

PROFITABILITY OF RADIATA PINE AFFORESTATION FOR THE EXPORT LOG TRADE — ON SITE INDEX 110

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ABSTRACT

The economics of radiata pine (*Pinus radiata* D. Don) afforestation for the export log trade are evaluated for scrub-covered country of easy topography of site index 110. Twenty thousand eight hundred net of the 25,000 acres gross are initially planted in 11 yr, felling begins in the 16th year, and yields fluctuate between 4 million and 10 million cu ft annually until normality is reached in year 47. The yield for the normal rotation of 20 yr is 8,235 cu ft per acre net of utilisation losses. Silviculture aims at producing two 39-ft logs to a 6-in small end diameter (s.e.d.) by planting at 10 × 7 ft, thinning (probably to waste) to 150 stems per acre (s.p.a.) at 35-ft top height, and clearfelling at 110 ft.

Interest rates from 3% to 14% are evaluated; 1967 costs are used.

At normality 108 men are employed, 64 of them on logging, giving an average production of 79,300 cu ft per man-year.

The proportions of major costs at 7% interest are: logging, 45%; administration, 16%; social, 14%; establishment, 11%; and tending, 7%.

A net price-on-truck of 20.8c per cu ft is obtained after allowing 8.8c for port handling and 8.7c for a single log haul of 89 miles.

Comprehensive sensitivity analyses are made on the effects of altering costs and returns; the most important effects (expressed for a 7% interest rate) are:

1. Differences in yield of 500 cu ft per acre alter land expectation values (LEV) by 16%.
2. Differences in realisations of 1c per cu ft alter LEV by 10%.
3. Break-even growing costs are 6.4c per cu ft on stump.
4. The effect of locating the forest 40 miles nearer the port increases LEV by 36%.

The net LEVs at 7% are \$145 and \$166 when social costs are included and excluded respectively. The corresponding rates of return are 13.3% and 15.7%.

Compared with results from site index 95, growing costs are 17% less; productivity per man increases by 3%, and volume production per acre is 13% higher.

INTRODUCTION

The profitability of radiata pine (*Pinus radiata* D. Don) afforestation for export logs on site indexes 95 and 80 (Lewis, 1954) has been evaluated (Fenton and Tustin, 1972; Fenton and Dick, 1972a). Results from other site indices were required by the National Development Conference, 1969 (Forestry Committee, 1969); and profitability on site index 110 (Lewis, 1954) is calculated here.

Origins of the management and financial data have been given earlier (Fenton and

Tustin, 1972); so these are only briefly considered. Costs, returns, and technical knowledge are as in 1967, except for *Dothistroma* needle blight (*Dothistroma pini* Hulbary) prevention, where the recent advent of the disease justifies use of the latest defined protection.

ASSUMED CHARACTERISTICS OF THE AREA

The area initially evaluated has been described (Fenton and Grainger, 1965). It is assumed that 20,800 out of 25,000 acres gross are planted, initial cover is inflammable scrub, topography is easy to rolling, and the port is 89 miles distant. The previous isolation of frost flats (of 1,600 acres) has been dropped; it is contended there would be few frost flats on sites of this high overall quality. The site index of Tihoi Forest adjoining the Maraetai block is 110 ft, as are extensive areas of northern Kaingaroa and Waiotapu Forests. (Most of Whakarewarewa, Rotoehu, and the Tarawera ash sites in the Bay of Plenty are of still higher site indices.)

TECHNICAL SPECIFICATIONS AND SILVICULTURE

The minimum log small-end diameter inside bark (s.e.d.) required is 6 in.; the minimum ratios of volume by log length are 60%, 39 ft; 35%, 26 ft; 5% or less, 13 and 20 ft. Logs should be reasonably straight (the tolerance of 5% of volume down to a 5.5-in. s.e.d. has been ignored). The mean tree on a 20-yr rotation yields two 39-ft lengths to a 6-in. s.e.d.

Silviculture is:

1. Planting sites are cleared and burnt before establishment.
2. Initial spacing: trees 7 ft apart in rows 10 ft apart (620 s.p.a.).
3. Blanking: 10% replacement in the year following planting is assumed.
4. Release cutting: one operation in each of the first and second years after planting. The extra operation, in comparison with the other two sites is assumed to be needed because of extra fertility.
5. Thinning (to waste): at 35-ft top height to 150 s.p.a.
6. Protection: for *Dothistroma* prevention stands would be aerially inspected each year with closer ground inspection of suspect areas; planted stands would be sprayed when at 8-10 ft, and at 18-25 ft. It is possible a third spray would be required after thinning at 35 ft. Regenerated stands would have an extra spray when trees are 3-4 ft high.
7. Clearfelling at normality at 110 ft top height at age 20.
8. Second and subsequent rotations are assumed to be replanted on a third of the area; direct seeded from the air on a third; and naturally regenerated on the remaining third. Subsequent treatment for sown and regenerated stands includes spraying against *Dothistroma* and slasher-thinning cum release-cutting at age 2. Sown and regenerated stands are not blanked. Treatment of stands of all origins is the same from about 5 ft in height onwards.

MANAGEMENT

Afforestation is complete in half the rotation, with eventual conversion to normality by more extensive felling of young stands, and retention of some stands beyond normal rotation age. The aim of normality is for convenience in accounting, it does not imply strict normality is necessary or desirable. In practice, fluctuating yields would be acceptable. The annual areas of planting, silvicultural operations, and felling are given in

Table 1. Felling begins in the 16th year (85-ft top height) and after a gradual build-up to 1,600 acres annually, finally stabilises at 1,040 acres a year.

TABLE 1—Management plan: areas of annual operations (acres)

Year	Planting		Sowing	Blanking	Release Cutting		Slasher Thinning	Thinning to Waste	Clearfelling			
	Machine	Hand			1	2			Area acres	Age yr	Year Planted	
1	1,000											
2	1,600				1,000							
3	2,000			1,000	1,500	1,000						
4	2,000			2,000	2,000	1,600						
5	2,000			2,000	2,000	2,000						
6	2,000			2,000	2,000	2,000						
7	1,000	1,000		2,000	2,000	2,000		1,000				
8		2,000		2,000	2,000	2,000		1,600				
9		2,000		2,000	2,000	2,000		2,000				
10		2,000		2,000	2,000	2,000		2,000				
11		2,200		2,000	2,000	2,000		2,000				
12				2,200	2,200	2,000		2,000				
13						2,200		2,000				
14								2,000				
15								2,000				
16		200	200					2,000	600	15	1	
17		333	333	200	200			2,200	400	16	1	
									600	15	2	
18		466	466	333	333	200	400		1,000	16	2	
									400	15	3	
19		466	466	466	466	333	666		1,400	16	3	
20		466	466	466	466	466	932		200	17	3	
									1,200	16	4	
21		466	466	466	466	466	932		800	17	4	
									600	16	5	
22		533	533	466	466	466	932	600	1,400	17	5	
									200	16	6	
23		533	533	533	533	466	932	1,000	1,600	17	6	
24		533	533	533	533	533	1,066	1,400	200	18	6	
									1,400	17	7	
25		400	400	533	533	533	1,066	1,400	600	18	7	
									600	17	8	
26		333	333	400	400	533	1,066	1,400	1,000	18	8	
27		346P	346P	333	333	400	800	1,400	400	19	8	
									640	18	9	
28				346P	346P	333	666	1,600	1,040	19	9	
29						346P	692P	1,600	320	20	9	
									720	19	10	
30								1,600	1,040	20	10	
31								1,200	240	21	10	
									800	20	11	
32								1,000	1,040	21	11	
33								1,040P	360	22	11	
									600	17	16	
									80	16	17	
34									920	17	17	
									120	16	18	
35									1,040	17	18	
36									240	18	18	
									800	17	19	
									600	18	19	

TABLE 1 (continued)

Year	Planting		Sowing	Blanking	Release Cutting		Slasher Thinning	Thinning to Waste	Clearfelling		
	Machine	Hand			1	2			Area	Age	Year Planted
37									440	17	20
38									960	18	20
									80	17	21
39									1,040	18	21
40									280	19	21
									760	18	22
41									840	19	22
									200	18	23
42									1,040	19	23
43									360	20	23
									360	20	23
44									680	19	24
									120	19	25
45									1,040	20	25
46									40	21	25
									1,000	20	26
47									1,040P	20	27

P = in perpetuity

Yield predictions are given elsewhere (Appendix 2 of Fenton and Tustin, 1972); summaries are included here in Appendix 1. The net volume logged at age 20 (normality) is 8,235 cu ft per acre.

LABOUR REQUIREMENTS: DIRECT GROWING COSTS

The direct labour content in establishing and growing the forest is given in Table 2. Logging yields and labour requirements are given in Table 3. Overall supervisory staff, and indirect labour are scheduled in Table 4; total manpower required is summarised in Table 5.

The costs of production are considered in four main groups: direct costs of growing, immediately below, following by protection costs, social costs, and indirect costs.

The labour content and costs of forest operations are as given elsewhere (Fenton and Tustin, 1972). These direct costs comprise wages and production bonus; compensation and holiday pay; direct stores charges; and transport and machinery hire. Supervision and indirect costs are charged separately. The costs of land preparation needed are listed in Appendix 2. Table 6 lists the logging equipment needed (based on Appendix 4 of Fenton and Tustin, 1972).

PROTECTION

This comprises fire and *Dothistroma* prevention and control; and some minor items. Fire prevention costs are summarised in Table 7, and *Dothistroma* costs elsewhere (Fenton and Tustin, 1972). Briefly, for *Dothistroma* protection, crops are sprayed two or three times by age 14; regenerated crops receive an extra spray by height 5 ft, spraying frequency depending on aerial and ground assessment.

TABLE 2—Manpower for forest operations

Year	Planting		Blanking	Release Cutting		Slasher Thinning	Thinning to Waste	Total man-yr
	Machine	Hand		1	2			
				man-days				
1	155							1
2	248		300	670				5
3	310		480	1,072	570			11
4	310		600	1,340	1,072			14
5	310		600	1,340	1,340			15
6	310		600	1,340	1,340			15
7	310	625	600	1,340	1,340		1,500	21
8	155	1,250	600	1,340	1,340		2,400	27
9		1,250	600	1,340	1,340		3,000	32
10		1,375	600	1,340	1,340		3,000	32
11			600	1,340	1,340		3,000	32
12			660	1,474	1,340		3,000	27
13					1,474		3,000	19
14							3,000	13
15							3,000	13
16		125					3,000	13
17		210	60	138			3,300	16
18		292	100	223	138	266		5
19		292	140	312	223	446		6
20		292	140	312	312	624		7
21		292	140	312	312	624		7
22		333	140	312	312	624	900	11
23		333	160	357	312	624	1,500	14
24		333	160	357	357	714	2,100	17
25		250	160	357	357	714	2,100	17
26		208	120	268	357	714	2,100	16
27		216P	100	223	268	536	2,100	15
28			104P	232P	223	446	2,400	15
29					232P	463P	2,400	15
30							2,400	15
31							1,800	13
32							1,500	12
33							1,560P	12P

P = in perpetuity

SOCIAL COSTS

These comprise roading, accommodation, and minor items. Table 8 shows the items charged in roading (and minor items). The schedule of housing and other accommodation is given in Table 9; 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 are based on charges of \$122 per man per year.

TABLE 3—Staff and indirect labour schedule

	Year 1	2	3	4-5	6-8	9-14	15	16	17-18	19	20-24	25-26	27
STAFF													
Officer in charge	1P												1
Forester		1P											1
Forest ranger)		1P				1P		1P					3
Forest foreman)													
Clerk	1P												1
Stores clerk						1P							1

Roading													
Officer in charge	1P												1
Men	2P						4					-3	3

Logging													
Officer in charge							1P						1
Forest ranger)								1P		1P	1	-1	2
Forest foreman)													
Clerk								1P					1
Other Labour													
Fleet													
Mechanic	1P					1P		2P					4
Driver	1P					1P		1P					3

Others													
Tractor-driver	1P												1
Fire L/O			1P										1
Camp attendant									1P				1
Carpenter)						1P				1P			2
Painter)													
Fire stores			1P										1
HQ gangs	1P			1P		1P							3
Tool maintenance	1P												1
Total	10	12	14	15	16	21	26	32	33	35	36	32	32

P = in perpetuity

INDIRECT COSTS

Staff salaries are given in Table 10; external overheads have been taken as 60% of these amounts. A forest building programme is outlined in Table 11; vehicles and stores are listed in Table 12; net charges for "services and general" costs are given in Table 13. (Compared with the lower site indexes these have been increased, or charged earlier.)

Depreciation is charged by allowing the cost of the asset concerned at the end of its service life. The service lives are as given earlier (Fenton and Tustin, 1972).

General administration costs have been charged on a per acre basis, and are included in Table 13.

RETURNS

Returns are based on the export free-on-board price at port of \$4.25 per 106 "Japanese Haakon Dahl" (JHD) units. Log cartage costs for a 178-mile round trip

TABLE 4—Volume yields and logging labour

Year	Age Class yr	Net Vol. per Acre cu ft	Total Net Volume 00 cu ft	Man-hour Production cu ft	Total Labour man-yr
16	15	4,583	27,498	65	25.2
17	16	5,310	21,240	75	
	15	4,583	27,498	65	42.0
18	16	5,310	53,100	75	
	15	4,583	18,332	65	59.0
19	16	5,310	74,340	75	59.0
20	17	5,616	11,320	80	
	16	5,310	63,720	75	58.9
21	17	5,616	44,928	80	
	16	5,310	31,860	75	58.7
22	17	5,616	78,624	80	
	16	5,310	10,620	75	66.9
23	17	5,616	89,856	80	66.9
24	18	6,318	12,636	80	
	17	5,616	78,624	80	67.9
25	18	6,318	37,908	80	
	17	5,616	33,696	80	53.3
26	18	6,318	63,180	80	47.0
27	19	6,993	27,972	80	
	18	6,318	40,435	80	50.9
28	19	6,993	72,727	80	54.1
29	20	8,235	26,352	80	
	19	6,993	50,350	80	57.1
30	20	8,235	85,644	80	63.7
31	21	9,342	22,421	80	
	20	8,235	65,880	80	65.7
32	21	9,342	97,157	80	72.3
33	22	10,584	38,102	80	
	17	5,616	33,696	80	
	16	5,310	4,248	75	53.4
34	17	5,616	51,667	80	
	16	5,310	6,372	75	41.8
35	17	5,616	58,406	80	48.5
36	18	6,318	15,163	80	
	17	5,616	44,928	80	44.6
37	18	6,318	37,908	80	
	17	5,616	24,710	80	46.6
38	18	6,318	60,653	80	
	17	5,616	4,493	80	45.1

TABLE 4 (continued)

Year	Age Class yr	Net Vol. per Acre cu ft	Total Net Volume 00 cu ft	Man-hour Production cu ft	Total Labour man-yr
39	18	6,318	65,707	80	52.2
40	19	6,993	19,580	80	
	18	6,318	48,017	80	50.3
41	19	6,993	58,741	80	
	18	6,318	12,636	80	53.1
42	19	6,993	72,727	80	54.1
43	20	8,235	29,646	80	
	19	6,993	47,552	80	57.4
44	20	8,235	75,762	80	
	19	6,993	8,392	80	62.6
45	20	8,235	85,644	80	63.7
46	21	9,342	3,737	80	
	20	8,235	82,350	80	64.0
47	20	8,235	85,644	80	63.7

are 8.7c per cu ft. Export costs and returns are given elsewhere (Fenton and Tustin, 1972); and the price loaded-on-truck at the forest is 20.8c per cu ft.

House rents of \$3 per week for 50 weeks a year, and hut rents of \$0.10 per week for 45 weeks a year comprise social returns.

PROFIT CALCULATION: RESULTS

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

The land expectation value (LEV) equivalents — or the present net worth per acre — for each individual cost-and-return element was calculated for interest rates of 3% to 14%. Costs are grouped by major classes in Table 14. The net LEVs — the prices which could be paid for the land to break-even at the various interest rates — are also given in Table 14 and graphed in Fig. 1. The internal rates of return, or the rates of interest generated by the project are found from Fig. 1. They are:

- (a) including social costs — 13.3%
- (b) excluding social costs — 15.7% (by extrapolation).

The relative importance of the major classes of costs to loaded-on-truck is shown in Fig. 2, and the proportion of the major growing and utilisation costs in Fig. 3.

The break-even growing costs are given in Table 15; these are the forest costs of production per net unit of wood (viz., the volume which is finally extracted and loaded). They are shown graphically in Fig. 4.

The effect of forest location on profitability is given in Table 16, and illustrated in Figs. 5 and 6.

The effects of differences in volume yield are shown in Table 17 as the LEV equivalent of logged volume per acre; they are illustrated in Fig. 7.

TABLE 5—Total labour in man-years

Year	Forest*	Staff and Indirect†	Logging‡	Total
1	1	10		11
2	5	12		17
3	11	14		25
4	14	15		29
5	15	15		30
6	15	16		31
7	21	16		37
8	27	16		43
9	32	21		53
10	32	21		53
11	32	21		53
12	27	21		48
13	19	21		40
14	13	21		34
15	13	26		39
16	13	32	25	70
17	16	33	42	91
18	5	33	59	97
19	6	35	59	100
20	7	36	59	102
21	7	36	59	102
22	11	36	67	114
23	14	36	67	117
24	17	36	68	121
25	17	32	54	103
26	16	32	47	95
27	15	32P	51	98
28	15		54	101
29	15		57	104
30	15		64	111
31	13		66	111
32	12P		73	117
33			54	98
34			42	86
35			49	93
36			45	89
37			47	91
38			45	89
39			52	96
40			51	95
41			53	97
42			54	98
43			58	102
44			63	107
45			64P	108P

* From Table 2

‡ From Table 4

† From Table 3

P = in perpetuity

The effects of changes (reductions) in net returns are given in Table 18, and graphed in Fig. 8.

The labour needed, by number and skills, is given in Tables 2 to 5.

DISCUSSION OF RESULTS: CONCLUSIONS

Comparative results from afforesting the three site indices are fully considered in a further paper (Fenton and Dick, 1972b); hence comment here is restricted to a few

Fenton & Dick — Site Index 110
 TABLE 6—Schedule of logging equipment

Year	Tractors			Arches		Loaders		Gang Trucks		Power Saws		F.S.U.*	Misc.
	D/7	D/6		T	+/-	T	+/-	T	+/-	T	+/-	T	
	T	T	+/-	T	+/-	T	+/-	T	+/-	T	+/-	T	
15	1												\$4,600†
													2 tip trucks at \$4,500 each
													1 Trekka truck at \$1,770
16		3	3	3	3	2	2	1	1	12	12		\$2,500†
17	2	6	3	5	2	3	1	2	1	24	12	1	
18	P	8	2	8	3	4	1	3	1	32	8		\$2,500†
20		9	1							36	4		
22		10	1	10	2	5	1	4	1	40	4	2P	
25		8	-2	8	-2	4	-1	3	-1	32	-8		
28		9	1							36	4		
30		10	1	9	1	5	1	4	1	40	4		
32		11	1	10	1					44	4		
33		9	-2	8	-2	4	-1			36	-8		
34		7	-2	6	-2	3	-1	3	-1	28	-8		
36				7	-1								
38		8	1			4	1			32	4		
41				8	1								
43		9	1	9	1			4	1	36	4		
44		10	1	P		5	1	P		40	4		
		P				P				P			

*F.S.U. = Field Service Unit
 † Miscellaneous equipment
 ‡ Stores
 T = total
 +/- = addition or deletion
 P = in perpetuity

TABLE 7—Fire protection costs

Item	Year	Cost
Firebreaks - preparation	1-9	\$433 p.a.
Fencing	1-5	\$500 p.a.
Equipment - Radio	3	\$1,200
Fire engine	3	\$10,200
Miscellaneous equipment	3	\$3,400
Fire pumps (2)	4	\$1,200
Fire tanker	5	\$3,600
Telephone	3	\$1,225
Buildings - Lookout		
Capital	3	\$5,500
Maintenance	4 onwards	1½%*
Depreciation		65-year life
Garage and store		
Capital	5	\$4,400
Maintenance	6 onwards	1½%*
Depreciation		

Annual charges are roughly proportional to the area planted

\$0.81 per ac up to 7,500 ac

\$0.53 per ac from 7,500 to 13,000 ac

\$0.46 per ac above 13,000 ac

* Included in annual charges

TABLE 8—Social costs, excluding housing

Year	Formation \$	Metalling	ROADING				MISCELLANEOUS				
			Maintenance		Equipment		Water Supply*	Site Preparation	Share of Services [†]		Services N.E.I.‡
			Forest Area acres	Cost/ acre \$	Item	Cost \$			Acreage	Cost/ acre \$	
1	8,800		1,000	0.30	tip truck (½)	2,250	2,500	1,000	1,000	0.215	3,000
2	8,800		2,600	0.30			2,500		2,600	0.19	
3	8,800		4,600	0.30			1,100	1,200	4,600	0.16	6,000
4	8,800		6,600	0.30					6,600	0.13	
5	8,800		8,600	0.30	Grader 10-cwt truck	20,000 2,000			8,600	0.11	
6	8,800		10,600	0.30					10,600	0.088	
7	8,800		12,600	0.30					12,600	0.075	3,000
8	8,800		14,600	0.30					14,600	0.0675	
9	8,800		16,600	0.30					16,600	0.0625	3,700
10	8,800		18,600	0.30					18,600	0.06	
11	8,800		20,800	0.30P	tip truck (½)	2,250			20,800	0.06P	
12	8,800										
15		\$9,600 per year up to and including year 24									

* These amounts are half of the total costs; an equal amount is allotted to 'Capital Works' - Table 11.

† These amounts are half of the 'Services' component of the repairs and maintenance charge - Table 13.

‡ N.E.I. = not elsewhere indicated.

P = in perpetuity

TABLE 9—Forest accommodation requirements

Year	Number to Be Accom.	Houses		Huts		Other
		New	Total	New	Total	
1	1	1	1	-	-	House units costs
2	7	6	7			\$8,400 each;
3	14	7	14			65-yr life;
4	18	4	18			1¼% annual
5	19	1	19			repairs and
6	20	1	20			maintenance
7	26	6	26			charge
8	32	6	32			
9	42	10	42			
10	42	-	42			
11	42	1	43P			
12	37					
15		Cookhouse	\$17,000			1¼% annual
		Caterer's house	\$6,700			repairs and
		Ablution block	\$5,600			maintenance
						charge.
16	59			16	16	Hut unit costs
17	80			21	37	\$700 each;
18	86	Cookhouse extension	\$10,700	6	43	20-yr life;
		Ablution block extn	\$3,300			
19	91			3	48	
20	91			2	48	
21	91				48	
22	103			12	60	
23	106			3	63	
24	110			4	67	
	(maximum)					
33				-10	57	Credit for huts

salient points. When results are compared with those from site index 95:

1. The 15% greater annual volume increment requires only 11% more labour and overall productivity per man increases by 3%. This is due largely to more efficient spread of supervisory staff: it could be argued that they ought to be paid more for greater responsibilities.
2. The higher increment reduces the rotation by 13%; hence greater volumes are available earlier throughout. Much the same initial investment in labour, tree-stock, and capital items results in 13% earlier yields on the higher quality site; the implications for national planning are considerable. The discussion on planting programmes summarised in the Forestry Sector Report, Forestry

TABLE 10—Salaries

Category	Year											
	1	2	3	4-6	7	8	9-14	15	16-18	19	20-24	25+
A. <u>Forest Staff</u>												
Officer in charge	3,410	3,410	3,410	3,550	3,550	3,750	3,750	3,750	,900	,900	,900	,900
Forester		2,570	2,570	2,810	2,810	2,810	2,810	2,810	3,170	3,170	3,710	3,710
Foreman		2,250	2,250	2,250	2,360	2,360	2,360	2,360	4,160	4,610	4,610	4,610
Ranger							2,570	2,690	2,690	2,690	2,690	2,690
Roading ranger	2,250	2,250	2,250	2,360	2,570	2,570	2,570	2,570	2,690	2,690	2,690	2,690
Clerk	2,230	2,230	2,230	2,450	2,450	2,450	2,450	2,690	2,690	2,690	2,690	2,690
Stores clerk							2,450	2,450	2,450	2,450	2,450	2,450
Total (A)	7,890	12,710	12,820	13,510	13,740	13,940	18,960	19,320	22,200	22,200	22,200	22,200
B. <u>Logging Staff</u>												
Officer in charge								3,410	3,410	3,410	3,410	3,410
Foreman									2,360	2,360	2,360	2,360
Ranger										2,690	5,380	2,690
Clerk									2,230	2,230	2,230	2,230
Total (B)								3,410	8,000	10,690	13,380	10,690
Total (A + B)								22,730	30,200	32,890	35,580	32,890

Fenton & Dick — Site Index 110
TABLE 11—Capital works required

Year	Item	Cost \$
1	Office and store	7,750
	Petrol store	3,300
	Telephone line	1,225*
	Water supply	2,500 [†]
2	Garage/workshop	16,000
	Water supply	2,500 [†]
3	Water supply	1,100 [†]
15	Office extension	7,750
	Garage extension	16,000

*An equal amount is charged to protection

[†]An equal amount is charged to social costs

Other services N.E.I. charged to social costs; fencing has been charged to forest protection.

TABLE 12—Vehicles and stores

Year	No.	Description	Cost (\$)	Charged to
1	1	10-cwt truck*	2,000	Forest
	2	Gang trucks	5,000 each	Forest
1	1	Tip truck	4,500	Forest ($\frac{1}{2}$) Roading ($\frac{1}{2}$)
	1	HD6 tractor	13,250	Forest
	3	1	Office car* Class 'A' stores Consumable stores	2,500 1,100 1,150
5	1	10-cwt truck*	2,000	Roading
	1	Grader	20,000	Roading
		Consumable stores	1,725	Forest
8	1	10-cwt truck	2,000	Forest
		Class 'A' stores	5,000	Forest
10		Consumable stores	2,875	Forest
11	1	Tip truck	4,500	Forest ($\frac{1}{2}$) Roading ($\frac{1}{2}$)
		Class 'A' stores	5,000	Forest
15		Class 'A' stores	3,500	Forest
19		Miscellaneous plant and equipment	9,200	Forest ($\frac{1}{2}$) Logging ($\frac{1}{2}$)
	1	Trekka truck*	1,770	Logging
22	3	10-cwt trucks*	2,000 each	Forest
		Consumable stores	2,900	Forest
22		Consumable stores	2,900	Forest

* Annual charges, excluding depreciation, on these vehicles are \$755 per year

TABLE 13—Services and general assets, repairs and maintenance, and administration costs

Year	Acreage	'General' Charge per acre, \$	Total S. and G. charge, \$*	General Administration Costs per acre, \$
1	1,000	0.86	1.075	1.152
2	2,600	0.76	0.95	1.152
3	4,600	0.64	0.80	0.576
4	6,600	0.53	0.66	0.576
5	8,600	0.44	0.55	0.576
6	10,600	0.36	0.39	0.408
7	12,600	0.30	0.375	0.408
8	14,600	0.27	0.34	0.408
9	16,600	0.25	0.31	0.348
10	18,600	0.24	0.30	0.348
11	20,800	0.24	0.30	0.348

* Total = services and general repairs and maintenance.

Services = $\frac{1}{2}$ of the general charge, but half of the 'Service' total is already debited to Social accounts (in Table 8).

Committee, 1969) of the National Development Conference states: "[data] . . . show arrested growth in the period 1980-95. This arises as a result of small plantings in the 1940s and 1950s. The main impact of the recommended programme is on the wood supply available after the year 2000." Clearly the sooner the wood is available, the better.

3. The more concentrated volume reduces overall log hauls, though this is not reflected in the profits. To produce the same volume from a lower site quality, a greater area, and hence haul, would be needed.
4. Reduced degrees of biological, physical, and marketing risk are incurred in a shorter rotation, but cannot be quantified on present knowledge. The area of annual re-establishment of second, and subsequent rotations is, however, greater for short rotation crops, and any delays in restocking are proportionally more significant; hence managerial risks are higher.
5. The shorter rotation increases the relative importance of utilisation costs. Results are still very sensitive to changes in realisation.
6. Profitability is greatly increased, the LEV at 7% is over 50% higher, and the cost of production per cu ft is 17% lower. The internal rates of return generated (13 1/3% and 15 1/2% respectively including and excluding social costs) are high for a long term project such as forestry.

TABLE 14—Costs, returns, and net

	LEV at Interest					
	3	4	5	6	7	8
	\$ per acre					
FOREST COSTS						
<u>Direct</u>						
Land clearing	3.59	3.52	3.44	3.35	3.31	3.2
Establishment	29.73	24.49	21.14	18.74	16.90	15.4
Tending	34.41	25.05	19.40	15.62	12.92	10.8
Total Direct	67.73	53.06	43.98	37.71	33.13	29.5
<u>Protection</u>						
Dothistroma	14.05	10.54	8.38	6.91	5.84	5.0
Fire	14.29	10.50	8.24	6.75	5.70	4.9
Total Protection	28.34	21.04	16.62	13.66	11.54	9.9
<u>Administration</u>						
Salaries and external overheads	58.01	42.14	32.79	26.62	22.30	19.1
Buildings, stores	3.87	3.18	2.76	2.46	2.24	2.0
Vehicles	11.56	8.43	6.55	5.33	4.48	3.8
Total Administration	73.44	53.75	42.10	34.41	29.02	25.0
Total Growing Costs	169.51	127.85	102.70	85.78	73.69	64.5
<u>Logging</u>						
Salaries and external overheads	14.37	9.30	6.43	4.64	3.46	2.6
Machinery	92.25	60.70	42.77	31.51	23.91	18.5
Extraction	231.82	146.82	99.76	70.95	52.07	39.1
Total logging	338.44	216.82	148.96	107.10	79.44	60.3
Total Forest Costs	507.95	344.67	251.66	192.88	153.13	124.8
<u>Social</u>						
Roading	16.87	13.19	10.85	9.22	8.03	7.0
Accommodation	31.25	24.53	20.57	17.96	16.04	14.5
Total Social Cost	48.12	37.72	31.42	27.18	24.07	21.6
Total Cost	556.07	382.39	283.08	220.06	177.20	146.5
RETURNS						
Logs	1,381.20	881.33	603.37	432.19	319.52	241.8
Rent (social)	7.39	5.25	4.00	3.18	2.61	2.1
NET VALUES						
Excluding Social Items	873.25	536.66	351.71	239.31	166.39	116.9
Including Social Items	832.52	504.19	324.29	215.31	144.93	97.4

TABLE 15—Break-even growing costs

Interest rate	LEV equivalent of 1c per cu ft	Break-Even Growing Cost	
		Including Social Costs	Excluding Social Costs
%	\$ per acre	c per cu ft	c per cu ft
3	66.404	3.277	2.552
4	42.372	3.907	3.017
5	29.008	4.623	3.540
6	20.779	5.436	4.128
7	15.362	6.363	4.796
8	11.625	7.415	5.551
9	8.956	8.615	6.406
10	7.000	9.967	7.365
11	5.534	11.532	8.478
12	4.419	13.285	9.712
13	3.558	15.295	11.124
14	2.885	17.545	12.703

APPENDIX 1

VOLUME YIELDS

The stand data are summarised in Table 19. The origin of the yields is given in Appendix 2 of Fenton and Tustin 1972. The Japanese log trade requires a minimum of 60% of volume in 39-ft lengths; 35% in 26-ft; and 5% in 13- and 20-ft lengths. The log yield for mean trees is shown in Table 20. The net yield has been calculated by reducing the gross yield by approximately 10%. The mortality trend in such stands is difficult to forecast (only a minor area reaches age 22); data on stem-breakage points are not available; and more data to predict yields with greater accuracy are desirable.

APPENDIX 2

LAND PREPARATION

The unit costs are the same as in the original model. The area burnt in year 4 has been reduced as more of the forest has been planted before this. For a similar reason, the felling, burning, and bulldozing of the remaining bush has been advanced. The schedule is given in Table 21.

TABLE 16—Effect of location on profitability

	Distance of Forest from Port miles	Log Haul Cost c per cu ft	Interest Rate %											
			3	4	5	6	7	8	9	10	11	12	13	14
A.			Change in LEV (\$ per acre)											
Positive	18-20	3.21	393.02	250.84	171.70	122.95	90.85	68.74	52.92	41.40	32.69	26.11	21.05	17.05
	21-30	4.05	336.87	215.01	147.17	105.39	77.87	58.92	45.36	35.48	28.02	22.38	18.04	14.62
	31-40	4.89	280.73	179.17	122.64	87.82	64.89	49.10	37.80	29.57	23.35	18.65	15.04	12.18
	41-50	5.73	224.80	143.34	98.11	70.26	51.91	39.28	30.34	23.65	18.68	14.92	12.03	9.74
	51-60	6.57	168.44	107.50	73.58	52.69	38.93	29.46	22.68	17.74	14.01	11.19	9.02	7.31
	61-70	7.41	112.29	71.67	49.06	35.13	25.96	19.64	15.12	11.83	9.34	7.46	6.01	4.87
	71-80	8.25	56.15	35.83	24.53	17.56	12.98	9.82	7.56	5.91	4.67	3.73	3.01	2.44
	81-90	9.09	0	0	0	0	0	0	0	0	0	0	0	0
Negative	91-100	9.93	56.15	35.83	24.53	17.56	12.98	9.82	7.56	5.91	4.67	3.73	3.01	2.44
			and so on in parallel series											
B.			Net LEV (\$ per acre)*											
	18-20		1,223	753	495	337	235	166	117	82	56	37	23	12
	21-30		1,167	718	471	320	222	156	109	76	52	33	20	10
	31-40		1,111	682	446	303	209	146	102	70	47	30	17	7
	41-50		1,056	647	422	285	197	136	94	64	42	26	14	5
	51-60		1,000	611	397	268	184	127	87	58	38	22	11	2
	61-70		944	575	373	250	171	117	79	53	33	19	8	-1.5
	71-80		888	540	349	233	158	107	72	47	28	15	5	-3
	81-90		832	504	324	215	145	97	64	41	24	11	2	-5

* Including social costs and returns

TABLE 17—Effect of lower yields on total returns; net LEV

cu ft/ac less	Interest Rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
A. Returns, LEV reduction												
500	98.84	65.38	46.12	33.86	25.56	19.70	15.40	12.40	9.76	7.88	6.40	5.23
1000	197.68	130.77	92.24	67.73	51.13	39.39	30.81	24.81	19.52	15.76	12.80	10.47
1500	296.52	196.15	138.36	101.59	76.69	59.08	46.21	37.21	29.28	23.64	19.20	15.70
B. Net LEV's becomes												
500	733.68	438.81	278.17	181.45	119.37	77.75	48.91	28.39	13.91	3.30	-4.53	-10.22
1000	634.84	373.42	232.05	147.58	93.80	58.06	33.50	15.98	15	-4.58	-10.93	-15.46
1500	536.00	308.04	185.93	113.72	68.24	39.39	18.10	3.58	-5.61	-12.46	-17.33	-20.69
C. Net LEV's if logging cost is proportionally reduced*												
500	747	447	292	184	122	79	50	30	14	3	-4	-10
1000	661	389	242	155	99	61	36	18	5	-4	-10	-15
1500	575	332	201	124	76	45	22	7	-3.7	-11	-17	-20

* Including social costs and returns, when logging costs are proportionately reduced.

TABLE 18—Effect of changes in returns on profitability

Price loaded on truck at forest c per cu ft	Interest Rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
A. Value of logs - LEV in \$ per acre												
20.8	1,381	881	603	432	320	242	186	146	115	92	74	60
19.8 (1c less)	1,315	839	574	411	304	230	177	139	110	88	70	57
10.8 (10c less)	717	457	313	224	166	126	97	76	60	48	38	31
2.8 (18c less)	186	119	81	58	43	33	25	20	15	12	10	8
B. Net LEV in \$ per acre*												
20.8	833	504	324	215	145	97	64	41	24	11	2	-5
19.8 (1c less)	767	462	295	194	130	85	55	34	19	7	-2	-8
10.8 (10c less)	169	80	34	7	-9	-19	-25	-29	-31	-33	-34	-34
2.8 (18c less)	-362	-258	-198	-159	-132	-112	-97	-85	-76	-69	-62	-57

*Including social costs and returns

TABLE 19—Volume summary

Rotation Age yr	Top Height ft	Basal Area per acre sq ft	Mean d.b.h. in.	Total Volume cu ft	Net yield cu ft
15	85	178	14.8	5,100	4,583
16	90	195	15.4	5,800	5,310
17	95	211	16.1	6,500	5,616
18	100	228	16.8	7,500	6,318
19	105	245	17.4	8,500	6,993
20	110	261	17.9	9,400	8,235
21	116	281	18.6	10,600	9,342
22	122	301	19.2	11,900	10,584

TABLE 20—Log lengths from mean trees

Stand Age yr	Top Height ft	Approximate Height 6-in. Top ft	Log Lengths Yielded ft	
15	85	57	40	13
16	90	62	40	20
17	95	67	40	26
18	100	72	40	26
19	105	77	40	26
20	110	82	40(2)	
21	116	87	40	26
22	122	95	40	26(2)

TABLE 21—Land preparation schedule

Year	Method	Area acres	Rate/Acre \$	Cost \$
1	Cut heavy scrub	1,500	17	25,500
	Crush heavy scrub	1,500	6	9,000
	Crush light scrub	6,000	4	24,000
	Overall burn	24,000	0.06	1,440
4	Overall burn	14,000	0.5	7,000
5-10	Annual of bush	2,000 p.a.	0.5	6,000
6	Felling of bush	500	32	16,000
7	Burn of bush	500	1	500
11	Bulldozing bush slash	500	16	8,000

REFERENCES

- FENTON, R., and DICK, M. Merle. 1972a: Profitability of radiata pine afforestation for the export log trade — on site index 80. **New Zealand Journal of Forestry Science 2 (1) (this issue)**:
- . 1972b: Significance of the profit studies of afforestation for the export log trade. **New Zealand Journal of Forestry Science 2 (1) (this issue)**: 144-64.
- FENTON, R., and GRAINGER, M. B. 1965: Economic results from afforestation of the Maraetai blocks. **New Zealand Forest Service, Forest Research Institute Silviculture Branch Report 31** (unpublished).
- FENTON, R., and TUSTIN, J. R. 1972: Profitability of radiata pine afforestation for the export log trade — on site index 95. **New Zealand Journal of Forestry Science 2 (1) (this issue)**: 7-68.
- LEWIS, E. R. 1954: Yield of unthinned *Pinus radiata* in New Zealand. **New Zealand Forest Service, Forest Research Institute Research Note 1 (10)**.
- FORESTRY COMMITTEE, 1969: "Report of the Forestry Committee to the Second Plenary Session of the National Development Conference" (NDC 5). Government Printer, Wellington.

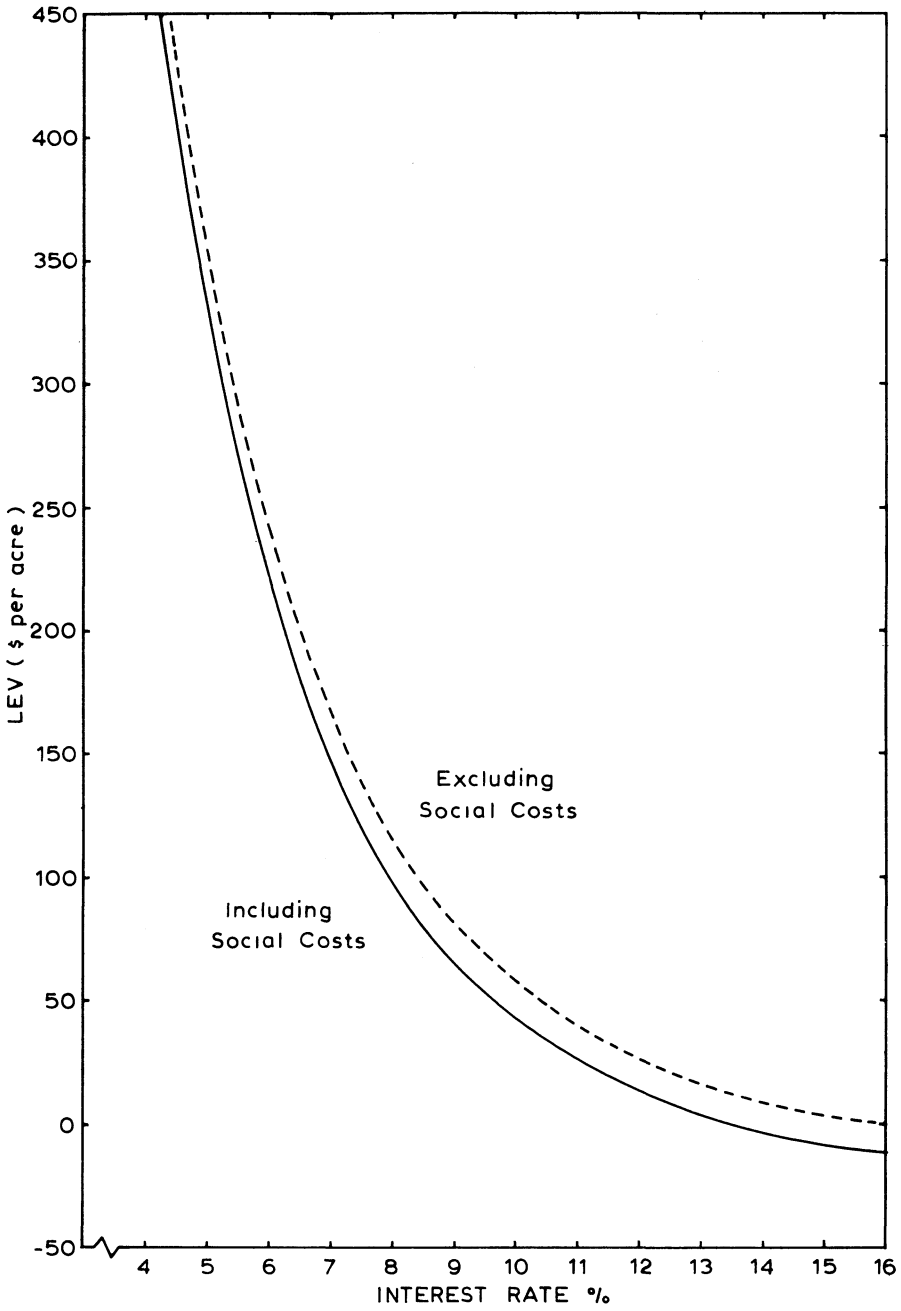


FIG. 1—Net LEV, site index 110

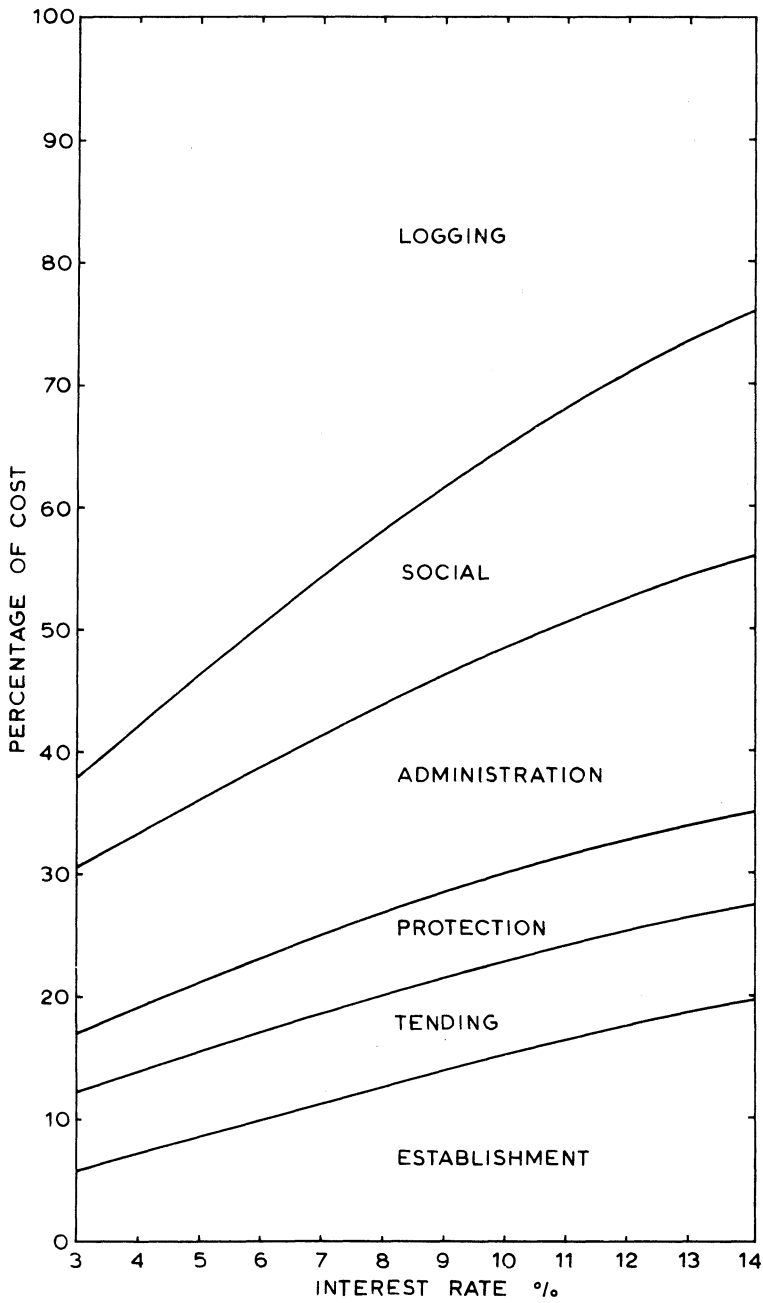


FIG. 2—Relative importance of forest costs: percentage of cost loaded-on-truck.

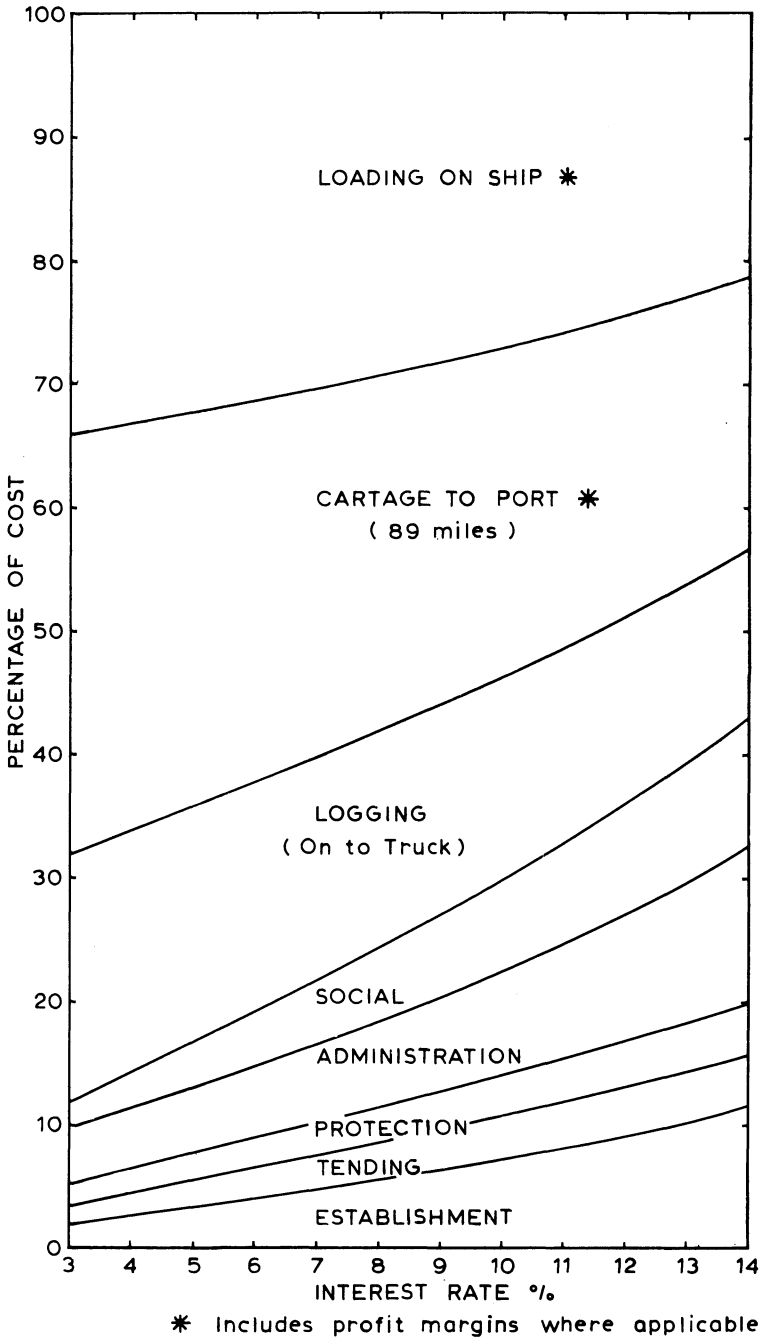


FIG. 3—Relative importance of forest and utilisation costs: percentage of cost f.o.b. Mt Maunganui (based on equivalent LEV)

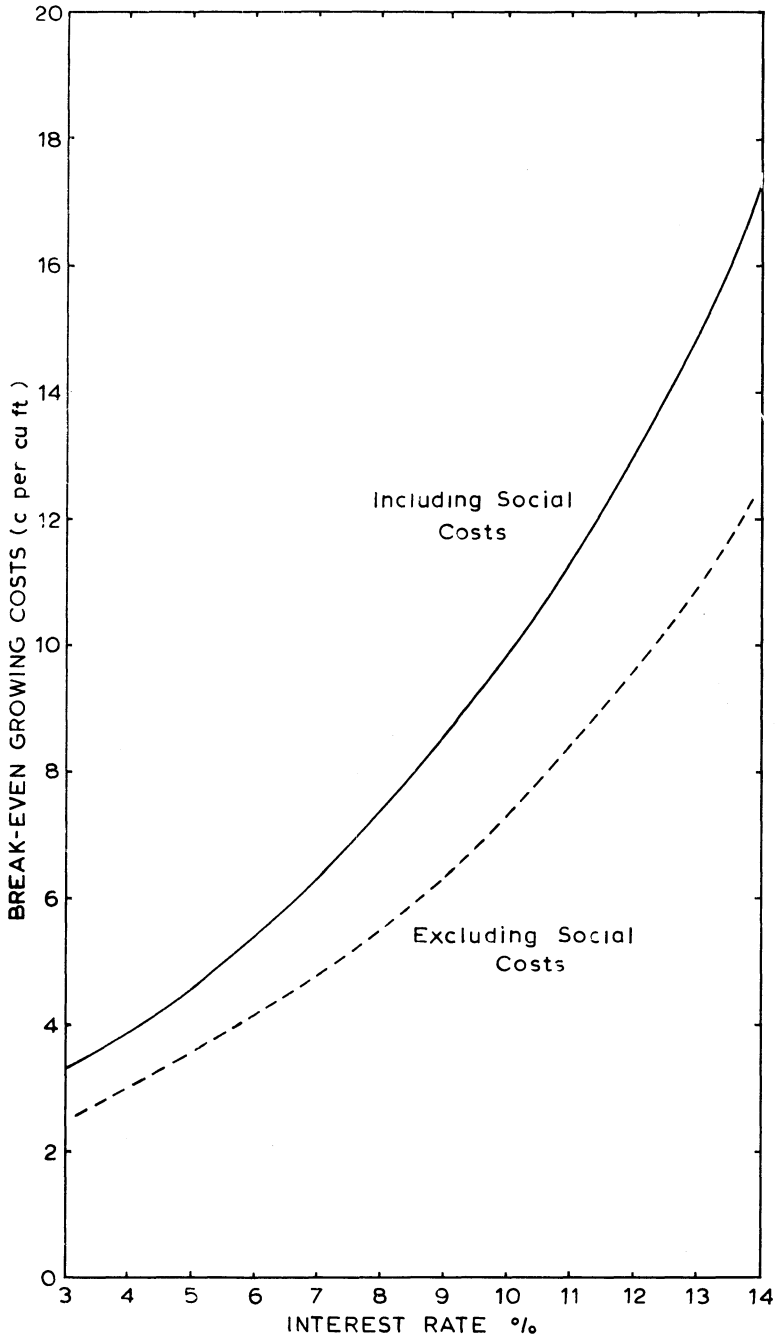


FIG. 4—Break-even growing costs.

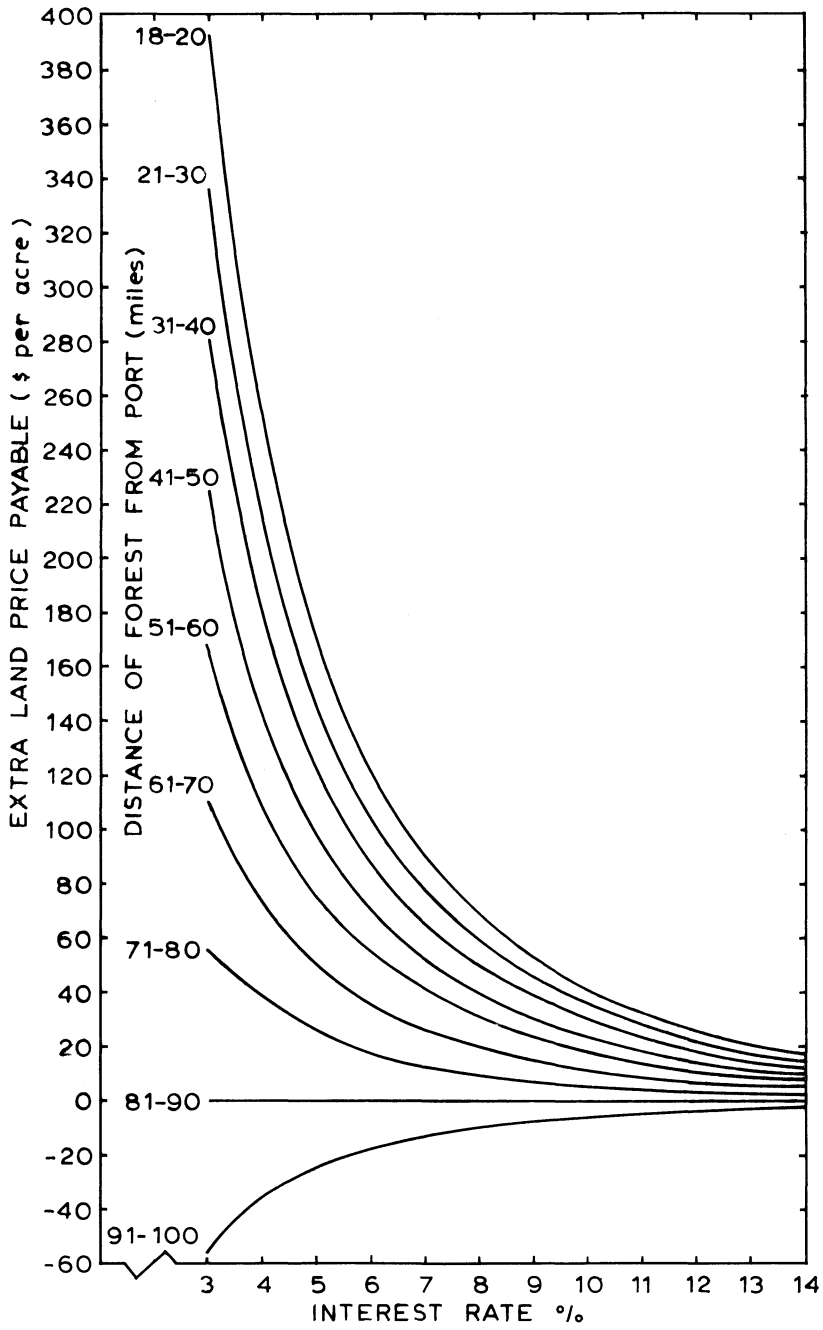


FIG. 5—Location effect on profit.

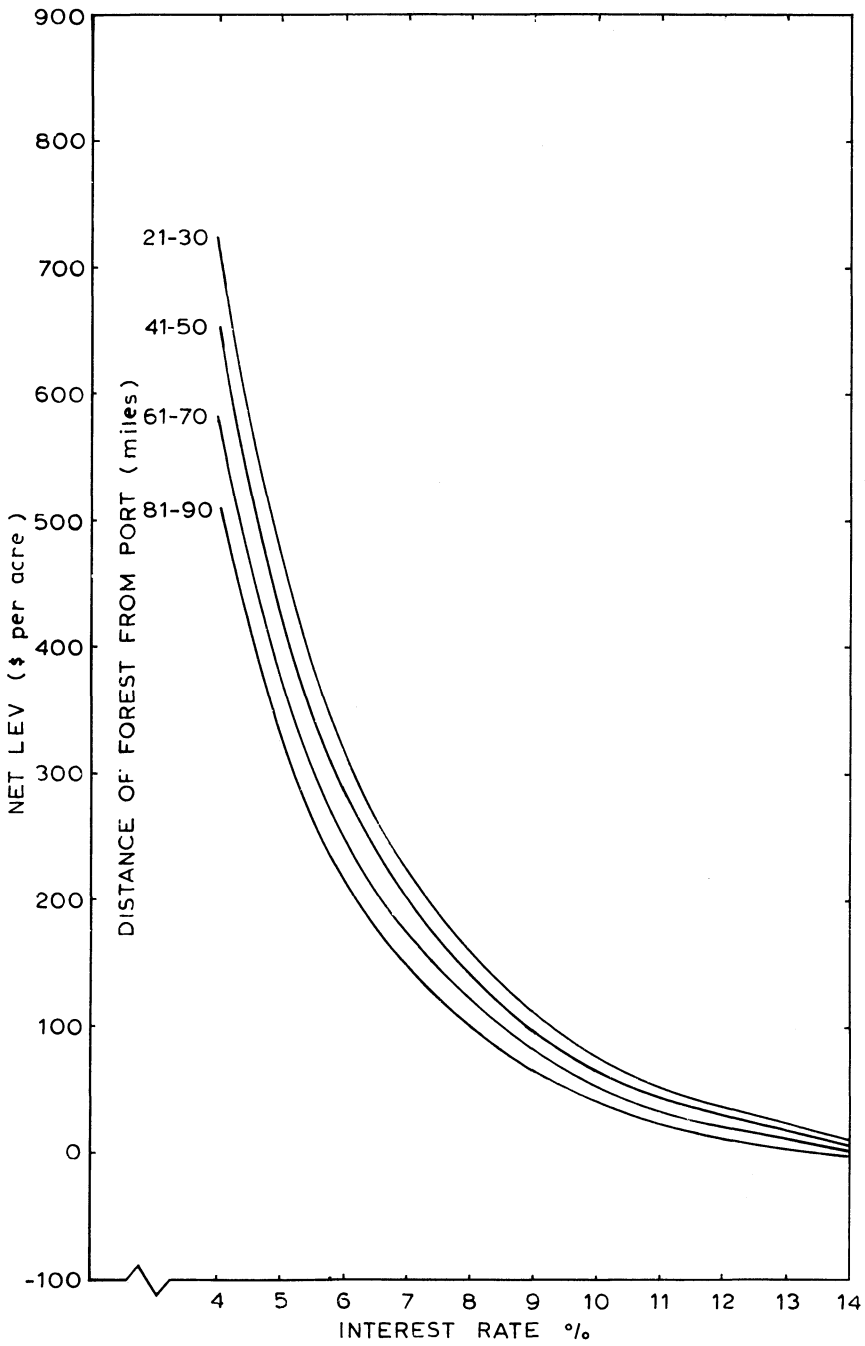


FIG. 6—Effect of location on net LEV

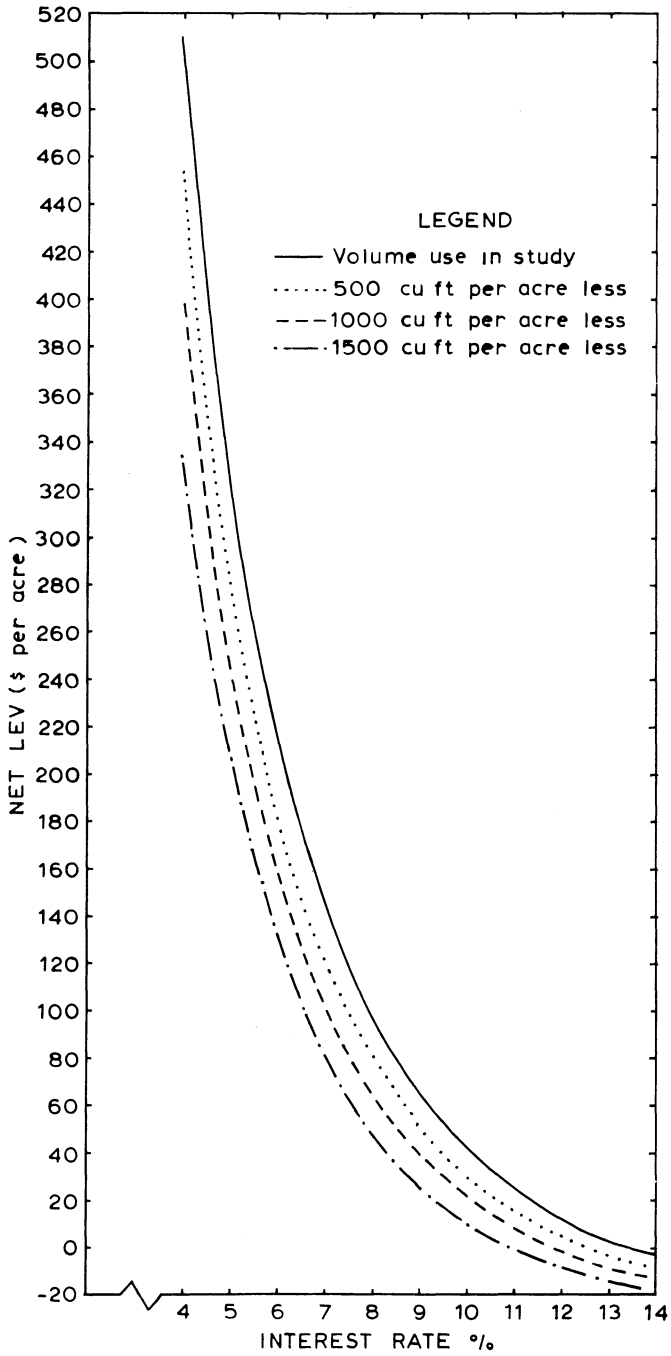


FIG. 7—Effect of lower yields on net LEV.

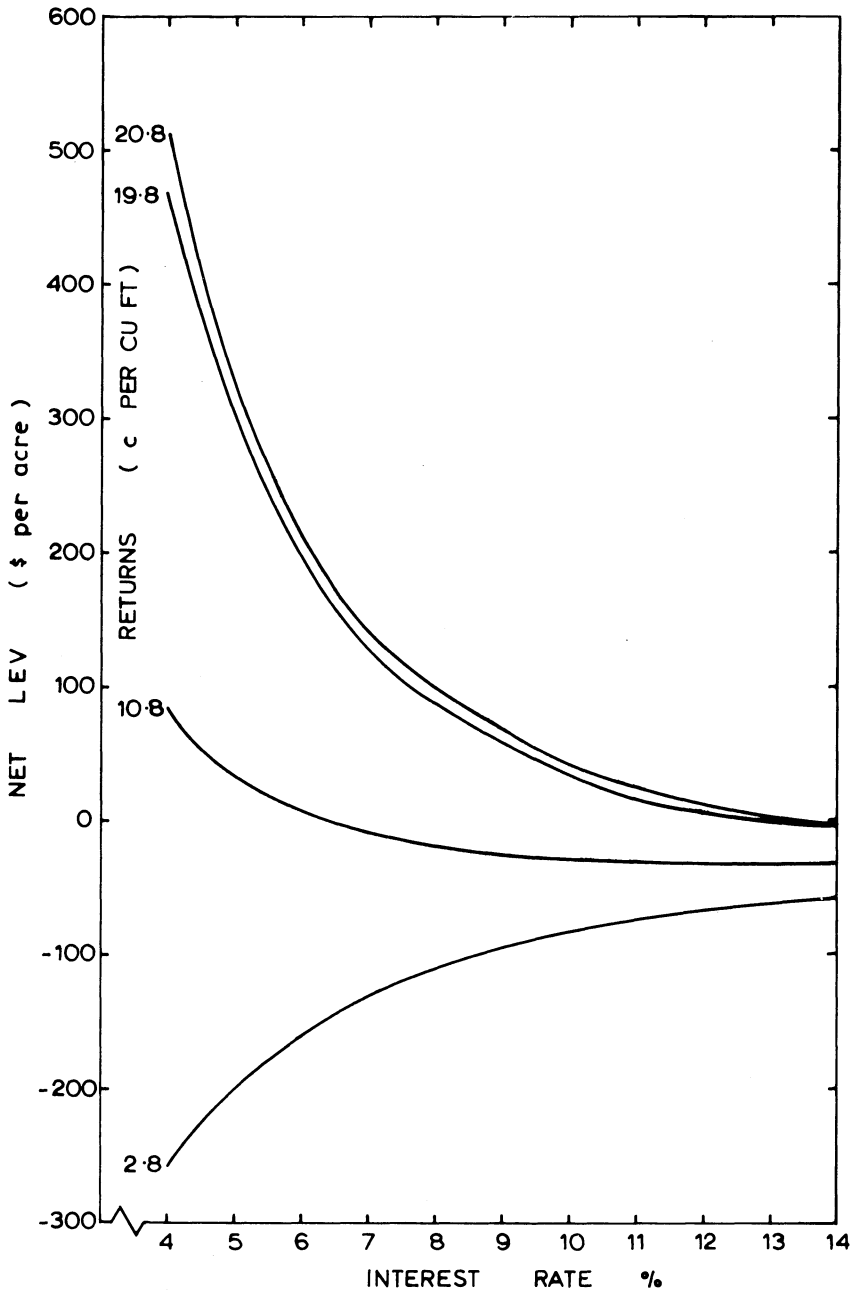


FIG. 8—Effect of changes in returns on net LEV.