ECONOMIC ANALYSIS OF SELECTED SPECIAL-PURPOSE SPECIES REGIMES

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ABSTRACT

The economics of growing **Pinus radiata** D. Don (radiata pine) in a small farm woodlot in the central North Island were compared to certain special-purpose species, viz cypresses, eucalypts, **Acacia melanoxylon** R. Br. (Australian blackwood), and **Juglans nigra** L. (black walnut). The blackwood was assumed to be planted in gaps in a scrub canopy, and the other species on grass cover. The tending regimes for all the species were designed to produce high-quality, clear, butt logs which would be sawn in Rotorua and sold on the domestic market.

The economic analysis included, for each species, the calculation of the internal rates of return and the net present values at the 5% and 10% real discount rates (on a pre-tax basis). The analysis indicated that the following real rates of return could be expected for each species: radiata pine 4.0–9.9%; cypresses 4.0–8.0%; eucalypts 3.1–7.5%; blackwood 5.3–8.0%; and black walnut 3.8–5.6%.

Keywords: economic analysis; woodlots; special-purpose species; **Cupressus macrocarpa**; **Cupressus lusitanica**; **Eucalyptus regnans**; **Eucalyptus fastigata**; **Eucalyptus delegatensis**; **Eucalyptus saligna**; **Eucalyptus botryoides**; **Acacia melanoxylon**; **Juglans nigra**.

INTRODUCTION

The New Zealand Forest Service has recently outlined a strategy for the local supply of special-purpose timbers to meet domestic needs in end-uses for which radiata pine may not be suitable (N.Z. Forest Service 1981). These uses include furniture and cabinet work, turnery, exterior joinery, decorative veneer, and panelling, where "higher standards in decorative features, dimensional stability and surface hardness are required."

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At present these needs are being satisfied by indigenous timbers and imported special-purpose species. However, both of these sources of supply are expected to decline substantially in the future.

In general, the special-purpose species require more favourable sites than radiata pine and such sites are more likely to be available in small quantities on farms. Consequently, this paper provides an economic analysis, from the point of view of the small-woodlot owner, of growing radiata pine compared to various special-purpose species.

FOREST MANAGEMENT REGIMES AND COST

Species and Tending

The special-purpose species considered in this analysis are those specified in the N.Z. Forest Service's (1981) "Policy on Exotic Special Purpose Species" –

Cypresses – *Cupressus macrocarpa* Hartw. and *C. lusitanica* Mill.;

Eucalypts – *Eucalyptus regnans* F. Muell., *E. fastigata* Deane et Maid., *E. delegatensis* R.T. Bak., *E. saligna* Sm., and *E. botryoides* Sm.;

Australian blackwood – *Acacia melanoxylon* R. Br.;

Black walnut – *Juglans nigra* L.

Special-purpose species generally require sites of at least moderate fertility for timber production. The site index, or productivity, of the site considered in this analysis is assumed to be 30 m (i.e., mean top height for a radiata pine stand at age 20 years). Ground slope ranges from 0° to 10°, with a maximum gradient of 15° over distances less than 50 m.

To maintain a consistent basis for comparison, all species are assumed to have been planted on single hectare sites or in small woodlots, i.e., less than 10 ha. These sites are assumed to be located in the Bay of Plenty region about 60 km from a Rotorua sawmill.

The tending schedules for radiata pine and the special-purpose species are designed to produce clearwood from a 6-m butt log. The individual schedules used in this analysis represent feasible although not necessarily optimal tending treatments.

The radiata pine regime is similar to the sawlog regime proposed by Fenton (1972), i.e., two thinnings to a final-crop stocking of 200 stems/ha, with pruning in three lifts to 6.1 m. The special-purpose species regimes involve heavy early thinning and intensive pruning of single species plantations, with the exception of blackwood which is assumed to have been planted into gaps cleared in an indigenous scrub canopy. It is assumed that the other species are planted on perennial grass cover. For further details refer to Appendix 1.

Growth Rates and Yields

A silvicultural stand model, "SILMOD" (Whiteside & Sutton 1983), was used to provide growth and yield estimates for radiata pine. Special-purpose species growth rates were derived from current data. In recognition of the limitations of these data the growth estimates appearing in Appendix 1 are deliberately conservative.

The tending regimes adopted for the special-purpose species aim to produce a "target" tree, or the mean-sized tree in the stand in terms of breast height diameter and minimum small-end diameter. Target tree dimensions were chosen to provide a similar basis for comparison, except for the eucalypts where target tree dimensions are determined by utilisation criteria (i.e., internal growth stress distribution or the need to quarter-saw logs).

Recoverable sawlog volume estimates for eucalypts, blackwood, and black walnut target trees were calculated assuming taper to be independent of height up the stem. Volume tables (T115 and T40 – Deadman & Goulding 1979) were used to derive recoverable sawlog volume estimates for radiata pine and the cypresses, respectively. Clearfelling occurred when target tree dimensions were reached, and yields were calculated from recoverable volumes and final-crop stockings (*see* Table 1 and Appendix 1).

Operation Costs

Where possible, costs were derived from labour content inputs or previously collected data; otherwise, estimated costs were used. Costs were adjusted for stocking differences, depending on the tending regime, and were chosen as being representative of small woodlots (i.e., less than 10 ha). Administration costs vary because of the different management intensities required for each regime (for further details *see* Appendix 1).

Since the analysis is being prepared for a small farm woodlot, it is assumed that no establishment tracks will be required and that logging will take place in the summer, precluding the need for pre-harvesting roads. Taxes and financial incentives have not been included in this analysis.

Although it is assumed that the woodlot is located on a farm and there will not be any cash outlays for the land, it is necessary to impute a charge to the project for the services of the land. This is normally the highest net return that would have been returned in the absence of the project (FAO 1979, p. 95). However, as a substitute for the actual opportunity costs, a land rental is calculated. This is based on the value of grazing land of $1000/ha (Valuation Department 1983) multiplied by a land rental of 7% per annum, which is the normal rental for pastoral farmland for agricultural purposes including farm woodlots (J. Cawston, N.Z. Forest Service, pers. comm.). This gives an annual land rental of $70/ha for all species except blackwood.

It is assumed that the blackwood will be planted in gaps cleared in an indigenous scrub canopy rather than on grazing land. The value of this land is estimated to be $500/ha, which is the grazing land value of $1000/ha less development costs of $500/ha (Arthur-Worsop & Allan 1984). Hence, the annual land rental for blackwood is calculated to be $35/ha.

SAWN TIMBER PRICES AND DERIVED STUMPAGES

It is assumed that the output from the woodlot discussed in this paper will be processed in Rotorua and sold ex mill as green sawn timber for the domestic market. However, in order to determine realistic stumpages for the woodlot grower, it is assumed that the final point of sale for the clear grades of sawn timber will be dried, ex yard, in Wellington.

TABLE 1—Summary of target tree dimensions and clearfelling yields by species

Species	Clearfelling age (yr)	Final-crop stocking (stems/ha)	Breast height diameter (cm)	Height (m)	Minimum small-end diameter (cm)	Recoverable volume	
						(m^3/tree)	(m^3/ha)
Radiata pine	30	200	60	42	20	3.1	620
Cypresses	35	200	60	30	20	2.9	580
Eucalypts	35	100	75	35	40	4.3	430
Blackwood	35	100	60	25	20	1.7	170
Black walnut	40	70	60	22	20	2.0	140

Retail Prices for Clear Sawn Timber

Table 2 shows the expected retail prices for the clear grades of dried sawn timber, ex yard, Wellington. The radiata pine clearwood price was the actual mid-1983 price obtained from J. L. Lennard Ltd in Wellington (pers. comm.).

Currently there are no well-established markets for the clear grades of special-purpose species grown in New Zealand. However, it is assumed that these timbers will be substitutes for particular indigenous and imported timbers in certain applications (N.Z. Forest Service 1981). The expected prices (Table 2) were estimated from this information and a weighted average of Forest Service and industry sources from Wellington, Rotorua, and Auckland. The comparable retail prices ($/m^3 sawn) for selected indigenous and imported timbers were: North Island rimu $860, silver beech $830, Fijian kauri $1060, sapele (mahogany) $1440, Australian blackwood $2970, and United States black walnut $3030 (J. L. Lennard Ltd, Wellington, pers. comm.).

TABLE 2—Expected retail prices for the Clear grades of sawn timber by species* (1983 prices)

Species	$/m^3 sawn
Radiata pine†	640
Cypresses	750
Eucalypts	900
Blackwood	1200
Black walnut	1500

* All expected prices are ex yard, Wellington; 150 × 25 mm, dried, and clear grade.

† Price obtained from J. L. Lennard Ltd, Wellington.

Wholesale Prices for Green Sawn Timber

The estimated wholesale prices for green sawn timber ex mill in Rotorua are summarised in Table 3. Briefly, these are estimated as follows:

(1) The prices of the Clear grades for all species are derived from the ex yard, Wellington, retail prices (Table 2). The radiata pine clearwood retail mark-up over the cost, ex rail, Wellington, is assumed to be 65% (N.Z. Timber Industry Federation, Wellington, pers. comm.) and to be the same for all species. This mark-up includes the costs of freight from rail to yard, billeting, timber drying, debilleting, and a normal profit margin (J. L. Lennard Ltd, pers. comm.). The transport cost ex mill, Rotorua, to the railyard Wellington is assumed to be $70/m^3 (sawn).

(2) The Factory, Merchantable, Building and Box grade prices for radiata pine are derived from the North Island Guide Price List for Radiata pine (Timber Industry Federation 1983). The Building grade is assumed to be an average of the No. 1 and No. 2 Framing grades.

(3) The price ratio of the Factory grade to the Clear grade for the special-purpose species is assumed to be the same as the ratio for radiata pine.

(4) It is assumed that the Merchantable, Building, and Box grades for the cypresses are direct substitutes for radiata pine.

(5) It is assumed that the non-Clear and non-Factory grades for the hardwoods (i.e., eucalypts, blackwood, and black walnut) may not have traditional building uses in New Zealand. However, they may have specialty uses as short cuttings; hence, they are assumed to command a slight premium over the price for Box grade radiata pine.

TABLE 3—Estimated wholesale prices ($/m^3 sawn) for green sawn timber by grade, ex mill, Rotorua (1983 prices)

Grade	Radiata pine	Cypresses	Eucalypts	Blackwood	Black walnut
Clear	318	385	475	657	839
Factory	150	182	224	310	396
Merchantable	120	120	–	–	–
Building	160	160	–	–	–
Box	110	110	–	–	–
Others	–	–	120	120	120

Derived Stumpages

The stumpage values for each species (Table 4) are calculated as follows:

(1) Firstly, the net green sawn timber prices by grade, ex mill, Rotorua are derived from the wholesale prices (Table 3), less trade and cash discounts of 7.5% and 2.5% respectively (Timber Industry Federation 1983).

(2) These net prices are multiplied by the volume of sawn timber by grade (derived from Appendix 2) to give a net value ($/ha) of sawn timber at the mill.

(3) Sawing costs are deducted to give a value per hectare for the roundwood delivered to the mill. Rough sawing costs for radiata pine are assumed to be $70/m^3 (sawn). The same costs are assumed for the cypresses, blackwood, and black walnut, but a cost of $90/m^3 (sawn) is assumed for the eucalypts because of the greater difficulty in sawing.

(4) Harvesting and transport-to-mill costs are deducted to give the net returns per hectare to the grower. Transport-to-mill costs, based on a distance of 60 km from the Bay of Plenty woodlot to the Rotorua mill ,are assumed to be $10/m^3 (round). Harvesting costs are assumed to be $8/m^3 (round) for radiata pine and the cypresses, $9/m^3 (round) for the eucalypts, and $10/m^3 (round) for blackwood and black walnut.

(5) The net returns per hectare are divided by the recovered volume per hectare to give the derived stumpage values by species.

TABLE 4—Derived stumpages by species for the Base Case (1983 prices)

Species	$/m^3$ (round)
Radiata pine	30
Cypresses	40
Eucalypts	45
Blackwood	87
Black walnut	164

ECONOMIC ANALYSIS OF THE BASE CASE

Method

The method used to evaluate the economic costs and returns for the different species is the discounted cash flow technique. In particular, the investment criteria calculated are the Internal Rate of Return (IRR) and the Net Present Value (NPV) criteria (for further details of these *see* Fraser *et al.* 1977, or FAO 1979). Two real discount rates are used to derive the NPVs in this analysis – a 10% rate (Treasury's discount rate) and a 5% rate (which is frequently used in the private sector).

The economic analysis is undertaken from the private woodlot grower's point of view. However, since the investment criteria are calculated on a pre-tax basis, this analysis can also be interpreted from the viewpoint of the State.

Results

The forest management costs, land rentals, and yields (Appendix 1) were combined with the residual stumpages (Table 4) to produce annual cash flows for the Base Case for each species. The IRRs and NPVs at the 5% and 10% real discount rates were then calculated and these are summarised in Table 5 (note that these are pre-tax returns).

The IRRs ranged from 4.8% for black walnut to 7.9% for radiata pine. If a 5% real rate of return was required on the investment then all the species would be acceptable, since they all yielded positive NPVs (except black walnut which was only slightly negative). At the 10% real discount rate all species yielded negative NPVs indicating that they should not be planted if this is the sole criterion for decision making.

TABLE 5—Results of the economic analysis for the Base Case

	Internal Rate of Return (IRR) (%)	Net Present Value (NPV) at 5% (1983 $/ha)	Net Present Value (NPV) at 10% (1983 $/ha)
Radiata pine	7.9	1907	-588
Cypresses	6.5	1271	-1157
Eucalypts	5.9	694	-1238
Blackwood	6.9	995	-625
Black walnut	4.8	-174	-1863

SENSITIVITY ANALYSIS

Various sensitivity tests were performed analysing changes to the Base Case costs and prices. However, the investment criteria were most sensitive to changes in the prices for sawn timber, and these will be reported here.

Price Changes

Cavana (1983) and Cavana & Coyle (1984) have shown that, because of the boom in new plantings of radiata pine since 1960 and the uncertainties regarding New Zealand's future export markets, an over-supply of wood compared with demand may occur around the turn of the century. If this happens then the real price of radiata pine is likely to drop. However, Sutton (1975) has predicted world shortages of knot-free timbers in the future, which could have the effect of increasing the real price of radiata pine clearwood.

Further reductions in New Zealand's indigenous roundwood removals (N.Z. Forest Service 1981) and in high-quality timber yields from tropical forests (FAO 1982) are likely to cause the real prices for indigenous and imported timbers to increase in the future. If this occurs then the real price of New Zealand-grown special-purpose species may also increase. However, unless continuity of supply can be ensured in the future and markets developed properly, then the real prices of the special-purpose timbers may be lower than the expected prices assumed for the Base Case.

For these reasons two alternative price scenarios were considered: the low price scenario assumes that all the wholesale prices for green sawn timber ex mill, Rotorua, are 20% below the Base Case shown in Table 3, and the high price scenario assumes that all the prices are 20% above the Base Case.

The related price changes associated with these sensitivity tests are summarised in Table 6, along with the Base Case assumptions for comparative purposes. The retail

TABLE 6—Summary of the sensitivity analysis price changes

	Low price scenario	Base Case	High price scenario
(a) **Retail prices for Clear grades** (1983 $/m^3 sawn)			
Radiata pine	536	640	745
Cypresses	624	750	878
Eucalypts	743	900	1056
Blackwood	983	1200	1416
Black walnut	1223	1500	1777
(b) **Derived stumpages** (1983 $/m^3 round)			
Radiata pine	14	30	47
Cypresses	21	40	58
Eucalypts	22	45	67
Blackwood	59	87	116
Black walnut	121	164	207

prices for the clear grades were derived by working backwards from the calculations used to derive Table 3 and the derived stumpages were calculated by the method outlined to produce Table 4.

As mentioned earlier, reliable information on the growth and yields of the special-purpose species is not available yet. The sensitivity analysis has been calculated for changes in the price assumptions, but the adjustments made could also be interpreted as the results of changes to the estimates of volume or grade out-turn. For example, the 20% increase in the wholesale timber price for eucalypts corresponds to a 49% increase in stumpage value (from Table 6). This would produce the same rate of return to the grower as if the price was held constant and the yield was increased by 49% (assuming that the conversion factors in Appendix 2 remain constant).

Results

The detailed results of the economic analysis with the two alternative price scenarios are provided in Table 7 along with the Base Case for comparison. In general, the species with shorter rotations (e.g., radiata pine) were more sensitive to the price changes than the species with longer rotations (e.g., black walnut).

For the low price scenario, blackwood was the only species to exceed a 5% real rate of return. This is due partly to the lower land rental assumed for blackwood. However, all the IRRs are between 5% and 10% for the high price scenario, with radiata pine almost meeting Treasury's 10% real rate of return criterion.

TABLE 7—Results of the sensitivity analysis

	Low price scenario	Base Case	High price scenario
(a) **Internal Rate of Return (IRR)** (%)			
Radiata pine	4.0	7.9	9.9
Cypresses	4.0	6.5	8.0
Eucalypts	3.1	5.9	7.5
Blackwood	5.3	6.9	8.0
Black walnut	3.8	4.8	5.6
(b) **Net Present Value (NPV) at 5%** (1983 $/ha)			
Radiata pine	–422	1907	4236
Cypresses	–598	1271	3140
Eucalypts	–1012	694	2400
Blackwood	145	995	1846
Black walnut	–1017	–174	670
(c) **Net Present Value (NPV) at 10%** (1983 $/ha)			
Radiata pine	–1152	–588	–25
Cypresses	–1516	–1157	–799
Eucalypts	–1565	–1238	–911
Blackwood	–788	–625	–462
Black walnut	–1991	–1863	–1735

The results provided in Table 7 indicate the range of the likely returns that could be expected from growing radiata pine and the selected special-purpose species under the conditions discussed in this paper. However, the returns shown for black walnut may be understated, since it may be possible to combine agricultural activities with forestry later in the rotation after the final waste thinning to 70 stems/ha.

Although the results in Table 7 are presented as three separate scenarios, the data could allow a total of 243 different possibilities to be evaluated if the prices for each of the species were totally independent of each other. However, the price relativities between the grades and the species are highly interdependent *(see* Table 3), although there is more independence between the prices assumed for radiata pine and the hardwoods (eucalypts, blackwood, and black walnut) than between radiata pine and the cypresses. Therefore a comparison of the results of, for example, the Base Case for radiata pine with the high price scenario for the eucalypts would not be unreasonable.

CONCLUDING REMARKS

The economic analysis indicated that the following pre-tax real rates of return could be expected for each species: radiata pine (4.0–9.9%); cypresses (4.0–8.0%); eucalypts (3.1–7.5%); blackwood (5.3–8.0%); and black walnut (3.8–5.6%). However, if agricultural activities are combined with growing black walnut later in the rotation, then the returns for black walnut may be higher. Also if the non-tangible benefits of farm woodlots (e.g., aesthetic values, soil protection, water conservation, shelter) are taken into consideration (as discussed by Smaller & Meister 1983), then additional benefits may accrue to small woodlot owners from growing the special-purpose species.

Finally, it must be emphasised that the choice of species and silvicultural regime, and the costs and returns to the grower will, naturally, vary according to the location of the woodlot and the access to and conditions of the market.

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APPENDIX 1

SUMMARY TABLES OF THE DIFFERENT FOREST MANAGEMENT REGIMES AND COSTS

TABLE A1—Summary of the management regime and costs for radiata pine (1983 prices)

Operation	Mean top height (m)	Stand age (years)	Average cost ($/ha)
Site preparation - grass spray (spot)		0	100
Nursery stock		0	55
Planting (hand) - 1250 stems/ha		0	110
Dothistroma spray	3.7	3	35
Waste thin to 600 stems/ha	5.2	4	90
Low prune	5.2	4	210
Waste thin to 200 stems/ha	9.1	6	60
Medium prune	9.1	6	90
Dothistroma spray	11.3	7	35
High prune	13.0	8	110
Administration		0–30	30
Land rental		0–30	70
Clearfell: Recovered sawlog volume = 620 m^3/ha	42.0	30	

TABLE A2—Summary of the management regime and costs for the cypresses (1983 prices)

Operation	Mean top height (m)	Stand age (years)	Average cost ($/ha)
Site preparation - grass spray (spot)		0	120
Nursery stock		0	375
Planting (hand) - 1500 stems/ha		0	155
Waste thin to 600 stems/ha	5	6	100
Low prune	5	6	210
Waste thin to 200 stems/ha	9	10	60
Medium prune	9	10	90
High prune	13	14	110
Administration		0–35	35
Land rental		0–35	70
Clearfell: Recovered sawlog volume = 580 m^3/ha	30	35	

TABLE A3—Summary of the management regime and costs for the eucalypts (1983 prices)

Operation	Mean top height (m)	Stand age (years)	Average cost ($/ha)
Site preparation – grass spray (spot)		0	100
Nursery stock – bare rooted		0	275
Planting (hand) – 1250 stems/ha		0	130
Fertiliser (hand) 60 g urea		0	50
Waste thin to 600 stems/ha	5	3	80
Low prune	5	3	160
Waste thin to 300 stems/ha	9	6	50
Medium prune	9	6	80
Waste thin to 100 stems/ha	13	8	35
High prune	13	8	80
Administration		0–35	35
Land rental		0–35	70
Clearfell: Recovered sawlog volume = 430 m^3/ha	35	35	

TABLE A4—Summary of the management regime and costs for blackwood (1983 prices)

Operation	Mean top height (m)	Stand age (years)	Average cost ($/ha)
Site preparation – group cutting		0	140
Nursery stock – bare rooted		0	125
Planting (hand) – 5 trees/gap 100 gaps/ha		0	70
Fertiliser (hand) – 100 g Magamp		0	100
Waste thin to 1 tree/gap	13	14	120
Prune to 6 m	13	14	100
Administration		0–35	30
Land rental		0–35	35
Clearfell: Recovered sawlog volume = 170 m^3/ha	25	35	

TABLE A5—Summary of the management regime and costs for black walnut (1983 prices)

Operation	Mean top height (m)	Stand age (years)	Average cost ($/ha)
Site preparation - grass spray (spot)		0	100
Nursery stock - 1250 spots/ha - 2 nuts/spot		0	375
Planting		0	140
Release - chemical spray (spot)		1	100
Release - chemical spray (spot)		2	100
Seedling removal - 1 seedling/spot	2	3	100
Form prune	2	3	170
Waste thin to 600 stems/ha	5	6	90
Low and form prune	5	6	280
Waste thin to 70 stems/ha	9	11	70
Medium and form prune	9	11	90
High prune	13	15	80
Administration		0–40	40
Land rental		0–40	70
Clearfell: Recovered sawlog volume = 140 m^3/ha	22	40	

APPENDIX 2

SAWN TIMBER GRADE DISTRIBUTION (% m^3 ROUND) AND LOG VOLUME RECOVERY BY (5-m) LOG HEIGHT CLASSES

	First log	Second log	Third log	Fourth log
(a) **Radiata pine**				
Clear	35	–	–	–
Factory	4	4	3	3
Merchantable	13	–	–	–
Building	–	35	27	27
Box	3	11	15	15
Conversion factor (%)	55	50	45	45
Volume recovery (m^3 round)	1.1	0.8	0.6	0.6
(b) **Cypresses**				
Clear	31	–	–	–
Factory	2	2	1	–
Merchantable	11	–	–	–
Building	–	46	37	26
Box	6	2	7	14
Conversion factor (%)	50	50	45	40
Volume recovery (m^3 round)	1.2	0.8	0.6	0.3
(c) **Eucalypts**				
Clear	21	–	–	
Factory	12	38	29	
Others	22	17	21	
Conversion factor (%)	55	55	50	
Volume recovery (m^3 round)	2.0	1.4	0.9	
(d) **Blackwood**				
Clear	18	–		
Factory	9	28		
Others	21	17		
Conversion factor (%)	50	45		
Volume recovery (m^3 round)	1.2	0.5		
(e) **Black walnut**				
Clear	35	–	–	
Factory	11	28	20	
Others	11	12	15	
Conversion factor (%)	55	40	35	
Volume recovery (m^3 round)	1.1	0.6	0.3	

Note: It is assumed that 150 × 25-mm boards are cut from the first (butt) log and 150 × 50-mm boards are cut from the upper logs.