

PROFITABILITY OF RADIATA PINE AFFORESTATION FOR THE EXPORT LOG TRADE — ON SITE INDEX 80

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ABSTRACT

The economics of radiata pine (*Pinus radiata* D. Don) afforestation for the export log trade are evaluated for easy to rolling scrubland of site index 80. Twenty thousand eight hundred net of the 25,000 acres are initially planted by year 13, felling begins in year 25, and yields fluctuate between 4 million and 8.4 million cu ft annually until formal normality is reached in year 58. The yield for the normal rotation of 29 yr is 8,235 cu ft per acre net of utilisation losses. Silviculture aims at producing two 39-ft logs to a 6 in. s.e.d. by planting at 10×7 ft, thinning (probably to waste) to 150 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.

Eighty-two men are employed at normality, 49 of them on logging, giving an average production of 72,000 cu ft per man per year.

The proportions of major costs to a loaded-on-truck basis at 7% interest are logging 32%, administration 24%, establishment 13%, tending 7%, and social 16%.

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) being differences in yield of 500 cu ft per acre altering land expectation values (LEV) by 45%, differences in realisations of 1c per cu ft altering LEV by 23%, break-even growing costs being 11.3c per cu ft on stump, and the effect of locating the forest 40 miles nearer the port increasing LEV by 74%. The net LEVs at 7% are \$31 and \$48 when social costs are included and excluded respectively. The corresponding internal rates of return are 8.5% and 9.6%.

Compared with results from site index 95, growing costs are 47% greater (at 7%); productivity per man decreases by 6½%, and a 25% greater area would be required to obtain the same volume.

INTRODUCTION

This paper evaluates profitability of afforestation for export log production on site index 80 ft (Lewis, 1954). The origins of the management and financial data have been given in an earlier paper (Fenton and Tustin, 1972) and are only briefly recapitulated.

The base year for costs, returns and technical knowledge is 1967, except for *Dothistroma* needle blight (*Dothistroma pini* Hulbary) prevention where the recent advent of the disease justifies use of the latest-defined protection.

LIMITS OF THE STUDY

Only radiata pine is considered.

The effects of early costs and yields become increasingly dominant as interest rates rise, and management becomes more complex and expensive. It is probable that alternative rates of afforestation and felling would be more profitable or at least would give higher internal rates of return. But such extensions require better computer and other facilities, and refined micro-economic data which are not now available. Consequently results are not optimum solutions. The qualification, however, should not be used as an excuse to ignore the implications of the results.

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 from the centre of the forest. Frost flats requiring special management total 1,600 acres net.

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 lengths are 60%, 39 ft; 35%, 26 ft; 5% or less of 13 ft 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 29-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 stems per acre (s.p.a.)).
3. Blanking: 10% replacement assumed in the year following planting.
4. Release cutting: one operation in the first year after planting. On steeper sites, which comprise 2,200 acres net, a further operation is prescribed in the second year after planting. This second operation has also been costed for the planting in year 2, as the sites would have been burnt only once. (Blanking and release-cutting operations can only be nominal in these studies; obviously they depend on local circumstances; on this site index at Tairua, for example, no release cutting is needed; in parts of Nelson more operations would be necessary).
5. Thinning (to waste) at 35-ft top height to 150 s.p.a.
6. Protection: *Dothistroma* prevention measures are as given elsewhere (Fenton and Tustin, 1972) and are summarised under PROTECTION COSTS, p. 71.
7. Clearfelling at normality at 110 ft top height at age 29.
8. The only variation from this regime is on frost flats where it has been assumed that *Pinus contorta* Dougl. planted at 20 × 7 ft spacing would form an initial shelterwood; this would be poisoned at about age 11 and radiata pine interplanted in the gaps between the rows. It has been assumed that further rotations could be re-established on old frost flats without undue trouble; as

subsequent rotations begin at least 42 yr after the year of origin of the forest, the financial effect of frost-flat re-establishment will be slight.

9. 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 an extra spraying against *Dothistroma*; slash-thinning cum release cutting at age 2; and no blanking. 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. Forest normality is for accounting convenience, its use does not imply it is otherwise necessary or desirable. Fluctuating yields would be acceptable in practice. Annual areas of planting, silvicultural operations, and felling are given in Table 1. Felling begins in 23-yr-old trees (93-ft top height) and after an initial 1,500 acres, stabilises at 717 acres a year.

Yield predictions are given elsewhere (Appendix 2 of Fenton and Tustin, 1972); summaries for this model are given in Appendix 1, herewith. The net volume logged at age 29 (normality) is 8,235 cu ft per acre.

LABOUR REQUIREMENTS: DIRECT COSTS

The labour required to establish and tend 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; the total manpower required is summarised in Table 5.

Costs are in four main groups: direct costs of growing and protection costs mentioned immediately below; then social costs and indirect costs, p. 73. Costs have been reduced, where appropriate, compared with those of the earlier model (Fenton and Tustin, 1972).

The direct labour-content and costs of forest operations are as in 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 costs are included in indirect costs.

The land preparation schedule is given in Appendix 2.

The logging costs are 3.80c per cu ft for 28-yr-old and 3.57c per cu ft for older stands; the equipment required is listed in Table 6 (based on Appendix 4 of Fenton and Tustin, 1972).

PROTECTION COSTS

These comprise fire and *Dothistroma* needle blight prevention and control; and some minor items. Fire prevention costs are summarised in Table 7. *Dothistroma* costs are as given earlier (Fenton and Tustin, 1972). Briefly, for *Dothistroma* protection, 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 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. (Few site index 80 stands seem to have been infected as yet with *Dothistroma*).

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

Year	Planting		Sowing	Blanking	Release Cutting		Slasher Thinning	Thinning to Waste	Clearfelling		
	Machine	Hand			1	2			Area acres	Age yr	Year Planted
1	1,592										
2	1,000										
3	1,000			1,000	1,000						
4	2,000			1,000	1,000	1,000					
5	2,000			2,000	2,000						
6	2,000			2,000	2,000						
7	2,000			2,000	2,000						
8		2,000		2,000	2,000						
9		2,000		2,000	2,000			800*			
10	800	2,000		2,000	2,000			792*			
11	792	1,000		2,800	2,800			1,000			
12		1,000		1,792	1,792			1,000			
13		1,000		1,000	1,000			2,000			
14		200		1,000	1,000	1,000		2,000			
15				200	200	1,000		2,000			
16						200		2,000			
17								2,000			
18								2,000			
19								2,800			
20								1,792			
21								1,000			
22								1,000			
23								200			
24											
25		166	166					500	23	2	
26		500	500	166	166			500	24	2	
27								1,000	23	3	
27		500	500	500	500		333	1,500	23	4	
28		500	500	500	500		1,000	500	24	4	
28								1,000	23	5	
29		500	500	500	500		1,000	1,000	24	5	
29								500	23	6	
30		239P	239P	500	500		1,000	717	24	6	
31				239P	239P		1,000	717	25	6	
32							478P	66	26	6	
32								651	25	7	
33								717	26	7	
34								500	632	27	7
34								85	26	8	
35								1,500	717	27	8
36								1,500	717	28	8
37								1,500	481	29	8
37									236	28	9
38								1,500	717	29	9
39								717P	717	30	9
40									330	31	9
40									387	30	10
41									717	31	10
42									717	32	10
43									717	33	10
44									262	34	10
44									455	33	11

TABLE 1 (continued)

Year	Planting		Sowing	Blanking	Release cutting		Slasher Thinning	Thinning to waste	Clearfelling		
	Machine	Hand			1	2			Area acres	Age yr	Year Planted
45									717	34	11
46									620	35	11
									97	34	12
47									717	35	12
48						97			186	36	12
									531	35	13
49							717		469	36	13
									200	35	14
									48	24	25
50								717	452	25	25
									265	24	26
51						669			717	25	26
52									518	26	26
									199	25	27
53									717	26	27
54									584	27	27
									133	26	28
55									717	27	28
56									650	28	28
									67	27	29
57									717	28	29
58							75P		717	29	29P

P = in perpetuity

* = poison overwood

SOCIAL COSTS

These comprise roading, accommodation, and minor costs. Table 8 shows the components 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 that they have not been housed on the forest. The costs of running the camp are based on charges of \$122 per man per year.

INDIRECT COSTS

Staff salaries are given in Table 10; external overheads have been taken as 60% of these amounts. A forest building programme is given in Table 11. Vehicles and stores are listed in Table 12, the initial provision of consumable stores has been allowed at 10% less than for site index 95 in line with the lesser activity. Net charges for "services and general" costs are given in Table 13.

Depreciation is charged by allowing the cost of the asset concerned at the end of its service life. The service lives of all replaceable assets 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 100 "Japanese Haakon Dahl" (JHD) units (100 JHD = 9 cu ft). Log cartage costs for a 178-mile round trip are 8.7c per cu ft.

TABLE 2—Direct labour requirements, forest growing and tending

Year	Planting		Blanking	Slasher Thinning	Release Cutting		Thinning to Waste	Total man-days	Total man-yr
	1st Rotation Tractor	Hand			1	2			
1	247						247	1	
2	155						155	1	
3	155		300		670		1,125	5	
4	310		300		670	670	1,950	8	
5	310		600		1,340		2,250	9	
6	310		600		1,340		2,250	9	
7	310		600		1,340		2,250	9	
8		1,240	600		1,340		3,180	13	
9		1,240	600		1,340		533*	3,713	15
10	124	1,240	600		1,340		533*	3,837	16
11	123	620	840		1,876		1,500	4,959	21
12		620	538		1,200		1,500	3,858	16
13		620	300		670		3,000	4,590	19
14		124	300		670	670	3,000	4,764	20
15			60		134	670	3,000	3,864	16
16						134	3,000	3,134	13
17							3,000	3,000	13
18							3,000	3,000	13
19							4,200	4,200	18
20							2,688	2,688	11
21							1,500	1,500	6
22							1,500	1,500	6
23							600	600	3
24									
25		103					103	103	1
26		310	50		112		472	472	2
27		310	150	223	335		1,018	1,018	4
28		310	150	670	335		1,465	1,465	6
29		310	150	670	335		1,465	1,465	6
30		148P	150	670	335		1,303	1,303	5
31			72P	670	160P		1,050	1,050	3
32				320P			700	700	3
33							700	700	3
34							750	1,450	6
35							2,250	2,950	12
36							2,250	2,950	12
37							2,250	2,950	12
38							2,250	2,950	12
39							1,075P	1,775	7
40-47								1,775	7
48						65		1,840	8
49						480		2,255	10
50						480		2,255	10
51						446		2,221	10
52-57								1,775	8
58						50P		1,825P	8(7.6)

* Poison overwood

P = in perpetuity

Export costs and returns are as given elsewhere (Fenton and Tustin, 1972) and they result in a price loaded-on-truck at the forest of 20.8c per cu ft.

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

PROFIT CALCULATION; RESULTS

Costs and returns have been discounted to the year of origin of the forest; they are charged from the mid-point of the year in which they occur. Details of the programmes used are in an earlier paper (Fenton and Tustin, 1972). The LEV equivalents, or the present net worth per acre, for cost-and-return elements were calculated for the same numerous individual items as in the earlier paper, for interest rates of 3% to 14%. These are grouped by major classes (establishment, tending, protection, indirect, logging, and social) 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 relative importance of the major classes of costs to loaded-on-truck are shown in Fig. 2, and the proportions of the major growing and utilisation costs in Fig. 3.

The internal rates of return (IRR), or the rate of interest generated by the project as a whole, can be found from Fig. 1. They are:

- (a) including social costs — about 8½%
- (b) excluding social costs — about 9½%

The break-even growing costs are given in Table 15; these are the forest cost of production per net unit of wood (viz., the volume which is finally extracted and loaded) at the interest rates of 3% to 14%. 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.

Effects of differences in volume yield are shown in Table 17, as the LEV equivalents of logged volume per acre; they are illustrated in Fig. 7. The effects of lower returns for logs are given in Table 18, and illustrated in Fig. 8. The labour required, by number and skill category, is shown in Tables 2 to 5.

DISCUSSION OF RESULTS

The longer time scale of 29 instead of 23 yr incurs a greater degree of marketing, physical, and biological risk on a site index of 80 compared with one of 95. As the final top height of 110 ft is the same, extra risk of windblow is incurred only by the longer rotation and depends on the frequency of destructive gales. The extra risks cannot be quantified on present knowledge.

The earlier discussion on sensitivity applies here. Costs are again dominated by logging at interest rates up to 8%. There is a sharp decrease in profit as interest rates rise; the technical specification of two 40-ft logs was devised for a higher site index and, while desirable, is not essential. So a higher internal rate of return (IRR) would probably be generated if, say, one 40-ft log per tree was the aim of management. As interest rates rise the contribution from earlier yields increases and regimes devised to give more of these yields would probably make higher internal rates of return. The

TABLE 3—Logging: volume production, labour, and basic tractor needs

Year	Area acres	Vol./Acres cu ft net	Total Production cu ft	Total Labour days	Tractors
25	500	5,490	2,745,000	5,229	2.3
26	500	5,756	2,878,000	5,139	
27	1,000	5,490	5,490,000	10,458	7
27	1,500	5,490	8,235,000	15,688	7
28	500	5,756	2,878,000	5,139	
28	1,000	5,490	5,490,000	10,458	7
29	1,000	5,756	5,756,000	10,278	
29	500	5,490	2,745,000	5,229	7
30	717	5,756	4,127,000	7,370	3.4
31	717	6,318	4,530,000	8,089	3.8
32	66	6,720	443,500	792	
33	651	6,318	4,113,000	7,345	3.8
33	717	6,720	4,818,000	8,604	4
34	632	7,240	4,575,680	8,171	
35	85	6,720	571,200	1,020	4.3
35	717	7,240	5,191,000	9,269	4.3
36	717	7,730	5,542,410	9,897	4.6
37	481	8,235	3,961,000	7,073	
37	236	7,730	1,824,280	3,258	4.8
38	717	8,235	5,904,500	10,544	5
39	717	8,525	6,112,425	10,914	5
40	330	8,815	2,909,000	5,195	
41	387	8,525	3,299,175	5,891	5.2
41	717	8,815	6,320,355	11,286	5.3
42	717	9,150	6,560,550	11,715	5.5
43	717	9,550	6,847,350	12,227	5.7
44	262	9,950	2,606,900	4,655	
44	455	9,550	4,345,250	7,759	5.8
45	717	9,950	7,134,150	12,739	6
46	620	10,080	6,249,600	11,160	
47	97	9,950	965,150	1,723	6
47	717	10,080	7,227,360	12,906	6
48	186	10,300	1,915,800	3,421	
49	531	10,080	5,352,480	9,558	6
49	469	10,300	4,830,700	8,626	
	200	10,080	2,016,000	3,600	
50	48	5,756	276,288	493	6
50	452	6,318	2,855,736	5,099	
51	265	5,756	1,525,340	2,724	3.7
51	717	6,318	4,530,000	8,089	3.8
52	518	6,720	3,481,000	6,216	

TABLE 3 (continued)

Year	Area acres	Vol./Acre cu ft net	Total Production cu ft	Total Labour days	Tractors
	199	6,318	1,257,282	2,245	4
53	717	6,720	4,818,240	8,604	4
54	584	7,240	4,228,160	7,550	
	133	6,720	893,760	1,596	4.3
55	717	7,240	5,191,000	9,270	4.3
56	650	7,730	5,024,500	8,972	
	67	7,240	485,080	866	4.6
57	717	7,730	5,542,100	9,897	4.6
58	717	8,235	5,904,495	10,544	4.92

TABLE 4—Staff and indirect labour schedule

	Year 1	2	3	4	5-6	7-9	10-23	24	25	26-29	30-37	38-45	46	47+
STAFF														
Officer in charge	1P													1
Forester		1P												1
Ranger/Foreman		1P					1P		1P	1P				3
Clerk/Stores	1P						1P							2
Logging														
Ranger in charge								1P						1
Ranger/Foreman									1P	1	-1	1	-1	1
Clerk									1P					1
Rooding														
Ranger	1P													1
OTHER LABOUR														
Grader driver					1P									1
Men	2P							3				-3		2
Mechanic	1P						1P		2P					4
Driver	1P						1P							2
Other														
Tractor Driver	1P													1
Fire stores			1P											1
Camp attendant									1P					1
Carpenter/painter						1P				1P				2
Tool maintenance	1P													1
HQ gang	1P			1P			1P							3
Total Indirect	10	12	14	15	16	17	22	26	32	34	30	31	30	30P

P = in perpetuity

TABLE 5—Total manpower required

Year	Forest Operations	Logging	Sub totals		Staff and Indirect Labour	Total
	man-days	man-days	man-days	man-yr	man-yr	man-yr
1	247			1	10	11
2	155			1	12	13
3	1,125			5	14	19
4	1,950			8	15	23
5	2,250			10	16	26
6	2,250			10	16	26
7	2,250			10	17	27
8	3,180			14	17	31
9	3,713			16	17	33
10	3,837			16	22	38
11	4,959			21	22	43
12	3,858			16	22	38
13	4,590			19	22	41
14	4,764			20	22	42
15	3,864			16	22	38
16	3,134			13	22	35
17	3,000			13	22	35
18	3,000			13	22	35
19	4,200			18	22	40
20	2,688			12	22	34
21	1,500			7	22	29
22	1,500			7	22	29
23	600			3	22	25
24				0	26	26
25	103	5,229	5,332	23	32	55
26	472	15,597	16,069	67	34	101
27	1,018	15,688	16,706	70	34	104
28	1,465	15,597	17,062	71	34	105
29	1,465	15,507	16,972	71	34	105
30	1,303	7,370	8,673	36	30	66
31	1,050	8,089	9,139	38	30	68
32	700	8,037	8,737	37	30	67
33	700	8,604	9,304	39	30	69
34	1,450	9,191	10,641	45	30	75
35	2,950	9,269	12,219	51	30	81
36	2,950	9,897	12,847	54	30	84
37	2,950	10,331	13,281	56	30	86
38	2,950	10,544	13,494	57	31	88
39	1,775	10,914	12,689	53	31	84

TABLE 5 (continued)

Year	Forest Operations	Logging	Sub totals		Staff and Indirect labour	Total
	man-days	man-days	man-days	man-yr	man-yr	man-yr
40	1,775	11,086	12,861	54	31	85
41	1,775	11,286	13,061	55	31	86
42	1,775	11,715	13,490	57	31	88
43	1,775	12,227	14,002	59	31	90
44	1,775	12,414	14,189	59	31	90
45	1,775	12,739	14,514	61	31	92
46	1,775	12,883	14,658	61	31	92
47	1,775	12,906	14,681	62	31	93
48	1,840	12,979	14,819	62	31	93
49	2,255	12,719	14,974	63	31	94
50	2,255	7,823	10,078	42	30	72
51	2,221	8,089	10,310	43	P	73
52	1,775	8,461	10,236	43		73
53	1,775	8,604	10,379	44		74
54	1,775	9,146	10,921	46		76
55	1,775	9,270	11,045	46		76
56	1,775	9,838	11,613	49		79
57	1,775	9,897	11,672	49		79
58	1,825	10,544	12,369	52		82

TABLE 6—Schedule of logging equipment

Year	Tractors			Arches		Loaders		Gang trucks		Power saws		Other	
	D7	D6		T	+/-	T	+/-	T	+/-	T	+/-		
	T	T	+/-	T	+/-	T	+/-	T	+/-	T	+/-		
24	1											(Trekka truck (\$4,600* (2 tip trucks (P	
25		3	3	3	3	2	2	1	1	12	12	\$2,500†	
26		2	10	7	9	6	5	3	4	3	40	28	\$2,500‡
		P											2 F.S.U., P
30		6	-4	5	-4	3	-2	3	-1	24	-16		
									P				
34				6	1								
36		7	1							28	4		
37				7	1	4	1						
40		8	1							32	4		
43				8	1								
44		9	1							36	4		
50		6	-3	5	-3	3	-1			24	-12		
						P	†						
54				6	1								
56		7	1	7	1					28	4		
		P		P						P			

T = total
 +/- = addition or deletion
 P = in perpetuity
 * Miscellaneous equipment
 † This may be insufficient; 3.2 are needed at normality
 ‡ Stores purchase

TABLE 7—Fire protection costs

Item	Year	Cost
Firebreak preparation	1-10	\$ 390 p.a.
Fencing	1-5	\$ 590 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
Buildings		
Lookout		
Capital	3	\$ 5,500
Maintenance	4 onwards	1 $\frac{1}{4}$ %*
Depreciation		65-yr life
Telephone	3	\$ 1,225
Garage and store		
Capital	5	\$ 4,400
Maintenance	6 onwards	1 $\frac{1}{4}$ %*
Depreciation		65-yr life

Annual charges are roughly proportional to the area planted:
 \$0.81 per acre up to 7,500 acres
 \$0.53 per acre from 7,500 to 13,000 acres
 \$0.46 per acre above 13,000 acres

* Included in annual charges

TABLE 8—Social costs excluding houses and camp

Year.	Formation	Metalling	Maintenance		Equipment	
			Forest Area acres	Cost per Acre \$	Item	Cost \$
A. Roading						
1	8,800		1,600	0.30	Tip truck ($\frac{1}{2}$)	2,250
2	8,800		2,600	0.30		
3	8,800		3,600	0.30		
4	8,800		5,600	0.30		
5	8,800		7,600	0.30	10-cwt truck Grader	2,000 20,000
6	8,800		9,600	0.30		
7	8,800		11,600	0.30		
8	8,800		13,600	0.30		
9	8,800		15,600	0.30		
10	8,800		17,600	0.30		
11	8,800		18,592	0.30	Tip truck ($\frac{1}{2}$)	2,250
12	8,800		15,592	0.30		
13			20,592	0.30		
14			20,792	0.30P		
24		\$9,600 per year from 24 up to and including year 33				
25		\$9,600				
33						
Year	Water Supply*	Site Preparation	Share of Services [†]			
			Acreage	Cost/Acre \$		
B. Miscellaneous						
1	2,500	1,000	1,600	0.21		
2	2,500		2,600	0.19		
3	1,100	1,200	3,600	0.17		
4			5,600	0.145		
5			7,600	0.12		
6			9,600	0.10		
7			11,600	0.08		
8			13,600	0.07		
9			15,600	0.065		
10			17,600	0.06		
11			18,592	0.06		
12			19,592	0.06		
13			20,592	0.06		
14			20,792	0.06P		

* Half cost allotted to social cost, the other half to capital works (see Table 11)

† These amounts are half of the "Services" component of the repairs and maintenance charge (Table 13).

TABLE 9—Accommodation required

Year	Houses		Huts		Other expenses	\$
	New	Total	New	Total		
1	1	1			Services N.E.I.*	3,000
2	2	3				
3	5	8				
4	4	12				
5	3	15			Services N.E.I.	6,000
6	0	15				
7	1	16				
8	4	20				
9	2	22			Services N.E.I.	3,000
10	5	27				
11	5	32			Services N.E.I.	3,700
12-24						
25			12	12	Cookhouse Caterer's house Ablution block	17,000 6,700 5,600
26			46	58	Cookhouse ext. Ablution block ext.	10,700 3,300
27			3	61		
28			1	62		
29				50†		
50				40‡		

*N.E.I. = not elsewhere indicated

† = transfer 12 huts

‡ = transfer 10 huts

Ten men are recruited locally; the fire lookout is already housed.

result would typically illustrate differences between profitability criteria (Fenton, 1969) with probably a higher IRR but lower future net worths. The minimum IRR of 7% required by Treasury has been exceeded, however, and this site quality is still not limiting to management for the export log trade.

Overall cost of production is naturally higher than on site index 95, with commensurably lower production per man and lower profits. The importance of the results is that these anticipated differences are largely quantified here. There are major implications:

1. The extra value of better quality land is found. Use of fertilisers to raise site quality can be evaluated directly.
2. The additional cost of production of a given annual volume of wood can be calculated. Thus: "In a country where development capital is becoming almost a luxury commodity, it is right that increasing weight should be given to quantitative economic analysis in assessing the soundness of investment decisions." (Stonyer and Donovan, 1968) and, "Insistence on cost/benefit analysis forces those responsible to quantify . . . as far as possible . . . and

TABLE 10—Salaries (\$ per yr)

No.	Designation	Year									
		1	2-3	4-9	10-23	24	25	26-29	30-37	38-49	50+
<u>Forest</u>											
1	Officer in charge	3,410	3,410	3,550	3,750	3,750	3,900	3,900	3,900	3,900	3,900
1	Forester		2,570	2,570	2,810	2,810	3,170	3,170	3,170	3,170	3,170
1-2	Forest Foreman		2,250	2,250	2,360	2,360	4,610	4,610	4,610	4,610	4,610
1	Forest Ranger				2,570	2,690	2,690	2,690	2,690	2,690	2,690
1	Forest Ranger - Roading	2,250	2,250	2,360	2,570	2,570	2,690	2,690	2,690	2,690	2,690
1	Office clerk	2,230	2,230	2,450	2,450	2,690	2,690	2,690	2,690	2,690	2,690
1	Stores clerk				2,450	2,450	2,450	2,450	2,450	2,450	2,450
Total		7,890	12,710	13,180	18,960	19,320	22,200	22,200	22,200	22,200	22,200
<u>Logging</u>											
1	Officer in charge					3,410	3,410	3,410	3,410	3,410	3,410
1	Foreman						2,360	2,360	2,360	2,360	2,360
1	Ranger							2,690		2,690	
1	Clerk						2,230	2,230	2,230	2,230	2,230
Total						3,410	8,000	10,690	8,000	10,690	8,000
<u>Grand Total</u>		7,890	10,460	13,180	18,960	22,730	30,200	32,890	30,200	32,890	30,200

TABLE 11—Capital works required

Year	Item	Cost \$	
1	Office and store	7,750	
	Petrol Store	3,300	
	Telephone line	1,225	An equal amount is charged to Protection
	Water supply	2,500	An equal amount is charged to Social Costs
2	Garage/workshop	16,000	
	Water supply	2,500	An equal amount is charged to Social Costs
3	Water supply	1,100	An equal amount is charged to Social Costs
24	Office extension	7,750	
	Garage extension	16,000	

Other services not elsewhere indicated are charged to Social Costs; fencing has been charged to forest Protection.

TABLE 12—Miscellaneous vehicles and equipment

Year	No.	Description	Cost \$	Charged to
1	1	10-cwt truck*	2,000	Forest
	1	Tip truck	4,500	Forest - half Roading - half
	1	HD6 tractor	13,250	Forest
2	1	Gang truck	5,000	Forest
3	1	Office car*	2,500	Forest
		Class 'A' stores	1,100	Forest
		Consumable stores	900	Forest
5	1	10-cwt truck*	2,000	Roading
	1	Grader	20,000	Roading
		Consumable stores	1,350	Forest
9	1	Gang truck	5,000	Forest
10		Class 'A' stores	4,000	Forest
		Consumable stores	2,250	Forest
11	1	10-cwt truck*	2,000	Forest
	1	Tip truck	4,500	Forest - half Roading - half
18		Class 'A' stores	5,000	Forest
19	1	Gang truck - CREDIT	5,000	Forest
		Consumable stores	2,250	Forest
22		Consumable stores	2,250	Forest
24		Class 'A' stores	2,500	Forest
		Miscellaneous plant and equipment	9,200	Forest - half Logging - half
	1	'Trekka' truck*	1,770	Logging
	3	10-cwt trucks*	2,000 each	Forest

* Annual charges, excluding depreciation, are \$755 per year.

TABLE 13—Services and general: repairs and maintenance and administration costs

Year	Acreage	'General' Charge per Acre \$	Total 'S & G' Charge* \$	General Administration per Acre \$
1	1,600	0.82	1.05	1.152
2	2,600	0.76	0.95	1.152
3	3,600	0.69	0.86	1.152
4	5,600	0.58	0.725	0.576
5	7,600	0.48	0.60	0.576
6	9,600	0.39	0.49	0.576
7	11,600	0.33	0.41	0.408
8	13,600	0.28	0.35	0.408
9	15,600	0.26	0.325	0.348
10	17,600	0.24	0.30	0.348
11	18,592	0.24	0.30	0.348
12	19,592	0.24	0.30	0.348
13	20,592	0.24	0.30	0.348
14	20,792	0.24	0.30P	0.348P

* Total = 'services and general';
services = half general charge but half of the
'service' total is already debited to social
accounts (in Table 8).

P = in perpetuity

... help in the rejection of inferior projects which are nevertheless promoted for empire-building or pork-barrel reasons." (Prest and Turvey, 1965). The results here can start to show the extra costs involved in planting poorer land or promoting inferior schemes.

3. The additional labour needs (largely of administrative staff) can be found.
4. Increased log hauls inevitably result from afforestation of lower site quality land; the lower increment necessitating a greater area to produce the same volume. An extra 6,500 acres, or about 10 sq miles would be needed to produce the same volume from site index 80, as from a 25,000 acre (gross) block of site index 95. At a maximum, assuming the land is all more remote than the present area, but available in a square block, this would add 5 miles from the mid-point of the existing area to the far boundary and 1½ miles from the boundary of the existing area to the centre of the new block, totalling 13 miles extra on the round hauls. Other examples would vary with the particular location.
5. Yields come later on lower quality sites. This must be taken into account in New Zealand export plans which require a rapid increase from 160 million to 292 million cu ft for export between 1991 and 2006 (Forestry Committee, 1969).
6. The remaining result of importance is the rate of return exceeding 7% (actually 8.5%), when social costs are included. Hence afforestation of this site index still exceeds the minimum levels of profitability required—as long as the logs are exported.

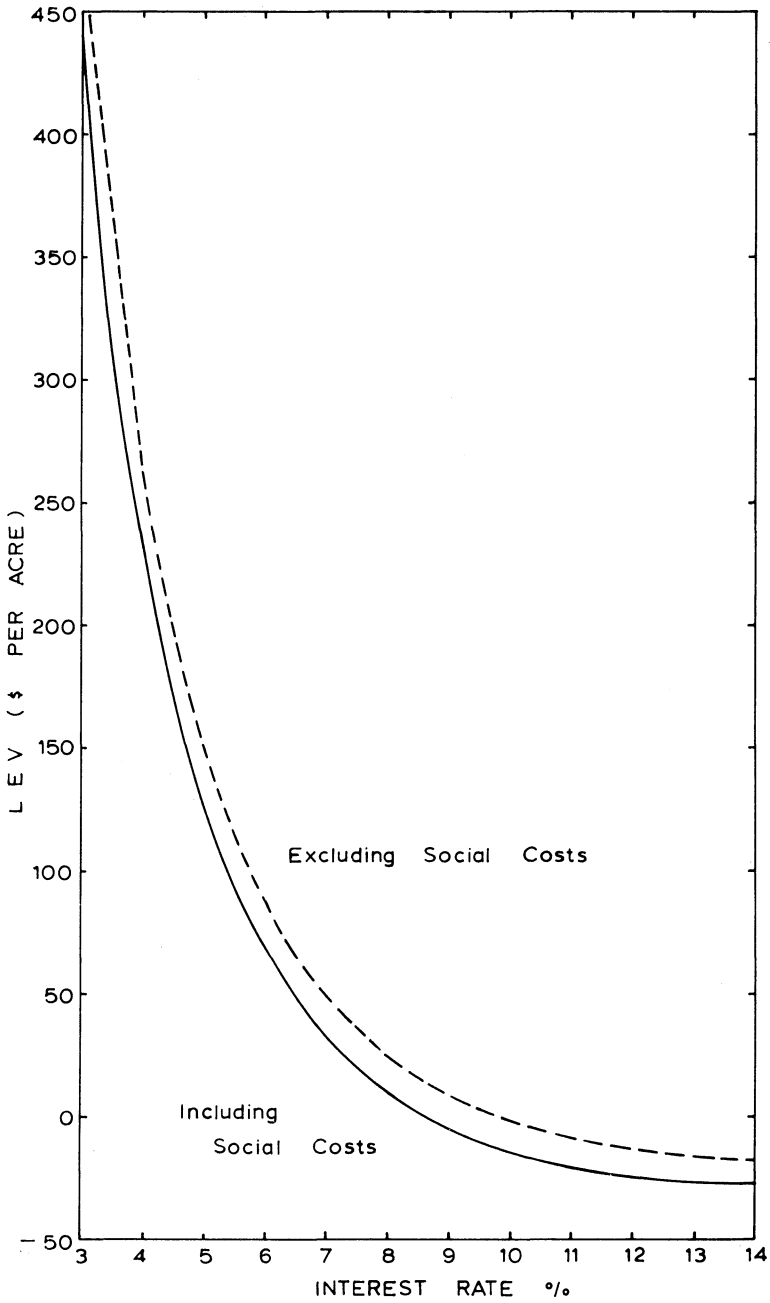


FIG. 1—Net land expectation values—site index 80.

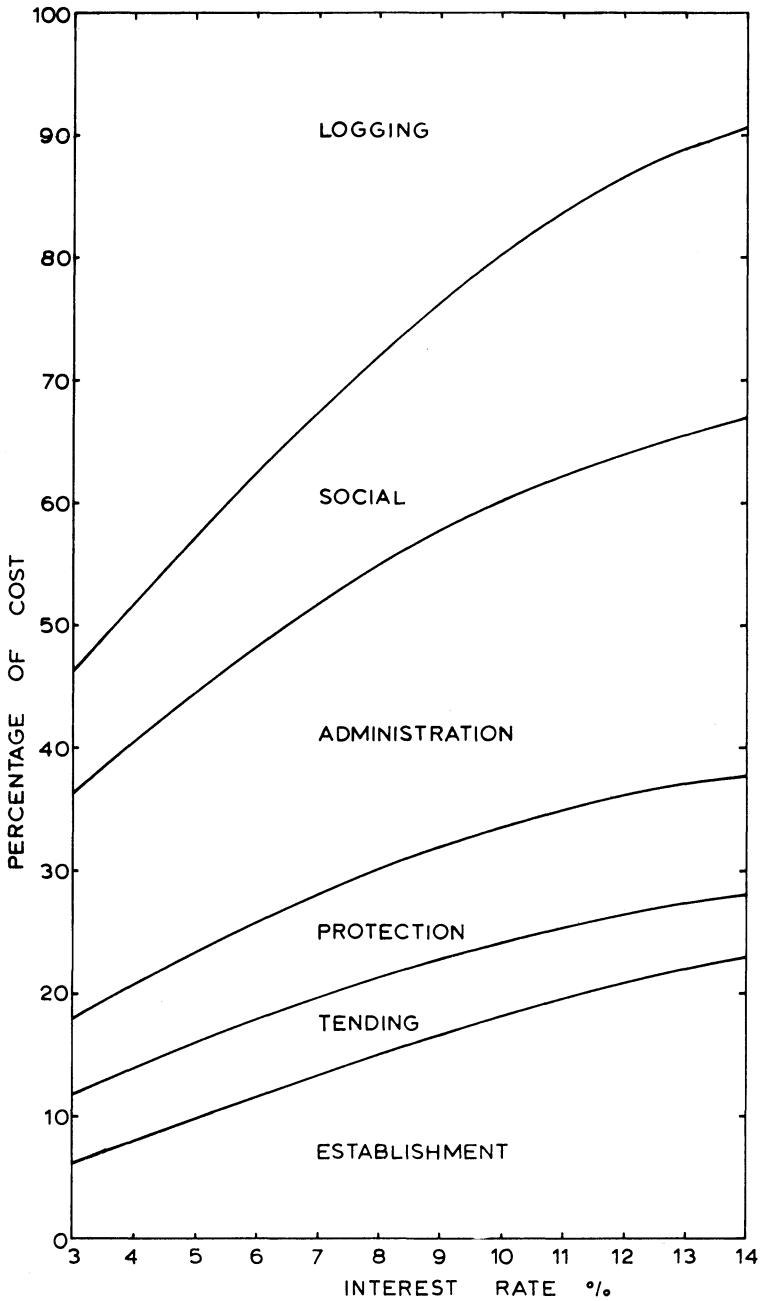


FIG. 2—Relative importance of forest costs percentage of cost loaded-on-truck.

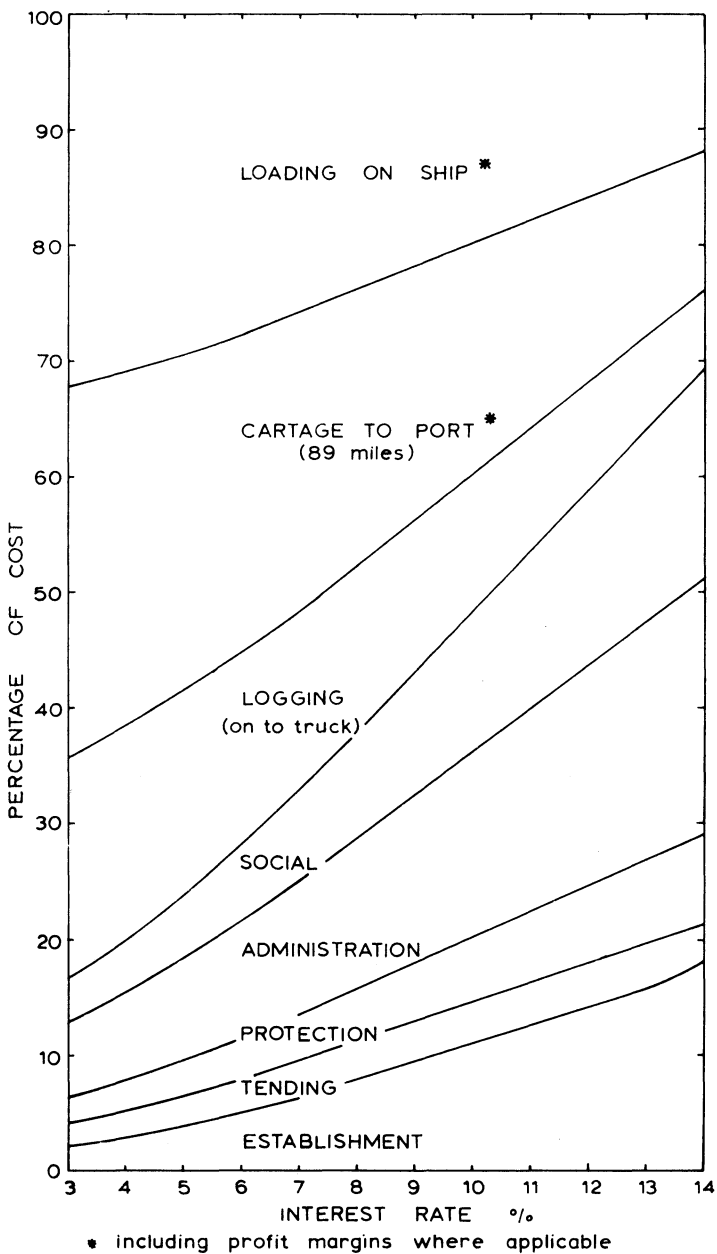


FIG. 3—Relative importance of forest and utilisation costs. Percentage of cost f.o.b. Mt Maunganui (based on equivalent LEV).

TABLE 14—Costs, returns, and net LEV

FOREST COSTS	LEV at interest rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
<u>Direct</u>	\$ per acre											
Land clearing	3.28	3.18	3.11	3.01	2.95	2.88	2.82	2.75	2.72	2.67	2.63	2.59
Establishment	20.36	17.02	14.87	13.27	12.04	11.04	10.20	9.50	8.85	8.28	7.77	7.32
Tending	22.79	16.42	12.57	9.99	8.15	6.76	5.69	4.82	4.14	3.56	3.08	2.69
Total Direct	46.43	36.62	30.55	26.27	23.14	20.68	18.71	17.07	15.71	14.51	13.48	12.60
<u>Protection</u>												
Dothistroma	9.95	7.50	5.99	4.96	4.21	3.62	3.16	2.78	2.46	2.21	1.97	1.78
Fire	14.09	10.30	8.07	6.60	5.55	4.81	4.22	3.74	3.37	3.05	2.79	2.58
Total Protection	24.04	17.80	14.06	11.56	9.76	8.43	7.38	6.52	5.83	5.26	4.76	4.36
<u>Administration</u>												
Salaries and external overheads	56.73	41.09	31.91	25.91	21.72	18.63	16.26	14.42	12.93	11.71	10.69	9.82
Buildings, stores	3.44	2.77	2.38	2.10	1.89	1.75	1.64	1.55	1.47	1.41	1.35	1.31
Vehicles	10.24	7.33	5.62	4.54	3.80	3.27	2.85	2.54	2.30	2.11	1.94	1.78
Total Administration	70.41	51.19	39.91	32.55	27.41	23.65	20.75	18.51	16.70	15.23	13.98	12.91
Total Growing Costs	140.88	105.61	84.52	70.38	60.31	52.76	46.84	42.10	38.24	35.00	32.22	29.87

TABLE 14 (continued)

FOREST COSTS	LEV at interest rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
<u>Logging</u>												
Salaries and external overheads	9.41	5.73	3.71	2.51	1.74	1.23	0.90	0.66	0.48	3.70	0.27	0.21
Machinery	59.72	36.92	24.37	16.78	11.86	8.56	6.30	4.69	3.52	2.69	2.06	1.58
Extraction	136.45	81.03	51.46	34.17	23.35	16.31	11.62	8.40	6.13	4.53	3.37	2.52
Total Logging	205.58	123.68	79.54	53.46	36.95	26.10	18.82	13.75	10.13	7.59	5.70	4.31
Total Forest Costs	346.46	229.29	164.06	123.84	97.26	78.86	65.66	55.85	48.37	42.59	37.92	34.18
<u>Social</u>												
Roading	16.33	12.63	10.30	8.69	7.54	6.65	5.94	5.38	4.89	4.51	4.19	3.90
Accommodation	22.88	17.70	14.68	12.16	11.25	10.49	9.37	8.67	8.07	7.58	7.15	6.76
Total Social Costs	39.21	30.33	24.98	21.35	18.79	17.14	15.31	14.05	12.96	12.09	11.34	10.66
Total Costs	385.67	259.62	189.04	145.19	116.05	96.00	80.97	69.90	61.33	54.68	49.26	44.84
<u>RETURNS</u>												
Logs	816.99	490.02	314.26	210.35	145.08	102.32	73.42	53.44	39.35	29.26	21.95	16.59
Rent (social)	5.17	3.63	2.75	2.18	1.78	1.50	1.28	1.11	0.98	0.86	0.77	0.70
<u>NET VALUES</u>												
Excluding Social Items	470.53	260.73	150.20	86.51	47.82	23.46	7.76	-2.41	-8.96	-13.33	-15.97	-17.59
Including Social Items	436.49	234.03	127.97	67.34	30.81	7.82	-6.27	-15.35	-21.00	-24.56	-26.54	-27.55

TABLE 15—Break-even growing costs

Interest rate	LEV equivalent of 1c per cuft	Break-even growing cost	
		Including social costs	Excluding socials costs
%	\$ per acre	c per cuft	c per cuft
3	39.278	4.585	3.586
4	23.558	5.770	4.482
5	15.108	7.247	5.594
6	10.112	9.071	6.960
7	6.974	11.342	8.647
8	4.919	14.210	10.725
9	3.530	17.606	13.269
10	2.569	21.856	16.387
11	1.891	27.075	20.222
12	1.406	33.492	24.893
13	1.055	41.289	30.540
14	0.797	50.853	37.478

CONCLUSIONS

- When compared with site index 95:
 - Growing costs increase by 47% to total 11.3c per cu ft at 7% interest.
 - Annual productivity per net acre at normality decreases by 74 cu ft to 284 cu ft.
 - Annual production per man at normality decreases by 4,750 cu ft to 72,000 cu ft.
 - The greatest costs are still in utilisation, at interest rates up to 8%.
 - Location greatly affects profits; results are still sensitive to changes in prices and volume logged; demands for managerial and labour skills remain low.
- Afforestation is still profitable, at 1967 costs and returns, even on this site index and 90 miles from a port, if logs are exported.

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TABLE 16—Location effects on profitability

	Distance of forest from port miles	Log Haul Cost c/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	230.95	138.52	88.83	59.45	41.00	28.92	20.75	15.10	11.11	8.26	6.20	4.68
	21-30	4.05	197.96	118.73	76.14	50.96	35.14	24.79	17.79	12.94	9.53	7.08	5.31	4.01
	31-40	4.89	164.96	98.94	63.45	42.47	29.29	20.65	14.82	10.78	7.94	5.90	4.43	3.34
	41-50	5.73	131.97	79.15	50.76	33.97	23.43	16.52	11.86	8.63	6.35	4.72	3.54	2.67
	51-60	6.57	98.98	59.36	38.07	25.48	17.57	12.39	8.89	6.47	4.76	3.54	2.65	2.00
	61-70	7.41	65.98	39.57	25.38	16.98	11.71	8.26	5.93	4.31	3.17	2.36	1.77	1.33
	71-80	8.25	32.99	19.78	12.69	8.49	5.85	4.13	2.96	2.15	1.58	1.18	0.88	0.67
	81-90	9.09	0	0	0	0	0	0	0	0	0	0	0	0
Negative	91-100	9.93	-32.99	-19.78	-12.69	-8.49	-5.85	-4.13	-2.96	-2.15	-1.58	-1.18	-0.88	-0.67
			And so on in parallel series											
B.			Net LEV (\$ per acre)*											
	18-20		667	364	217	126	72	37	14	-0.3	All LEV's negative			
	21-30		634	344	204	118	66	33	11	-2	All LEV's negative			
	31-40		601	324	191	109	60	29	9	-5	All LEV's negative			
	41-50		568	304	179	101	54	25	6	-7	All LEV's negative			
	51-60		535	294	166	92	49	20	3	-9	All LEV's negative			
	61-70		502	274	153	84	43	16	0	-11	All LEV's negative			
	71-80		469	254	141	75	37	12	-3	-13	All LEV's negative			
	81-90		436	234	128	67	31	8	-6	-15	-21	-24	-26	-28

* Including social items

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TABLE 17—Effect of lower volume yield on total returns, net LEV*

Cu ft/Acre Less	\$ per Acre										
	Interest Rate %										
	3	4	5	6	7	8	9	10	11	12	
A. Returns, LEV reduction											
500	55	34	22	15	11	8	6	4	3	2	
1,000	109	65	44	30	21	15	11	8	6	4.5	
1,500	164	101	66	45	32	23	17	12	9	6.5	
B. Net LEV becomes*											
500	381	200	106	52	20	0	-11	-18	-23	-26	
1,000	327	267	84	37	10	-7	-17	-23	-27	-28	
1,500	272	133	62	22	-1	-15	-23	-27	-30	-31	
C. Net LEV if logging cost is proportionally reduced											
500	390	206	110	54	22	1	-11	-17	-23	-26	
1,000	346	179	92	42	14	-4	-15	-22	-26	-27	
1,500	300	151	74	29	4	-11	-20	-24	-29	-30	

* Including social costs and returns

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
Value of logs - LEV in \$ per acre												
20.8	817	490	314	210	145	102	73	53	39	29	22	16.6
19.8 (1c less)	778	466	299	200	138	97	70	51	37	28	21	15.8
10.8 (10c less)	424	254	163	109	75	53	38	27	20.4	15	11	8.6
2.8 (18c less)	110	66	42	28	19.5	13.8	9.9	7.2	5.3	4.0	3.0	2.2
Net LEV in \$ per acre*												
20.8	436	234	128	67	31	8	-6	-15	-21	-25	-27	-28
19.8 (1c less)	397	210	113	57	24	3	-9	-17	-23	-26	-28	-29
10.8 (10c less)	43	-2	-23	-34	-39	-41	-41	-40	-40	-39	-38	-36
2.8 (18c less)	-271	-190	-144	-115	-95	-80	-69	-61	-55	-50	-45	-42

* including social costs and returns

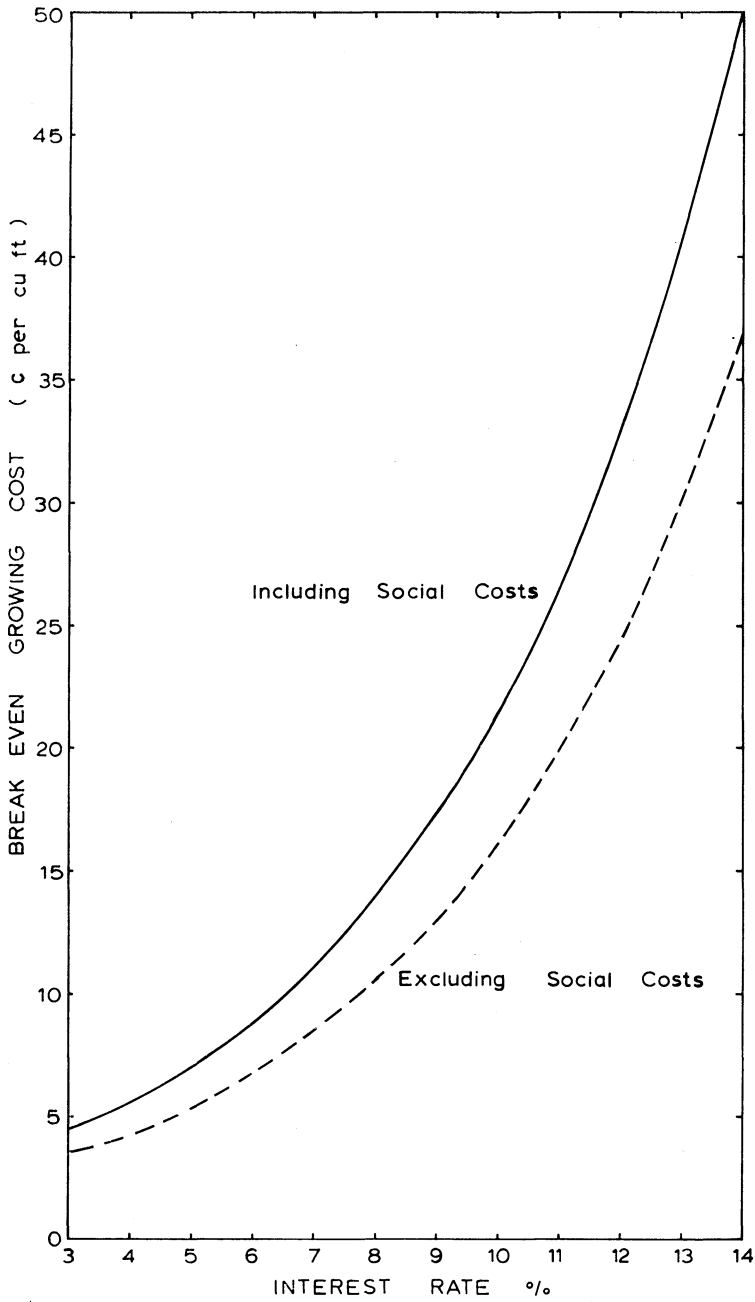


FIG. 4—Break-even growing costs.

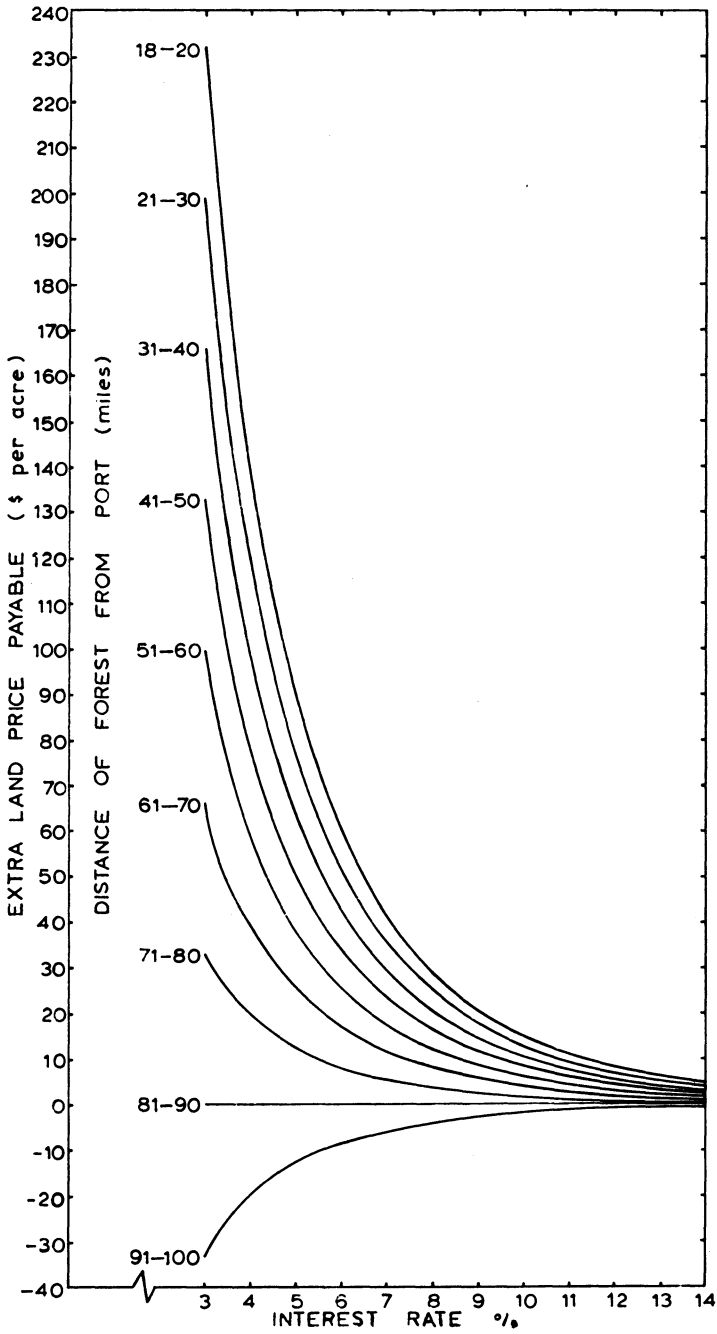


FIG. 5—Location effect on profit.

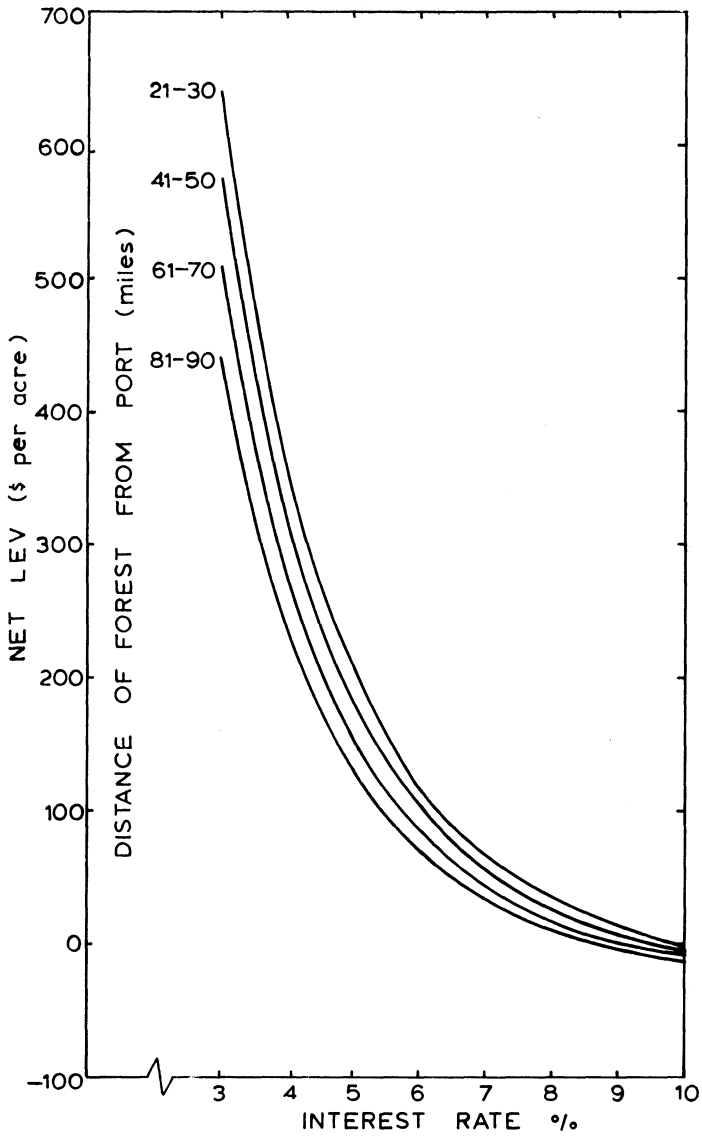


FIG. 6—Effect of location on net LEV.

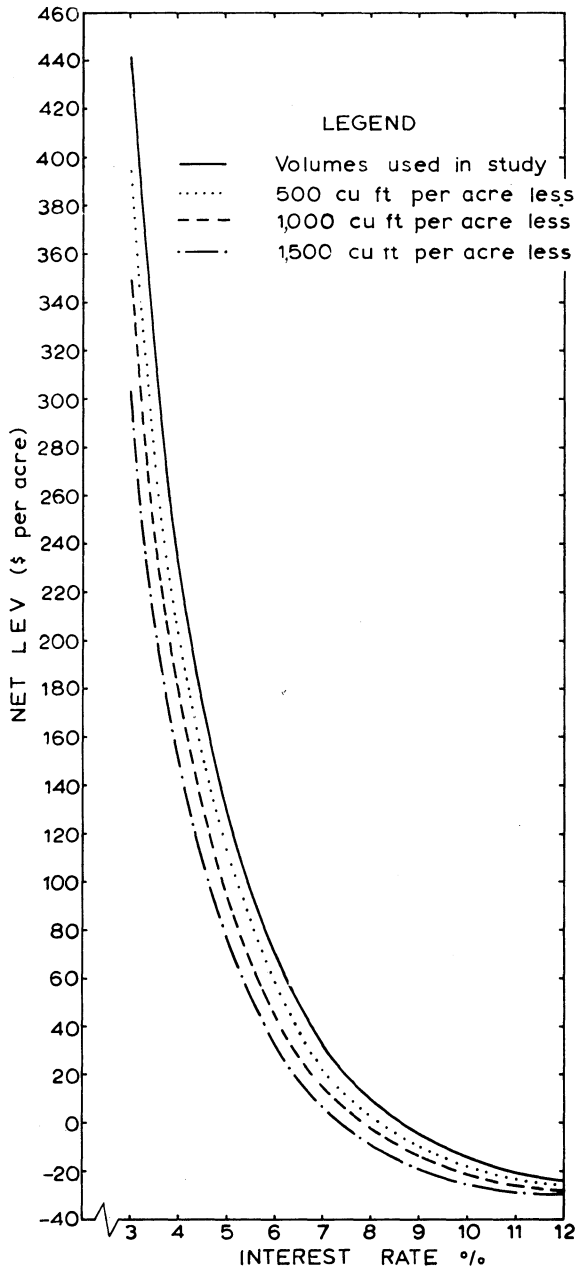


FIG. 7—Effect of lower yields on net LEV.

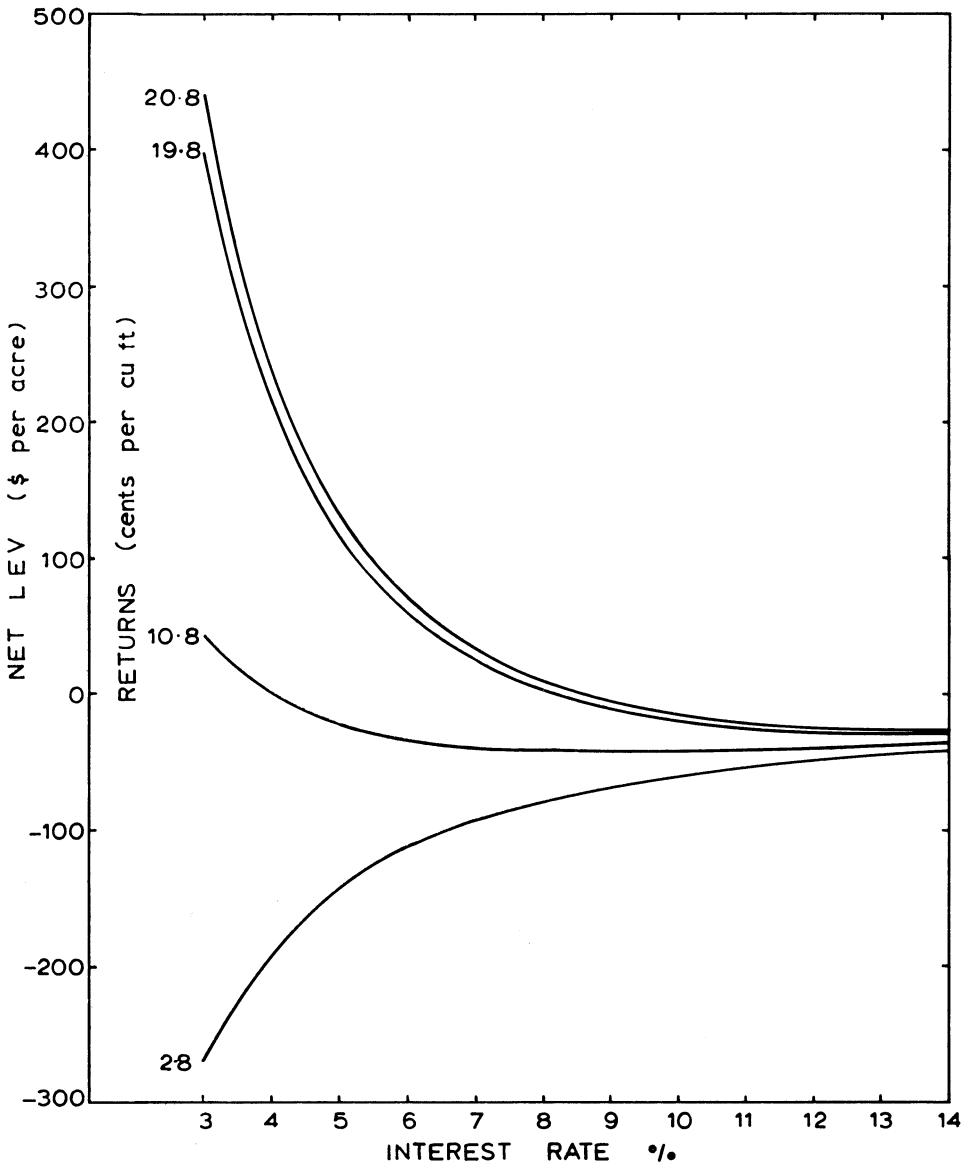


FIG. 8—Effect of changes in returns on net LEV.

APPENDIX 1

YIELD PREDICTIONS

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 lengths, 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; data on stem-breaking points are not available; more data to predict yields with greater accuracy are desirable.

APPENDIX 2

LAND PREPARATION

The land preparation schedule is given in Table 21. (Unit costs are the same as those used in the 95 model. Some of the operations have been delayed by 2 yr in line with the more extended initial planting.)

TABLE 19—Volume summary

Age yr	Top Ht ft	Basal Area per Acre sq ft	Mean d.b.h. in.	Total Vol. cu ft	Net Vol. cu ft
23	93	200	15.6	6,200	5,400
24	96	217	16.3	6,900	5,756
25	100	228	16.7	7,500	6,318
26	103	239	17.1	8,100	6,720
27	106	250	17.5	8,700	7,420
28	108	256	17.7	9,100	7,730
29	110	262	17.9	9,400	8,235
30	112	268	18.1	9,800	8,525
31	114	274	18.3	10,100	8,815
32	115	280	18.5	10,500	9,150
33	117	283	18.6	10,800	9,550
34	119	286	18.7	11,000	9,950
35	120	289	18.8	11,300	10,080
36	121	293	18.9	11,500	10,300

TABLE 20—Log lengths from mean trees

Stand Age	Top Height	Approximate Height, 6 in. diam. top	Log Lengths Yielded	
yr	ft	ft	ft	
23	93	65	40	20
24	96	69	40	26
25	100	72	40	26
26	103	75	40	26
27	106	78	40	20 13
28	108	80	40	20 13
29	110	82	40(2)	
30	112	84	40(2)	
31	114	86	40(2)	
32	115	87	40(2)	
33	117	89	40	26 20
34	119	91	40	26 20
35	120	92	40	26 20
36	121	93	40	26 20

TABLE 21—Land preparation schedule

Year	Method	Area acres	Rate \$ per acre
1	Cut heavy scrub	1,500	17
	Crush heavy scrub	1,500	6
	Crush light scrub	6,000	4
	Overall burn	23,500	0.06
5-10	Annual burns	2,000 p.a.	0.5
10	Bush felling	500	32
11	Bush burning	500	1
13	Bulldozing bush slash	500	16