thinning. Pruning was considered necessary to remove the large branches that would result with heavy non-commercial thinning. Pruning was assumed to be done in three lifts in years three, four and six. Pruning costs were estimated from current *Pinus radiata* figures at \$550/ha (including the non-commercial thinning), \$250/ha and \$300/ha for the three lifts (Neilsen 1990).

It was assumed that only the pruned, bottom 5.4 m log would make sawlog quality material; this is approximately one-third of the total merchantable volume, with the remainder being considered pulpwood. This approach gives a more realistic sawlog to pulpwood ratio of 33:67 rather than the optimistic estimates from STANDSIM.

Clearwood plus veneer. A slight variant of the clearwood regime was to consider the impact of a small proportion of higher value veneer material being produced from a 2.5 m billet within the 5.4 m pruned lower stem. The veneer, sawlog and pulpwood percentages were thus assumed to be 15%, 18% and 67% respectively for this analysis.

The commercial-thinning sawlog regime. The pulpwood thinning was simulated to be from below and done as early as practicable, with the constraints being that 130 m^3/ha were required for a commercial mechanical thinning based on *Pinus radiata* operational experience (D. Riddell, pers. comm.). In addition, the stand needed to have about 150–200 stems/ha left after thinning to grow on for sawlogs. The age of this thinning varied considerably from 9 to 20 years, with the higher site indices having earlier thinnings.

The two highest site indices (SI) with very early thinnings were outside the scope of STANDSIM's usual parameters, which does not simulate thinnings or give detailed stand descriptions below age 15. Volume growth of an unthinned stand to age 15 for these site indices was used to interpolate when sufficient volume would be present on these stands giving ages 9 and 12, for SI 37 and SI 43 respectively for a 130 m^3/ha thinning. Simulations were then run from the age of thinning using 200 stems/ha.

Site index and associated mean annual increment

The aim in using site index was to enable comparisons of the various regimes on areas having the same site quality. A range of SI values has been used which covers the better end of the range of land qualities available. Although Tasmania has considerable areas of lower quality land having potential plantation productivities below 15 m^3/ha/yr (Orme *et al.* 1992), they were not presented in this paper because they are outside the current Forestry Commission guidelines for plantation establishment (Wilkinson and Neilsen 1985). Preliminary analysis for this study confirmed that sites with productivities below 15 m^3/ha/yr are not financially viable for eucalypt plantations under our assumptions.

Initial stocking levels can markedly affect the productivity of young eucalypt plantations (Schonau and Coetzee 1989). In a recent review of a range of silvicultural practices for eucalypt plantations, Jenkin (1992) notes that initial stocking rates vary from 873 to 1736 stems/ha depending on site conditions and the silvicultural regime required to achieve the desired objectives. For this study, all simulations were started using initial stockings of 1000 stems/ha which is the current recommended rate for most eucalypt plantations in Tasmania (J. Walsh, pers. comm.). Four site indices (SI 23, 30, 37, 43) were chosen to represent a range of site qualities which gave mean annual increments (MAI) under a pulpwood regime of 15, 20, 25 and 30 m^3/ha/yr. These site indices broadly relate to the Tasmanian Forestry Commission's photo-interpreted mature forest height potential (PI-type) classes of E3+, E2, E1 and E1+, though estimation of plantation MAI from PI-type is highly variable (Wells 1991; Goodwin 1988).

The site index values used in this analysis are based on the mean dominant height (MDH) at age 20 using the STANDSIM equations of Campbell *et al.* (1979) and are not to be confused with those of Lawrence (1981), which give site index figures based on age 50. The latter are mainly used for native forest in Tasmania, and Lawrence cautions against their use for young stands. Similarly, Campbell *et al.* (1979) note the lack of data for young stands but present a separate equation for stands under 10 years old, which was thought by the authors to be more applicable to plantations. The site index classes chosen have been broadly equated with native forest PI-types for ease of estimation by field staff familiar with the PI-type system; these should be regarded as approximate estimates only.

We have assumed that one tonne of pulpwood is equivalent to 0.95 m^3 of timber. Merchantable volumes allowing for harvesting losses were assumed to be 80% of entire stem volume (ESV).

Discount rate

Selection of an appropriate discount rate is problematical. In recent times, some groups have called for the Forestry Commission to use an 8% real discount rate while some other forestry organisations are using a rate as low as 4% (de Laborde 1992). Clearly, a rate of 8% is so high that it precludes the possibility of virtually any long-term investment such as forestry being profitable due to the effect of compounding. For example, it results in $1 in today's terms compounding to $47 in 50 years.

The discount rate has a very large effect on the financial viability of forestry operations. But, because of the complexity of interactions between it and the effects on NPV of the management regime, site quality, and royalties, we have chosen to present a sensitivity analysis on the effects of discount rates between 2% and 10% on the four management regimes for one site quality and set of royalty figures only. For the sensitivity analysis, a good quality site of SI 30 was evaluated with royalties of \$18/m^3 for pulpwood (approximating a moderate haulage of 80 km), \$20/m^3 for knotty sawlogs, and \$25/m^3 for clearwood sawlogs.

For the rest of the analysis and the preparation of the map, a discount rate of 6% was selected. This is supported by the October 1991 *Reserve Bank Bulletin* (Anon. 1991) which discusses the historical performance of real interest rates. This article notes that the real long-term annual bond rate has varied between 1% and 1.5% while the rate applicable to equities and property has been around 4%. This pattern has been noted in most industrialised countries around the world. This 4% rate may be thought of as the opportunity cost applicable to moderate risk investments. It is considered that higher risk investments such as plantations would require the addition of a 2% risk premium giving a 6% discount rate. By way of comparison, $1 today compounds to $18 in 50 years at 6%.

Royalty rates

Plantation pulpwood. The current royalty rate for premium native forest export eucalypt pulpwood is $15.30/t. The pulpwood industry argues that this royalty exceeds their ability to pay at current market prices and that a rate of around $11/t would be a more realistic base royalty.

For plantations, it is considered that it should be possible to increase this royalty due to the higher quality of plantation pulpwood through a more uniform species mix and younger age, which result in higher pulp yields and reduced pulping costs. Farrington and Hickey (1989) have estimated that the use of plantation wood has the capacity to 'reduce the cost of pulp ex-mill by 20% and increase mill output by 30%'. Harvesting costs of plantations should be lower than for native forests due to site factors such as stable soils, lack of rock, moderate slopes and a high standard and dense network of roading. We have assumed these factors combined should be reflected in an increase in royalties in the order of $6 above the assumed base native forest rate of $11/t.

Ideally, new plantations would be established within close proximity to processing plants to reduce transport costs. This benefit is mainly applicable to pulpwood because it makes up by far the majority of the volume. Transport costs have been assumed to decrease pulpwood royalties at the rate of 10 cents per tonne kilometre for distances in excess of 40 km. Thus, plantations within a 40 km radius by road from a pulp mill would have an \$8/m^3 advantage over those further than 120 km away where the minimum rate of \$11/t would apply. Sawlog royalties were assumed to be unaffected by transport distance.

It should be noted that the above relationship between distance to processing plant and royalty is highly simplified. It is likely that, in reality, there would be decreasing savings with reduced transport distances as handling overheads become an increasing proportion of total transport costs. It is possible that the transport benefit captured would be less than the full 10 cents per tonne kilometre. Figure 1 highlights this relationship between distance to market and pulpwood royalty rate.

One cost which would be higher than for native forest pulpwood would be the cost of

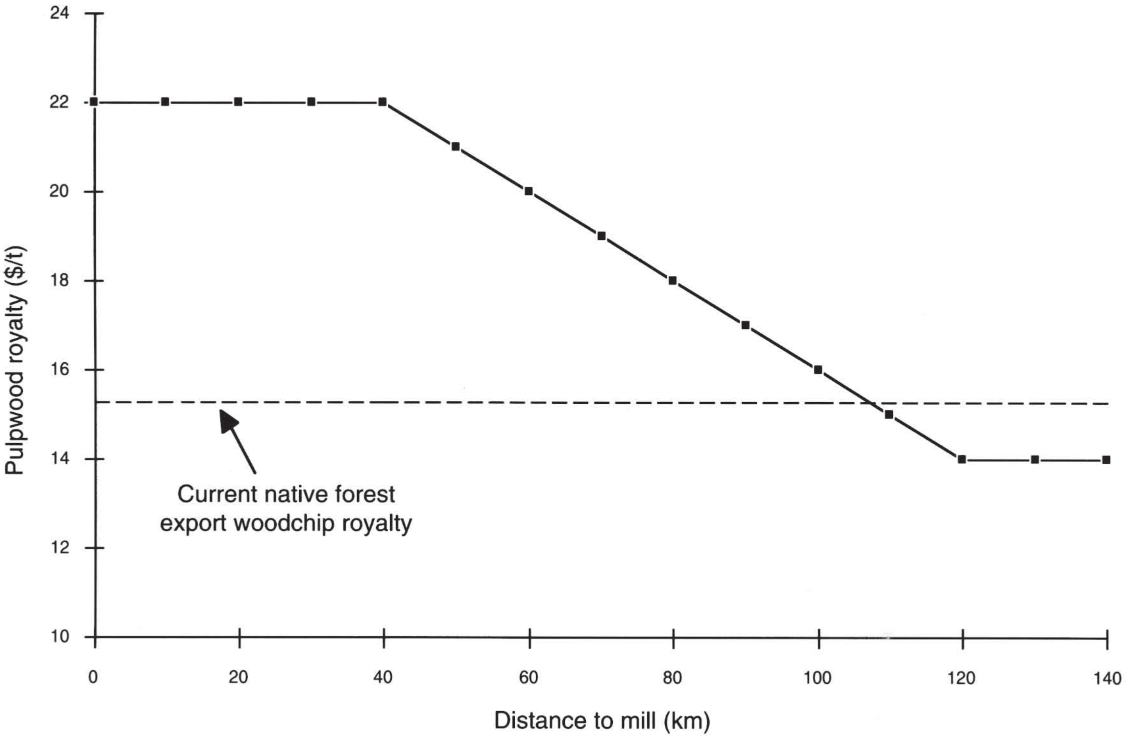

Figure 1. Relationship between assumed plantation pulpwood royalty and distance to mill.

debarking the plantation logs due to their smaller piece size. This is currently still a considerable technical difficulty although progress has been made through the Young Eucalypt Program (YEP) project (Wingate-Hill and MacArthur 1987, 1991). In the YEP study, the authors were reluctant to put cost estimates on debarking but showed that by using a modified fixed grapple excavator the costs were $3 and $4/m^3 for an average piece size of 0.5 and 0.3 m^3 respectively. The YEP debarking trials were relatively small and it was noted that improvement was possible through development and refinement of an appropriate machine and with operational experience. For simplicity in this analysis, we have assumed a flat rate of $3/m^3 for debarking irrespective of log size.

Thus, it is estimated that the royalty applicable to plantation pulpwood grown within 40 km of the processing plant would be in the order of $22/t. This is calculated from the base native forest value of $11, plus quality improvements and cost savings of $6, plus $8 in transport savings, minus $3 for increased debarking costs.

Plantation sawlogs. It is not clear whether it will be possible to produce a high quality plantation-grown eucalypt sawlog for which there will be a market and, if so, what royalty might apply.

There has been very little experience with clearwood eucalypt management regimes and such a regime may or may not be capable of producing a high quality clear sawlog.
For the purposes of this analysis, it is assumed that, in order to produce *high quality* sawlogs, it will be necessary to follow an intensive management regime such as the clearwood regime presented here. The current oldgrowth sawlog royalty averages about $24/m^3 while the average regrowth sawlog royalty is about $19 m^3. If a eucalypt

clearwood log of high quality suitable for milling can be produced, we have assumed it may receive a royalty in the order of \$25/m^3. It is possible that the bottom 2.5 m of the clearwood tree would be suitable for veneer production. If so, we have assumed that an appropriate royalty would be approximately \$60/m^3. This has been included as an option to the clearwood regime.

The commercial-thinning regime is expected to produce a sawlog of quality equivalent to knotty pine. However, given that the processing of eucalypt sawlogs imposes higher costs than with pine, due in part to considerably longer drying times (Waugh and Rozsa 1991), it is expected that a knotty eucalypt sawlog would fetch a royalty lower than for equivalent quality knotty pine. Where plantation sawlogs are of relatively low quality (equivalent to knotty pine), we have assumed they may attract a royalty between \$16 and \$20/m^3. This is less than the \$23.50/m^3 which currently applies to knotty pine but, given the lack of an established market and the higher processing costs of eucalypt sawlogs, the authors consider it reasonable.

Annual plantation maintenance costs

Annual plantation maintenance costs of \$20/ha/yr have been included in the analysis. This figure represents the estimated direct average annual maintenance cost associated with an additional hectare of eucalypt plantation. This figure does not include any Forestry Commission overheads because such costs are part of the normal running costs and should not have an impact on financial investment decisions.

Treatment of land costs

Land is a gift of nature—or at least at some time in the past it was annexed without payment! This is often used as justification for concluding that analysis of public sector projects should exclude consideration of the value of public land. From a broader community perspective, or from an economic perspective, this exclusion is not justified.

In developing a map to assist in determining potentially viable sites, it was recognised that land prices are not equal across the State. For the purpose of this analysis, values for plantation land are based on State forest Valuation Zones as determined by the Valuer General. These values are detailed in Table 1 and range from \$100/ha at Trial Harbour to \$1200/ha at Wynyard. Indicative boundaries of these zones are located on the map of Tasmania shown in Figure 2.

The land values were used to determine the discounted present value of the annual rental for each zone under the various site index and management regime combinations which affect rotation length. Annual land rentals were calculated at 6% of the land value. Land *rental* is not intended to cover land *purchase*. Note that the land rental is included in calculations for deriving the map only; all other NPV figures presented in Tables 4 to 7 exclude land costs because the value of the land is unknown.

Derivation of a map showing the Nett Present Value of eucalypt plantations in Tasmania

It was considered that a useful extension to the financial analysis of eucalypt plantations would be to present the results in a map form that was easily interpreted and useful for field staff involved in plantation planning. In addition, this would enable comparison of sites with different distances to mill and/or site quality. The map was compiled using the royalty/distance trade-off model assuming a constant site index of 23. The NPV of a pulpwood management regime as detailed in Table 4 was then used as the base figure from which land rental costs (from Table 1) and estimated haulage cost based on Figure 1 were subtracted in order to arrive at zones of equivalent discounted financial benefit. These zones represent the maximum establishment and roading cost which will allow the plantation to be financially viable.

Although a digitised map was available showing the road network in Tasmania at a

Table 1. Present value of discounted land rental by rotation length.

[1]Zone no.	Location	[2]Land value ($/ha)	[3]Annual rental at 6%	[4]Present value of annual rental ($/ha) by rotation length (years)								
				10	12	15	20	30	35	40	45	50
1	South Weld	125	7.50	55	63	73	86	103	109	113	116	118
2	Styx	300	18.00	132	151	175	206	248	261	271	278	284
3	Wayatina	250	15.00	110	126	146	172	206	217	226	232	236
4	Shannon	325	19.50	144	163	189	224	268	283	293	301	307
5	Arthurs Lake	150	9.00	66	75	87	103	124	130	135	139	142
6	Tasman	400	24.00	177	201	233	275	330	348	361	371	378
7	Bruny Island	250	15.00	110	126	146	172	206	217	226	232	236
8	Broadmarsh	400	24.00	177	201	233	275	330	348	361	371	378
9	Buckland	250	15.00	110	126	146	172	206	217	226	232	236
10	Cygnet	325	19.50	144	163	189	224	268	283	293	301	307
11	Esperance	400	24.00	177	201	233	275	330	348	361	371	378
12	East Coast	150	9.00	66	75	87	103	124	130	135	139	142
13	Ben Lomond	200	12.00	88	101	117	138	165	174	181	185	189
14	Scottsdale	275	16.50	121	138	160	189	227	239	248	255	260
15	Beaconsfield	350	21.00	155	176	204	241	289	304	316	325	331
16	Liffey	300	18.00	132	151	175	206	248	261	271	278	284
17	Railton	850	51.00	375	428	495	585	702	739	767	788	804
18	Gunns Plains	550	33.00	243	277	321	379	454	478	497	510	520
19	Wynyard	1200	72.00	530	604	699	826	991	1044	1083	1113	1135
20	Lapoinya	650	39.00	287	327	379	447	537	565	587	603	615
21	Black River	450	27.00	199	226	262	310	372	391	406	417	426
22	Roger River	275	16.50	121	138	160	189	227	239	248	255	260
23	Marrawah	700	42.00	309	352	408	482	578	609	632	649	662
24	Trial Harbour	100	6.00	44	50	58	69	83	87	90	93	95
25	King Island	350	21.00	155	176	204	241	289	304	316	325	331
26	Flinders Island	175	10.50	77	88	102	120	145	152	158	162	165
27	North Pieman	400	24.00	177	201	233	275	330	348	361	371	378
28	North Midlands	300	18.00	132	151	175	206	248	261	271	278	284
29	Central Midlands	150	9.00	66	75	87	103	124	130	135	139	142
30	South Midlands	275	16.50	121	138	160	189	227	239	248	255	260

[1] Zone numbers refer to areas of State forest only, located on Figure 2 and based on the map provided by the Valuer General and held by the Forestry Commission.

[2] Private land values may be significantly different.

[3] Land rentals are calculated at 6% of the land value.

[4] The present values of land rentals are calculated on the basis of the discounted value of land rents paid over the rotation length. Rotation lengths presented cover the range of management regimes and site qualities given in Table 3.

1:500 000 scale, the work involved in determining the actual road distances along this network proved to be a very time-consuming task. It was decided to simplify the procedure by assuming a general relationship between the distance along a road and straight-line distances. Some data used for determining this relationship are given in Table 2. The data may not faithfully represent the distances that plantation grown pulp would travel but are appropriate for the purpose of this exercise. The value of 1.5 was used for such a 'winding factor'.

A polygon coverage (digital version of a map stored on computer) of Tasmania was produced using the ARC/INFO GIS software to determine the distance in a straight line

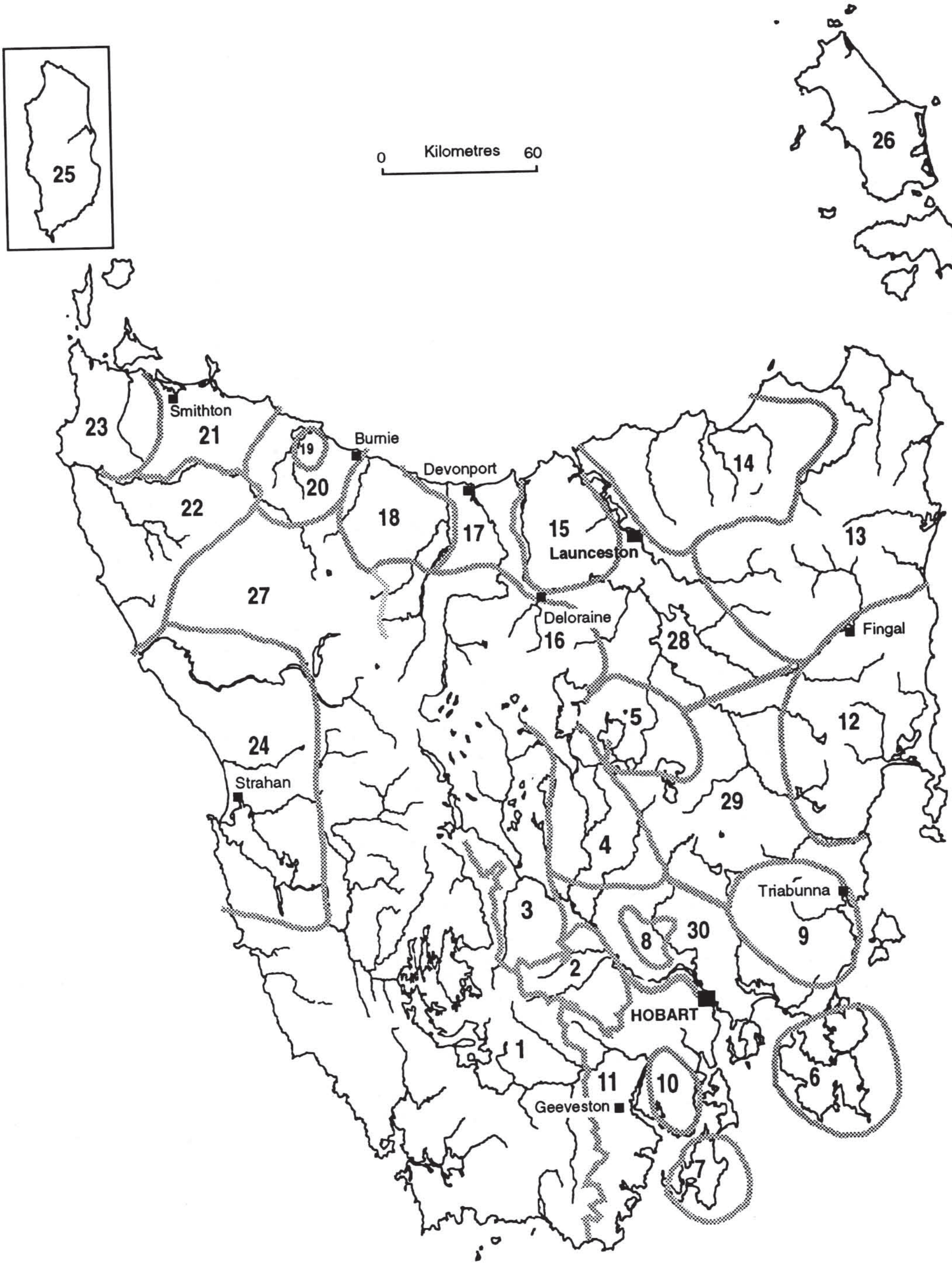

Figure 2. Land Valuation Zones for State forest in Tasmania as determined by the Valuer General. See Table 1 for actual dollar values and discounted rental estimates for land within these zones over a range of rotation lengths.

Table 2. Comparison of some straight-line distances and distances by road used to determine a 'winding factor'.

Place	Type of road	Straight-line distance (km)	Road distance (km)	'Winding factor'
Hobart – Launceston	Highway	160	200	1.25
Hobart – Derwent Bridge	Twisty, sealed	122	175	1.43
Launceston – Derwent Bridge	Twisty, unsealed, mountainous	108	175	1.62
Strahan – Derwent Bridge	Twisty, sealed, mountainous	75	125	1.67
Average 'winding factor'		-	-	1.5

from each of the six existing or potential pulp-mill sites to any point in the State. This straight-line distance was then multiplied by the winding factor of 1.5 to estimate the road haulage distance. The closest mill site was assumed to be the logical market. We have assumed a transport cost of 10 cents per tonne kilometre and show the influence of this using circles representing 15 km by road (assumed equal to 10 km in a straight line) out to 120 km where a minimum rate would apply. We actually used 10 km radius circles (15 km by road) to present the map in a less cluttered form but this meant that the inside circle that we had intended to be at 40 km was in fact at 45 km. This was not considered to be a serious enough distortion of this preliminary guide to warrant re-doing the whole analysis. A more precise map using actual road distances could be produced at a later date if required.

The distance-to-mill coverage was then combined with the land-value coverage to enable the mapping of zones of equivalent discounted financial value across the State. The World Heritage Area and National Parks were excluded.

The NPV for each polygon was calculated using the following procedure:

1. The land value for each polygon is known using the coverage shown in Figure 2.
2. The discounted present value of annual rent assuming both a 6% rental and discount rate is calculated and is presented in Table 1. This varies with both the site index and the rotation length.
3. The present value of the desired management regime (in this case pulpwood) is determined using the royalty rate from Figure 1 which is determined by the distance to the mill.
4. The NPV is equal to the result of step (3) minus the result of step (2).

The map is actually made up of over 8000 small polygons. For ease of presentation, polygons smaller than 100 ha were dissolved and the results shown as categories of $100 intervals for the SI 23 values. These boundaries may vary slightly for the other site indices.

Results

Annual rental

Table 1 details the present value of the land rental (charged over one rotation) for varying rotation lengths depending on site quality and management regime. The difference between these figures results from the longer rotation associated with the sawlog regimes compared to a pulpwood regime and the resulting increase in notional land rent. For the purposes of the present value calculations, differing rotation lengths are assumed to be associated with both different site qualities and management regimes.

Table 3. Estimated rotation length and productivity for four site index values and three management regimes based on STANDSIM simulations. Volumes (m^3) are entire stem volumes (ESV) from STANDSIM, with minor modifications as noted in the text. Merchantable volumes are assumed to be around 80% of ESV. Rotation lengths (years) are rounded to the nearest 5 years. MAI = Estimate of mean annual increment ($m^3/ha/yr$) over the rotation.

	Regime		
	Pulpwood	Commercial thinning	Clearwood
Site Index 23 (PI-type: E3+)*			
Rotation age	20	50	50
Thinning age		20	4
Volume thinned		130	
Final standing volume	300	450	450
Total volume harvested	300	580	450
MAI at clearfall	15	12	9
Site Index 30 (PI-type: E2)*			
Rotation age	15	45	40
Thinning age		15	4
Volume thinned		130	
Final standing volume	300	600	500
Total volume harvested	300	730	500
MAI at clearfall	20	16	13
Site Index 37 (PI-type: E1)*			
Rotation age	12	40	35
Thinning age		12	3/4
Volume thinned		130	
Final standing volume	300	700	550
Total volume harvested	300	830	550
MAI at clearfall	25	21	16
Site Index 43 (PI-type: E1+)*			
Rotation age	10	35	30
Thinning age		9	3
Volume thinned		130	
Final standing volume	300	800	600
Total volume harvested	300	930	600
MAI at clearfall	30	27	20

* PI-type is only a poor estimate of site index.

Rotation length and productivity of the management regimes

Table 3 presents the estimated MAI for entire stem volume (ESV) associated with each of our chosen management regimes and SI values based on the STANDSIM outputs. Most eucalypt plantations in Tasmania are under 15 years of age (Tibbits 1986) and thus there is very little long-term information on the growth of plantations over a full rotation length, particularly the longer rotations needed for sawlog plantations.

Goodwin and Candy (1986) present growth data based on stem analysis of a 42-year-old stand of *Eucalyptus globulus* Labill. in northern Tasmania which had a peak MAI of just over 30 $m^3/ha/yr$ at age 20. In a recent review of the productivity of eucalypt plantations,