PROFITABILITY OF RADIATA PINE AFFORESTATION FOR THE EXPORT LOG TRADE — ON SITE INDEX 95

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ABSTRACT

The economics of radiata pine (**Pinus radiata** D. Don) afforestation for the export log trade are evaluated for characteristic scrub-covered Taupo pumice land, of relatively easy topography. Site index is 95. Twenty thousand eight hundred acres net of the 25,000 acres gross are initially planted in 11 yr, felling begins in the 19th year, and major yields fluctuate between 4.5 and 9 million cu ft annually until formal normality is reached in the 51st year. The yield for the normal rotation of 23 yr is 8,235 cu ft per acre net. Silviculture aims at producing two 39-ft logs to a 6-in. small-end diameter top by planting at 10 x 7 ft, thinning (probably to waste) to 150 stems per acre at 35 ft top height, and clearfelling at 110 ft.

Costs are based on 1967 levels and are charged from the mid-point of the year of origin. Interest rates from 3% to 14% are evaluated.

Ninety-seven men are employed at normality, 59 of them on logging, giving an average production of 76,750 cu ft per man per year. The approximate proportion of costs to a loaded-on-truck basis at 7% interest are: logging 40%; administration 19%; establishment 11½%; protection 8%; tending 7%; and social 15%. A net price-on-truck of 20.8c per cu ft is obtained after allowing 8.8c for port handling costs 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 at 7%) are:

1. Differences in yield of 500 cu ft per acre alter net land expectation values (LEV) by 18%.
2. Differences of 1c per cu ft in realisations alter LEV by 12½%.
3. Break-even growing costs — excluding logging — are about 7.7c per cu ft on stump.
4. Locating the forest 40 miles nearer the port increases LEV by 42% to $135 per acre, and reduces haulage from 16.5 million to 9.3 million ton-miles annually.

Net LEVs at 7% are $95 when social costs are included and $115 when they are excluded. Corresponding internal rates of return are 11.2% and 12.8%.

The high accident rate in logging, the demand for a fit male labour force, and the volume of road traffic are the main non-financial costs. Non-financial benefits from protection and lack of pollution are considerable.

The actual area has been farmed since 1947 and dairy units are now being replaced by sheep farms. No large-scale afforestation for the log trade has been planned; nor is there other evidence that land use decisions, or investments, are being taken on economic grounds.

INTRODUCTION

Radiata pine (*Pinus radiata* D. Don) is the major species used in New Zealand forestry; its growth rate, or site index, is assessed in terms of the height of the 100 largest trees per acre at age 20 (Lewis, 1954). A site index of 95 (meaning the 100 biggest trees per acre will average 95 ft in height at age 20) is typical of much of the inland pumice areas of the Bay of Plenty, where the bulk of the exotic forests are planted. Hence results for this site index and locality are a useful first step in assessing forest profitability in New Zealand; ultimately a schedule of the cost of production for different national volume targets can be prepared (Hummel and Grayson, 1962).

It may appear that the origin and constituents of some costs have been given at egregious length; in a pioneer study of this nature it was considered necessary to show a considerable amount of detail.

LIMITS OF THE STUDY

This paper deals with the profitability of managing successive radiata pine plantations on a given area (described below). It is essentially micro-economic. It covers the effects of different costs, returns, interest rates, profitability criteria, yields, and location for a given pattern of management

The purpose of the original forest profitability calculations (Fenton and Grainger, 1965) was to provide a comparison with agriculture (Ward *et al.,* 1966). A given block of scrub-covered land was deemed to have been used for forestry or for agriculture, each use following an average rate of development. Extension of the work for the 1969 National Development Conference retained the comparative element with agriculture and hence a comparable tempo of management. This paper does not deal with the effects of variations in the rate of afforestation and felling. Further study of the effects of other rates of afforestation and utilisation, in line with simulation and optimising techniques, should logically follow, but experience with the simpler budget methods has been invaluable in defining the difficulties in analysing forest profitability.

Radiata pine is the only species considered for production purposes.

The base year for the Forestry Development Conference was 1967 and prices, costs, and forest practice are generally for that year. There are exceptions where technical practice has been outmoded at the time of writing (mid-1971); this applies to *Dothistroma* needle blight protection, for example; because the disease is recent in New Zealand, there will probably be changes in methods of combating it. A number of inconsistencies present in the earlier reports have been corrected.

CHARACTERISTICS OF THE AREA

Full details of climate, topography, geology, soils, and productivity class are given in an earlier report (Fenton and Grainger, 1965). The original concept of specific results for a given area can be usefully extended if the description is made in generalised terms:

Altitude: 900 to nearly 2,000 ft; general level 1,000-1,300 ft.

Topography: Easy to rolling hills, with fairly coarse texture of dissection, but short,

steep areas occur near two streams, the Mangakino and the Mangakowhiriwhiri. Gully erosion on the latter, following farming, is severe; this stream debouches into the Waikato River immediately above the Whakamaru Dam. Frost flats total 1,700 acres and steep slopes total 2,800 acres gross.

Climate: At Tokoroa, the mean annual rainfall is 55 in. and rain falls on an average of 147 days a year; ground frosts average 97 a year; mean annual temperature is 12°C.

Soils: Taupo silty sand, and Taupo silty sand-hill phase.

Site index: 95 (Lewis, 1954).

Initial ground cover: Manuka (*Leptospermum scoparium*), bracken (*Pteridium aquilinum* var. *esculentum*), tutu (*Coriaria arborea*) and broadleaved shrubs. There were no large wild animals, other than horses present initially.

Boundaries: The actual area includes "that land known to the Lands and Survey Department, Land Development Branch as the Maraetai Block together with the developed part of the Kaahu Block bounded by the Kaahu Road and the Mangakowhiriwhiri Stream" (Fenton and Grainger, 1965). In its original state the area would adjoin undeveloped land and rivers.

Undoubtedly the class of land represented has favourable characteristics for exotic forestry in New Zealand. These include:

1. Altitude, climate, and soil are all favourable for forest growth, and site quality is high.
2. The inflammable scrub cover present (i.e., before land development for farming) is such that initial clearing is cheap and establishment costs are not high. The absence of troublesome weeds, such as gorse, and of noxious animals, such as rabbits and deer, serve to reduce initial costs and facilitate good standards of establishment.
3. Topography is favourable, as over half the net plantable area could be afforested by machine planting. (Three-quarters of the area is capable of extraction thinning by tractor, on present standards.)
4. Similarly, the pattern of dissection and drainage is such that few bridges or culverts are required on over 100 miles of forest roading. On the other hand, the major river crossing of the Waikato necessary between the forest and the market is guaranteed by the Whakamaru Dam itself. The Waikato and the two large streams present on the Block, together with the pattern of major electricity grid lines could present a well laid out and cheap system of major fire breaks (which were largely excluded in fact).
5. Twenty-five thousand acres is a reasonable size of forest to consider; many unit costs decrease sharply above *ca.* 10,000 acres, and the high administrative costs of small units (Sutton, 1969) are avoided.
6. The forest being new, not a botch of earlier mistakes, has no "backlog" of work. Only one species is planted, the outstanding plantation softwood, radiata pine.

These cumulative advantages are formidable, but they are not in any way unique; points (1) to (3) are common to much of the Bay of Plenty-South Waikato area.

The major disadvantage is the distance to a port. The location of the area is shown on the map, Fig. 1.

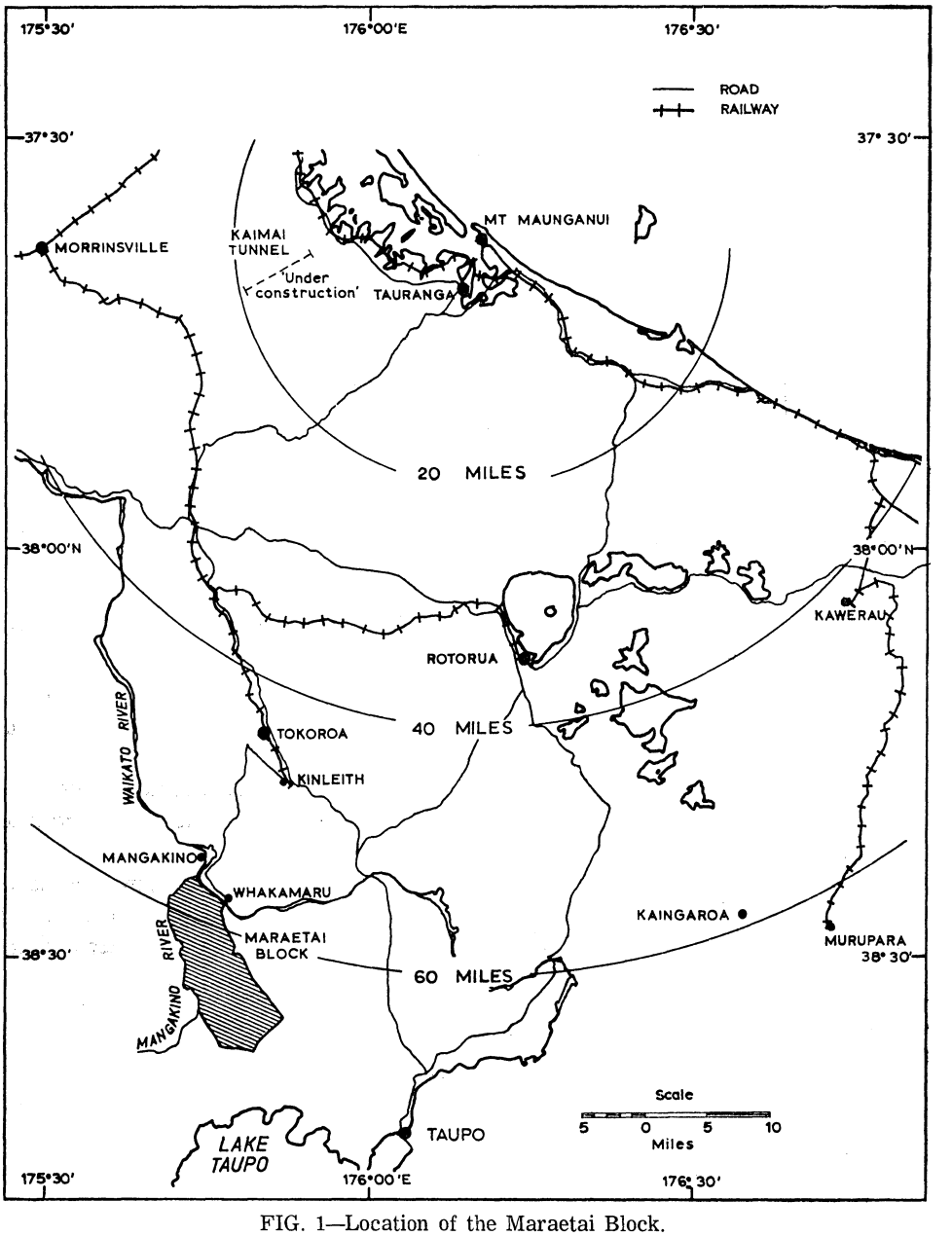

FIG. 1—Location of the Maraetai Block.

TECHNICAL SPECIFICATIONS AND SILVICULTURE

The export trade requires a minimum log small-end diameter (s.e.d.) of 6 in.; and (for the Japanese trade) the following minimum ratios of log lengths by volume:

39 ft, 60%; 26 ft, 35%; 13 ft and 20 ft, 5% or less; and a reasonable degree of straightness. The long lengths are strongly preferred. The acceptance by the Japanese of 5% of log volumes in sizes as small as 5.5 in. s.e.d. instead of 6 in. has been ignored. On a 23-yr rotation the mean tree would comfortably yield two 39-ft lengths to a 6-in. s.e.d. top.

Silviculture is:

(1) Planting sites (excluding frost flats) are thoroughly cleared and burned before establishment.

(2) Initial spacing: trees 7 ft apart in rows 10 ft apart (620 stems per acre (s.p.a.)).

(3) Blanking: it is assumed that 10% of the trees will need replacement the year following planting.

(4) Release cutting: on frost flats — not required; on hill sites — one operation in each of the first and second years after planting; on all other sites — one operation the year after planting.

(5) Thinning to waste: at 35 ft top height to 150 s.p.a. (using power saws).

(6) Protection: *Dothistroma pini* prevention is given in detail in Appendix 1: basically stands would be aerially inspected each year with closer ground inspection of suspect areas; the area planted would be sprayed when trees are 8-10 ft and again at 18-25 ft. It is possible that a third spray would be required after the thinning to waste at 35 ft.
Regenerated areas would have an extra spray when trees are 3-4 ft high.

(7) Clearfelling: at normality at 110-ft top height at age 23.

The only variation from this regime is on frost flats (of 1,600 acres net). It has been assumed that *Pinus cortorta* Dougl. planted at 20 x 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 regenerated on old frost flats without undue difficulty; as subsequent rotations begin at least 36-yr after the year of origin of the forest the financial effect of frost-flat re-establishment will be relatively slight. It is possible that, with well hardened nursery stock, shelterwood methods would be unnecessary.

Second and subsequent rotations are assumed to be restocked on the basis: one-third of the area planted; one-third direct seeded from the air; one-third naturally regenerated. Subsequent treatment for sown and regenerated stands includes an initial spraying against *Dothistroma,* after slasher thinning-cum-release cutting at age 2-3. Sown and regenerated crops are not blanked, but this is still prescribed for planted stands. Treatment of stands of all origins is the same from about 5 ft height onwards.

MANAGEMENT

1. Areas

The pattern followed is of rapid initial afforestation, completed in half the rotation, with eventual conversion to normality by more extensive initial 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 that strict normality is necessary (or desirable); in practice, fluctuating inputs and yields can be accepted. The schedule

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

Year	Planting		Sowing	Blanking	Release Cutting		Slasher Thinning	Thinning to waste	Clearfelling		Year Planted
	Machine	Hand			One	Two			Area acres	Age yr	
1	1592 +1,000										
2	2,000			1,000	1,000						
3	2,000			2,000	2,000	1,000*					
4	2,000			2,000	2,000						
5	2,000			2,000	2,000						
6	1,000	1,000		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			1,000 +800+			
10	800	2,200		2,000	2,000			2,000 +792+			
11	792			3,000	3,000			2,000			
12				792	792	2,200		2,000			
13								2,000			
14								2,000			
15								2,000			
16								2,000			
17								2,000			
18								3,000			
19		140	130					792	400	18	1
20		270	265	140	140				600 200	19 18	1 2
21		270	265	270	270		260		800	19	2
22		400	400	270	270		530		1,000 200	20 19	2 3
23		500	500	400	400		530		1,500	20	3
24		500	500	500	500		800		300 1,200	21 20	3 4
25		534	533	500	500		1,000		800 800	21 20	4 5
26		534	533	534	534		1,000		1,200 400	21 20	5 6
27		534	533	534	534		1,066	400	1,600	21	6
28		534	533	534	534		1,066	800	1,600	21	7
29		332	332	534	534		1,066	800	400 596	22 21	7 8
30		302P	301P	332	332		1,066	1,200	904	22	8
31				302P	302P		664	1,500	500 404	23 22	8 9
32							602P	1,500	904	23	9
33								1,600	692 212	24 23	9 10
34								1,600	904	24	10
35								1,600	904	25	10
36						392)		1,600	904	26	10
						)			76	27	10
37						904)	occurs	996	792	26	11
						)	every		36	18	19
						)	rotation ‡				
38						)			364	19	19
						904)		904P	540	18	20
39									260 644	19 18	20 21
40									156 748	19 18	21 22

TABLE 1 (continued)

Year	Planting		Sowing	Blanking	Release Cutting		Slasher Thinning	Thinning to Waste	Clearfelling		Year Planted
	Machine	Hand			One	Two			Area acres	Age yr	
41									452	19	22
									452	18	23
42									904	19	23
43									144	20	23
									760	19	24
44									740	20	24
									164	19	25
45									904	20	25
46									532	21	25
									372	20	26
47									904	21	26
48									324	22	26
									580	21	27
49									904	22	27
50									116	23	27
									788	22	28
51									812	23	28
									92	22	29
52						96P°			904	23	29

* An additional releasing is allowed as this 1,000 acres is planted on land which is less thoroughly cleared than for later planting.

+ Poison overwood.

‡ The steeper hill country (of 2,200 acres net) is release cut twice for all rotations.

o Hill country release cutting average.

P = in perpetuity

of planting, silvicultural operations, and felling is given in Table 1, and the land clearing schedule in Appendix 3A. Felling begins in the 19th year and after a gradual build-up to 1,600 acres a year finally stabilises at 907 acres a year.

The management divisions by area are:

			Release Cuttings	Acres (net)
Tractor Plantable	Frost flats		nil	1,600
	Not frost flats		1	10,000
Not Tractor Plantable	Not frost flats		1	7,000
	Not frost flats	"Hill country"	2	2,200
			Total	20,800

The total comprises 83% of the gross area of 25,000 acres.

2. *Yield Prediction*

The yield predictions for the regime are based on Beekhuis, 1966, and details are given in Appendix 2. In summary, the initial basal area at top height 35 ft after thinning to 150 s.p.a. has been taken as 37 sq ft. On the sparse data available at present, only three-quarters of the projected basal area increment up to top height

75 ft has been allowed. The full projected basal area has been accepted after 75 ft top height, as the total basal area, 145 sq ft, is then within the limits of accuracy of the method of projection (viz., basal area in square feet = top height in feet). A further, artificial assumption is that there is no mortality. At age 23, top height 110 ft, the total basal area is predicted to be 245 sq ft, and the total volume 9,400 cu ft; the net logged volume has been taken as 8,235 cu ft or about 12½% less.

More accurate projections should become available in the future. The uncertainty has been accommodated in the results by expressing the returns per 1,000 cu ft an acre of yield obtained. This approach is possible as the technical prescription (of 60% by volume of logs 39 ft long to a 6-in. top) is attained with a wide margin to spare when stand height is 110 ft. The actual yields of 39-ft and 26-ft log lengths based on the projected range of d.b.h. classes (Beekhuis, 1966) around the mean tree at age 23 are shown in Figs. 2 and 3.

LABOUR REQUIREMENTS

The direct labour content of establishing and growing the forest is given in Table 2. A schedule of the logging yields and man-day requirements is given in Table 3.

The supervisory staff and indirect labour needed to support the direct labour force is given in Table 4. The manpower sub-totals from direct forest operations, logging, and staff and indirect labour are summarised in Table 5.

The origins of these labour contents are given with details of their costs in subsequent sections; the net labour figures are required at this stage to facilitate calculation of the houses, staff, and logging plant required.

COSTS: DIRECT FOREST OPERATIONS

Table 6 summarises the labour content and costs of direct forest operations. These costs comprise wages and production bonus; compensation and holiday pay (12% on the wages and travel time paid); travel time; direct stores charges; and transport and machinery hire. All indirect costs such as supervision and other overheads are included under separate accounts. All machine capital costs, that is vehicles, tractors, and other engineering plant, have been enumerated separately; this is necessary to allow nominally correct depreciation charges to be made.

Details of the land preparation, hand and machine planting, aerial sowing, blanking, release cutting, and various thinnings are given in Appendix 3.

Logging costs and equipment needs have been calculated in Appendix 4, and the equipment needed is listed in Table 7. A man-hour production of 80 cu ft has been used for clearfelling 20-yr and older stands. A working day of 7 hours, and a working year of 240 days have been assumed for logging.

PROTECTION COSTS

These comprise fire, and *Dothistroma pini* (needle blight) prevention and control, and some miscellaneous items.

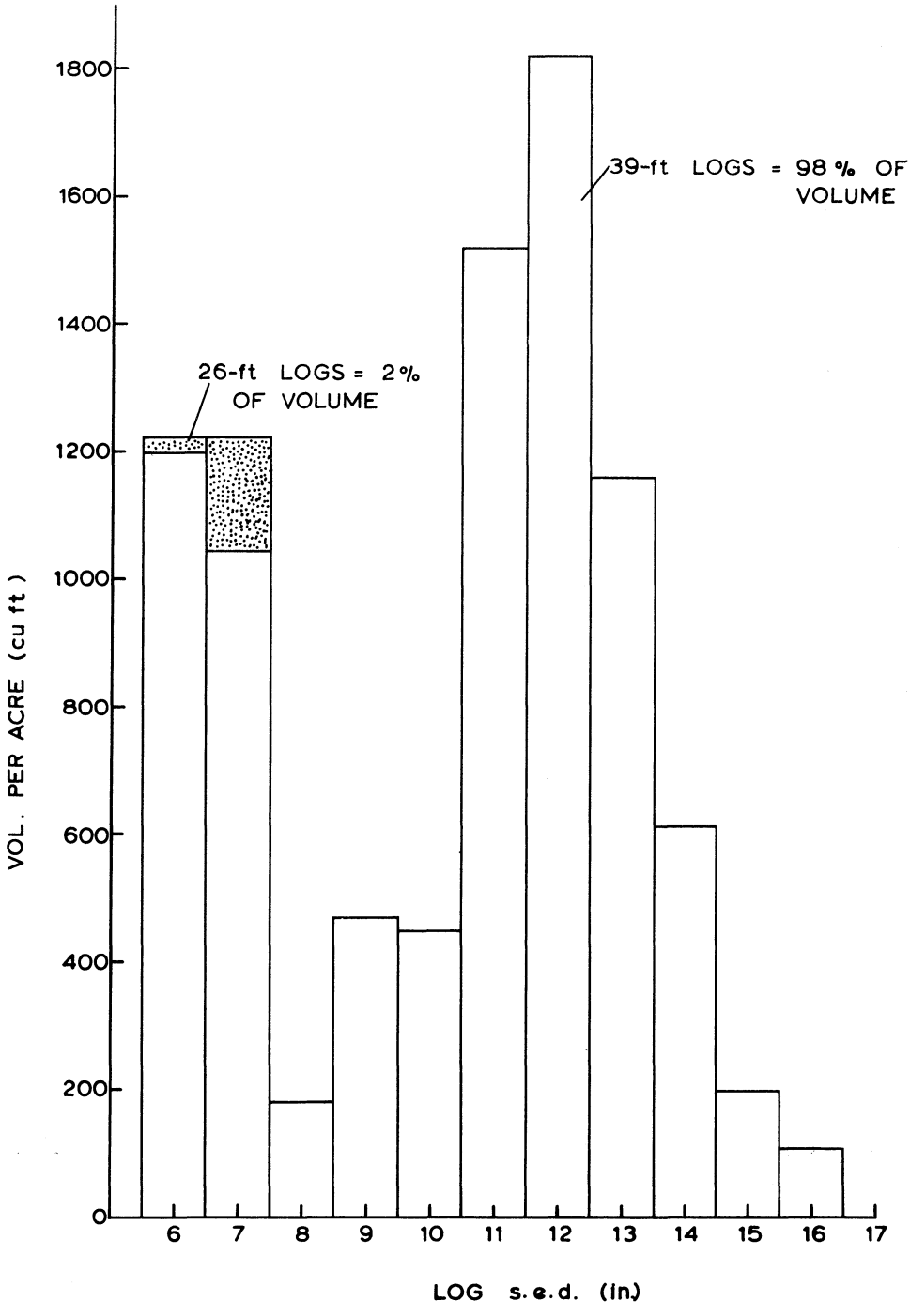

FIG. 2—Volume of stand by log s.e.d. and length at normality — age 23 (excluding logging losses).

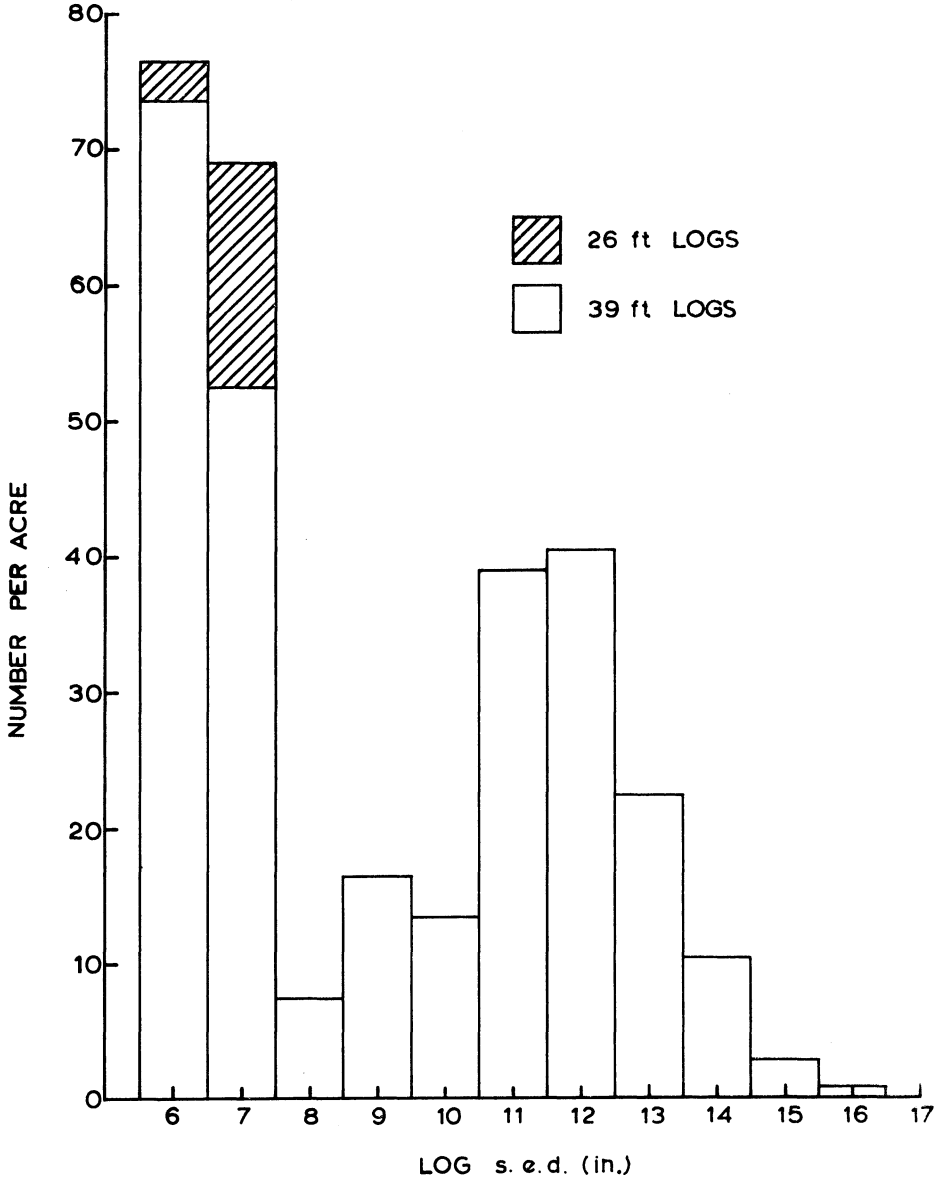

FIG. 3—Number of 39-ft and 26-ft logs per acre at normality—age 23 (excluding logging losses).

TABLE 2—Direct labour requirements, forest growing and tending

Year	Planting		Blanking	Slasher Thinning	Release Cutting		Thinning to waste	Totals	
	Tractor 1st rotation man-days	Hand man-days	man-days	man-days	One man-days	Two	man-days	days	years
1	402							402	2
2	310		300		670			1,280	6
3	310		600		1,340	670		2,920	13
4	310		600		1,340			2,310	10
5	310		600		1,340			2,310	10
6	155	622	600		1,340			2,715	12
7		1,244	600		1,340			3,180	14
8		1,244	600		1,340			3,180	14
9		1,244	600		1,340		1,500 + 533*	5,213	22
10	124	1,364	600		1,340		3,000 + 528	6,956	30
11	123		900		2,010		3,000	6,033	25
12			238		531	1,474	3,000	5,243	22
13							3,000		13
14							3,000		13
15							3,000		13
16							3,000		13
17							3,000		13
18							4,500		19
19		87					1,188	1,275	5
20		168	42		94			304	2
21		168	81	174	181			604	3
22		248	81	355	180			864	4
23		310	120	353	268			1,051	5
24		310	150	536	335			1,331	6
25		331	150	667	335			1,483	6
26		331	160	667	358			1,516	7
27		331	160	714	356		600	2,161	9
28		331	160	711	356		1,200	2,758	12
29		206	160	711	356		1,200	2,633	11
30		188	100	711	222		1,800	3,021	13
31		P	91	445	202		2,250	3,176	14
32			P	404	P		2,250	3,135	13
33				P			2,400	3,285	14
34							2,400	3,285	14
35							2,400	3,285	14
36						263	2,400	3,549	15
37						606	1,494	2,985	13
38						606 †	1,356 P	2,847	12
								2,241 †	9

* Poisoning overwood in frost flats

† The extra releasing on the hill averages 64 man days in perpetuity from year 52

P = in perpetuity

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

Year	Area acres	Vol/Acre cu ft net	Total Production cu ft	M.H.P.* cu ft/hr	Total Labour days	Tractors
19	400	4,583	1,833,200	65	4,029	1.5
20	200	4,583		65	4,014	
	600	5,310	4,102,600	75	6,285	3.4
21	800	5,310	4,248,000	75	8,379	3.5
22	200	5,316		75	2,095	
	1,006	5,616	6,678,000	80	10,028	5.5
23	1,500	5,616	8,424,000	80	15,043	7.0
24	1,200	5,616		80	12,034	
	300	6,318	8,634,600	80	3,384	7.2
25	800	6,318		80	9,025	
	800	5,616	9,547,200	80	8,023	8.0
26	400	5,616		80	4,011	
	1,200	6,318	9,828,000	80	13,538	8.2
27	1,600	6,318	10,108,800	80	18,051	8.5
28	1,600	6,318	10,108,800	80	18,051	8.5
29	596	6,318		80	6,724	
	400	6,993	6,562,700	80	4,995	5.5
30	904	6,993	6,321,700	80	11,288	5.3
31	404	6,993		80	5,045	
	500	8,235	6.942,700	80	7,352	5.8
32	904	8,235	7,444,400	80	13,293	6.2
33	212	8,235		80	3,117	
	692	8,815	7,845,800	80	10,892	6.5
34	904	8,815	7,968,800	80	14,230	6.6
35	904	9,504	8,591,600	80	15,342	7.2
36	904	10,395	9,397,100	80	16,780	7.8
37	792	10,395		80	14,701	
	76	11,002		80	1,493	
	36	4,583	9,233,900	65	362	7.7
38	540	4,583		65	5,439	
	364	5,310	4,407,600	75	3,812	3.7

TABLE 3 (continued)

Year	Area acres	Vol/ac cu ft net	Total Production cu ft	M.H.P.* cu ft/hr	Total Labour Days	Tractor No.
39	260	5,310		75	2,723	
	644	4,583	4,332,000	65	6,486	3.6
40	748	4,583		65	7,534	
	156	5,310	4,256,300	75	1,634	3.5
41	452	5,310		75	4,734	
	452	4,583	4,471,500	65	4,552	3.7
42	904	5,310	4,800,200	75	9,469	4.0
43	760	5,310		75	7,960	
	144	5,616	4,844,200	80	1,444	4.0
44	740	5,616		80	7,421	
	164	5,310	5,026,700	75	1,541	4.2
45	904	5,616	5,076,900	80	9,065	4.2
46	372	5,616		80	3,730	
	532	6,318	5,450,300	80	6,002	4.5
47	904	6,318	5,711,500	80	10,199	4.7
48	580	6,318		80	6,543	
	324	6,993	5,930,200	80	4,046	4.9
49	904	6,993	6,321,700	80	11,289	5.3
50	788	6,993	6,465,700	80	9,840	
	116	8,235		80	1,705	5.4
51	812	8,235		80	11,940	
	92	6,993	7,330,200	80	1,149	6.1
52	904	8,235	7,444,400	80	13,293	6.2

* M.H.P. = man hour production

TABLE 4—Staff and indirect labour schedule

Year	1	2	3	4	5–6	7–8	9–17	18	19–21	22	23–27	28	29+
STAFF													
Officer in charge	1P												1
Forester		1P											1
Ranger/Foreman		1P					1P		1P				3
Clerks/Stores	1P						1P		1P*				3
Logging													
Ranger in charge								1P					1
Ranger/Foreman									1P	1P	1	-1†	2
Roading													
Ranger	1P												1
OTHER LABOUR													
Grader driver					1P								1
Men	2P							3				-3	2
Fleet													
Mechanic	1P						1P		3*				5
Driver	1P						1P						2
Other													
Tractor driver	1P												1
Fire lookout			1P										1
Fire storekeeper			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	33	35	36	33	32

P = in perpetuity

* Attributable to logging

† In year 29

The fire lookout is the only man already housed

TABLE 5—Total manpower

Year	Labour			Staff and Indirect Labour	Total
	Forest Operations (1) man-days	Logging (2) man-days	Sub-total (3) man-yr	(4) man-yr	man-yr
1	402	-	2	10	12
2	1,280	-	6	12	18
3	2,920	-	13	14	27
4	2,310	-	10	15	25
5	2,310	-	10	16	26
6	2,715	-	12	16	28
7	3,180	-	14	17	31
8	3,180	-	14	17	31
9	5,213	-	22	22	44
10	6,956	-	30	22	52
11	6,033	-	25	22	47
12	5,243	-	22	22	44
13	3,000	-	13	22	35
14	3,000	-	13	22	35
15	3,000	-	13	22	35
16	3,000	-	13	22	35
17	3,000	-	13	22	35
18	4,500	-	19	26	45
19	1,275	4,029	22	33	55
20	304	8,299	36	33	69
21	604	8,379	38	33	71
22	864	12,123	54	35	89
23	1,051	15,043	67	36	103
24	1,331	15,418	70	36	106
25	1,483	17,048	78	36	114
26	1,516	17,549	80	36	116
27	2,161	18,051	85	36	121
28	2,758	18,051	87	33	120

TABLE 5 (continued)

Year	Labour			Staff and Indirect Labour	Total
	Forest Operations (1) man-days	Logging (2) man-days	Sub-total (3) man-yr	(4) man-yr	man-yr
29	2,634	11,719	60	32	92
30	3,021	11,288	60	32	92
31	3,176	12,397	65	32	97
32	3,135	13,293	69	32	101
33	3,285	14,009	72	32	104
34	3,285	14,230	73	32	105
35	3,285	15,342	78	32	110
36	3,549	16,780	85	32	117
37	2,985	16,556	82	32	114
38	2,847	9,251	51	32	83
39	2,305	9,209	48	32	80
40	2,305	9,168	48	32	80
41	P	9,286	49	P	81
42		9,469	49		81
43		9,404	49		81
44		8,962	47		79
45		9,065	48		80
46		9,732	51		83
47		10,199	52		84
48		10,589	54		86
49		11,289	57		89
50		11,545	58		90
51		13,089	65		97
52		13,293	65		97
		P			P

(1) From Table 2

(2) From Table 3

(3) Assuming 240 man-days per year

(4) From Table 4

P = in perpetuity

TABLE 6—Summarised direct costs and labour requirements

Operation	Direct Cost $ per Acre	Man-Days per Acre	Full Details in Appendix 3
Land clearing			
Burning	0.50		
Light scrub	4.00	Contractor	A
Heavy scrub	6 + 17	"	
Bush felling	32 + 16	"	
Planting			
Hand	15.34	0.62	B
Machine	10	0.155	C
Sowing	10.0	Negligible	D
Blanking	3	0.3	E
Release cutting	5.3	0.67	F
Thinning to waste	22.2	1.5	
Slasher thinning regeneration	6.50	0.67	G
Poison overwood (frost flats)	7.50	0.67	

TABLE 7—Schedule of logging equipment

Year	Tractors D/7 T	Tractors D/6 T	Tractors D/6 +/-	Arches T	Arches +/-	Loaders T	Loaders +/-	Gang Trucks T	Gang Trucks +/-	Power Saws T	Power Saws +/-	F.S.U. T	Other
18	1												2 tip trucks P $4600* Trekka truck P
19		2	2	2	2	1	1	1	1	8	8		$2,500†
20	2 P	5	3	5	3	2	1	2	1	20	12	1	
22		8	3	7	2	4	2	4	2	32	12		$2,500†
23		10	2	9	2	5	1			40	8		
24													
25		11	1	10	1			5	1	44	4	2	
26		12	1	11	1					48	4	P	
27						6	1						
29		8	-4	7	-4	4	-2	3	-2	32	-16		
32		9	1	8	1			4	1	36	4		
34				9	1								
35		10	1			5	1			40	4		
36		11	1	10	1			5	1	44	4		
38		5	-6	5	-5	3	-2	3	-2	20	-24		
42		6	1							24	4		
46				6	1								
47		7	1							28	4		
49		8	1	7	1	4 P	1			32	4		
51		9 P	1	8 P	1			4 P	1	36 P	4		

P = in perpetuity
F.S.U. = Field Service Unit
T = total
+/- = addition or deletion
* = miscellaneous equipment
† = stores (initial purchase)

1. *Fire Costs*

Fire prevention costs are summarised in Table 8; the origin and constituents of the annual costs is given in Appendix 5. It has been assumed that the fire engine, tanker, and pumps are replaced every 10 yr. (On the actual blocks much of the firebreak

TABLE 8—Summarised fire protection costs

Item	Year	Cost	Life of Asset yr
Firebreak - preparation	1-10	$390 p.a.	-
Fencing	1-5	$500 p.a.	-
Fire fighting equipment	3	$3,400	10
Radio	3	$1,200	10
Fire engine	3	$10,200	10
Fire pumps (2)	4	$1,200	10
Fire tanker	5	$3,600	10
Lookout - capital	3	$5,500	65
maintenance		1¼%*	
Telephone	3	$1,225	-
Fire garage and store - capital	5	$4,400	65
maintenance		1¼%*	

The rate for annual charges is roughly proportional to the acreage planted:

$0.81 per acre up to 7,500 acres

$0.53 per acre from 7,500-13,000 acres

$0.46 per acre above 13,000 acres

* Included in annual charges

construction and maintenance prescribed would be unnecessary. The continued presence of a farmed strip under the five sets of national grid electric power lines adjoining the Waikato River on the north, and the protection of native broadleaved shrubs along the two north-flowing streams on the east and west boundaries would both be better firebreaks than any discing, etc., and a more intelligent way of using the land. No risk of erosion would be incurred.)

2. *Dothistroma Costs*

These are summarised in Table 9; details are in Appendix 1.

As the disease is new in New Zealand, the appropriate control measures will probably vary with further experience. The estimates given are the best available at the time of writing (mid-1971).

3. *Miscellaneous Protection*

Fencing has been charged under forest protection. Although the area requires only 4 miles of fences (plus two gates and two cattle stops), fencing is specified separately because it may be of greater extent in other plantations.

TABLE 9—Anti-**Dothistroma** costs

Operation	Unit Cost per Acre $
Aerial survey	0.01
Ground survey	0.10
Spraying cost	
Chemicals	1.90
Aircraft	0.85–1.00*
Ground staff and transport	0.10–0.34*
	3.00 (say)*

* The range of costs is for large-scale operations (15,000 ac) for two organisations in the Bay of Plenty; the mean cost is close to $3.

SOCIAL COSTS

These comprise roading, accommodation, and minor items.

1. Roading

Forty-eight miles of main road, metalled ready for logging are needed. (The further 72 miles of secondary logging shunts are included in the logging costs.) Basic roading costs used on the easy pumice country are $2,000 a mile for formation and $2,200 for metalling. Annual costs, based on Kaingaroa, are 30c an acre of planted forest. No bridges are required. Table 10 shows the items charged in roading (together with some

TABLE 10—Social costs, excluding houses and camp

	A. ROADING						B. MISCELLANEOUS		
			Maintenance		Equipment				
Year	Formation $	Metalling	Forest Area acres	Cost per Acre $	Item	Cost $	Water Supply *	Site Preparation	Share of Services †
1	8,800		2,592	0.30	Tip truck (½)	2,250	2,500	1,000	538
2	8,800		4,592	0.30			2,500		677
3	8,800		6,592	0.30			1,100	1,200	972
4	8,800		8,592	0.30					666
5	8,800		10,592	0.30	10-cwt truck grader	2,000 20,000			820
6	8,800		12,592	0.30					976
7	8,800		14,592	0.30					872
8	8,800		16,592	0.30					995
9	8,800		18,592	0.30					1,115
10	8,800		20,792	0.30P	Tip truck (½)	2,250			1,235
11	8,800								P
12	8,800								
17		$9,600 p.a. from 17 up to and incl. yr 26							

* Half cost allotted to Social Cost, the other half to capital works (Table 13)

† Half of the "Services" component of the repair and maintenance charge (Table 15)

P = in perpetuity

minor social costs.) The extra cost of maintaining roads for logging traffic are included in the logging charges; this enables the cost of roads available for ordinary purposes to be isolated as part of "social" costs. Further discussion of roading costs is included in Appendix 6.

2. Accommodation

The total labour needed for direct forest production, logging, and staff and indirect labour, are shown in Table 5. The camp for single workers is deferred as sufficient houses are built for the labour needed in the establishment phase. It has been assumed that 10 men can be recruited locally and these are not housed in the forest.

The schedule of houses and other accommodation is given in Table 11.
Houses cost $8,400 each and huts $700 each. Repairs and maintenance costs are 1¼% annually (Fenton and Grainger, 1965).

The cost of running the camp is given in Appendix 6, and includes the cost of caretaking, stores, power, subsidy on the cookhouse when total labour is less than 25, repairs, and maintenance charges. The annual total at normality is $8,750. Some slight credits are due from hut rents of 10c a week, allowed for 45 weeks a year.

House rents of $3 a week for 50 weeks a year are recoverable.

3. Minor Social Costs

Minor social costs include half the water supply (as in Table 10) totalling $6,100, and "services not elsewhere indicated" including sewerage and stormwater drainage totalling $15,700 spread over the period of house construction. Village site preparation (which may not be necessary) has been costed at $1,000 in year 1 and $1,200 in year 3. The annual cost of repairs and maintenance on these assets (which form part of the composite Forest Service accounting group "Services and General Assets") is based on an analysis of costs for the forests of Auckland and Rotorua Conservancies.

Further details of social costs are given in Appendix 6.

INDIRECT FOREST COSTS

There are many indirect costs and the basis and application of some are hard to define. The two broad classes of "administrative" and "capital" costs, rated by the ease and hence the accuracy of their cost determination, are:

Administrative

1. Staff salaries — Easy
2. External overheads — Difficult
3. General administration — Difficult

Capital

Each capital cost is generally represented by three related costs:

the initial cost — Easy
the repair and maintenance cost — Reasonably easy
depreciation charges — Difficult

The items are

4. Forest buildings (excluding accommodation and protection)
5. Forest machines (excluding logging and protection)
6. "Services and general assets"
7. Stores (the economic treatment of which may vary from a government accounting system)

Some of these items are more significant than others.

TABLE 11—Accommodation required

Year	Houses		Huts		Other Expenses	$
	New	Total	New	Total		
1	2	2			Services N.E.I.*	3,000
2	6	8				
3	8	16			Services N.E.I.	6,000
6	1	17				
7	3	20			Services N.E.I.	3,000
9	13	33			Services N.E.I.	3,700
10	8	41				
12-17						
19			3	3†		
20			14	17	Cookhouse	17,000
					Caterer's house	6,700
					Ablution block	5,600
21			2	19		
22			18	37	Cookhouse extension	10,700
					Ablution block extension	3,300
23			14	51		
24			3	54		
25			8	62		
26			2	64		
27			5	69		
38	Maximum number thereafter is 97 - say 100			48	Move 21 huts (probably written off)	
	‡ 10 + 1 + 41 = 52		∴ 48 huts are enough			

*N.E.I. = not elsewhere indicated

† Larger, baching huts

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

1. *Staff Salaries*

The schedule of staff required is given in Table 4 in the section on manpower. Supervision costs (including staff) have been excluded from all direct forest operations. The cost of staff based on 1967 Forest Service salary scales is given in Table 12. The forester would have two degrees; most rangers would have spent at least 2 years on formal full-time training. Forests are not run by professionally qualified men in the New Zealand Forest Service.

TABLE 12—Salaries ($ per year)

No.	Designation	Year											
		1	2	3	4-6	7	8	9-17	18	19-21	22	23-28	29+
Forest													
1	Officer in charge	3,410	3,410	3,410	3,550	3,550	3,750	3,750	3,750	3,900	3,900	3,900	3,900
1	Forester		2,570	2,570	2,810	2,810	2,810	2,810	2,810	3,170	3,170	3,170	3,170
1-2	Forest Foreman		2,250	2,250	2,360	2,360	2,360	2,360	2,360	4,610	4,610	4,610	4.610
1	Forest Ranger							2,570	2,690	2,690	2,690	2,690	2,690
1	Forest Ranger, Roading	2,250	2,250	2,360	2,360	2,570	2,570	2,570	2,570	2,690	2,690	2,690	2,690
1	Office 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
1	Stores Clerk							2,450	2,450	2,450	2,450	2,450	2,450
Logging													
1	Officer in charge								3,410	3,410	3,410	3,410	3,410
1	Foreman									2,360	2,360	2,360	2,360
1-2	Rangers										2,690	5,380	2,690
1	Clerk									2,230	2,230	2,230	2,230

2. *External Overheads*

External overheads are difficult to cost as they comprise charges which are remote from the forest. An earlier study (Fenton and Grainger, 1965) assumed a private forest with greater autonomy needing higher salaries, extra vehicles, and some head office expenses, resulting in annual costs of 78c per planted acre. This was close to the average of 72c for Rotorua Conservancy. Later analysis (Fenton *et al.,* 1968b) showed considerable variation between forests. The cost can be based on the planted area or on salaries. The latter has been chosen and 60% of annual salaries charged; this is close to that charged earlier (Fenton and Grainger, 1965). The effects of varying this, and other costs, are given in the sensitivity analysis.

3. *General Administration*

These include:

(1) Office expenses: Printing and stationery, telephone, cleaning, audit, postages, light and heat, aerial photography, forest atlas.

(2) Administration expenses: Staff expenses which cannot be allocated to any specific operation (including salaries, overtime, sick leave and travel).

(3) Staff training: Cost of courses, etc., and travel in connection therewith.

(4) Working plans: Cost of preparation, control, and supervision.

(5) Recruitment: General costs, including expenses of applicants and medical examinations.

(6) Depreciation on "Class A" stores.

Details are given in Appendix 7; costs are from averages of all North Island forests, are based on planted area, and total $6,960 annually when the forest is fully planted.

County rates of $5,000 a year are costed separately, and excluded from the net results.

4. Forest Buildings (Capital Works)

The schedule of capital works required, and their initial costs, is given in Table 13. The costs of accommodation and roading are included under social costs given earlier; similarly the Forest Service item, "other services" including stormwater drains, sewerage, and other charges, has been allotted to social costs.

TABLE 13—Capital works required

Year	Item	Cost $	
1	Office and store	7,750	
	Petrol store	3,300	
	Telephone lines - ½ cost	1,225	Half charged to Protection*
	Water supply - ½ cost	2,500	Half charged to Social Costs†
2	Garage/workshop	16,000	
	Water supply - ½ cost	2,500	Half charged to Social Costs†
3	Water supply - ½ cost	1,100	Half charged to Social Costs†
18	Office extension	7,750	
	Garage extension	16,000	

* Table 8

† Table 10

The capital costs shown for forest buildings have been based on the original figures (Fenton and Grainger, 1965) increased by the 11% rise in the National Building and Construction Cost Index. The repairs and maintenance cost of these assets is 1¼% per annum and the service life of the forest buildings has been taken as 40 yr in line with commercial standards.

Both the office and garage are enlarged when clearfelling begins at age 18.

5. Forest Machines

Vehicle and other machinery requirements (apart from logging items already given in Table 7) are bought in relation to the forest area and activity. Details are given in

TABLE 14—Miscellaneous vehicles and equipment

Year	Description	Cost $	Charged to
1	10-cwt truck (OC)	2,000	Forest
	Gang truck	5,000	Forest
	Tip truck	4,500	Half to social, half to forest
	HD6 tractor	13,250	Forest
3	Class 'A' stores	1,100	Forest
	Consumable stores	2,000	Forest
	Car	2,500	Forest
5	Grader	20,000	Roading
	10-cwt truck	2,000	Roading
	Consumable stores	3,000	Forest
6	Gang truck	5,000	Forest
8	Class 'A' stores	5,000	Forest
10	Gang truck	5,000	Forest
	Tip truck	4,500	Half to social, half to forest
	10-cwt truck	2,000	Forest
	Consumable stores	5,000	Forest
13	Class 'A' stores	5,000	Forest
	Gang truck - CREDIT		Transfer to other projects
18	Class 'A' stores	2,500	Forest
	3 10-cwt trucks	6,000	Forest
	Miscellaneous equipment	9,200	Half to forest, half to logging
	Trekka truck (logging OC)	1,770	Logging
	2 Tip trucks	9,000	Logging
19	Gang trucks - CREDIT		Transfer to other projects
	Consumable stores	5,000	Forest
22	Consumable stores	5,000	Forest
28	Gang truck	5,000	Logging
Totals	8 light vehicles (1 for roading) 2 gang trucks 4 tip trucks (3 for roading, 2 of which are costed under logging) 1 grader (for roading) 1 tractor		

Table 14; costs are Forest Service purchase prices. Repairs and maintenance charges of heavy vehicles and plant are included in the hire rate debited against the job where the item is used. Depreciation here has been costed in at the end of the life of the vehicle; but in Forest Service accounts it forms an integral part of the hire charge and as such its incidence varies according to the interest rate. These depreciation costs can be isolated to some degree, and more convenient costing of these items is the subject of current research; depreciation is discussed on p. 32.

Annual operating charges of the eight light administrative vehicles are detailed in Appendix 8. They were based on 9,300 miles a year (from data based on 476,000 miles of running), and omitting the depreciation charge, cost 8.12c a mile. Service life has been taken as 10 yr.

6. *Services and General Assets*

The Forest Service cost item "services and general" includes the water supply, sewerage, telephone and power systems, and office grounds. The ratio of "general" to "services" is about 2 : 1. An analysis of seven Rotorua forests showed a decreasing unit cost per acre as forest size increased. Half of the "service" charges are allotted to social costs, as they are provided for the camp and village. Net charges are given in Table 15.

TABLE 15—Repairs and maintenance: services and general assets

Year	Acreage	'General' Charge per Acre $	Total* Charge per Acre $
1	2,592	0.83	1.0375
2	4,592	0.59	0.7375
3	6,592	0.59	0.7375
4	8,592	0.31	0.3875
5	10,592	0.31	0.3875
6	12,592	0.31	0.3875
7	14,592	0.24	0.3
8	16,592	0.24	0.3
9	18,592	0.24	0.3
10	20,792	0.24	0.3

* Services and general

7. *Stores*

"Class A" stores include all the hand and tradesmen's tools necessary for forest operations. Costs are allocated by years in Table 14, and their depreciation (costed in the form of direct replacements) is included under "general administration". Some of these items should be costed to "Protection", but it is too difficult to decide on a fair figure, so these have remained in the forest account.

Similarly the forest must invest in adequate stocks of consumable stores: petrol,

oil, tyres, vehicle spares, paint, stationery, etc. The actual usage is charged under appropriate cost headings, but the initial stock has to be purchased.

The amounts specified are little more than intelligent guesses for the scale of operations concerned.

DEPRECIATION CHARGES

The role of depreciation is to replace a semi-permanent asset when it wears out.

1. Applying Depreciation Rates

Conventionally, depreciation charges are costed annually at a given rate so set that the asset is more or less written off at the end of its service life; the accumulated depreciation funds then replace the asset. But if a project is evaluated over a range of interest rates, the annual depreciation charge is itself subject to interest, and the project is, in fact, overcosted. This is avoided if the asset is charged in at cost price at the end of its service life, which is done under a separate computer programme (FIN 2). The problem remains that depreciation is an integral part of the hire charge, or cost basis, of forest machines and as such is still overcosted. The overcosting is adjusted in this study by:

(1) evaluating the capital cost and annual depreciation charges of each semi-permanent asset;

(2) repeating this evaluation, but allowing for depreciation by charging the recurrent replacement cost at the end of each service life, in addition to the first capital cost;

(3) subtracting (2) from (1) to find the degree of overcosting where necessary. It has to be assumed that the equivalent of annual depreciation is built up in using the unadjusted rates for the semi-permanent assets.

2. Depreciation Rates — Buildings

The standard rate allowed for depreciation of wooden buildings by the Inland Revenue Department is 2½% on original cost, giving a service life of 40 yr. However, any well-maintained wooden building will normally have a service life in excess of 40 yr (Fenton and Grainger, 1965), and an average service life of 65-yr (about a 1½% depreciation rate) has been taken for houses, the fire look-out, and fire store. To maintain comparisons with other industries, the 40-yr life has been accepted for the office and administrative buildings. As a high rate of occupancy has been assumed for the camp, and ideas on appropriate quarters have changed faster for single than for married accommodation, a life of 20 yr has been taken for huts. The cookhouse and ablution blocks have been given a 40-yr life as obsolescence will apply.

3. Depreciation Rates — Logging Equipment

Logging equipment has the highest unit cost and the shortest working life of the items considered here. Optimum service life depends on the degree of use, maintenance, and operating difficulty experienced, as well as the scale of spare equipment. The lives listed in Table 16 are estimates based on current Forest Service experience.

TABLE 16—Service life

Item	Charge to	Life Years	Remarks
Houses	Social - accommodation	65	
Huts	Social - accommodation	20	Single men's camp
Caterers' 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
Office, store	Capital works	40	
Garage	Capital works	40	
Oil store	Capital works	40	
Fire lookout, store	Protection	65	
Fire engine, tanker pumps, radio	Protection	10	
Miscellaneous equipment	Forest vehicles and equipment	10	50% to forest; 50% to logging
10-cwt truck; car; Trekka	Forest vehicles and equipment	10	
Gang trucks	Forest vehicles and equipment	10	2 to forest; 4 to logging
Tip trucks	Forest vehicles and equipment	10	1 to forest; 2 to logging 1 to social - roading
HD6 tractor	Forest vehicles and equipment	6	
Grader	Social - roading	10	
Chain saws	Forest vehicles and equipment	2	
Chain saws	Logging	2	
D6 tractors	Logging	6	
D7 tractors	Logging	6	
Loaders	Logging	10	
Logging arches	Logging	10	
Field service units	Logging	10	

4. Depreciation Rates — Vehicles

The life for vehicles in the Forest Service is about 10 yr, though in common with other New Zealand vehicles many are run much longer than this. As administrative vehicles have been costed at 9,300 miles a year, this gives a 93,000-mile life, which is as long as is acceptable under pumice-land conditions, for private users. The standard of vehicles used to transport men has improved radically in the last two decades, open trucks giving way to canopied trucks, and now to specifically designed gang buses. It seems likely that the quality of the gang buses will improve further and although the total mileage is only 24,000 in a decade, they may be obsolete in this time. (Five miles average distance, twice a day, for 240 days a year = 2,400 miles a year maximum.) Gang buses probably have a salvage value when rebuilt for other purposes, and it is likely that the allowance for depreciation on them is too high. Tip trucks have higher average mileages than gang buses and a 10-yr life is reasonable.

Protection equipment includes the fire engine and tanker; these have low average annual mileages, but can be considered to be obsolete in 10 yr. Again, as for gang buses, some salvage credit is probably available then, and this depreciation rate may be too high.

5. Depreciation of Stores

The replacement rates needed for "Class A", and miscellaneous stores are not known accurately. The Forest Service accounting system charges these (usually small) assets

against appropriate annual administrative charges as and when they are purchased. For an economic analysis, they represent a border-line case and could be treated as for every other semi-permanent asset. Their replacement has, however, been costed in administration charges here.

6. *Depreciation — Discussion*

A disproportionate amount of time was spent in calculating depreciation rates and depreciation overcharges in this study. It is doubtful if accuracy has been improved much. But it has been useful to the extent of demonstrating differences between accounting systems and the requirements of economic analysis. In this model the financial differences are unimportant, but with other scales of values they could be considerable.

The solution is to use hire rates which exclude all depreciation, and to charge capital and depreciation as in 1. above; such hire rate charges are being studied now.

RETURNS

In contrast to the many varied cost components, returns are simple to calculate. They are based on the export sale price loaded at port of $4.25 per 100 "Japanese Haakon Dahl" unit (JHD). This incongruous east/west unit is equal to about one-ninth of a cubic foot. Log cartage rates are those ruling in 1967, which had then remained unaltered for over 5 yr, the tendency for cost increases being countered by increases in productivity; for a 178-mile round haul the cost was about 8.7c per cu ft.

Log handling costs at the port of Mount Maunganui were used for the free-on-board (f.o.b.) price. The log export costs and returns are given in Table 17; handling and loading cost about 8.5c a cu ft. The net value at forest is 20.8c a cu ft (loaded on truck).

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

	c per 100 JHD	c per cu ft
Wharfage and storage	19.2	
Marshalling	23.5	
Stevedoring	53.5	
Inspection	1.25	
Sub-total	97.45	8.7792
Cartage to port	96.67	8.7086
Total, FOB	194.12	17.4878
Sale price	425	38.2882
Margin for price on truck	230.88	20.8004
		= 20.8 c per cu ft

JHD = Japanese Haakon Dahl

FOB = free on board

PROFIT CALCULATION

To recapitulate, the technical aims of the project and the silviculture necessary to achieve these have been given under Technical Specifications and Silviculture, p. 10 and a schedule of management based on a practical tempo of development has been given under Management, p. 11. The direct, social, protection, and indirect costs have been presented under Costs (p. 14) and Depreciation Charges (p. 32). Valuation of the produce is dealt with under Returns (p. 34).

Calculations have been made:

(1) By isolating, for each year, the specific item on which discounted figures are required (100-200 items).

(2) The costs or returns are in effect discounted back to the year of origin.

(3) The amounts are then reduced to a per acre figure.

Details of the calculations made for any given cost or return item are given in Appendix 9. The programmes used (FIN 1 and FIN 2) solve for 100 cost (and/or return) items at interest rates of 3% to 16%. If more than 100 items are wanted in discounted form, the programmes are run the appropriate number of times.

The end result is a series of land expectation values (LEV) (in other terms, of discounted present net worth values per acre) for a range of interest rates. The LEV of the whole project is found by taking the sum of the cost items from the sum of the return items.

The internal rate of return (IRR), which is the rate of return generated by the project, is found by graphing the LEVs as in Fig. 4. Problems of multiple answers, where the graphs cut the horizontal axis more than once, only occur where net results by years contain both positive and negative amounts (Fenton, 1969). A pattern of investment of heavy early costs followed by increasing returns is typical of many afforestation projects; so unambiguous results are usually found for IRR.

If necessary, benefit/cost ratios can be calculated as costs, and returns are expressed separately. There are some practical disadvantages in using such ratios (Fenton, 1969) which depend on precise definition of what is net and what is gross in any cost or return.

There are considerable advantages in isolating the LEVs of individual cost or return items. The relative importance of each item can be found at once. Changes in cost or return items are made by multiplying the original LEV by the new cost over the old; hence sensitivity analyses become easy. Updating studies to allow for cost and price changes is simple, the appropriate LEVs being again multiplied by the new cost over the old cost.

In some studies uncertainties arising from indifferent basic data have been allowed for by increasing all costs (Webster, 1960; Vaux, 1954); the effects of such adjustments may be distorting when compound interest is applied. Usually some costs and returns are known reasonably accurately, and by isolating all items their relative importance is assessed.

RESULTS

As returns from agriculture are currently at, or below 3% (5 to 6 ewe-equivalent carrying capacity per acre), and returns from forestry managed by the schedule used are up to 14%, the results must cover a considerable range of interest rates. The

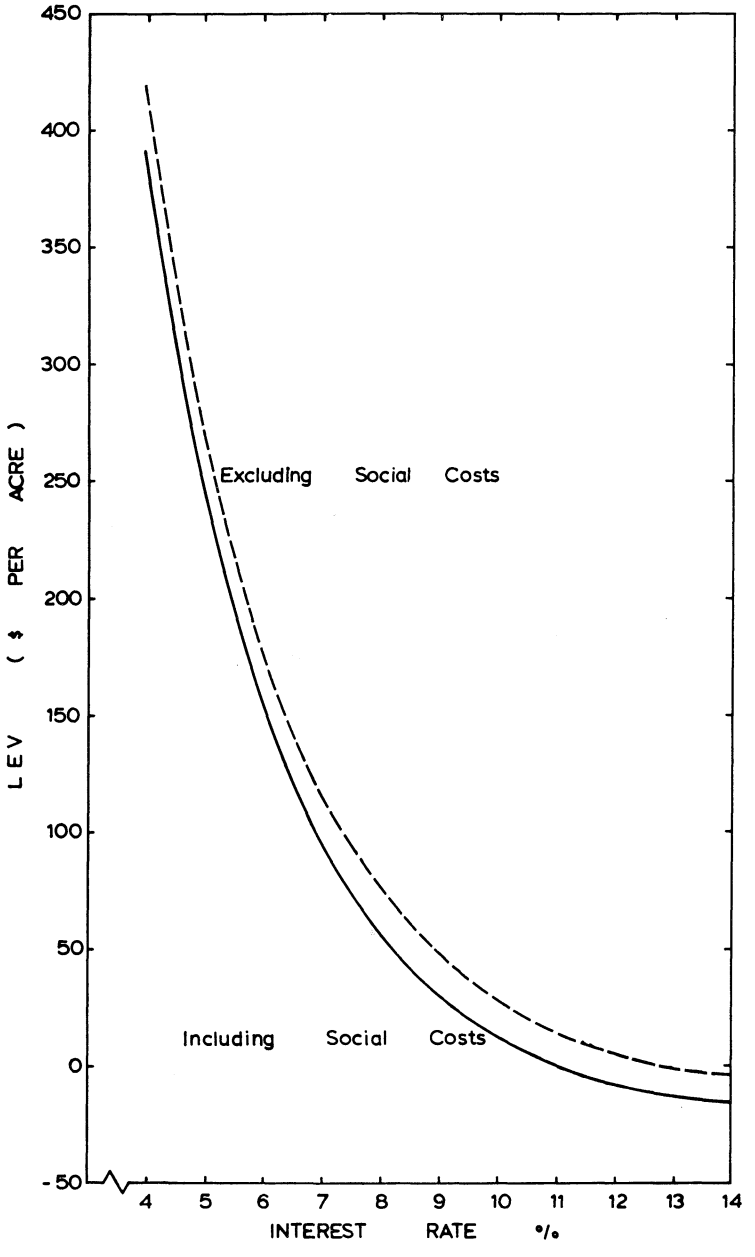

FIG. 4—Net land expectation values, site index 95.

Treasury guiding rate for the Forest and National Development Conferences in 1969 was 7%, and was increased to 10% in 1971.

The land expectation value (LEV) equivalents — or the present net worth per acre —for the cost and return elements are given in Appendix 10 for interest rates of 3% to 14%. These are grouped by major classes (establishment, tending, indirect, logging, and social) in Table 18. 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 18, and graphed in Fig. 4.

TABLE 18—Land expectation values, summarised costs, returns, and net values

	LEV at interest rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
FOREST COSTS	c per acre											
Direct												
Land clearing	364	353	346	336	329	321	314	308	303	298	293	288
Establishment	2,390	1,988	1,731	1,547	1,407	1,296	1,205	1,125	1,056	995	942	897
Tending	2,940	2,125	1,633	1,304	1,071	895	760	651	564	491	431	380
Total Direct	5,694	4,466	3,710	3,187	2,807	2,512	2,279	2,084	1,923	1,784	1,666	1,565
Protection												
Dothistroma	1,250	941	752	623	530	458	402	355	318	285	258	234
Fire	1,455	1,074	847	698	591	514	454	403	367	334	307	285
Total Protection	2,705	2,015	1,599	1,321	1,121	972	856	758	685	619	565	519
Administration												
Salaries and external overheads	5,809	4,226	3,295	2,682	2,228	1,933	1,690	1,500	1,344	1,218	1,112	1,023
Buildings, stores	371	301	260	232	210	194	181	170	162	154	148	142
Vehicles	1,113	802	620	500	417	360	315	280	252	231	212	198
Total Administration	7,293	5,329	4,175	3,414	2,855	2,487	2,186	1,950	1,758	1,603	1,472	1,363
Total Growing Costs	15,692	11,810	9,484	7,922	6,783	5,971	5,321	4,792	4,366	4,006	3,703	3,447
Logging												
Salaries and external overheads	1,363	864	586	413	301	224	170	130	101	80	62	50
Machinery	7,905	5,104	3,527	2,541	1,886	1,431	1,105	864	680	541	437	352
Extraction	19,149	11,897	7,920	5,505	3,948	2,895	2,154	1,630	1,242	959	747	586
Total Logging	28,417	17,865	12,033	8,459	6,135	4,550	3,429	2,624	2,023	1,580	1,246	988
Total Forest Costs	44,109	29,675	21,517	16,381	12,918	10,521	8,750	7,416	6,389	5,586	4,949	4,435
Social												
Roading	1,695	1,323	1,089	924	805	712	638	577	526	485	449	417
Accommodation	2,873	2,250	1,883	1,639	1,462	1,328	1,223	1,133	1,063	999	941	896
Total Social Costs	4,568	3,573	2,972	2,563	2,267	2,040	1,861	1,710	1,589	1,484	1,390	1,313
Total Costs	48,677	33,248	24,489	18,944	15,185	12,561	10,611	9,126	7,978	7,070	6,339	5,748
RETURNS												
Logs	114,064	71,573	48,125	33,808	24,478	18,116	13,635	10,399	8,017	6,236	4,889	3,859
Rent(social)	673	474	357	282	231	193	163	143	126	112	100	91
NET VALUES	$ per acre											
Excluding Social Items	699.55	418.98	266.08	174.27	115.60	75.95	47.92	29.83	16.28	6.50	-0.60	-5.76
Including Social Items	660.60	387.99	239.93	151.46	95.24	57.48	31.89	14.16	1.65	-7.22	-13.50	-17.98

The relative importance of the major classes of costs to loaded-on- truck are shown in Fig. 5, and the proportion of the major growing and utilisation costs in Fig. 6.

The internal rates of return (IRR), or the rate of interest generated by the project

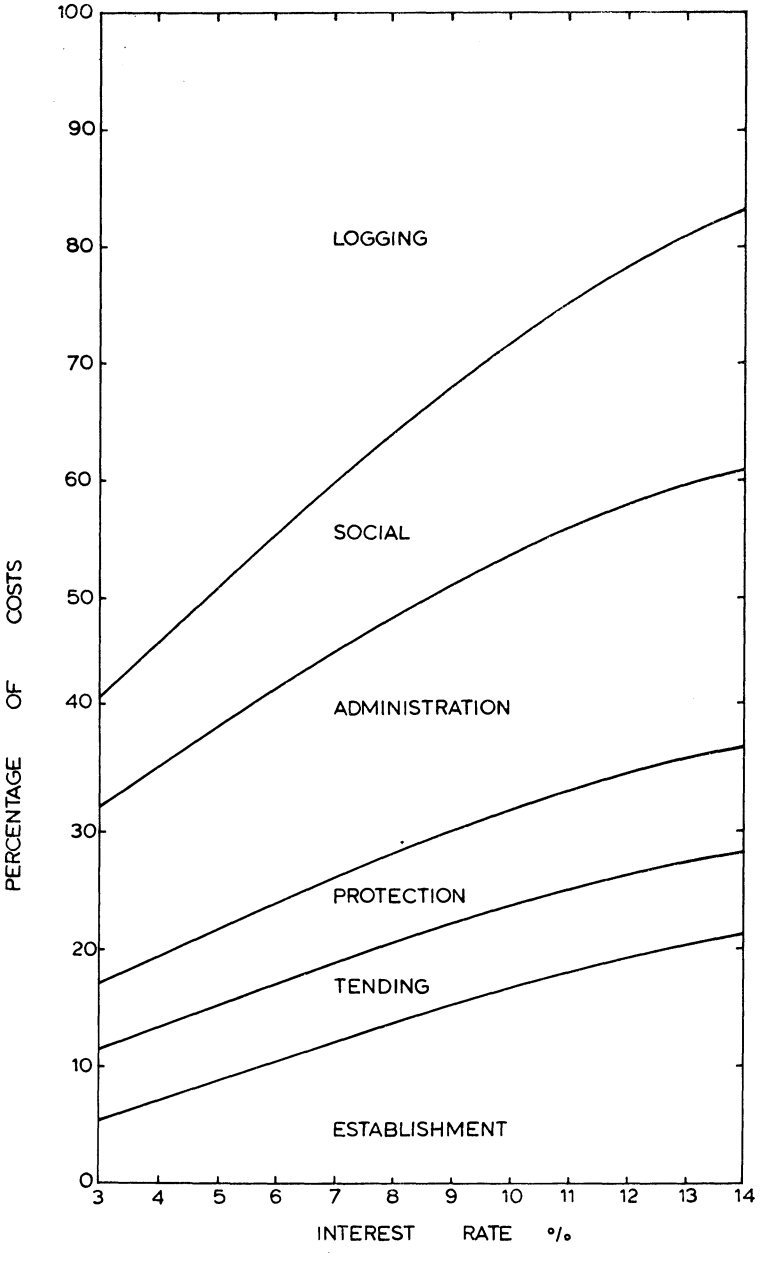

FIG. 5—Relative importance of forest costs. Percentage of costs loaded on truck.

as a whole, are found from Fig. 4. They are:

(a) including social costs — 11.2%

(b) excluding social costs — nearly 13% (12.8%).

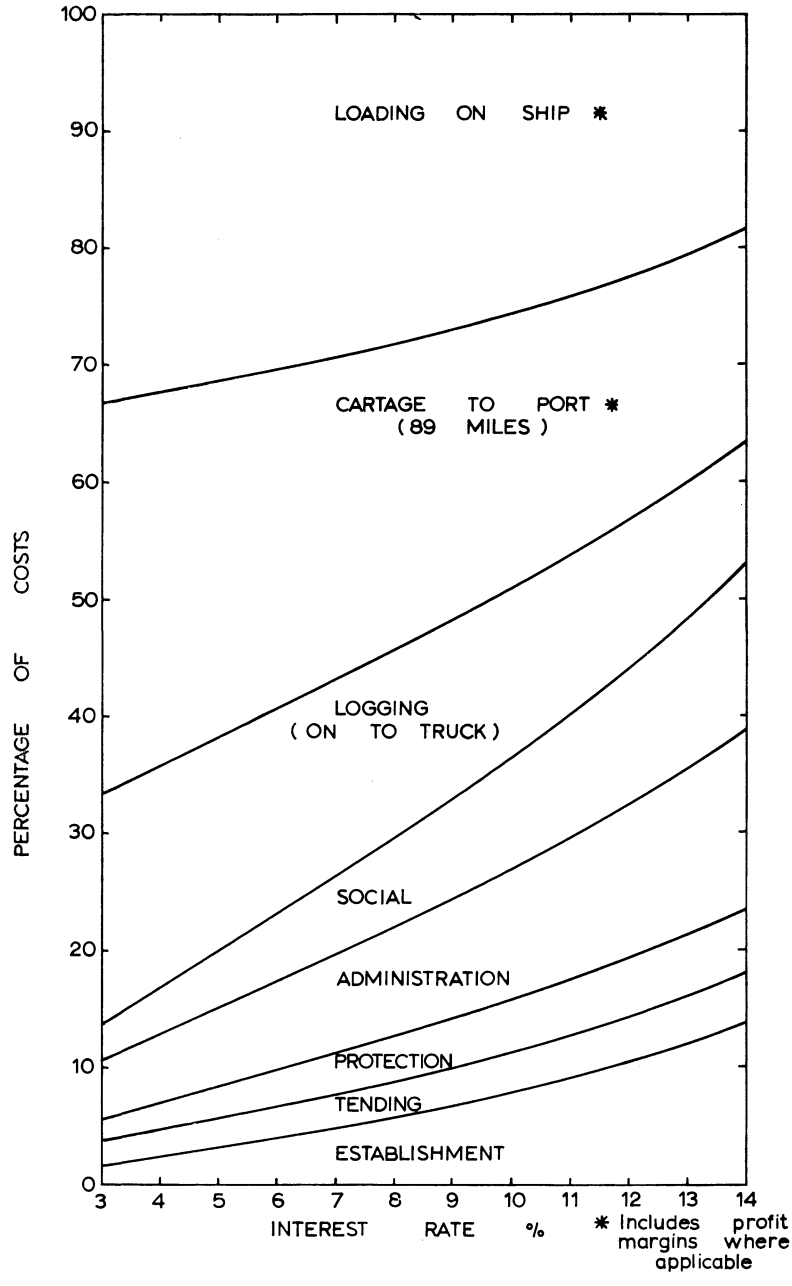

FIG. 6—Relative importance of forest and utilisation costs (percentage of costs f.o.b. Mt Maunganui).

The break-even growing costs given in Table 19 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. 7.

The effect of forest location on profitability is given in Table 20 and illustrated in Figs. 8 and 9.

Effects of differences in volume yield are shown in Table 21 and Fig. 10, as the LEV equivalents of logged volume per acre. Effects of changes in returns are shown in Table 22 and Fig. 11.

The labour required, by number and skill-category, is shown in Tables 2 to 5.

Little notice need be taken of negative values for LEVs. Negative values can become less in magnitude as interest rates rise—discounted present net worths (PNW) can have this anomaly (Fenton, 1969).

TABLE 19—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 cuft	c per cuft
3	54.838	3.694	2.861
4	34.410	4.470	3.432
5	23.137	5.383	4.099
6	16.253	6.451	4.874
7	11.768	7.690	5.763
8	8.709	9.198	6.856
9	6.555	10.956	8.117
10	4.999	13.006	9.586
11	3.854	15.451	11.328
12	2.998	18.312	13.362
13	2.350	21.672	15.757
14	1.855	25.660	18.582

SENSITIVITY ANALYSES; INTEREST RATE EFFECTS

1. Costs

The relative importance of the costs of growing and utilising the crop is shown in Figs. 5 and 6. The method of allowing for differences in costs has been indicated, and there is little point in going further into the numerous cost items once this method has been demonstrated and the relative importance of the different costs recognised.

TABLE 20—Location effects 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
			Change in LEV ($ per acre)											
Positive	18–20	3.21	322.44	202.33	136.04	95.56	69.19	51.20	38.54	29.39	22.66	17.62	13.81	10.90
	21–30	4.05	276.38	173.42	116.61	81.91	59.31	43.89	33.03	25.19	19.42	15.10	11.84	9.34
	31–40	4.89	230.31	144.52	97.17	68.26	49.42	36.57	27.53	20.99	16.18	12.59	9.87	7.79
	41–50	5.73	184.25	115.61	77.74	54.61	39.54	29.26	22.02	16.79	12.14	10.07	7.89	6.23
	51–60	6.57	138.19	86.71	58.30	40.95	29.65	21.94	16.51	12.59	9.71	7.55	5.12	4.67
	61–70	7.41	92.12	57.80	38.87	27.30	19.77	14.63	11.01	8.39	6.47	5.03	3.14	3.11
	71–80	8.25	46.06	28.90	19.43	13.65	9.88	7.31	5.50	4.19	3.23	2.51	1.17	1.55
	81–90	9.09	0	0	0	0	0	0	0	0	0	0	0	0
Negative	91–100	9.93	46.06 and so on in parallel series	28.90	19.43	13.65	9.88	7.31	5.50	4.19	3.23	2.51	1.17	1.55
			Net LEV ($ per acre)*											
	18–20	3.21	983	590	376	247	164	109	70	43	24	10	0	-7
	21–30	4.05	937	561	357	233	155	102	65	39	21	8	-2	-9
	31–40	4.89	891	533	337	220	145	95	59	35	18	5	-4	-10
	41–50	5.73	845	504	318	206	135	87	54	31	15	3	-6	-12
	51–60	6.57	799	475	298	192	125	80	48	27	11	0	-8	-13
	61–70	7.41	753	446	279	179	115	73	43	23	8	-2	-10	-15
	71–80	8.25	707	417	259	165	105	65	37	18	5	-5	-11	-16
	81–90	9.09	661	388	240	151	95	57	32	14	2	-7	-15	-18

* Including social items

TABLE 21—Effect of lower volume 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	80.91	52.26	35.94	25.70	18.88	14.15	10.76	8.29	6.44	5.05	3.99	3.18
1000	161.82	104.52	71.88	51.41	37.77	28.30	21.53	16.58	12.89	10.10	7.98	6.35
1500	242.73	156.78	107.82	77.11	56.65	42.45	32.29	24.87	19.33	15.15	11.97	9.52
	B. Net LEV becomes*											
500	580	336	204	125	76	43	21	5.9	-5	-12	-17	-21
1000	499	283	168	100	57	29	10	-2.4	-11	-17	-21	-24
1500	418	231	132	74	39	15	0	-10.7	-18	-22	-25	-27
	C. Net LEV if logging cost is proportionally reduced											
500	591	342	208	127	78	44	22	6.4	-5	-12	-17	-21
1000	520	295	176	105	60	31	11	-1.4	-11	-17	-21	-24
1500	450	249	144	81	44	18	1	-9.2	-17	-22	-25	-26

* Including social costs and returns

TABLE 22—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	1141	716	481	338	245	181	136	104	80	62	49	39
19.8 (1c less)	1086	682	458	322	233	172	130	99	76	59	47	37
10.8 (10c less)	592	372	250	176	127	94	71	54	42	32	25	20
2.8 (18c less)	154	96	65	45	33	24	18	14	11	8	7	5
B.	Net LEV in $ per acre*											
20.8	661	388	240	151	95	57	32	14	2	-7	-13	-18
19.8 (1c less)	606	354	217	135	83	48	26	9	-2	-10	-15	-20
10.8 (10c less)	112	44	9	-11	-23	-30	-33	-36	-36	-37	-37	-37
2.8 (18c less)	-326	-232	-176	-142	-117	-100	-86	-76	-67	-61	-55	-52

* Including social costs and returns

Comment is limited to the effects of the most important costs and to the inclusion of land taxes (rates).

At interest rates up to 10% the greatest costs are those of forest utilisation, despite the relatively long discounting period applicable. At higher interest rates the cost items incurred early in the rotation become of greater importance; the differential effects of interest rates apply throughout sensitivity analyses. The difference in importance of various costs is emphasised by the following statement of equal cost effects (at 7% interest):

1.5c per cu ft extracted = all clearing and establishment costs
= over twice the tending costs
= over three times the *Dothistroma* costs

= over three times the fire protection costs
= over twice the roading costs
= over twice the salaries total
= nearly 20 miles different distance from the port
= more than the effect of 500 cu ft less extracted per acre

Rates (or local land taxes), if payable at the amounts given, would reduce net LEV by about 3% (at 7% interest). There is little justification for their payment except as tax, as services provided by local administration (counties) are largely costed in the budget, apart from those which affect the quality of the life of forest employees. Even these are usually minimal as charges on the rates; for example, the rural library and district nursing services, are financed from national rather than from local taxes. Whether rates should be included or not depends on the circumstances of the particular analysis; it is

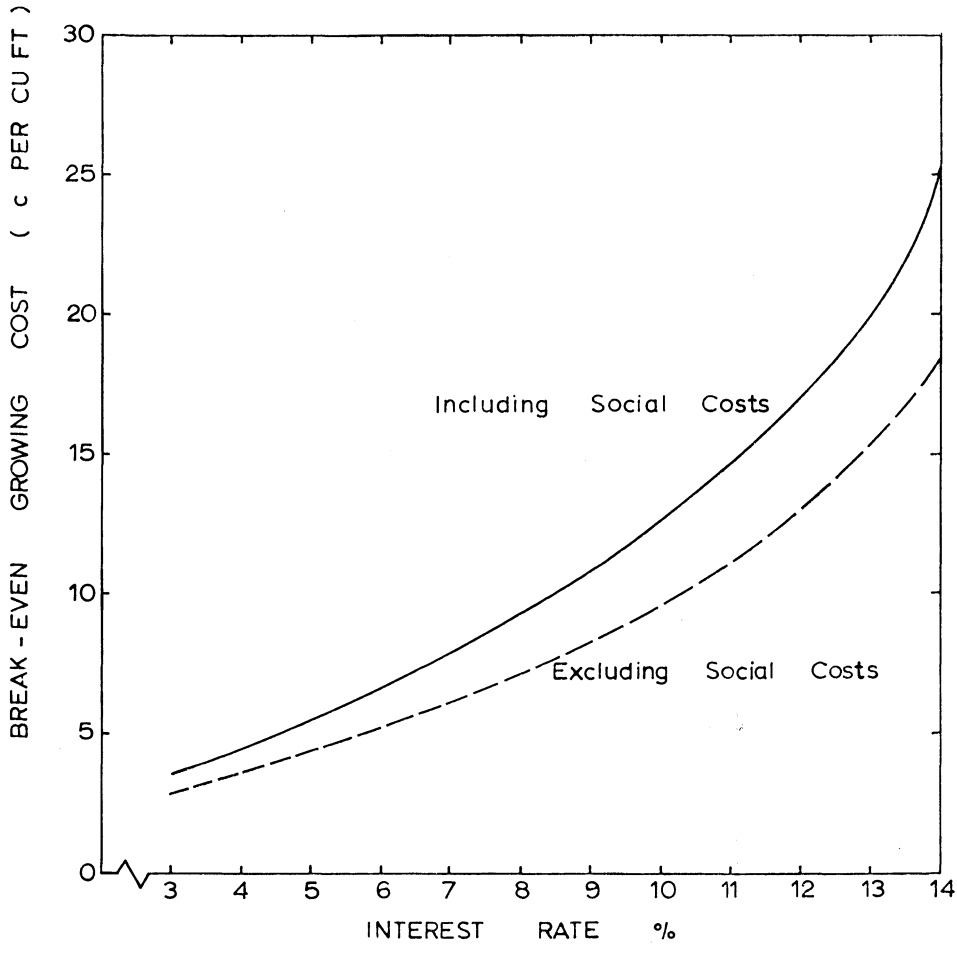

FIG. 7—Break-even growing costs.

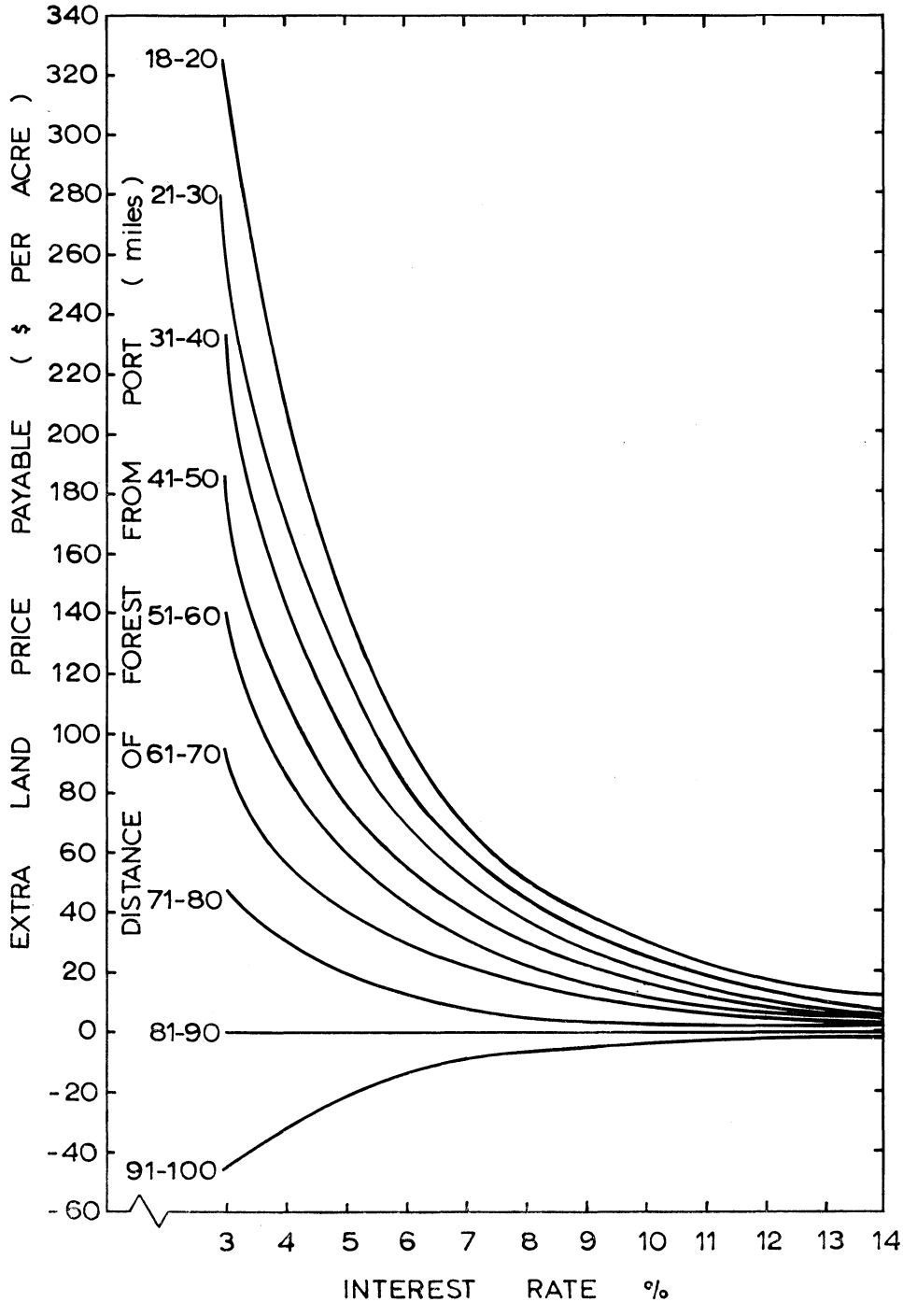

FIG. 8—Location effect on profit.

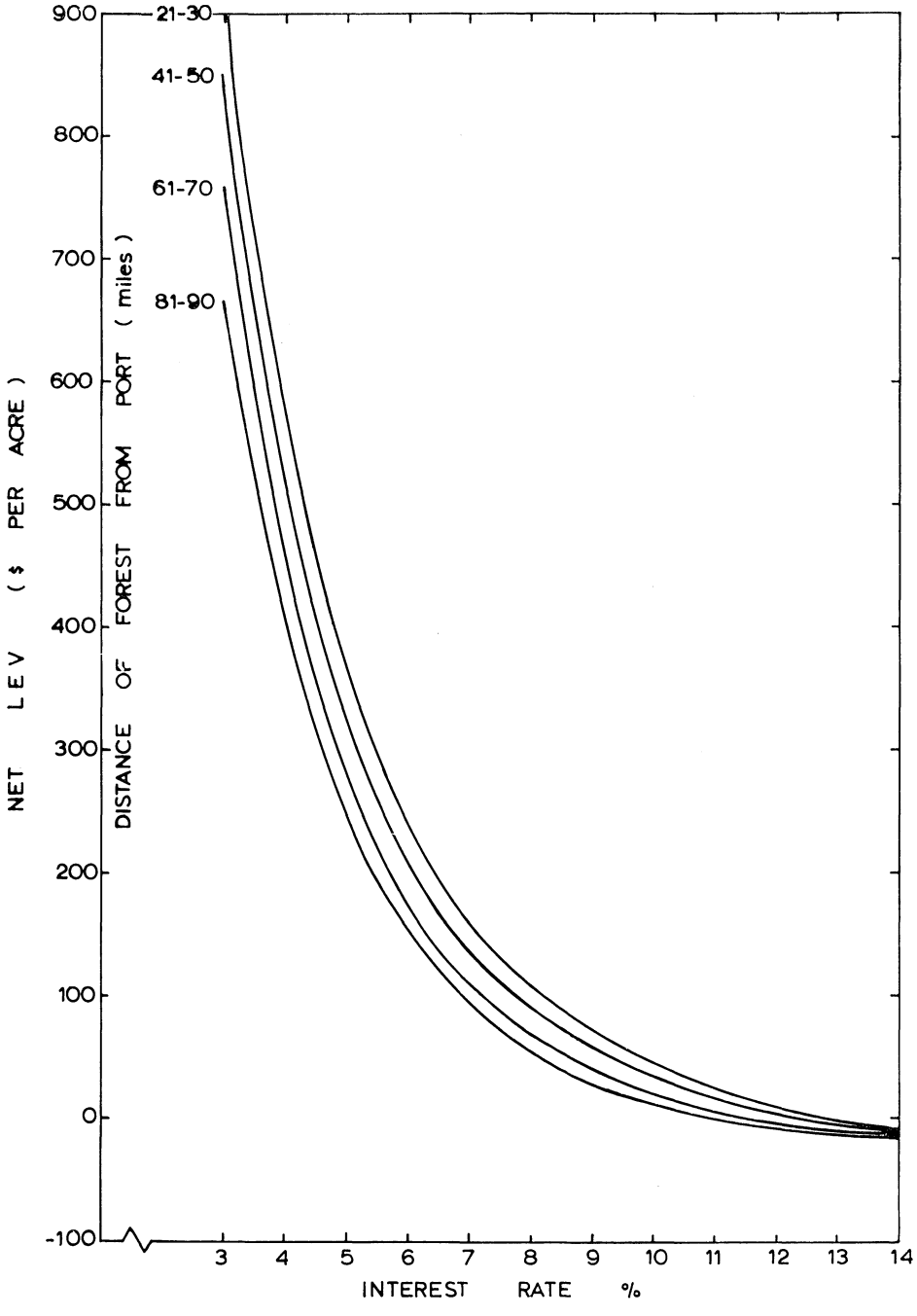

FIG. 9—Effect of location on net LEV.

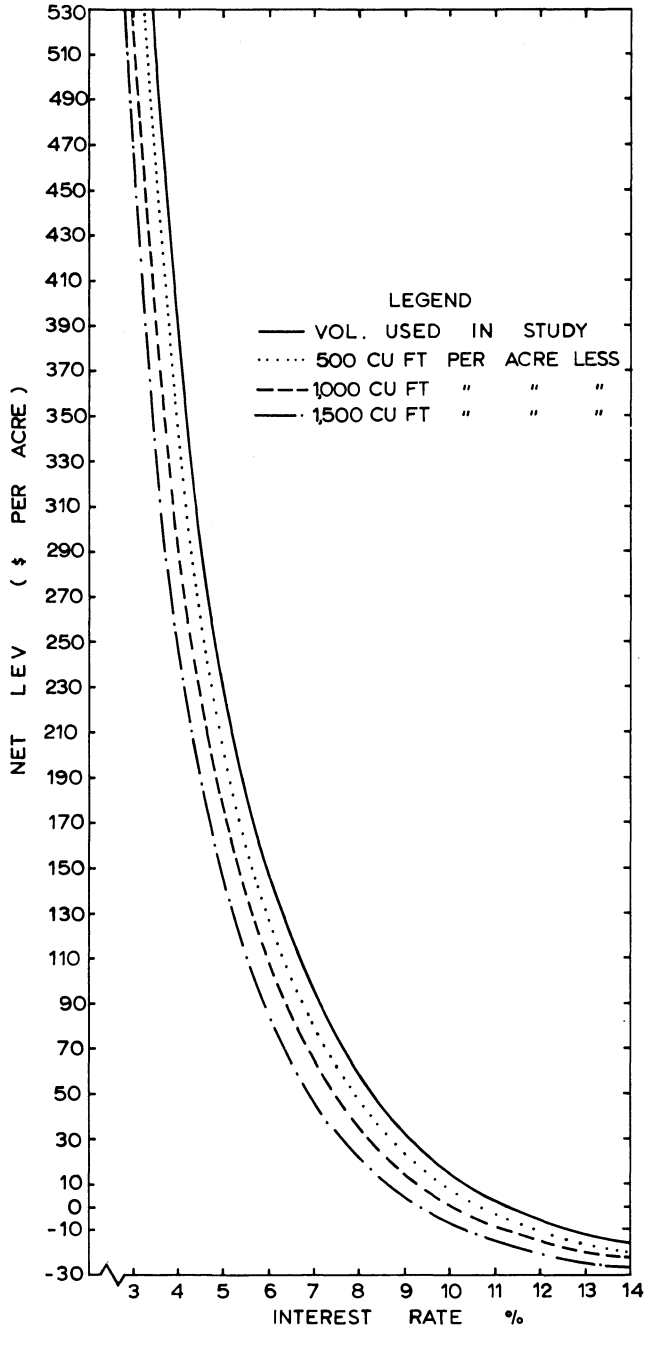

FIG. 10—Effect of lower yields on net LEV.

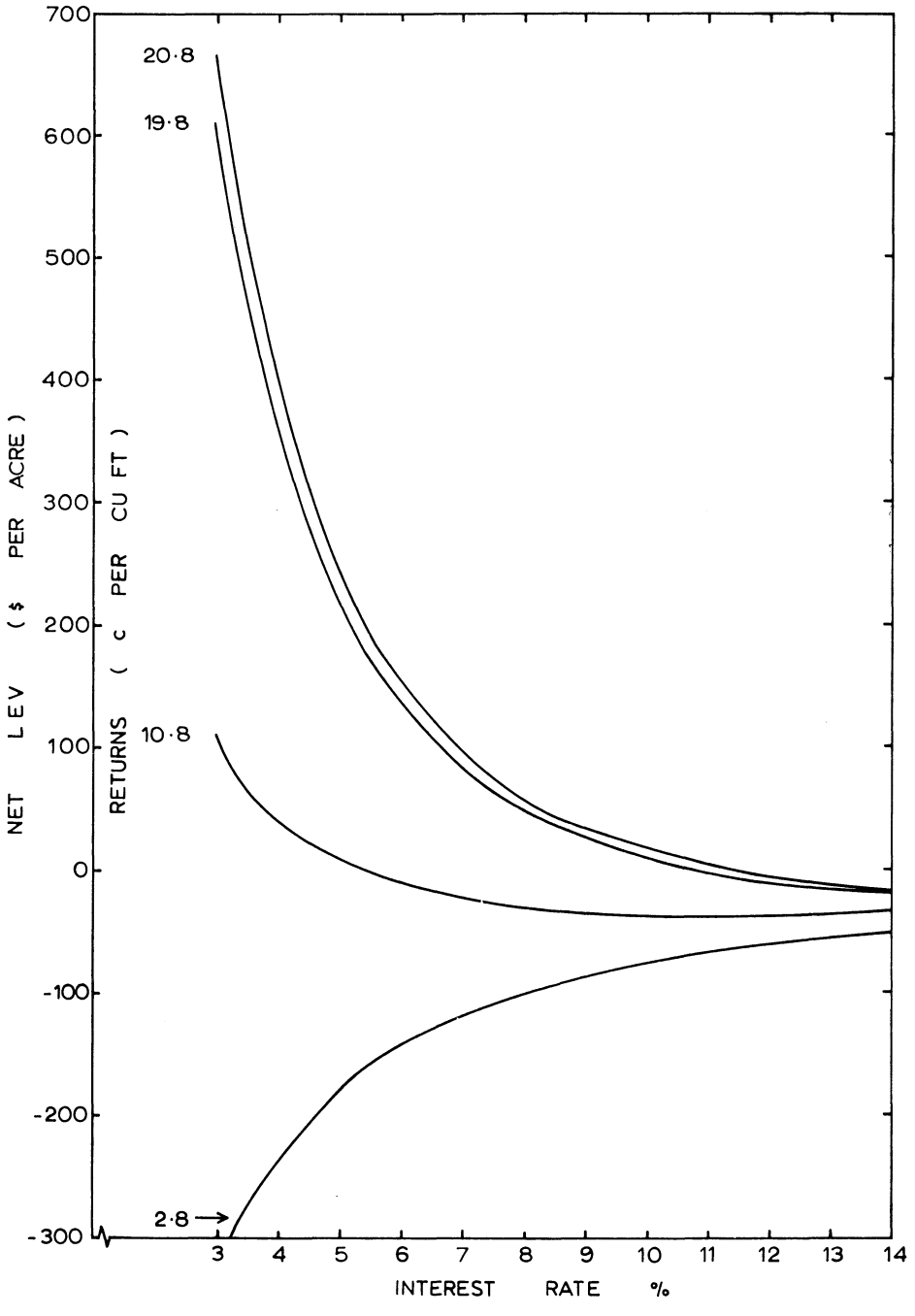

FIG. 11—Effect of changes in returns on net LEV.

relatively easy to supply the figures (as in Appendix 10) and this should be done to allow for comparability between different studies.

The effect of differences in external overhead mentioned under External Overheads (p. 28) depends on the staff salaries paid; the two items together total $22.60 LEV at 7% interest, or nearly a third of the forest growing costs. Salaries for staff connected with logging comprise another $1.88 LEV.

2. *Returns*

The results are sensitive to changes in free-on-board (f.o.b.) values; consequently changes due to price, or utilisation costs, have marked effects on profitability. Utilisation operations for the log export trade are relatively simple, consisting only of log handling. The degree of uncertainty in the costs is lower than in projects involving log conversion. The figures used include profit elements in the log haulage and loading. Naturally, decreases in utilisation costs increase forest-growing profits at constant f.o.b. prices; so effects of changes in location are considerable (Table 20, Fig. 9). The far greater mass (of 50-100 times) to be moved in forestry, compared with agriculture has scarcely been recognised in land allocation to date; it is doubtful if location is so critical in agriculture.

The effects of lower net volume yields are given in Table 21. As the same growing costs have to be carried by lower volumes, profits are markedly reduced. The process can be further refined if necessary to allow for variation in the yield or value of any of the final crop age-class components, and to calculate new break-even growing costs. But, as in cost sensitively analyses, the examples given of the significant variables demonstrate the extent of these effects on the results.

THE AREA ITSELF; AND LOG TRADE AFFORESTATION

The profits reported here are little different from the interim results given to the Forest Development Conference (Fenton *et al.,* 1968). The rate of return for forestry, compared with management, and cost and price levels given earlier (Ward *et al.,* 1966) has increased from 6% to 11%. LEV at 6% has increased from $2.00 to $152.00, when social costs are included; the projected physical levels of agricultural production gave LEVs of minus $46 to plus $36 (for pessimistic to optimistic prices). Hence log trade afforestation is overwhelmingly superior to both the earlier forest regime, and to agriculture (at optimistic agricultural price levels) .

The actual area is still farmed. The severe local erosion (*ca.* 1962) into the entrenched Mangakowhiriwhiri Stream is now presumably controlled, and the floating sheet of pumice pebbles ponded above the Whakamaru Dam is no longer present. A modest area has been fenced against incipient gullying elsewhere on the block and these costs should be debited against agriculture. A more insidious cost will be the extra quantities of phosphates and other nutrients which will be accumulating in the Waikato lakes of the hydro-dams at Whakamaru, Maraetai, and further downstream; heavy weed growth requires intake-screen cleaning and there are also some aesthetic objections to the weed. Over half the dairy units (Ward *et al.,* 1966) had (1970) been transferred to sheep farms, and the size of sheep farms increased, but profits must be severely

depressed by current low prices. There is no indication that afforestation is taken seriously there.

No forests are planned for the log trade.

CONCLUSIONS

1. The degree of managerial risk is low.
2. At interest rates up to 10%, the greatest costs are in utilisation.
3. Location affects LEV.
4. Results are sensitive to changes in price and volume logged.
5. The demands for managerial and labour skills are low.
6. Ninety-six men are required at forest normality, 59 of them for utilisation. Mean annual production per man at normality is 77,000 cu ft.
7. The export log trade is highly profitable on current costs and returns on this site index.
8. There is no evidence that these highly profitable results have influenced national policy.

ACKNOWLEDGMENTS

The assistance of Mrs M. M. Dick in the preparation of this study is gratefully acknowledged. Mr W. R. J. Sutton prepared the yield predictions given in Appendix 2.

APPENDIX 1

NEEDS FOR PROTECTION AGAINST **DOTHISTROMA PINI**

Dosage Rate

4 lb cuprous oxide (formulated as a 50% copper wettable powder) in 5 gal of water per acre.

Yearly Application

In Nov-Dec of any year when more than 30% of the "effective" crown has been affected or defoliated.

Rotational Frequency

Planted stands, pruned and unpruned (using copper-treated nursery stock)

	Mean top height
1st application	8-10 ft
2nd application	18-25 ft
Possible 3rd application	33-35 ft

Regeneration

1st application	3-4 ft
2nd application	12-15 ft
Possible 3rd application	30 ft

The dosage rate and schedules are considered to be reasonable on current experience and could be amended if future evidence so indicates. The aerial survey is done over the whole forest as age classes are interspersed, and ground survey is done on areas made apparent by the aerial survey (say about twice area sprayed).

Summary of Direct Spraying Costs per Acre Nov-Dec 1969 Spray Programme (Radiata Pine Only)

	NZFP	NZFS	Outlying areas over 20 ac	Woodlots under 20 ac
Aerial application	0.85	1.00	1.50 (average)	4.75
Copper spray	1.90	1.90	1.90	1.90
Ground control	0.10	0.34*	**ca.** 0.40	**ca.** 0.40
Totals	$2.85	3.24	**ca.** 3.80	**ca.** 7.05

* Based on 1968-69 ground control cost

APPENDIX 2

YIELD PREDICTION

Given that the technical specifications for log export material can be achieved by the silvicultural schedule: plant 10 × 7 ft (620 s.p.a.), thin (to waste) to 150 s.p.a. at 35 ft, clearfell at age 23 yr, steps for predicting the yield are:

1. Initial basal area trends in a stand planted at 10 × 7 ft to obtain the basal area at the time of thinning, 35 ft.
2. Basal area after thinning
3. Basal area increment to clearfelling
4. Conversion of basal area to total volume
5. Breakdown of yields by log length and s.e.d.

1. Initial Basal Area Trends

Measurements in spacing trials have indicated that basal area growth and branch development in rectangular spacings are similar to those found in the equivalent square spacing (Sutton, 1967, 1968). There are few data on the basal area growth in young planted radiata pine stands of stockings of 620 s.p.a. Those available are given in Table 23 and graphically in Fig. 11. These indicate that a basal area of 100 sq ft at top height 35 ft would be a reasonable estimate for a stocking of 620 s.p.a.

TABLE 23—Basal area growth in young stands

Site and Source	Stocking s.p.a.	Height ft	Basal Area sq ft
Tarawera	550	38	114
(R.N. James, pers. comm.)	935	39	145
Kaingaroa (northern boundary)	650	13	10
(J.B. Crowe, pers. comm.)		18	24
		24	46
		26	59
		31	78
		35	95
	934	27	99
		36	139
		41	178
		47	203
Rotoehu	650	13	19
(R.L. Knowles, pers. comm.)		22	45
Tokoroa	617	35	101
(Spurr, 1962) Height interpolated		39	131
from mean height		43	153
		47	168
		52	186

2. Basal Area after Thinning

There are three methods of calculating the basal area after thinning at top height 35 ft to 150 s.p.a.:

(1) That proposed by Beekhuis (1966) using the percentage of stems per acre and conversion factors given in table 4 of his paper. These figures predict that 33% of the basal area would be left or, since the basal area was 100 sq ft, 33 sq ft.

(2) Results of selection can be used. Trials on selection methods by the FRI economics group indicate that the basal area of selected trees at this top height would be approximately 85% of the basal area of the equivalent number of largest s.p.a. The basal area of the largest 150 s.p.a. at stand height 35 ft can be interpolated from data for a stocking of 617 s.p.a. (Spurr, 1962) by using alignment chart 5 of Lewis (1954). (For this it is necessary to assume that the mean d.b.h. of the largest 150, or any other stocking, is equal to the d.b.h. of the smallest tree of the largest 75, or half the specified stocking.) The value obtained is 43 sq ft. 85% of this is 37 sq ft.

(3) Further indications come from thinning trials. Initial selections in the Tarawera Spacing/Thinning Trial in 9 × 9 ft spacing (552 s.p.a.) gave an average basal area after thinning to 150 s.p.a. of 40 sq ft at predominant mean height 38 ft (R. N. James, pers. comm.). Similar results were obtained from thinning an understocked planted stand in Whakarewarewa Forest to 150 s.p.a. (R. L. Knowles, pers. comm.). These results suggest that 37 sq ft would be the best estimate of the residual stocking after thinning to 150 s.p.a.

3. Basal Area Increment to Clearfelling

Growth projections for this regime are difficult because no stands, apart from a few experimental plots, have been tended on this schedule. The limitations of the Beekhuis (1966) yield prediction method is that there must be a reasonable basal area left after thinning before the predicted increments are applicable—generally the basal area (in sq ft) should not be less than the stand top height (in ft). In the proposed regime the basal area after thinning (37 sq ft) is close to the stand height (35 ft). What is required is an alternative method of prediction for the period immediately after thinning to a point where there is sufficient basal area for the Beekhuis method to be applicable. The limited trends available from young stands subjected to heavy early thinning provide some data.

The only young and heavily thinned stands known to the writers, for which at least two periodic measurements are available, are:

Kaingaroa — Heavy thinning and pruning demonstration plots (2) (J. B. Crowe, pers. comm.)

Woodhill — FRI soils N-lupin trial (G. M. Will, pers. comm.)

Ngaumu — (a) Wellington Conservancy heavy thinning plot
(b) FRI Economics group heavy thinning plots

Nelson — (a) Nelson Conservancy pulpwood thinning trial (J. W. A. Handiside, pers. comm.)
(b) Baigents Ltd. trial — Trass Valley, Wakefield (R. L. Cornwell, pers. comm.)

Details of s.p.a. and measurements of heights and basal areas are given in Table 24 and presented graphically in Fig. 12. Beekhuis' (1966) projections are also presented in Fig. 13 for a stand thinned to 37 sq ft at top height 35 ft. From the growth trends it is thought that the full basal area increment projected is not likely to be achieved, at least in the initial stage of growth. The indications are that only about 75% of the predicted increment will be achieved — this projected increment is also shown in Fig. 12. How long this depressed increment will continue cannot be assessed yet, but the indications are that by about top height 75 ft the Beekhuis projections should be applicable (the basal area would then be expected to be 145 sq ft). In the absence of any conclusive data this is assumed to be the case.

TABLE 24—Basal area growth following heavy thinning

Site		Residual Stocking s.p.a.	Height ft	Basal Area sq ft
Kaingaroa		180	36	41
			41	53
			46	76
		80	36	23
			39	29
			48	39
Ngaumu	(a)	184	56	101
			74	156
			90	195
	(b)	116	43	34
			54	64
			60	81
Woodhill		161	42	38
			52	63
			64	92
Nelson	(a)	187	44	51
			57	85
		130	44	38
			59	68
	(b)	150	54	48
			61	80
			73	122
			90	155
		140	61	62
			76	100
			81	127

Before the basal area at rotation can be calculated it is necessary to know the stand height. On the assumption that Beekhuis' (1966) general finding that height growth is independent of treatment is applicable, the top height of a 23-yr-old crop on a site index of 95 can be obtained directly from Lewis (1954), viz. 110 ft.

Using the prediction method outlined above, the total basal area at top height 110 ft is 261 sq ft (mean d.b.h. 17.9 in.). It is assumed that there will be no mortality.

4. Conversion of Basal Area to Volume

In the Beekhuis method of yield prediction, volumes are obtained from the basal area

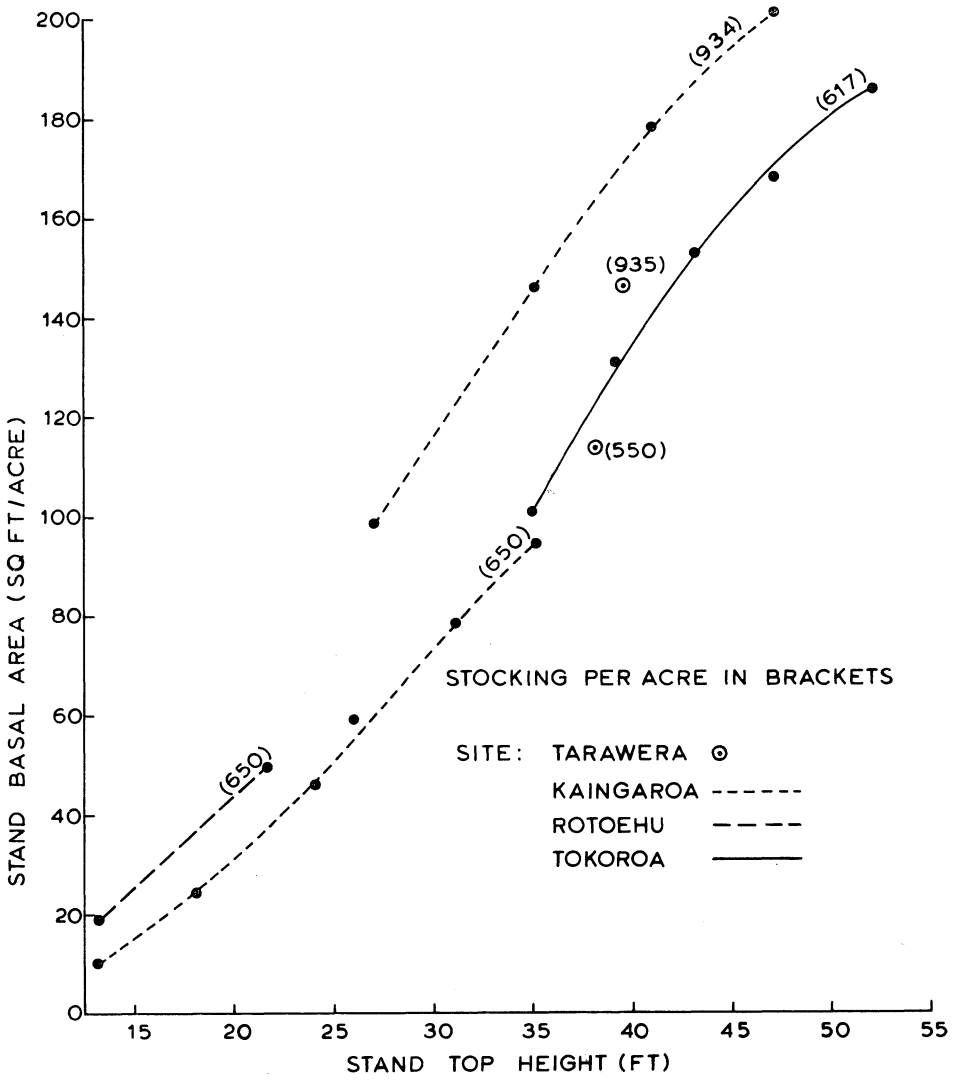

FIG. 12—Basal area development in young stands.

by use of volume per sq ft of basal area as given by the equation:

Volume per sq ft b.a. = 0.3H + 3

(Where H = height of stand)

This relationship is known to hold for conventionally thinned radiata pine but heavily thinned stands, similar to those adopted in this model, are not yet available and it is not known whether the equation will be equally applicable to them.

One stand which was thinned (at 45- and 90-ft top height) was Cpt 28, Waiotapu. Volume calculation on 15 of the largest trees from this stand is available and this can provide a test of the above relationship. (Beekhuis, 1966, reported that the stand relationship also applies to individual tree volumes). Newton's formula was used — the unmerchantable top being assumed to be a cone. Volumes were also calculated by the volume per sq ft of

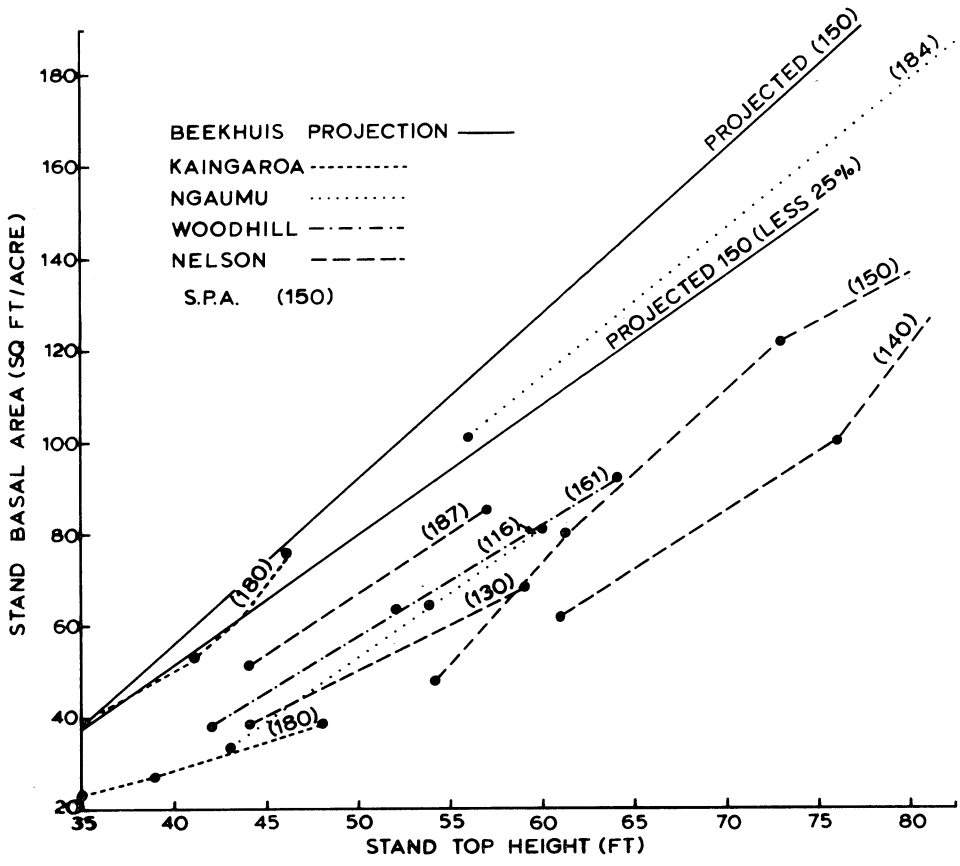

FIG. 13—Basal area development in stands thinned to low stocking.

basal area equation above, using the trees' basal area and height, and the volume table for radiata pine for Rotorua Conservancy (Duff, 1954) for a tree of the given dimensions.

Results indicate some variation among these three, but on the average the calculated and interpolated volumes were 2.8% lower than the actual volumes. As the actual volumes are similar to, or event slightly in excess of the predicted volumes, the use of Beekhuis' equation should be a satisfactory method for calculating total stand volume in heavily thinned stands. There are indications, however, that although total volume production may not be affected by treatment, the distribution of the volume within the stem can be significantly different. This is not considered to be an important consideration for this model, which is primarily concerned with the total volume to a 6-in. diameter top.

Applying Beekhuis' formula to the basal area at rotation age, 23 yr and height 110 ft, the total stand volume is calculated to be 9,400 cu ft per acre.

Calculations for Other Rotations

In order to achieve normality some stands must be felled prematurely and others must be held after normal rotation age. Yield models for these rotations have been

calculated by the same procedure as for the proposed regime. Summary is given in Table 25.

TABLE 25—Volume summary for log export model

Rotation Age yr	Top Height ft	Basal Area per Acre sq ft	Mean d.b.h. in.	Total Volume cu ft
18	85	178	14.8	5,100
19	90	195	15.4	5,800
20	95	211	16.1	6,500
21	100	228	16.8	7,500
22	105	245	17.4	8,500
23	110	261	17.9	9,400
24	114	274	18.3	10,100
25	118	288	18.8	10,900
26	121.5	299	19.1	11,600
27	124.5	309	19.4	12,300

In these projections no allowance has been made for mortality. It seems likely that after about 23 yr (height 110 ft) some mortality can be expected (150 s.p.a. at 110 ft corresponds to 15%-16% relative spacing—Beekhuis, 1966). However, the reduction in yield is not expected to be great. (The effect on overall profitability will be least important at high interest rates where the contribution of these delayed clearfellings is relatively small.)

5. Yields by Log Lengths and Small End Diameters (s.e.d.)

The d.b.h. distribution about the mean has been taken from the yield tables for thinned stands (Beekhuis, 1966). No taper tables are available for thinned stands, and the old tables for unthinned radiata pine (Duff, 1954) had to be used to find log s.e.d. at given height intervals. Volumes per log were calculated from a 1966 log volume table L102 calculated for Kaingaroa. The resultant d.b.h., log s.e.d., log length, and log volume distributions for the 10 age classes felled showed satisfactory yields of log sizes.

APPENDIX 3

COSTS OF DIRECT FOREST OPERATIONS

A Land Preparation
B Hand Planting
C Machine Planting — major areas
— frost flats
D Aerial Sowing
E Blanking
F Release Cutting
G Thinning to Waste — at 35 ft
— slasher thinning regeneration
— poison/cut overwood

A — Land Preparation

Origin of Costs

Unit costs for the cutting and crushing operations in year 1 are as quoted by the Lands and Survey Department, Rotorua, April 1968. Bush felling is based on three operations ex Rotorua Conservancy; the bulldozing of felled bush slash is derived from a Lands and Survey Department operation of "crushing heavy scrub with blade".

The initial burn cost is only $0.06 per acre, from Lands and Survey costs; protection of adjacent new plantations increases the costs of subsequent burns to $0.50 (Rotorua Conservancy cost).

Land clearing is a capital investment initially; for subsequent rotations it is a maintenance operation included in logging.

Actual costs by years are:

Year	Operation	Acres	Rate per acre $
1	Cutting heavy scrub	1,500	17.00
	Crushing heavy scrub	1,500	6.00
	Crushing light scrub	6,000	4.00
	Overall burn	23,500	0.06
4	Second main burn	17,000	0.50
8	Felling bush	500	32.00
5-10	Annual burns, 2,000 ac	12,000	0.50
9	Burning felled bush	500	1.00
11	Bulldozing bush slash	500	16.00

B — Hand Planting

1. Labour

Hand planting was originally based on the bonus rate for Kaingaroa, where 1,000 trees were planted per 7½-hour day (Fenton and Grainger, 1965). As 10 × 7 ft planting = 620 s.p.a., the planting rate is 1.6 ac per man-day.

The average labour cost excluding travelling time was $8.21 per acre; so this is reduced to $6.75 for the lower s.p.a. Thus:

Wages including bonus: $6.75 per acre

Compensation and holiday pay: 12% of the bonus wage + travel ($6.75 + $0.25 per ac) = $0.84 per ac.

2. Tree Stocks

The 1967 charge-out price to forests was $14 less 20%; 620 trees per ac at $11.20/1,000 = $6.94 per ac.

3. Transport and Distribution (Worked Out for 1,000 ac)

The assumption is that trees will be supplied from Kaingaroa Nursery and the cost has been computed on this basis.

(1) Transport — 620,000 trees at 75,000 trees/load = 8 trips;

	$
8 trips × 130 miles at 22c/mile =	229
Driver's wages: 4 days at $8/day =	32
Plus allowance for overtime	3
Cost of transport	$264

(2) Internal distribution = 24 trips × 10 miles;

	$
240 miles at 9c/mile =	22
Driver's wages at 1 hr/round trip = 24 hr at $1./hr	
Total	$46

Total cost for 1,000 acres = $310, i.e., $0.31 per acre.

4. Travel

10 men at \$0.80 for ½ hr = \$4 per day; in which
16 ac are planted = \$0.25 per acre.

5. Gang Truck

\$4 per day, carrying 10 men = \$4 for 16 ac, i.e., \$0.25 per acre.

6. Total Cost

Thus the total cost per acre for hand planting is:

	\$
Wages	6.75
Compensation and holiday pay	0.84
Tree stocks	6.94
Tree transport and distribution	0.31
Travel (men)	0.25
Gang truck	0.25
Total	\$15.34

C — Machine Planting

Major Areas

The original rate was based on a 20,000-tree/day achieved by Tasman Pulp and Paper Co., using two Lowther planters and a D6 (or equivalent) tractor for 7 × 7 ft spacing. (Tasman's actual rate was 24,000 per day (Fenton and Grainger, 1965). Hence a five-man team can plant

$$\frac{20{,}000}{620} = 32.3 \text{ ac per day.}$$

1. Labour

	Cost/ac \$
Wages on a bonus base = \$8 per man day, 5 men plant 32.3 ac	1.24
Compensation and holiday pay, 12% of (\$1.24 + \$0.06)	0.16
Wet time, 3% of bonus wages + travel	0.04

2. Tree stocks, as for hand planting — 6.94
3. Tree stocks, distribution, as for hand planting — 0.31
4. Travel time, ½ hr per day at \$0.80 per hr basic rate, 5-man gang, 5 × ½ × 0.80 ÷ 32.3 — 0.06
5. Gang truck, 1 gang truck day (\$4) per 32.3 ac — 0.12
6. Machine hire, based on Rotorua Conservancy, April 1968

1 tractor-day at \$30 plants	32.3 ac	\$0.93	
2 planter-days at \$2 each plants	32.3 ac	\$0.12	
(as 1 tractor tows 2 planters)			
			1.05

7. Total cost. Adding the above gives a total cost per acre of \$9.92, say \$10.00.

Frost Flats

Only one Lowther planter per tractor would be required, and a lighter tractor would suffice. As tree numbers are halved (20 × 7 ft spacing), and the gang strength is reduced to three—overall costs have been taken as 60% of those of full 10 × 7 ft establishment. The total area involved is limited. Costs are taken as \$6 per acre.

D — Aerial Sowing

The analysis given here relates to the sowing of 1,740 acres at Kaingaroa in October 1967. A conventional aircraft was used but the cost by helicopter is not significantly greater.

		$
Transport:	350 miles at 9c per mile	31.50
Wages:	80 man-hr (incl. 12%)	87.60
Seeding:	Application at $0.45 per ac	783.00
	Seed: 3,500 lb at $4.45 per lb	15,575.00
Poisoning:	Application 922 ac at $0.45 per ac	414.90
	Pellets 1,000 lb at $0.146 per lb	146.00
	Wheat 600 lb at $0.443 per lb	265.00
Photography:	Labour and materials	43.00
	Flying: 3½ hr at $32 per hr	112.00
	Cost for 1,740 ac	17,458.00

$$\text{Cost per ac } \frac{\$17{,}458}{1{,}740} = \$10$$

E — Blanking

The amount of blanking is, of course, conjectural; an arbitrary labour content of 0.3 man-days per acre and a 10% tree requirement have been assumed.

In the second and subsequent rotations, only the planted area—viz., one-third of the total annual re-establishment total—is blanked. (Comparable costs of "slasher thinnings" are charged to regenerated and direct seeded areas.)

	Cost per ac $
Wages: $0.80/hr (7½ hr day)	1.82
Compensation and holiday pay: 12% of wages and travel	0.23
Tree stocks + distribution: 10% of ($6.94 + $0.31)	0.73
Travel: ½ hr per day at $0.80 per hr, 10-man gang pay for 33 ac	0.12
Gang truck: $4 per day for 33 ac	0.12
	3.02
	say 3.00

F — Release Cutting

Again, the work content is difficult to estimate. This particular area has had considerable initial burning and clearing prescribed, which should reduce subsequent releasing.

Based on the original estimate that this operation requires 0.67 man-days per acre (1.5 ac per man-day).

	Cost per ac $
Wages ($0.80 × 7½)	4.02
Compensaton and holiday pay: 12% of $4.29	0.51
Wet time: 3% of $4.29	0.13
Travel: ½ hour per day at $0.80 per hr, 10-man gang for 15 ac	0.27
Gang truck: $4 per day for 15 ac	0.38
	5.31
	say 5.30

G — Thinning to Waste

1. Thinning to Waste at 35 ft, from ca. **600 to 150 s.p.a.**

The operation in pruned stands was rated at 2½ man-days per acre (a cost of $26 per acre) 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, but 1½ man-days per acre has been allowed for the 1968 revision.

	Cost per ac
	$
Wages and bonus (1½ days at $8)	12.00
Compensation and holiday pay: 12% on ($12.00 + $0.60)	1.49
Power saws: $5/day	7.50
Travel: ½ hr per day for 10 men for 6.6 ac at $0.80	0.60
Gang truck: $4 per day for 6.6 ac	0.60
	22.19
	say 22.20

2. Slasher Thinning

This operation is prescribed for second and subsequent crops originating from natural regeneration or direct seeding.

The current rate for Kaingaroa is $0.67 man-days per ac or 1½ ac per man-day.

	Cost per ac
	$
Wages and bonus (0.66 days at $8)	5.33
Compensation and holiday pay: 12% of ($5.33 + $0.27)	0.67
Travel: ½ hr per day for 10 men for 15 ac	0.27
Gang truck: $4 per day for 15 ac	0.27
	6.54
	say 6.50

3. Poison/Cut Overwood

Only poison thinning of **Pinus contorta** at 310 s.p.a. is required; marking is unnecessary. A rate of $0.67 man-day per ac has been assumed, and the cost has been taken proportionately from **2.** above at $6.50 an acre + poison at say $1 = $7.50 per ac.

APPENDIX 4

LOGGING (CLEARFELLING) COSTS AND EQUIPMENT

1. Man-Hour Production

Actual man-hour production (MHP) data are available for the past two decades of State logging operations. In 1967 the MHP for the two Waipa tractor gangs was 70 and 76 cu ft on flat and undulating country respectively (New Zealand Forest Service, Investigating Section Head Office, file 75/2). Work study data indicate that MHPs of 70 to 80 may be considerably improved (Appendix 10 of Fenton **et al.,** 1968b). Some further efficiency should result from the stand improvement obtained by a thinning to waste. However, in view of the productivity actually recorded, an MHP of 80 cu ft was used here for stands of age 20 and over. This was arbitrarily reduced to 65 and 75 cu ft for stands clearfelled at 18 and 19 respectively, to allow for lower volumes per acre and smaller piece sizes.

2. Working Day; Working Year

A 7-hr working day, and a 240 working-day year were assumed in calculating the total manpower and equipment needed.

3. Costs of Clearfelling

Weighted costs of labour and plant for the Waipa tractor gangs in 1967 totalled 3.56c

per cu ft loaded on truck. This amount excludes overhead. The figure has been used for clearfelling of stands aged 20 and over. The amount has been increased for 18- and 19-yr-old stands in proportion to the extra labour content.

Age	MHP (cu ft)	Cost (c per cu ft) Labour	Machine	Total
18	65	2.30	2.09	4.39
19	75	1.99	1.81	3.80
20 and over	80	1.87	1.70	3.57

The machine cost given includes an allowance for depreciation which is built into the hire charge.

4. Logging Equipment

(1) Logging Roading

The costs of logging shunts as access roading, and of higher forest main-road maintenance, are included in the 3.56c per cu ft recorded for Waipa operations. Logging shunts are temporary roads and are written off when each logging operation is completed. Two tip trucks and (part of time of) two heavy D7 or equivalent tractors have been allowed as extra capital equipment for logging roading. These roading costs are excluded from that of ordinary forest access, as the latter can be classed as a social cost and has been calculated separately.

(2) Logging Machinery

Part of the time of the two heavy D7 or equivalent tractors would be spent on stumping logging landings and on site preparation.

Calculation of the equipment required has been based on a tractor-day production of 5,000 cu ft (J. P. Fitzgerald, pers. comm.) for trees of mean d.b.h., 18 in. and mean voulme, 55 cu ft. A basic gang would consist of two D6 or equivalent tractors supplying one loader. A scale of spare gear based on 40% for tractors; 30% for arches and loaders, and 10% for gang trucks has been allowed. A ratio of four power saws per tractor unit (including spares) has been taken. Gang trucks have been assumed to carry 15 men. The total equipment needed is given in Table 7 in the text.

Service lives have been assessed (J. P. Fitzgerald, pers. comm.) and are given, with unit capital costs, in Table 26.

TABLE 26—Service lives of logging machinery

Equipment	Cost $ June 1967	Life Advised yr	Life Used yr
D7 tractors	53,000	5-6	6
D6 tractors	35,000	5-6	6
Loaders*	35,000	10	10
Logging arches	5,000	10-12	10
Gang trucks	5,000	-	10
Chain saws	150	2-3	2
Field service unit	5,000	10	10
Tip trucks	4,500	-	10
Miscellaneous stores	5,000	-	3
'Trekka' truck	1,770	-	10
Miscellaneous equipment	4,600	-	10

* Crane type

The proportion of tracked to wheeled tractors is debatable; pumice country with a maximum haul of **ca.** 13-15 chains may suit an approximately equal number of the two types.

There are many micro-economic problems involved in assessing logging costs. These include:

(a) the real effect on costs — including housing, garage space, number of mechanics, and so on — of altering productivity.
(b) when is a machine worn out?
(c) the best machine/men combination for different classes of felling.

APPENDIX 5

FIRE PROTECTION AND FENCING

1. Annual Charges — Fire Protection

Fire annual charges include cost of standby, routine patrols, break maintenance, look-out's wages, building maintenance, and operation and maintenance of equipment.

The data available are for five Rotorua forests in 1962 and 1967.

Forest	Total Annual Cost "fire" protection	
	1962	1967
	$	$
Patunamu	1,308	1,650
Whaka	9,184	12,025
Rotoehu	12,326	11,953
Mangatu	2,376	3,349
Kaingaroa	67,780	181,793

The disproportionate (270%) increase at Kaingaroa in 1967 is probably due to **Dothistroma** costs; these are now costed separately. The increase from 1962 to 1967 for the first four forests is 15%, and this has been taken on the 1962 Kaingaroa figure. The protection costs are then roughly governed by forest scale, being:

Acreage	Cost per acre, 1967
	$
Up to 7,500	0.81
7,500 to 13,000	0.53
Above 13,000	0.46

2. Fencing

Four miles are required. Contract rates for the Lands and Survey Department are **ca.** $1,200 per mile (less than in 1962). The forest pays half of this amount. $100 has been allowed for gates and cattle stops. The expenditure has been evenly spread over the first 5 yr.

APPENDIX 6

SOCIAL COSTS

1. Roading

Costs depend on the geology and climate of the area concerned. Formation, metalling, and maintenance costs have been isolated, as their incidence will vary with the locality.

The Forestry Development Conference, held in 1968, rejected the proposal that main road alignment and formation be done at the time of forest establishment; to do so would be to anticipate that changes in extraction methods over the period of a forest rotation would not alter a basic roading pattern. The limited activity involved in forest establishment hardly justifies earlier expenditure on improving roading standards.

2. House Costs

The original study (Fenton and Grainger, 1965) used 1962 costs for a three-bedroom State-type house at Kaingaroa Forest. The houses were costed complete with paths, fences, woodshed, and sewerage; the cost was $8,500.

Ministry of Works Housing Branch tenders in 1968 were competitive and costs had been reduced to $8,400. Houses are assumed to have a life of 65 yr.

3. Hut Costs

The original 1962 cost of $900 was that of larger, baching-type huts and is inappropportionate for the camp envisaged.

The 1968 cost of huts was $700 each; the huts are assumed to have a life of 20 yr. An extra $200 has been allowed for each of the three huts built before the cookhouse opens in year 19.

4. Camp Charges

The original analysis (Fenton and Grainger, 1965) was based on Rotoehu Forest where the camp roll was 25 men; the costs have been increased by the rise in the appropriate price index.

	1962 $	Increase	1967 cost/ hut-yr $
Caretaking	1,600	Wages index up 21%	68
Stores	110	Consumer price index up 15%	5
Fuel and power	1,066	Rotorua Tourist Department advise up 15%	49
Repairs and maintenance	256	Apply 1¼% to hut and building costs	

Hut rents are 10c per week; an occupancy rate of 45 weeks a year was allowed. The occupancy rate and subsidy allowances are given in Table 27.

TABLE 27—Camp charges

Year	No. of Huts Occupied	
19	3	Subsidy $600* + $122 x No. of huts
20	17	Subsidy 1.20 x 48 x 8 = $460
21	19	Subsidy 1.20 x 48 x 6 = $346
22	37	
23	51	
24	54	
25	62	
26	64	
27	69	
28	68	
29	40	
30	40	
31	45	
32	49	
33	52	
34	53	
35	58	
36	65	
37	62	

Year	No. of Huts Occupied
38	31
39	28
40	28
41	29
42	29
43	29
44	27
45	28
46	31
47	32
48	34
49	37
50	38
51	45 in perpetuity

* It would be uneconomical to subsidise a cook for three men; so baching huts are built in year 19 at a cost of an extra $200 each.

5. Miscellaneous and Services" Not Elsewhere Indicated"

Miscellaneous services include sewerage and minor items, termed "Services N.E.I.". The 1962 estimate was based on Rotorua Conservancy figures; it has been updated by taking the mean increase of the following indices:

(1) General Wage Index — up by 21%
(2) Wholesale Price Index — up by 13%
mean 17%
original cost, 1962 $13,400
Hence 1967 cost (+ 17% on 1962) = $15,700

APPENDIX 7

GENERAL ADMINISTRATION

1. The Forest Service cost code includes some salary charges, depreciation on buildings and non-consumable stores, and transport expenses. These comprise 60% of the total but have been costed separately in this analysis. Such costs generally decrease as forest area increases. They were originally worked out for 1962 data (Fenton and Grainger, 1965). The mean of the rise in the general Wages Index and the Consumer Price Index from 1962 to 1967 was 20%, and this percentage increase has been applied to the 1962 costs. This updating was done in preference to new analysis of the charge, as the basis for Forest Service costing was changed at 1 January, 1967. The amounts charged are:

Year	Acreage	Cost per acre
		$
1	1- 4,000	1.152
2-4	4-10,000	0.576
5-7	10-15,000	0.408
8+	15,000+	0.348

2. County rates (or grants in lieu) are now paid on all State exotic forests, but this cost has been treated as a transfer item. It is calculated, and isolated in the costs, in case comparisons are required with other industries. The Valuation Department advised the unit value of the original land for forestry would be about $8 per acre at 1 November 1964 when County rates were 2.58c per dollar of value. For convenience in extrapolation the total has been rounded to $5,000 p.a. on 25,000 acres gross.

APPENDIX 8

ANNUAL OPERATING COSTS FOR SUPERVISION AND ADMINISTRATION VEHICLES

1. Analysis of 51 vehicles selected from the Rotorua 1967 Fleet Account gave the following annual mileages:

		Miles per group
13	vans and station wagons	104,000
26	pickups (10-15 cwt)	231,000
12	passenger-cars	141,000
—		———
Totals 51		476,000

2. The average running per vehicle-year was therefore 9,300 miles.

3. As at April 1968 the hire rate in Rotorua Conservancy for this group of vehicles was 9c per mile. However, removal of depreciation allowances reduces this to 8.12c.

4. In the original study (Fenton and Grainger, 1965) two additional administration vehicles were included when assessing the cost of equivalent "external overhead" expenses. These represented State Forest Conservancy office mileage chargeable against the forest. However, it was visualised that the forest in private ownership would be more self-contained administratively; so these two vehicles have been added into the ordinary forest fleet. The overhead which remains is representative of the overhead expenses which could be expected to be charged against the Forest Account by a Head Office management domiciled elsewhere.

APPENDIX 9

CALCULATION OF DISCOUNTED VALUES

1. For each cost or return specified, except items involving depreciation, for interest rates of 3% to 16%, in steps of 1%:
   (1) Allowance is made for accounting from the mid-year of origin.
   (2) If a sum occurs in perpetuity, the capitalised amount is calculated for each interest rate.
   (3) The amount is discounted for each interest rate to the year of origin; viz., if it occurs in year 9 it is discounted in effect for 8½ years.
   (4) The amounts in each specified cost or return are added.
   (5) All items are then reduced to a per acre basis.
   (6) This process is repeated for up to 100 items in each programme run. If it is necessary to isolate further items the programme is run again.
   (7) The end result is the discounted present net worth per acre—the traditional forestry Land Expectation Value — for each cost or return item which has been specified.

2. For costs of semi-permanent capital costs involving depreciation. The year of origin, capital cost, number, and life of the item are given. The steps are then:
   (1) Allowance is made for charging the cost from the mid-year of origin.
   (2) The service life of each item is specified, and the capitalised value of the future streams of such purchases are discounted, e.g., if a grader is bought in year 5 and has a life of 10 yr, the programme allows for buying a grader at 10-yr intervals, in years 15, 25, 35, etc., and adds the discounted costs together.
   (3) As each item occurs, the capitalised cost is discounted for each interest rate, to the year of origin.
   (4) All items are reduced to a per acre basis.
   (5) The end result is the Land Expectation Value for each item, which has been charged in full at the end of its service life.

APPENDIX 10

LAND EXPECTATION VALUE EQUIVALENTS

Land expectation values (cents per acre) for individual cost and return items, at each interest rate, are presented below.

Cost Item	Interest Rate % 3	4	5	6	7	8	9	10	11	12	13	14
Land clearing												
Scrub cutting	101	100	100	99	99	98	98	97	97	96	96	95
Crushing heavy scrub	36	35	35	35	35	35	34	34	34	34	34	34
Crushing light scrub	95	94	94	93	93	92	92	91	91	91	90	90
Felling bush Burning bush Bulldozing bush	76	70	65	60	55	51	47	44	41	38	35	33
Overall burn 1st	6	6	6	5	5	5	5	5	5	5	5	5
2nd	50	48	46	44	42	40	38	37	35	34	33	31
Sub-total	364	353	346	336	329	321	314	308	303	298	293	288
Establishment												
Machine planting												
P.contorta	38	38	37	37	37	37	37	36	36	36	36	36
P.radiata	366	356	346	337	328	319	311	303	296	288	281	275
P.radiata (frost flats)	28	26	24	21	19	18	16	15	14	12	11	10
Hand planting	844	671	562	485	426	380	343	311	284	261	240	222
Sowing	254	163	111	79	58	43	33	25	19	15	12	10
Blanking	281	241	215	195	179	166	155	145	136	128	121	115
Release cutting 1	496	426	380	344	316	293	273	256	240	226	213	203
Release cutting 2	83	67	56	49	44	40	37	34	31	29	28	26
Sub-total	2,390	1,988	1,731	1,547	1,407	1,296	1,205	1,125	1,056	995	942	897
Tending												
Poison overwood	37	34	31	28	26	24	22	20	19	17	16	15
Thinning to waste	2,589	1,893	1,469	1,183	978	822	701	603	524	458	402	355
Slasher thinning	314	198	133	93	67	49	37	28	21	16	13	10
Sub-total	2,940	2,125	1,633	1,304	1,071	895	760	651	564	491	431	380
Land clearing, establishment and tending, sub-total	5,694	4,466	3,710	3,187	2,807	2,512	2,279	2,084	1,923	1,784	1,666	1,565
Protection												
Dothistroma												
Aerial inspection	21	15	11	9	7	6	5	4	4	3	3	2
Ground inspection	77	58	46	38	33	28	25	22	20	18	16	15
Spraying	1,152	868	695	576	490	424	372	329	294	264	239	217
Sub-total	1,250	941	752	623	530	458	402	355	318	285	258	234
Fire												
Annual charges	1,137	825	639	517	431	367	319	280	249	224	203	185
Firebreak establishment	14	13	12	12	11	11	10	10	10	9	9	9
Miscellaneous fire equipment	49	38	31	27	23	21	19	17	16	15	14	13
Fire engine	148	114	94	80	70	63	57	52	48	45	43	40
Fire tanker	49	37	30	25	22	19	17	15	14	13	12	11
Fire pumps	17	13	10	9	8	7	6	6	5	5	4	4
Fire lookout	24	22	20	19	19	18	18	17	17	17	16	16
Fire garage and store	18	16	15	14	13	13	12	11	11	10	10	10
Fire radio	17	13	11	9	8	7	7	6	6	5	5	5
Fire telephone (½ cost)	5	4	4	4	4	4	4	4	4	4	4	4
Fencing	9	9	9	9	8	8	8	8	8	8	7	7
Sub-total	1,487	1,104	875	725	617	538	477	426	388	355	327	304

Cost Item	Interest Rate % 3	4	5	6	7	8	9	10	11	12	13	14
Overcharge (depreciation)	32	30	28	27	26	24	23	23	21	21	20	19
Total fire charges	1,455	1,074	847	698	591	514	454	403	367	334	307	285
Total protection costs	2,705	2,015	1,599	1,321	1,121	972	856	758	685	619	565	519
Administration Costs												
External Overheads (excluding logging)	1,557	1,129	878	713	597	512	447	396	355	321	293	269
Salaries (excluding logging)	2,595	1,882	1,463	1,188	995	854	745	660	591	535	488	448
Administration general	873	636	496	403	338	289	252	223	199	179	163	149
Services and general R and M	760	556	435	355	298	256	224	199	178	162	147	136
Half of water supply	24	23	23	23	22	22	22	22	21	21	21	21
Sub-total	5,809	4,226	3,295	2,682	2,228	1,933	1,690	1,500	1,344	1,218	1,112	1,023
Rates	657	490	390	324	276	240	213	191	172	157	145	134
Buildings etc												
Office/Store; Garage; Oil store	233	191	167	151	139	130	124	118	114	110	107	104
Garage, workshop, Office and oil store R and M	65	45	34	27	22	18	15	13	11	10	9	8
Telephone ($\frac{1}{2}$ cost)	5	4	4	4	4	4	4	4	4	4	4	4
Consumable stores	28	25	22	20	18	17	15	14	13	12	11	10
Class 'A' stores	40	36	33	30	27	25	23	21	20	18	17	16
Sub-total	371	301	260	232	210	194	181	170	162	154	148	142
Vehicles												
10 cwt truck) Car)	147	106	83	67	56	49	43	38	34	31	29	27
Running costs of 10-cwt truck and car	451	312	231	180	145	120	101	87	75	67	59	53
Tip trucks	61	46	37	31	27	24	22	20	18	17	16	15
HD6 tractor	321	248	204	175	154	138	126	116	108	102	96	92
Gang trucks	138	106	87	74	65	59	54	49	47	44	42	40
Miscellaneous equipment	43	29	20	15	11	9	7	6	5	4	3	3
Sub-total	1,161	847	662	542	458	399	353	316	287	265	245	230
Overcharge (depreciation)	48	45	42	42	41	39	38	36	35	34	33	32
Sub-total	1,113	802	620	500	417	360	315	280	252	231	212	198
Total administrative costs excluding rates	7,293	5,329	4,175	3,414	2,855	2,487	2,186	1,950	1,758	1,603	1,472	1,363
Logging												
Logging plant-capital and depreciation												
D7 tractor	1,511	980	678	490	364	277	214	168	133	106	86	70
D6 tractor	4,159	2,664	1,828	1,310	967	730	560	436	342	271	217	174
Arches	340	223	156	114	85	66	51	40	32	26	21	17
Loaders	1,230	807	566	413	311	238	186	146	116	93	75	61
Gang trucks	167	108	75	55	41	31	24	19	15	12	10	8
Chainsaws	202	127	86	60	44	32	24	19	14	11	9	7
Field Service Unit	82	52	36	25	19	14	11	8	6	5	4	3
Tip trucks	84	56	40	29	22	17	14	11	9	7	6	5

Cost Item	Interest Rate % 3	4	5	6	7	8	9	10	11	12	13	14
Trekka truck	16	11	8	6	4	3	3	2	2	1	1	1
Trekka running costs	60	38	26	18	13	10	7	6	4	3	3	2
Miscellaneous stores	11	9	8	6	5	4	4	3	2	2	2	1
Miscellaneous equipment	43	29	20	15	11	9	7	6	5	4	3	3
Sub-total	7,905	5,104	3,527	2,541	1,886	1,431	1,105	864	680	541	437	352
Cost of logging operation												
18-yr-old stands	893	654	484	363	275	211	163	128	101	81	65	53
19-yr-old stands	1,449	1,082	818	626	485	379	299	238	191	155	126	103
20-yr-old and older stands	17,490	10,736	7,097	4,919	3,522	2,582	1,926	1,457	1,114	859	668	522
Sub-total	19,832	12,472	8,399	5,908	4,282	3,172	2,388	1,823	1,406	1,095	859	678
Overcharge (depreciation)	683	575	479	403	334	277	234	193	164	136	112	92
Sub-total	19,149	11,897	7,920	5,505	3,948	2,895	2,154	1,630	1,242	959	747	586
Salaries	852	540	366	258	188	140	106	81	63	50	39	31
External Overheads	511	324	220	155	113	84	64	49	38	30	23	19
Total net logging cost	28,417	17,865	12,033	8,459	6,135	4,550	3,429	2,624	2,023	1,580	1,246	988
Social Costs												
Roading												
Formation	356	337	320	304	289	276	263	251	240	230	221	212
Metalling	201	163	133	108	88	72	60	49	40	35	27	23
Maintenance	725	521	401	321	266	225	193	168	149	132	119	107
Grader	274	207	166	139	120	105	94	85	77	71	66	61
Tip trucks	61	46	37	31	27	24	22	20	18	17	16	15
10-cwt truck	27	21	17	14	12	11	9	8	8	7	7	6
Running cost of 10-cwt truck	88	63	48	39	32	27	23	20	17	15	13	12
Sub-total Overcharge	37	35	33	32	29	28	26	24	24	22	20	19
Sub-total	1,695	1,323	1,089	924	805	712	638	577	526	485	449	417
Accommodation												
Houses	1,363	1,197	1,094	1,020	962	912	869	830	795	762	736	704
Huts	183	125	91	68	53	41	32	26	22	17	14	12
Cookhouse	88	63	48	38	30	24	20	16	14	11	9	8
Caterer's house	18	14	11	9	7	6	5	4	4	3	2	2
Other camp buildings	28	20	15	12	10	8	6	5	4	4	3	3
Camp annual costs	410	258	174	122	88	65	49	37	29	22	17	14
Houses, R and M	472	333	251	198	161	134	113	97	84	74	65	58
Huts, R and M	33	21	14	10	7	5	4	3	2	2	1	1
Camp buildings, R and M	39	24	16	11	7	5	4	3	2	2	1	1
Service Charges												
Water supply and site preparation	32	32	31	31	30	30	30	29	29	29	28	28
Services, R and M	151	110	86	70	59	51	45	40	36	32	29	27
Other services	56	53	52	50	48	46	45	43	42	41	40	38
Sub-total	2,873	2,250	1,883	1,639	1,462	1,328	1,223	1,133	1,063	999	941	896
Social returns												
House rents	658	464	351	278	228	191	163	142	125	111	99	90
Hut rents	15	10	6	4	3	2	2	1	1	1	1	1
Sub-total	673	474	357	282	231	193	165	143	126	112	100	91

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