EXPORT LOG AFFORESTATION PROFITABILITY 1973

R. FENTON and R. B. TENNENT

Forest Research Institute, New Zealand Forest Service, Rotorua

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ABSTRACT

Profitability of radiata pine afforestation for the export log trade was re-evaluated for scrub-covered country of easy topography on site index 95 using normal management steps, and values as at 31 December 1973. Net yields of 576 m^3 per hectare are obtained from 23-year rotations, with a silviculture aimed at producing two 11.9-m logs to a 15.25-cm top by planting at 2.1 $\times$ 3.05 m spacing, thinning (probably to waste) to 370 stems/ha at 10.7 m top height, and clearfelling at 33.5 m.

Management changes since 1967 include different site preparation and complete replanting as opposed to reliance on seeding and natural regeneration in subsequent rotations.

Break-even growing costs have increased by 27% (at 10% interest) but returns are 88% higher, hence internal rates of return (I.R.R.) have risen from 10.2 to 13.7% since 1967 (when social costs of roading and housing are included). Volumes 12% lower would reduce the I.R.R. to 13%, but the I.R.R. would still be 10% if the price-on-truck were to fall 46%.

The profitability of the export forest-processing industries in New Zealand remains undemonstrated, and it is recommended that growing forests for log export should become a major objective of forest expansion as it is demonstrably highly profitable and has little management risk.

INTRODUCTION

Forest Service policy now aims at curtailing log exports from State Forests (N.Z. Forest Service, 1971). Volumes exported from all ownerships were 1.82, 1.82, and 1.87 million m^3 in 1970, 1971, and 1972, respectively (N.Z. Forest Service, 1973) and values of log exports exceeded those of pulp and paper by 25-45%. The log export trade offers private growers a profitable and relatively low-risk market. It represents an appropriate basis for comparing other management regimes. Costs and prices have increased formidably since the previous analysis (Fenton and Dick, 1972a) which was based on 1967 levels, and there have also been changes in management techniques over this period. Hence, it is appropriate to reassess the current profitability of such afforestation.

The analysis is again based on "normal" afforestation of a particular area — the Maraetai block in the Bay of Plenty — which is characteristic of much of the land being planted by both State and private growers. Only *Pinus radiata* D. Don (radiata pine) is considered. The main limitation of using "normal" rates of afforestation is that profitability is reduced when compared with that of accelerated planting, but it enables stricter comparisons to be made with other forest regimes. Macroeconomic aspects of the trade are also considered.

Assumed Characteristics of the Area

The area initially evaluated has been described (Fenton and Grainger, 1965). It is assumed that ca. 8420 ha out of 10 120 ha gross are planted (83% of the gross area); that initial cover is largely inflammable scrub; that topography is easy to rolling; and that the port is 143 km by road from the centre of the forest. These have been constant assumptions for all the profitability models tested. Site index is 95 (Lewis, 1954).

The management divisions, based on topography/machine classes, are:

Pre-planting	First rotation	Release cutting (First rotation)	Areas (net) ha
Giant-disced	Tractor plantable	Nil	4696
Giant-disced	Not tractor plantable	Nil	2834
Not giant-disced	Not tractor plantable (hill sites)	2	890
			8420

The original studies treated 648 ha of frost flats separately, but current techniques now allow direct establishment of radiata pine on such sites (D. Elliott, pers. comm.) at increased costs. The disced, hand-planted category includes 202 ha of native bush.

Dollars are New Zealand dollars, currently (May 1974) set at US$1.48 per NZ$1.00. The data have been converted to metric units, so many apparently exact figures appear. While these figures are as accurate as possible, they could be rounded if necessary.

TECHNICAL SPECIFICATIONS, SILVICULTURE AND MANAGEMENT

Log specifications are unaltered. The minimum log small end diameter inside bark (s.e.d.i.b.) is 15.25 cm; the minimum ratios of volume by log length are 60%: 11.9 m; 35%: 7.9 m; 5% (or less): 4 and 6.1 m. Logs should be reasonably straight. The mean tree achieved by the silvicultural regime given below, yields two 11.9-m lengths to a 15.25 cm s.e.d.i.b. at clearfelling, and over 95% of the log volume is available in 11.9-m lengths.

Establishment techniques have changed since the original studies were made in 1962/63, and are specified below as two alternative schedules. Forest operations by years are given in Table 1, unit costs in Table 2, and the first-rotation clearing schedule in Table 3.

Silviculture is:

1. Initial land clearing

(a) Original schedule: the previously published studies used repeated burning of the sites, and this has been evaluated again here, with the addition of discing and

TABLE 1—Management plan: area of each annual operation (ha)

Year	Planting Machine	Planting Hand	Blanking	Releasing One	Releasing Two	Thinning to waste	Clearfelling
1-8	366						
9-12	366					366P	
13	304	62					
14-21		366P					
22				157			
23				366P	157R		
24					366R		366P
25			366P		366R		

P = in perpetuity; R = every rotation (hill sites)

TABLE 2—Summarised direct costs and labour requirements

Operation		Direct cost ($/ha)	Man-days/ha
Land clearing	— Burning	2.10	Contractor
	— Light scrub	23.00	,,
	— Discing	14.83	,,
	— Heavy scrub*	67 + 22	,,
	— Bush felling*	143 + 59 + 4	,,
Planting	— Hand	47.77	1.53
	— Machine	24.04	0.23
Blanking		14.63	0.74
Release cutting		26.44	1.66
Thinning to waste		39.69	1.56
Clearfelling		$1.712/m^3	

* See Table 3a

TABLE 3—First rotation land preparation

a. Original schedule

Year	Operation	Area (ha)	Rate ($/ha)
1	Cut heavy scrub	607	67.72
	Crush heavy scrub	607	22.24
	Crush light scrub	2468	14.83
	Overall burn	9712	0.25
	Discing/harrowing	366	23.00
2-3	Discing/harrowing	366 p.a.	23.00
4	Overall burn	6880	2.10
	Discing/harrowing	366	23.00
5-10	Annual burns	732 p.a.	2.10
	Discing/harrowing	366 p.a.	23.00
10	Felling bush	202	143.32
11	Burning felled bush	202	4.15
	Discing/harrowing	366	23.00
12	Discing/harrowing	366	23.00
13	Bulldoze bush slash	202	59.30
	Discing/harrowing	366	23.00
14-20	Discing/harrowing	366 p.a.	23.00
21	Discing/harrowing	209	23.00

b. Revised schedule

Year	Operation	Area (ha)	Rate ($/ha)
1-9	Crush scrub	366 p.a.	22.00
	Burn	366 p.a.	4.15
	Discing/harrowing	366 p.a.	23.00
10	Fell bush	202	143.32
10-11	Crush scrub	366 p.a.	22.00
	Burn	366 p.a.	4.15
	Discing/harrowing	366 p.a.	23.00
12	Crush scrub	22	22.00
	Crush frost flats	344	9.00
	Burn	366	4.15
	Discing/harrowing	366	23.00
13	Crush frost flats	304	9.00
	Bulldoze bush slash	62	59.30
	Burn	366	4.15
	Discing/harrowing	366	23.00
14	Bulldoze bush slash	140	59.30
	Crush scrub	226	22.00
	Burn	366	4.15
	Discing/harrowing	366	23.00
15-20	Crush scrub	366 p.a.	22.00
	Burn	366 p.a.	4.15
	Discing/harrowing	366 p.a.	23.00
21	Crush scrub	210	22.00
	Burn	366	4.15
	Discing/harrowing	210	23.00
22-23	Burn	366 p.a.	4.15

p.a. = per annum

harrowing on suitable topography (Table 3a). This aims at reducing weed regrowth, especially of bracken (*Pteridium esculentum* L.)

(b) New schedule: this has been taken from current Kaingaroa practice, although that forest is at generally higher altitudes and much of the establishment there is for second-rotation stands.

The new schedule (Table 3b) omits pre-burning in the years preceding planting, but requires pre-crushing and burning of scrub in the year of planting, with discing and harrowing.

2. Initial spacing

Trees are planted 2.1 m apart in rows 3.05 m apart (1530 stems/ha). Trees from the nursery are about 8 months (spring sown), except on frostflats (648 ha) where 2/0 stock is used.

3. Blanking

It was previously assumed that 10% of the trees needed replacement in the year following planting. This has now been dispensed with in the first rotation, except on hill sites. All sites are blanked in second and subsequent rotations.

4. Releasing

First rotation releasing is now only on hill sites — one operation being allowed in each of the first and second years after planting. In subsequent rotations two operations are continued on hill sites and frost-flats, and one operation elsewhere. At Kaingaroa, chemical sprays from the air are now being used instead of hand cutting. This would reduce the men needed after year 25 by 2-3 with a corresponding decrease in housing costs.

5. Thinning to waste

This is carried out at 10.7 m top height (age 9) to 370 stems/ha (using power saws).

6. Protection

For *Dothistroma pini* (needle blight) prevention, stands are aerially inspected each year with closer ground-inspection of suspect areas. The area planted is sprayed when trees are 2.4-3 m and again at 5.5-7.5 m. It is possible that a third spray would be required after the thinning to waste at 10.7 m (Gilmour, Leggett, and Fitzpatrick, 1973) but only two spray treatments have been costed.

Standard fire protection measures would apply.

The increase of noxious animal and weed populations at Kaingaroa has necessitated control operations there. These have been costed at $0.70 per established hectare of forest, but it is reiterated that the area concerned, in its original state, was free of such problems (Fenton and Grainger, 1965).

7. Clearfelling

Stands are to be clearfelled at normality at 33.5 m top height (age 23). Yield predictions (Fenton and Tustin, 1972) are by W. R. J. Sutton. The net volume logged is 576 m^3/ha giving total annual yields of 210 800 m^3.

These projections used the yield tables for thinned radiata pine (Beekhuis, 1966). A referee's comment suggests that downward modification of all local radiata pine projections will be made, but this is not an appropriate place to anticipate these fundamental revisions. So, as in earlier analyses, another sensitivity analysis on the effects of reducing net yields has been included.

8. Second rotations

In earlier analyses, second and subsequent rotations were restocked by different proportions of replanting, aerial seeding, and natural regeneration. There may be favourable circumstances in some years which result in acceptable regeneration, but they have been excluded in the financial calculations. Following experience at Kaingaroa (D. Elliott, pers. comm.), restocking is now by replanting throughout.

Areas of each operation are given in Table 1.

Figs. 1 and 2 are of plots grown at stocking comparable to the management schedule, and show both the rapid exploitation of the canopy gaps and the quality-potential of the regime (the plot trees have been pruned for access).

COSTS AND RETURNS

Labour Requirements

The labour content and the costs of operations are given in Table 2. Details on which these direct, and all other costs, are based are given by Fraser and Walker (1974). Direct costs comprise wages, production bonus, compensation, holiday pay, direct stores charges, transport, and machinery hire. Supervision and indirect costs are charged separately.

FIG. 1—**P.radiata**, 2.74 × 2.74 m initial spacing, reduced to 370 stems/ha at 11 m top height. Photo taken after thinning. (R. N. James photo)

FIG. 2—**P.radiata,** same plot, 4 years later.

The costs of annual burns have been given variously as between \$4 and \$10/ha, and the \$4.15 used in the analysis has been taken from the cost of bush clearing operations (Kaingaroa's costs refer to second rotation stands).

Total supervisory staff and indirect labour are scheduled in Table 4, and the total manpower required is summarised in Table 5. One foreman/ranger less has been allowed than in earlier models, in proportion to the reduced labour force.

The logging equipment needed and costs are listed in Table 6 (based on data given in Appendix 1).

Protection

This comprises fire and *Dothistroma pini* prevention and control, and some minor items. Fire protection costs are summarised in Table 7, and *Dothistroma* costs in Table 8.

Annual fire costs include stand-by and routine patrols, break maintenance, building maintenance, and operation and maintenance of equipment. These are roughly proportional to the area planted.

For *Dothistroma* protection, crops are sprayed at ages 4 and 7, but actual spraying frequency will depend on aerial and ground assessments.

Weed and animal control costs were taken from Kaingaroa at \$50 000 and \$35 000 per year, respectively (D. Elliott, pers. comm.) and applied proportionately to the planted area. Fencing costs of \$680 per year are required in years 1 to 5 inclusive.

TABLE 4—Staff and indirect labour schedule
(in perpetuity from the years given)

	Staff	Year: 1	2	3	22	23	24	Total
Staff: Forest	— Officer in charge	1						1
	Forester		1					1
	Ranger/Foreman						2	2
	Clerk	1						1
	Clerk/Stores					1		1
Logging	— Officer in charge					1		1
	Ranger/Foreman						2	2
	Clerk						1	1
Roading	— Officer in charge	1						1
Other Labour:								
Roading	— Men	2				1		3
Fleet	— Mechanics	1					3	4
	Drivers	1					2	3
Other	— Tractor driver	1						1
	Fire storekeeper		1					1
	Camp attendant						1	1
	Carpenter/Painter	1					1	2
	HQ gang		1				2	3
	Tool maintenance	1						1

TABLE 5—Total manpower

Year	Forest labour	Staff and Indirect	Total
1	1	10	11
2	1	11	12
3–8	1	13	14
9–13	3	13	16
14–21	5	13	18
22	6	13	19
23	9	16	25
24	49P	30P	79P*

P = in perpetuity; * Plus an additional man every 20th to 23rd year

TABLE 6—Logging equipment

Year	No.	Item	Unit Cost $
23	1	D7 tractor	68 000
	2	Tip trucks	8 500
	1	½-tonne truck	2 700
24	1	D7 tractor	68 000
	4	Skidders (124 - 140 hp)	26 000
	4	Loaders	58 000
	4	Gang trucks	6 000
	20	Power saws	320
	2	Field service units	6 000
		Miscellaneous equipment	6 900
		Stores (purchase)	10 000

TABLE 7—Fire protection costs

Item	Year	Cost $
Firebreaks — preparation	1–23	310 p.a.
Equipment : Radio	3	2 000
Fire engine	3	18 000
Fire tanker	5	6 300
Fire pumps (2)	4	2 120
Miscellaneous	3	6 000
Buildings : Fire store — capital	5	6 900
depreciation		65 yr life
Annual charges : $1.48/ha up to 3035 ha		
$1.11/ha from 3035 to 5260 ha		
$0.74/ha above 5260 ha		

TABLE 8—Anti-**Dothistroma** costs

Operation	Unit cost/ha $
Aerial survey	0.025
Ground survey	0.25
Spraying cost : Chemicals	3.58
Aircraft	3.41
Ground staff and transport	0.72
Total spraying	7.71*

* The costs are for large-scale operations over 6000-ha areas

Social Costs

These comprise roading, accommodation, and minor items. Table 9 shows the items charged in roading (and minor items). The schedule of housing and other accommodation is given in Table 10. It has been assumed that 10 men can be recruited locally and they have not been housed on the forest. The costs of running the camp have been taken as \$100/man/year. Houses cost \$17 000 each, have a 65-yr life, and incur a $1\frac{1}{4}$% annual charge for repairs and maintenance. Huts cost \$1 400 each. The service components (and miscellaneous items) of social costs are listed in Table 11.

The 1967 costs have been amended to use the 1973 Ministry of Works prices for houses; other buildings have been increased by the mean of the rises in the building and construction price indices.

Indirect Costs

Staff salaries are given in Table 12, and external overheads have been taken as 60% of these amounts. Forest building programmes are given in Table 13 and vehicles and stores are listed in Table 14. Net "Service and General" costs, and "General Administration" costs have been charged on a per hectare basis, and are included in Table 15.

Depreciation is allowed by charging the cost of the asset concerned at the end of its service life. The service lives are given in Table 16.

TABLE 9—Social costs : Roading

		$	Year
Road formation		8 360 p.a.	1–23
Road metalling		5 225 p.a.	23–45
Road maintenance \$1.48/ha of established forest			
Equipment :	Tip truck ($\frac{1}{2}$)	4 250	1*
	Grader	28 000	12
	½ tonne truck	2 700	12
	Tip truck ($\frac{1}{2}$)	4 250	23*

* The other half is charged to forest administration

TABLE 10—Accommodation requirements

	Houses			
Year	New	Total	Camp	
1	1	1		
2	1	2		
3	2	4		
9	2	6		
14	2	8		
22	1	9		
23	6	15		
24	20	35	45 huts	
			Cookhouse	\$43 210
			Caterer's house	\$15 000
			Ablution block	\$13 880

TABLE 11—Social costs and services

Year	Water supply $	Site preparation $	Services N.E.I. $	Share of services R. & M. $
1	4200	1820	1150P	334
2	4200	—		615
3	1850	2180		868

Thereafter only changing component is share of services, increasing until year 22 as follows:

Year :	4	5	6	7	8	9	10	11	12
$:	1080	1175	1300	1390	1450	1460	1630	1690	1750

Year :	13	14	15	16	17	18	19	20	21	22
$:	1870	1920	1970	1970	1970	1970	1970	1970	2060	2080P

N.E.I. = Not elsewhere indicated
R. & M. = Repairs and maintenance
P = in Perpetuity

TABLE 12—Staff and salaries

	Year : 1	2	3–6	7–12	13–22	23	24+
A. FOREST STAFF							
Officer i/c	6 357	6 357	6 790	6 790	7 237	7 705	7 705
Forester		4 851	4 851	5 067	5 497	5 497	5 497
Foreman							4 636
Ranger							5 283
Roading ranger	4 475	4 475	4 475	4 636	4 636	4 851	4 851
Clerk	4 291	4 291	4 517	4 517	4 517	4 740	4 740
Stores clerk							4 496
Forest total ($)	15 123	19 974	20 633	21 010	21 887	22 793	37 208
B. LOGGING							
Officer i/c						6 357	6 357
Foreman							4 636
Ranger							5 283
Clerk							4 291
						6 357	20 567

TABLE 13—Capital works

Year	Item	Cost
1	Office and store	$12 100
	Petrol store	5 100
	Telephone	3 000
	Water supply	4 200*
2	Garage, workshop	25 000
	Water supply	4 200*
3	Water supply	1 800*
23	Office extension	12 100
	Garage extension	25 000

* An equal amount is charged to social costs

TABLE 14—Miscellaneous vehicles and equipment

Year	Description	Cost $	Charged to
1	½-tonne truck*	2 700	Forest
	Gang truck	6 000	Forest
	Tip truck	8 500	Forest - half; Roading - half
	HD6 tractor	20 000	Forest
	Consumable stores †	840 p.a. for 20 yrs	Forest
	Class 'A' stores †	1 140 p.a. for 20 yrs	Forest
3	Office car *	2 700	Forest
9	½-tonne truck *	2 700	Forest
	Gang truck	6 000	Forest
12	½-tonne truck *	2 700	Roading
	Grader	28 000	Roading
23	Tip truck	8 500	Forest - half; Roading - half
	Miscellaneous plant and equipment †	6 900	Forest
	½-tonne trucks — 3 *	2 700	Forest

† Adjusted by index applied to 1967 data
* Annual charges, excluding depreciation, on these vehicles are $1 270

TABLE 15—Services and general assets: repairs and maintenance, and administration costs

Year	Total services and general charge ($/ha*)	General administration ($/ha*)
1	4.52	5.19
2	4.27	5.19
3	4.15	5.19
4	3.73	5.19
5	3.11	4.20†
6	2.92	3.58†
7	2.74	3.09†
8	2.52	2.72†
9	2.32	2.59
10	2.10†	2.59
11	2.00	2.59
12	1.90	2.22†
13	1.75	1.98†
14	1.66†	1.85†
15	1.56†	1.83
16	1.48†	1.83
17	1.41†	1.75†
18	1.36†	1.68†
19	1.31†	1.61†
20	1.26†	1.58C
21	1.235C	

* Of established forest
† The values include minor adjustments to maintain a smooth cost increase
C = Charge per established hectare thereafter

TABLE 16—Service lives

Item	Charge to	Life (yr)	Remarks
Houses	Social : accommodation	65	
Huts	Social : accommodation	20	Single men's camp
Caterer's quarters	Social : accommodation	65	Single men's camp
Ablution block	Social : accommodation	40	Single men's camp
Cookhouse	Social : accommodation	40	Single men's camp
Water supply	Social : accommodation — half; Capital works — half	—	Depreciation covered in Services and General Charge
Office; store	Capital works	40	
Garage	Capital works	40	
Oil store	Capital works	40	
Telephone	Capital works	—	Depreciation covered in Services and General Charge
Fire store	Protection	65	
Fire engine; tanker	Protection	10	
Pumps; radio	Protection	10	
$\frac{1}{2}$-tonne trucks; car	Forest vehicles and equipment	10	One $\frac{1}{2}$-tonne truck to logging; one $\frac{1}{2}$-tonne truck to roading
Gang trucks	Forest vehicles and equipment	10	Two to forest; four to logging
Tip trucks	Forest vehicles and equipment	10	One to forest; two to logging
HD6 tractor	Forest vehicles and equipment	6	
Miscellaneous equipment	Forest vehicles and equipment — half; Logging — half		
D7 tractors	Logging	6	
Skidders	Logging	6	
Loaders	Logging	6	
Field service units	Logging	10	
Miscellaneous equipment	Logging	3	
Chain saws	Logging	$1\frac{1}{2}$	
Grader	Social : roading	10	

Returns

Returns are based on the export free-on-board price at port, of \$8 per 100 "Japanese Haakon Dahl" (JHD) units. Log cartage costs for a 286 km round-trip are \$3.53/m^3. Export costs and returns are given in Table 17, and give the price loaded-on-truck at forest as \$17.62/m^3.

House rents of \$6.60 per week for 50 weeks a year, and hut rents of \$1.00 per week for 45 weeks comprise social returns.

The "Japanese Haakon Dahl" unit is variable, and a conversion of 9 cu. ft per 100 JHD was used in the earlier studies. It is not known when conversion to metric units will apply, and a more reliable volume unit will be employed.

PROFIT CALCULATION; RESULTS

Costs and returns have been discounted to the year of origin of the forest and are charged from the mid-point of the year in which they occur.

The land expectation value (L.E.V.) equivalent, that is the discounted present net worth per hectare, have been calculated for each cost constituent. They are summarised in Table 18 with the returns and net L.E.V.

The net L.E.V. are graphed in Fig. 3, with the corresponding 1967 results (Fenton and Dick, 1972a). The break-even growing costs per m^3 are given in Table 19 and graphed in Fig. 4. The internal rates of return (I.R.R.) are given in Table 20.

The results can be varied to allow for any change in a cost or return element by multiplying by $\dfrac{\text{New cost (or return)}}{\text{Old cost (or return)}}$

A large number of variables were analysed previously (Fenton and Tustin, 1972; Fenton and Dick, 1972a) and effects will be as reported earlier. Results are, of course, very sensitive to changes in the log price, but a reduction of 46% in price-on-truck would still give a 10% I.R.R.

The effects of reductions in yield are given in Table 21. If net yields are reduced

TABLE 17—Log export costs, returns and price on truck

Cartage to port (143 km)	111.11c/100 JHD	
Wharfage and storage	22.73	
Marshalling	31.37	
Stevedoring	75.00	
Inspection	1.25	
Documentation	2.00	
Fumigation contingency	2.00	
	245.46	
Sale price FOB	800.00*	
Margin for price on truck	554.54	
		= 17.62 \$/m^3

* Price at 31 December 1973

TABLE 18—Land expectation values

	L.E.V. AT INTEREST RATE % ($/ha)												
	3	4	5	6	7	8	9	10	11	12	13	14	15
DIRECT													
Land clearing) original land	27.0	25.5	24.1	22.9	21.9	20.9	20.1	19.3	18.6	18.0	17.4	16.9	16.4
Establishment) clearing schedule	75.6	51.1	37.1	28.4	22.6	18.5	15.5	13.2	11.5	10.2	9.1	8.2	7.5
Tending	37.2	25.7	19.0	14.6	11.5	9.3	7.7	6.4	5.4	4.6	3.9	3.4	2.9
Total Direct	139.8	102.2	80.2	65.9	56.0	48.7	43.2	38.9	35.5	32.7	30.3	28.4	26.7
PROTECTION													
Dothistroma	17.1	12.2	9.3	7.4	6.1	5.1	4.3	3.8	3.3	2.9	2.6	2.3	2.1
Fire	30.9	22.9	18.2	15.1	12.9	11.3	10.0	9.0	8.2	7.5	7.0	6.5	6.1
Noxious plant and animal control	14.2	9.7	7.1	5.5	4.4	3.6	3.0	2.5	2.2	1.9	1.7	1.5	1.3
Total Protection	62.2	44.9	34.7	28.0	23.4	19.9	17.3	15.3	13.6	12.3	11.2	10.2	9.4
ADMINISTRATION													
Salaries and external overheads	219.1	155.9	119.4	95.9	79.8	68.1	59.3	52.4	47.0	42.6	38.9	35.9	33.2
Buildings and stores	14.1	11.5	9.9	8.9	8.1	7.5	7.0	6.6	6.3	6.1	5.8	5.6	5.5
Vehicles	41.5	30.0	23.3	19.0	16.0	13.9	12.2	11.0	10.0	9.2	8.5	8.0	7.5
Total Administration	274.7	197.4	152.6	123.8	103.9	89.4	78.5	70.1	63.3	57.8	53.3	49.4	46.2
TOTAL GROWING COSTS	476.7	344.5	267.5	217.7	183.2	158.1	139.1	124.3	112.4	102.8	94.8	88.5	82.3
LOGGING													
Salaries and external overheads	54.6	32.8	21.0	14.1	9.7	6.8	4.9	3.6	2.6	2.0	1.5	1.1	0.9
Machinery	140.9	87.8	58.4	40.6	29.0	21.2	15.8	11.9	9.1	7.0	5.4	4.2	3.3
Cost of logging operation	593.9	354.9	226.7	151.2	103.9	73.1	52.3	38.0	27.9	20.7	15.5	11.7	8.9
Total Logging	789.4	475.4	306.2	205.8	142.6	101.1	73.0	53.4	39.6	29.7	22.4	17.0	13.1
TOTAL FOREST COSTS	1266.1	820.0	573.7	423.6	325.9	259.2	212.0	177.7	152.0	132.4	117.2	105.1	95.4
SOCIAL													
Roading	61.7	45.6	35.7	29.0	24.2	20.6	17.9	15.7	13.9	12.4	11.2	10.2	9.3
Accommodation	83.4	60.5	46.9	37.9	31.5	26.8	23.2	20.4	18.2	16.4	14.9	13.7	12.7
Total Social	145.1	106.0	82.5	66.9	55.7	47.4	41.1	36.1	32.1	28.8	26.1	23.9	22.0
TOTAL COSTS	1411.2	925.9	656.2	490.4	381.6	306.6	253.1	213.8	184.1	161.2	143.3	129.0	117.4
RETURNS													
Logs	6111.0	3652.0	2333.0	1555.7	1069.3	751.8	538.0	390.6	287.0	213.0	159.5	120.4	91.5
Rent (Social)	25.5	16.1	11.0	7.9	5.9	4.5	3.6	2.9	2.4	2.0	1.7	1.5	1.3
TOTAL RETURNS	6136.5	3668.1	2343.9	1563.6	1075.1	756.3	541.6	393.5	289.4	215.0	161.2	121.9	92.8

(Totals may not add due to rounding)

TABLE 19—Comparative break-even growing costs ($/m³)

Interest rate %	Including Social Costs 1967*	1973†	1973‡	Excluding Social Costs 1967*	1973†	1973‡
3	1.250	1.785	1.794	0.982	1.371	1.383
4	1.529	2.164	2.174	1.201	1.662	1.672
5	1.875	2.631	2.639	1.473	2.020	2.028
6	2.299	3.207	3.210	1.805	2.466	2.469
7	2.821	3.915	3.910	2.211	3.019	3.013
8	3.461	4.788	4.765	2.712	3.705	3.682
9	4.252	5.862	5.810	3.334	4.556	4.504
10	5.226	7.182	7.089	4.093	5.607	5.515
11	6.417	8.798	8.650	5.022	6.901	6.754
12	7.882	10.785	10.573	6.162	8.504	8.275
13	9.669	13.215	12.882	7.550	10.473	10.133
14	11.852	16.247	15.699	9.252	12.952	12.399
15	—	19.804	17.848	—	15.626	13.974

* Fenton & Dick, 1972(a)
† With original land clearing schedules
‡ With revised land clearing schedules

TABLE 20—Comparative Land Expectation Values (L.E.V.) and Internal Rates of Return (I.R.R.) ($/ha)

Interest rate %	Including Social Items 1967	1973†	1973‡	Excluding Social Items 1967*	1973†	1973‡
3	1495	4725	4772	1574	4845	4842
4	835	2742	2740	895	2832	2830
5	487	1688	1687	534	1759	1758
6	287	1073	1073	326	1132	1132
7	166	694	694	200	743	744
8	89	450	451	119	493	494
9	40	288	290	64	326	328
10	7.4	180	182	30	213	215
11	—14.9	105	108	7.4	135	137
12	—27	54	57	—9.9	81	83
13	—37	18	21	—20	42	45
14	—42	—7.2	—3.8	—27	15.3	18.6
15	—	—25	—21	—	—3.9	—0.4
			I.R.R. (%)			
	10.2	13.7	13.8	11.4	14.8	15.0

(Figures are rounded)
* Fenton & Dick, 1972(a)
† With original land clearing schedule
‡ With revised land clearing schedule

TABLE 21—Effects of lower volume yields on total returns and net L.E.V. (using the revised land clearing schedule, and including social items)
Land expectation values in $/ha

m^3/ha less volume	Interest rate % : 3	4	5	6	7	8	9	10	11	12	13	14	15
					A. Net L.E.V. become								
35	4351	2518	1545	979	629	405	257	158	90	44	11	—11	—27
70	3980	2298	1403	884	564	359	225	134	73	31	1.6	—18	—32
105	3609	2074	1262	789	499	313	192	111	55	18	—8	—26	—38
				B. Net L.E.V. if logging cost is proportionally reduced									
35	4399	2547	1563	991	638	411	261	161	92	46	13	—10	—26
70	4076	2356	1440	908	580	371	234	141	78	35	4	—16	—30
105	3753	2161	1318	826	524	331	205	121	62	22	—4	—23	—36

(Figures are rounded)

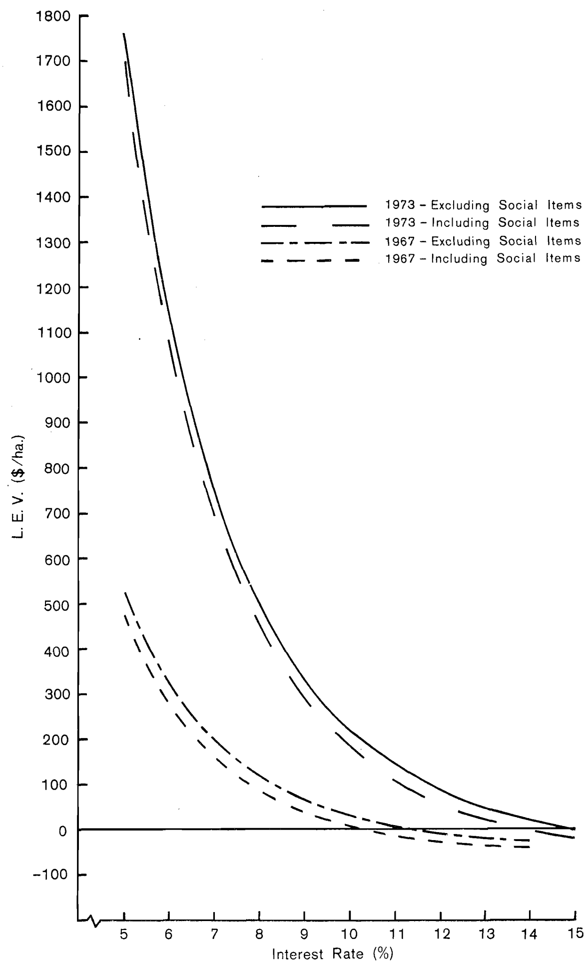

FIG. 3—Net Land Expectation Values.

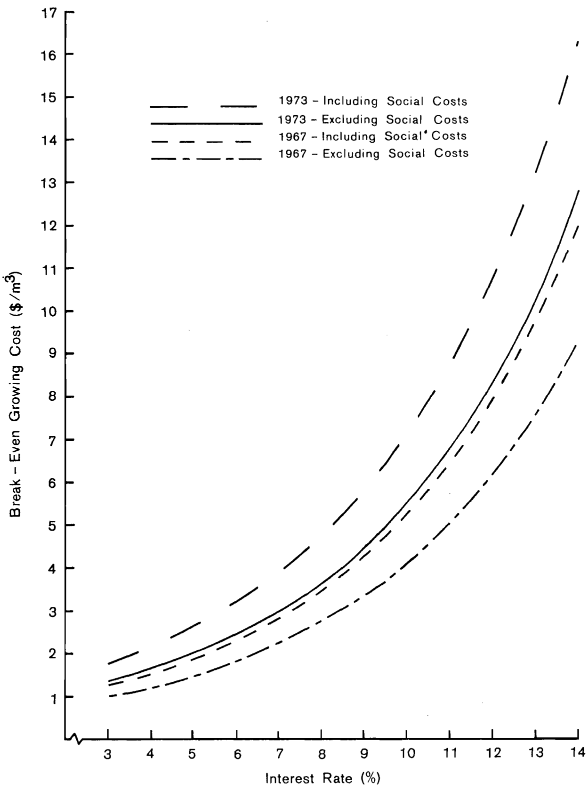

FIG. 4—Break-even Growing Costs.

by over 12% in volume, the I.R.R. is reduced from about 13.7% to 13% (using the revised land-clearing schedule and including social items). In practical terms, results at the high log prices are more rapidly affected by price than by volume changes.

DISCUSSION OF RESULTS

(a) Amendments to Previous Practice.

A number of factors have remained, or have been taken to be constant, since 1967. These include log specification, initial spacing and thinning schedules, and *Dothistroma* control. The same ratios of housing have been used, though there is a strong trend towards housing forest personnel in towns and transporting them to work. This trend was proposed earlier:

> "Overall, it seems preferable to reduce the number of people housed on the forest to a minimum, as there are strong social advantages in concentrating the population in towns so that facilities, e.g., shops, can be provided (Fenton, 1968; Fenton and Terlesk, 1971). Future forest workers will be commuters." (Fenton and Dick, 1972a).

The New Zealand Treasury opinion in 1968 was to incorporate social costs. In intra-industry studies then, corresponding social costs should presumably be charged. In any case, the isolation of each cost constituent, including roading, housing, huts, and so on, allows the effects of each to be found.

The most important management changes are at the beginning and end of the rotation in the machinery used in site preparation, re-establishment, and clear-felling. The absence of small surface streams and the relatively coarse texture of dissection allows the use of heavy machines for ground preparation before planting. This gives the first rotation a better guarantee of successful establishment, eliminates most blanking and release cutting, and permits direct establishment on frost flats. The reduction of reliance on natural regeneration/aerial seeding has been dramatic — from 90% of areas in 1962, to 66% in 1967, to zero in 1973.

The change from tracked to predominantly wheeled logging machines and a considerable increase in productivity have reduced the relative importance of logging costs. It was previously indicated:

> "The proportion of tracked to wheeled tractors is debatable; pumice country with a maximum haul of ca. 13-15 chains (260-300 m) may suit an approximately equal number of the two types. There are many microeconomic problems involved in assessing logging costs. These include:
> 1. the real effect on costs — including housing, garage space, number of mechanics, and so on — of altering productivity.
> 2. when is a machine worn out?
> 3. the best machine-men combination for different classes of felling." (Fenton and Tustin, 1972).
> Problems 1-3 still remain.

The differences in cost between the original and the revised land-clearing schedules (Tables 3a and 3b) have been calculated, and net results are given in Tables 19 and 20. At interest rates up to and including 6%, the net L.E.V. decreased very slightly with the revised schedules. At rates of 7% and over, the deferring of land-clearing costs improves results, and at the high I.R.R. obtained in these studies (over 13½%) the marginal effect is to raise I.R.R. by 0.1-0.2%.

The addition of control measures against noxious weeds and animals increases total protection costs. The forest growing-cost totals are increased by about 3, 2, and 1% at interest rates of 3, 10, and 14%, respectively. (The L.E.V. is reduced by $14, $2.5 and $0.6/ha at these interest rates). It is reiterated that for the original sites, at the time when they would have been planted, such measures would have been unnecessary (Fenton and Grainger, 1965).

(b) Changes in Costs

There has been a sharp decrease in the labour requirements of thinning to waste. It was previously reported:

> "Thinning to waste at 35 ft from ca. 600 to 150 s.p.a. (at 10.7 m from 1480 to 270 stems/ha).
> The operation in pruned stands was rated at 2½ man days per acre — a cost of $26 per acre (6.2 man days/ha, cost $64.25/ha) in the 1962 model. However, improvements in power saws and the method of using them have reduced work times. Some areas are known to have been thinned at rates of over an acre per man day (2.47 man days/ha) but 1½ man days per acre (3.47 man days/ha) have been allowed for the 1968 revision." (Fenton and Tustin, 1972).

The rate per hectare has dropped from 6.2 man days in 1962, the 3.47 in 1967/68, to 1.56 in 1973. This is considered to be the result of thinning at younger ages (stems are smaller and easier to deal with), of using better saws, and of carrying out large-scale operations on contract whenever possible.

There has been an overall reduction in fire prevention costs: look-outs have been largely been replaced by aerial patrols in times of high hazard; internal telephones have been dispensed with; and fire fighting equipment often doubles for other purposes instead of being reserved exclusively for fires.

The total staff required has been reduced by one foreman/ranger throughout, as it is considered that the relativity of staff/labour activity was unduly weighted. The Officer-in-Charge and the forester should be sufficient staff to handle the simple operations needed in export-log-trade forest management.

The amount charged and the method used for charging "external overheads" remain indeterminate and have been costed, as before, at 60% of the salary charges. State research alone cost $2.9 million in 1973 (N.Z. For. Serv. 1973), though how much the growing of forests for the log trade benefited, is conjectural. If $0.9 million is arbitrarily allotted to protection forestry (20 graduates out of a total of 106), the remaining $2 million is equivalent to about $3.3/ha annually. At 10% interest, this capitalises to $33. Head Office, Conservancy Offices, and District offices all add further to the overheads.

One deterrent to updating these studies has been the indifferent state of the Forest Service costing system.

(c) *Macroeconomic Influences*

There have been four macroeconomic factors which have affected results in the period 1967-73: inflation; the relative depression/boom in the New Zealand economy; the currency exchange rates; and the surging wood demand of Japan. The interaction of these has been complex, and only the net effect is quantified in this paper.

Inflation has, of course, increased unit costs formidably. The greatest increases have been in buildings, which have doubled in cost, and in basic labour rates—up from $0.80 to $1.80 per hour. These increases have been accentuated by the difference in the overall national economy 1967-1973. The gross national product actually fell in 1967 which was a year of economic depression, while 1973 was a boom year when the economy was fully extended. These changes were affected by a 19.45% devaluation in November 1967, and a 10% revaluation in September 1973. (There has since been a 9.45% devaluation in September 1974). During this period the Japanese yen rose and then fell in relation to the United States dollar. Log sale contracts are written primarily in New Zealand dollars. In 1967 import costs comprised 17% of total discounted costs at 7% interest, and 15% at 10% interest (Fenton, 1972).

The sustained growth of the Japanese economy, despite a relative slowdown in 1970/71, and the increase in log prices, is one of the fundamental reasons why the trade is so profitable. New Zealand remains the cheapest source of supply of softwood logs to Japan, and supplies less than 2% of Japan's total wood needs.

(d) *Comparison of 1967 and 1973 Results*

Although there have been some compensatory increases in managerial efficiency, the break-even growing costs show considerable rises since 1967 (Table 19). Inflation is raising wood-growing costs at a formidable rate and, unlike the situation in agriculture, there has been little compensatory increase in net forest yield per unit area (none in this analysis). An outstanding feature of New Zealand forestry is that the net increment actually logged from radiata pine is only about half that potentially available.

The net L.E.V. reflect the soaring increase in the log price, from around $7.7/m^3 in 1959 (Fenton, 1968) to $8.8/m^3 in 1966/67, and $17.6/m^3 in 1970 (Fenton, 1974) to $25.4/m^3 in 1973. Log exports more than tripled in volume over this period. The largest individual exporter was an integrated pulp, paper, and sawmilling company.

An I.R.R. of around 14% (13% if the unpublished volume projections apply), is high for plantation forestry and should not be ignored. Further data on the profitability of plantations plus utilisation plants, and of the Japanese market, are needed before final decisions on the scale and/or proportion of planting for the log trade can be made. But it is an outstanding prospect. Variations in log price (it is unlikely that prices will always increase) can be accommodated to some extent by retaining growing stock — an option which is less open to agriculture or to forest-processing capital. As stated previously, if the trade entirely disappears the resulting forests will be superior in quality to original 'first rotation' plantations in New Zealand (Figs. 1 and 2), and available for domestic utilisation if necessary.

The calculated level of profit is based on 'normal' afforestation, and profits can be increased by accelerated planting (Fenton and Tustin, 1972; Fenton and Dick, 1972a; 1972b). As silviculture is minimal especially in the first rotation, further managerial cost savings, as well as greater returns, are potentially available — e.g., by postponing capital costs, and results could be enhanced.

The proper balance between different forest products for export needs economic reassessment. Economic justification for the processing of forest products for export has not been forthcoming. Local industry has developed under considerable protection.

The earlier arguments:

> "There has recently been considerable emphasis on the further processing of forest products to return the highest value per unit of raw material; this is also argued to support, for example, additional aluminium and iron processing in Australia. Any such processing should also be assessed in terms of profitability, coupling forest and processing units. Calculations show total rates of return of less than 10% for pulp forests and newsprint mills where profit margins are $26 per ton — 22% of sales price f.o.b. (In the long run, commonsense should imply that in relation to states such as Japan which lack a raw material base commensurate with their population and which can only remain prosperous by efficient processing, it is better to maintain a trade in raw materials than drive them back to imperialist nationalism.)" (Fenton, 1970),

and . . .

> "If the value-added concept is to be taken seriously, the value of the final output should be expressed against each constituent of the input — e.g., it is no more logical to maximize value added per unit of wood than, say, per unit of labour, of electric power, of water used, of worker training time, or any other major input." (Fenton, 1970)

should now be fully considered.

(e) *Markets*

New Zealand has a limited Free Trade Agreement with Australia, in which forest products were supposed to be a key component. In practice there was negligible increase in forest products trade in the first 5 years of the agreement (Fenton, 1974). The trade is likely to improve in the next 5-year period. It was contended earlier:

> ". . . there is no economic reason to complacently hope Australia is going to buy New Zealand products. There will probably be political reasons, especially as New Zealand will, inevitably, be making a trade agreement with Japan in the next 5-7 years" (Fenton, 1974).

A fundamental economic case has been published (Kojima, 1971) for extended pan-Pacific trade. It appears likely that the Japanese market for wood will continue to be available on a large scale. The United States demand projections indicate that the most critical supply situation is likely to be in softwood sawn timber and plywood (USDA, 1973). The potential market of mainland China is still relatively unknown, but general market prospects appear to be encouraging, and market risks are relatively low for such a long-term prospect as the log trade. It is desirable that New Zealand should continually review its export prospects. Market forecasts for pulp and paper sales do not mention price or profitability, but only global or Pacific demand. The relevance of this criterion to a country which has to pay for the cost of production of its wood is limited, and recognition of this is long overdue. The balance between processing wood and exporting logs should be reconsidered and the real degree of advantage, if any, for forest processing should be publicly demonstrated.

CONCLUSIONS

1. Costs of production/m^3 from 1967 to 1973 have increased by 27%, at 10% interest (when social costs are included, assuming that previous yield projections apply).
2. Returns/m^3 have increased by 88% in the same period.
3. The internal rate of return has correspondingly increased from 10.2 to 13.7% when social costs are included, and from 11.2 to 14.7% when they are excluded (assuming that previous yield projections apply).
4. The profit, or the net economic benefit, of forest processing remains undemonstrated. It is recommended that because it is profitable, the export of logs should be reinstated as a major aim of forest expansion.

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APPENDIX I — Logging (clearfelling) Costs and Equipment

1. **Man hour production**

   Man hour production was set at 4.03 m^3 after consultations with work study staff.

2. **Working day; Working year**

   An 8-hour working day, and a 240-working-day year were assumed in calculating the total manpower and equipment needed.

3. **Costs of clearfelling**

   Calculations based on available data gave the following cost figures for the clearfelling operation :

Labour	0.87	\$/m^3
Machine	0.31	
Loading	0.53	
Total cost on truck	1.71	

4. **Logging equipment**

   (i) **Logging roading**

   The cost of skid site preparation is included in the cost/m^3 given above. Skid sites and associated rides are temporary roads written off when logging is completed. Two tip trucks and part of the two D7 tractors' time have been included for logging roading. These roading costs are excluded from those of ordinary forest access, the latter being classed as a social cost and calculated separately.

   (ii) **Logging machinery**

   Part of the time of the two D7 tractors would be spent on stumping logging-landings and on loading-site preparation.

   Calculation of the equipment required has been based on a tractor-day production of 224 m^3 for trees of mean d.b.h. 46 cm and mean volume 1.6 m^3. A basic gang would consist of one 120 HP skidder and one loader. It seems likely that crawler stackers would be a cheaper alternative. A ratio of six power saws per tractor unit (including spares) has been taken. One gang truck per gang of 10 men has been allowed. Table 6 gives the total equipment needed. Tractor spares are included in the cost/m^3. Service lives are given in Table 16.

These data are based on figures supplied by T. Johnson and R. O'Reilly.