SIGNIFICANCE OF THE PROFIT STUDIES OF AFFORESTATION FOR THE EXPORT LOG TRADE

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(Received for publication 6 December 1971)

ABSTRACT

Profitability evaluation of non-normal afforestation by the budget method has the disadvantage that: only one time stream is investigated; it is difficult to maintain comparability between different site indexes; and work is laborious. Advantages are: results are easy to follow and directly applicable to current afforestation rates; the weaker points and significant variables are identified; and results are easily updated as costs and prices change.

The profitability of radiata pine (**Pinus radiata** D. Don) on three site indexes, whether assessed by internal rate of return (IRR), present net worth (or land expectation value (LEV)), benefit/cost ratio, cost of production per cu ft criteria, or export dollars earned per import dollar required, at interest rates of 3% to 14%, showed the same ranking. Site index 110 was the most, 95 the intermediate, and 80 the least profitable. The IRR on all sites exceeded 8%.

Risks could not be quantified, but the degree of marketing, biological, and physical risk increases with longer rotations. The faster tempo of work on the highest (110) site index incurs a higher management risk, and hence requires staff of better calibre.

The greater and earlier yields from high site qualities increase profits, and are particularly valuable to national forest strategy in filling target gaps.

While forest location greatly affects profit within one site index, the greater profit of 110 against 95 is outweighed only by a 60-mile closer proximity of the forest to the port. But more favourable forest location considerably increases the ratio of export dollars earned by the forest.

The relative costs of clearing heavy initial forest cover on different site qualities at different distances from the port, and of steeper country are indicated, and a means of finding effects of other significant variables on profitability is provided.

Profitability is high throughout and market prospects are good; the cost of prohibiting log exports can now be calculated.

INTRODUCTION

The profitability of radiata pine (*Pinus radiata* D. Don) afforestation for export log production has been evaluated for site index (Lewis, 1954) 80 (Fenton and Dick, 1972a); 95 (Fenton and Tustin, 1972) and 110 (Fenton and Dick, 1972b). This paper considers the overall results of the three studies. The advantages and limitations of the budget method are discussed with suggestions for further work. The differences in criteria, and bases for choosing an interest rate are then considered. Risks and uncertainties are outlined. The direct comparison of results from the three site indices follows, with the genesis of a national wood-production cost schedule. The paper concludes with the implications to national planning.

To avoid excessive cross-referencing the papers and sites quoted are referred to as 95, 80, and 110 for site index 95 (from Fenton and Tustin, 1972), those for site index 80 (from Fenton and Dick, 1972a), and those for site index 110 (from Fenton and Dick 1972b) respectively, unless otherwise stated.

PROFITABILITY MODELS AND BUDGET METHOD

The profitability models discussed are nominative. No forests are managed on the lines presented here. The answers can be only approximate, owing to the uncertainties inherent in projections into the future. The latter qualification applies to any study of medium or long term projects. Forest management for export-log production may be planned in the future.

The budget method has limitations when used to compare profitability in the present studies as results from only one pattern of events through time have been evaluated for each site index. It is also difficult to maintain fair comparability between different site qualities as the higher the site quality the larger the annual area involved. Both costs and returns occur earlier and are on a bigger scale on the higher site qualities. An alternative is a strict Faustmann type approach using regular annual programmes. The Faustmann formula suffers from limitations, including underestimating the annual indirect expenditure (Grainger, 1968). This can be corrected by a budget evaluating "normal" afforestation; such studies will be published later.

The initial burst of planting in the three site indexes has aimed at completing afforestation in a little under half the appropriate rotation, and so represents the probable course of many forests in the next million acres of New Zealand exotic forestry. The tempo parallels agricultural development when breaking in new land, and so facilitates comparisons between industries. Undoubtedly extensions to study different rates of afforestation and utilisation should logically follow, but the definition of the restraints necessary in linear programming, for example, is difficult and possibly the optimising techniques available may still fail, through initial human error, to give the most profitable (and practical) solutions. Because of the simplicity of the models used, the factors affecting profit are recognisable and the guides for management are clearer than in more sophisticated analyses.

The greatest difficulty in these studies was obtaining accurate costs, despite the simplicity of the management which restricted the range of data required. Highest costs are in logging, and the best man/machine combinations for different age-classes of clearfelling are not known.

Correct treatment of depreciation was troublesome. The effect of interest on annual depreciation is to overcharge, and it has been necessary to find both an annual and a periodic (service-life) basis for replaceable capital items. Where the depreciation cost has been charged in Forest Service accounts the difference between these two amounts has then been subtracted from the appropriate administrative or direct cost. While computer programmes have been used to find the LEV equivalents, the volume of work involved in working up the data from these LEV, using pre-electronic desk calculators, has been formidable. For example, the overcharge in machine depreciation in the annual fire protection costs required evaluation of 10 cost streams for each interest rate. No doubt the treatment is largely nominative as the imperfections of the overall costs used make the hidden depreciation costs uncertain. For instance, depreciation of buildings incorporated into annual fire protection, general administration, and camp charges will be based on historical costs, and not current replacement cost. As stated earlier the best solution is to exclude all depreciation elements in the annual administrative charges. It is possible that a wholly nominative approach would give equally useful results.

Lack of facilities has prevented preparation of compounded capital profiles which allow correctly for the lumpiness of replacement capital, against an annual charge. Future programmes will have to allow for this. It is doubtful if a "normal" cash flow is possible. For example replacement of large parts of the logging fleet in any one year would cause considerable lumpiness. In practice the effects when discounted, would decrease to insignificant proportions as the expenditure becomes more remote in time. More practically, technical changes would make future capital and depreciation costs quite uncertain. It is not improbable that the New Zealand logging industry, for example, will soon change under inexorable trading pressures, from using North American and European to Japanese equipment.

The simple budget approach adopted has, in compensation, a number of advantages. The isolation of each cost element, and its breakdown into constituent parts facilitates an infinite range of sensitivity analyses. As the usual practical objection to any profitability analysis is suspicion of or disagreement with the cost used, this cost breakdown enables results to be altered to suit other cases. For example, planting costs of $15.34 per acre have six constituents specified: direct labour; compensation and holiday pay; tree stock cost; tree stock distribution; travel time; and gang truck running. If different data are applicable elsewhere for any one of these (as is probable) the LEV equivalents can be altered by multiplying by the new cost divided by the old cost.

Another advantage is that management can see, without mathematical obscurity, what has been done: the forest has been established and equipped at a currently acceptable rate, the silviculture and practice is straightforward, and implications of the results are reasonably clear.

The comparable tempo of both agricultural development of new land, and afforestation make the results directly applicable to current practice.

The humdrum budget preparation method has been successful, too, in indicating the relative importance of the gaps in the data; in identifying problems in treatment of periodic capital changes; and in demonstrating the range of data necessary to calculate forest profitability.

The theoretical superiority of comprehensively computerised analysis (Whyte, 1968) is acknowledged, but these models have been completed; waiting for the appropriate computer programming facilities would have delayed them formidably. Elsewhere: " . . . . as to the comparative costs of expanding forest products output in North America and in other major forest regions of the world only the most fragmentary information now exists on such cost structures, and current judgments in this field tend to be largely subjective impressions with a minimum of underlying analysis" (Zivnuska, 1967). There are, presumably, no shortages of computer facilities in the USA. Overall, while the role of the machines is theoretically impeccable, in a rough pragmatic fashion local forestry economics have to depend on more primitive methods if studies are to be produced.

In summary, the budget method followed has:

Disadvantages

1. Analyses have been restricted to one sequence through time.
2. A fair basis for comparison is hard to maintain.
3. Optimum solutions are not obtained.

Advantages

1. Analysis shows up both weak points and the significant variables in evaluating profitability.
2. The basic data are not masked by elaborate mathematical techniques.
3. Management should find it easy to interpret results.
4. The analyses have been completed, and results are available.

Further work is desirable on:

1. Effects of different afforestation and utilisation patterns, including normal time flow;
2. Cost analyses to exclude depreciation;
3. Further programmes, including provision for "lumpiness" in capital profiles through depreciation changes;
4. Better micro-economic and physical data.

DIFFERENCES IN PROFITABILITY CRITERIA; INTEREST RATES

There is a voluminous literature on different ways of measuring profit on investments spread over several years (Fenton, 1968a, 1970). Discrepancies between the various methods have been considered by some authorities to be less worrying than discrepancies in the assumed cost and return data (Toren, 1961), a view supported by experience in these case studies. As there are relatively few examples in which alternative criteria are evaluated in forestry, their ranking effects are worth brief mention.

Results by internal rates of return (IRR), land expectation values (LEV), or discounted present net worth per acre, and break-even cost of production per cu ft are given in Table 1. Return/cost ratios are given in Table 2. Results show clear and consistent trends with site index 110 superior and site index 80 the least profitable. Similar congruity in profitability ranking by use of these different criteria was found in studies of a range of treatments of Pennsylvanian forests (Webster, 1965), and in Douglas fir plantations in New Zealand (Fenton, 1968b). The stable pattern of heavy and prolonged initial capital investment in the build-up of a forest, followed by a single change to large and uninterrupted returns probably accounts for the consistent ranking by the three criteria used.

The LEV criterion can yield anomalous results in sub-optimisation calculations where net values are negative; the LEV can increase with a rise in interest rate. This occurs in these studies, for example, when results allowing returns of 2.8c per cu ft have been calculated. Consequently results at interest rates beyond the IRR are of limited use.

The assumption of all three criteria is that land is free; the actual cost (if any) of land would have to be subtracted from the LEV if land was bought. The LEV per acre equals the net difference between discounted revenues and costs (apart from land) divided by the gross area (in acres). The profitability analyses have covered the same area—whether subsequently used for forestry or agriculture. Charging the land cost would naturally reduce the LEV from each interest rate by the same amount. But the change in internal rate of return will depend on the capital profile of the forest budget concerned.

Interest charges represent the largest constituent of forestry costs, but choice of an appropriate interest rate remains empirical. The rate cannot be chosen from pure theory, as such theory does not exist. For example, a recent text, in discussing investment decisions with imperfect funds markets, states: "Procedurally, one might expect the higher-level authority that issues the capital ration . . . to simultaneously establish

TABLE 1—LEV and cost of production

In Section A of the table, under "Including Social Items, 110" the amount in the 4% column should read "504", not "324".

	Interest rate %											
	3	4	5	6	7	8	9	10	11	12	13	14
A. Net LEV by Site Indexes ($ per acre)*												
Excluding social items												
80	471	261	150	87	48	23	8	-2	-9	-13	-16	-18
95	700	419	266	174	116	76	48	30	16	7	-1	-6
110	873	537	352	239	166	117	82	57	39	26	16	8
Including Social Items												
80	436	234	128	67	31	8	-6	-15	-21	-25	-27	-28
95	661	388	240	151	95	57	32	14	2	-7	-13	-18
110	832	324	324	215	145	97	64	41	24	11	2	-5
B. Cost of Production (c per cu ft)†												
Excluding social costs												
80	3.6	4.5	5.6	7.0	8.7	10.7	13.3	16.4	20.2	24.9	30.5	37.5
95	2.9	3.4	4.1	4.9	5.8	6.9	8.1	9.6	11.3	13.4	15.8	18.6
110	2.6	3.0	3.5	4.1	4.8	5.6	6.4	7.4	8.5	9.7	11.1	12.7
Including Social Items												
80	4.6	5.8	7.3	9.1	11.3	14.2	17.6	21.9	27.1	33.5	41.3	50.9
95	3.7	4.5	5.4	6.5	7.7	9.2	11.0	13.0	15.5	18.3	21.7	25.7
110	3.3	3.9	4.6	5.4	6.4	7.4	8.6	10.0	11.5	13.3	15.3	17.4

C. Internal Rates of Return %

	Excluding Social Items	Including Social Items
80	9.6	8.5
95	12.8	11.2
110	15.7	13.3

*Rounded to the nearest $

†Rounded to the 0.1 c

TABLE 2—Return/cost ratio including logging costs (taken on a 'loaded-on-truck' basis, 90 miles from the port)

Interest rate %	Site Index 80		95		110	
	+ Social Costs	- Social Costs	+ Social Costs	- Social Costs	+ Social Costs	- Social Costs
3	2.13	2.36	2.36	2.59	2.50	2.72
4	1.90	2.14	2.17	2.41	2.32	2.56
5	1.68	1.92	1.98	2.24	2.15	2.40
6	1.46	1.70	1.80	2.06	1.98	2.24
7	1.27	1.49	1.63	1.89	1.82	2.09
8	1.08	1.30	1.46	1.72	1.67	1.94
9		1.12	1.30	1.56	1.52	1.80
10			1.16	1.40	1.38	1.65
11			1.02	1.25	1.25	1.51
12				1.12	1.14	1.39
13					1.03	1.27
14						1.15

the level [of the interest rate] for the guidance of lower-level administrators [this should be called the Sinai principle] . . . But more typically, perhaps, the [interest rate] is not stated in advance. Instead it emerges . . . as a 'shadow price' revealing the marginal productive rate of return given the projects available to the executive agency. This represents an information 'feed-back' to the higher-level authority, which can be used in deciding on modification of the assigned ration . . ." (Hirshleifer, 1970, p.210). The working compromise is to adopt the prevailing rate (if known) for local investments of the same scale, risks, and class of ownership; in practice this means in New Zealand some extrapolation from rates applying in agriculture and power development. Rates for debentures raised by a large company in late 1970 were around 7½%. The 1967 Treasury directive was to use 7% (now 10%), but there are no signs that this, or any other rate, was used for the National Development Conference as a whole. A December 1970 Australian opinion stated "Given certain practical problems in determining [the rate of social time preference], analysts have tended to use the long-term bond rate or, since this in the past has let rather more projects through than there have been physical resources to handle them, a figure of 7% has been popular" (Jay, 1970). Australian Paper Manufacturers Ltd use a 7% rate in calculating their plantation growing costs (Chandler, 1969). The World Bank Mission to New Zealand advocated centralised Treasury control, and strengthening the Treasury Planning unit, but did not attempt to specify a desirable minimum rate of interest (World Bank, 1968). The World Bank implied the rate of return was an appropriate criterion, and considered that the overseas dollars earned per overseas dollar spent was of major importance in New Zealand; this has been evaluated for the three site indexes (Fenton and Dick, 1972c).

The present method of deciding on, or accepting, a given rate is hardly satisfying, but is the only one available. If management decides rates other than 7% are applicable and can demonstrate some basis for a choice, the range of values given at 3% to 14% will enable other results to be immediately obtained. Current (January, 1971) Treasury thinking is apparently in the range of 8%-10%, but this possibly includes an inflation factor.

SOCIAL COSTS

Roads and accommodation comprise social costs in forestry. The extent to which these costs should be allocated to production depends on circumstances. In Britain, it was argued that inclusion of forestry's housing costs depended on whether they represented net claims on national resources, because if the workers were not housed on the forest, they would be housed elsewhere ". . . by town corporations and we should . . . only charge the extra cost (if any) of providing forestry houses" (Walker, 1960). Walker concluded ". . . on economic grounds the inclusion of such costs is not correct". Forests established to utilise existing labour resources, as in Northland and Westland, may have a local cost advantage in using existing rural housing, when compared with forest extension in areas lacking housing. Overall, it seems preferable to reduce the number of people housed on the forest to a minimum, as there are strong social advantages in concentrating the population in towns so that facilities, e.g. shops, can be provided (Fenton, 1968a; Fenton and Terlesk, 1971). Future forest workers will be commuters.

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

RISKS AND UNCERTAINTIES

Strictly speaking chances whose effects on outcome can be calculated from past experience are termed risks, but if their probability cannot be calculated they are uncertainties (Marty, 1964). It is necessary to discuss the likelihood of achieving the results given in the earlier papers.

Risks

Fire losses are low in New Zealand State exotic forests. The rates have been calculated for Australasian State forests (Fenton, 1968a); for New Zealand they are 0.019, 0.032, and 0.089% for the last 5, 10, and 20 yr respectively. As considerable volumes of fire-killed timber can usually be salvaged and overall losses are so low, no adjustments to profit have been made beyond charging fire-prevention costs at the present levels of the Forest Service. Although basic data were available to show plantation fire losses are low, the bogey of fire has often been raised against forestry. It appears possible that plantations are below average in industrial fire losses.

Biological risks are difficult to quantify. The spacing and thinning regime proposed prevents undue overstocking, but as mortality has been irregular in the past, estimates of losses can only be conjectural. Generally, the shorter the rotation the lower the risks, as there are increased opportunities to change species or management. (Until biological losses can be assessed quantitatively, they are strictly uncertainties rather than risks.)

Wind losses have been irregular in past plantings. If quantified they would allow wind to be treated as a risk. Most losses have been in untended or late-thinned stands. Losses are correlated with crop height and treatment (Chandler, 1970); the management in this model anticipates negligible losses.

Fire, biological, and wind risks all tend to reduce profits.

Uncertainties

These are considered under variations in the physical and financial data used, the level of management, and marketing.

It is unlikely there will be unanimity over the costs, despite the details given of their origin. The present Forest Service costing system has many faults. The net effect of altering any cost or return element can be found by using Appendix 10 of Fenton and Tustin, 1972. For example, if the direct cost of thinning to waste is $28 per acre, and not the $22.2 used, the LEV equivalent of this operation (at, say, 7% interest) becomes:

$$\$9.78 \times \frac{28}{22.2} = \$12.34$$

and the net LEV is decreased by ($12.34 — $9.78) or $2.56. All the cost or return items given can be similarly adjusted — hence, the range of sensitivity analyses possible, once cost and returns are broken down into small constituents, is infinite, and allowance for this type of uncertainty in the basic data becomes simple in contrast to more complex adjustments (Dowdle, 1962). The dangers of over-simplification in adjustment of all costs are apparent from Table 5. Uncertainty about, say, tending costs cannot be allowed for by percentage adjustments to all costs as have been made elsewhere (Vaux, 1954). Profit can be either increased or decreased by these cost uncertainties.

The same type of adjustment to net results can be made in allowing for volume yield variation, and even changes in forest area. Overall losses in net forest area can be allowed for by the proportional reduction of discounted returns, while maintaining the appropriate costs.

The level of management has been a costly uncertainty in earlier afforestation. The silviculture and management proposed here is simple, however, and should avoid the generally late attainment of prescription that can attend silviculture. The most serious problems of faulty execution are in initial and subsequent establishment; although direct seeding and regeneration are allowed in line with conservancy practice, it is debatable if the chance of loss of a year's increment is worth running. It is often a line of least resistance in negligent management to "wait for regeneration". Tending is limited to thinning to waste, which is easy to do and avoids both the marketing complications and the chances of losing crop trees, which are concomitants of production thinning. The yield levels set are not high and the uncertainty here could as well result in increases as in decreases of profit.

Other management uncertainties, in addition to supervision, are the availability of labour and capital at the right time. Chances of not attracting labour are met to some extent by provision of accommodation and by payment of incentive or other above-average rates; both these measures are adopted here. Capital availability depends, in theory, on economic attractiveness of the proposals. Little useful comment can be added to these managerial problems, apart from recognising their existence.

This is primarily a micro-economic study concerned with production, but obviously profitability is dependent on the marketability and price of the logs. The export log specification is simply met by the silviculture specified. The effects of lower prices on profitability are shown in Table 4. The price of export logs has risen since the trade began in 1958 (Fenton, 1968c). The strength of New Zealand as a source of supply is its insignificent total production, e.g. "New Zealand [is] excluded somewhat arbitrarily . . . [and] . . . in the present context will not play an important part in the timber supply developments of the South Pacific" (Woolwine, 1969). Again, ". . . as these examples indicate, fast growing plantations [in the *world*] can contribute to international trade in softwoods. However, the total area of such exotic softwood plantations is only about 4 million acres. While they can be of importance in particular local situations in international trade, their total volume is too limited to be of appreciable significance to evaluation of and planning for the North American forest resource", (Zivnuska, 1967).

Current local log exports are at record high levels of 55 million cu ft annually, but represent only about 5% of Japan's softwood imports. Further markets now opening include Taiwan (pop. 13 million) where the pulp and paper capacity installed considerably exceeds local forest production, and South Korea (pop. 31 million) whose indigenous resources supply about half the industrial wood used. The rates of economic development in Japan, Korea, and Taiwan are among the highest in the world, and their chances of self-sufficiency are decreasing. The market prospects require further study, but at a preliminary estimate they are outstanding (MacGregor, 1970; Newport, 1969).

In any case, the silviculture and management, simple though they are, at least guarantee a higher quality crop than the current untended first rotation. The crop would have the same range of local end uses as present log production. There is built-in versatility of both markets and products, though probably at the cost of decreasing profit.

Use of probability distributions for different outcomes has been suggested as an approach to uncertainty (Dowdle, 1962), but it is difficult to estimate the likely standard deviation of a mean result in the future. Profitability calculations for natural forests have high levels of uncertainty (Dowdle, 1962; Webster, 1965; Vaux, 1954) compared with the data available for plantations. The growth rate and silvicultural characteristics of the species concerned, the utilisation aim of management, and the general level of organisation required are all better known for exotic plantations than for natural forest. Decisions to proceed with afforestation for the log export trade are probably less risky than for other courses of action, as capital is required mainly in the form of time, rather than cash for utilisation plants; the market appears to be substantial; both the skills and technical requirements are simple; the final product would have some versatility in sales; and rotations are reasonably short (20 to 29 yr on these site indexes). In many examples of uncertainty, profits may rise when final results are achieved. The biggest uncertainty in the log trade at present is the protective attitude developing in New Zealand which advocates maximum domestic processing of raw materials. This paper should at least enable the cost of the effects of prohibiting exports to be calculated: present indications are that log exports are highly profitable.

The opposite uncertainty—the imposition of trade barriers by importing countries —is extremely remote. The lack of tariffs and controls is favourable to the log trade.

Relative Risks on the Different Sites

Comparatively, as rotations are extended, the degree of marketing, physical, and biological risk increases. But as the extra risks cannot be quantified on present knowledge, relative profitability of the three site indexes has not been adjusted. The greater area to be re-established annually on 110 compared with 80, incurs a greater risk (of reduced profits) from second and subsequent rotations if management failures occur. The higher the site quality, the better the calibre of management needed. The implications of the different risks incurred by different site qualities should, however, be acknowledged in national planning and forest management.

RELATIVE PROFITABILITY OF SITE INDEXES 80, 95, AND 110

Afforestation of site index 110 is the most, and of site index 80 the least profitable of the projects studied. Summarised yields and results are given in Table 3.

TABLE 3—Comparative yields and results from site indexes, 80, 95, and 110 (at normality)

	Site Index		
	80	95	110
Total employed	82	97	108
Total yield per yr, million cu ft	5.9	7.44	8.56
Yield per man per yr, cu ft	72,000	76,750	79,300
Area worked per yr, acres	717	904	1,040
Rotation, yr	29	23	20

The IRR, LEV, costs of production, and benefit/cost ratios given in Tables 1 and 2 give the same ranking order. The LEVs are graphed in Fig. 1, and the costs-of-production in Fig. 2. While all three site indexes satisfy the minimum criterion of a 7% IRR when social costs are included, in fact, all yield better than 8%; sites 95 and 110 show highly profitable results. Direct comparisons with agriculture are available for 1962 only; up to 6% interest rates; and on land equivalent to site index 95 (Ward and Parkes, 1966). No combination of the three agricultural price ranges, or of the three management regimes used could achieve results even as good as for site index 80 for log-trade afforestation, whether social costs were included or not, at the interest rate evaluated of 4% to 6%. Again, export log production is as overwhelmingly superior to the earlier forest regime evaluated (Fenton and Grainger, 1965), as it is to agriculture.

Clear expositions justifying less profitable forest projects will be necessary in the face of these profit levels at current export prices.

The effect of lower prices on profit is marked for all site indexes. These are demonstrated in Table 4: a reduction of 10c per cu ft (from 20.8) reduces the IRR to 4% and 6½% for site indexes 80 to 110 respectively. At stumpages of 2.8c of course, all LEV are negative. Although a National Development Conference has been held recently,

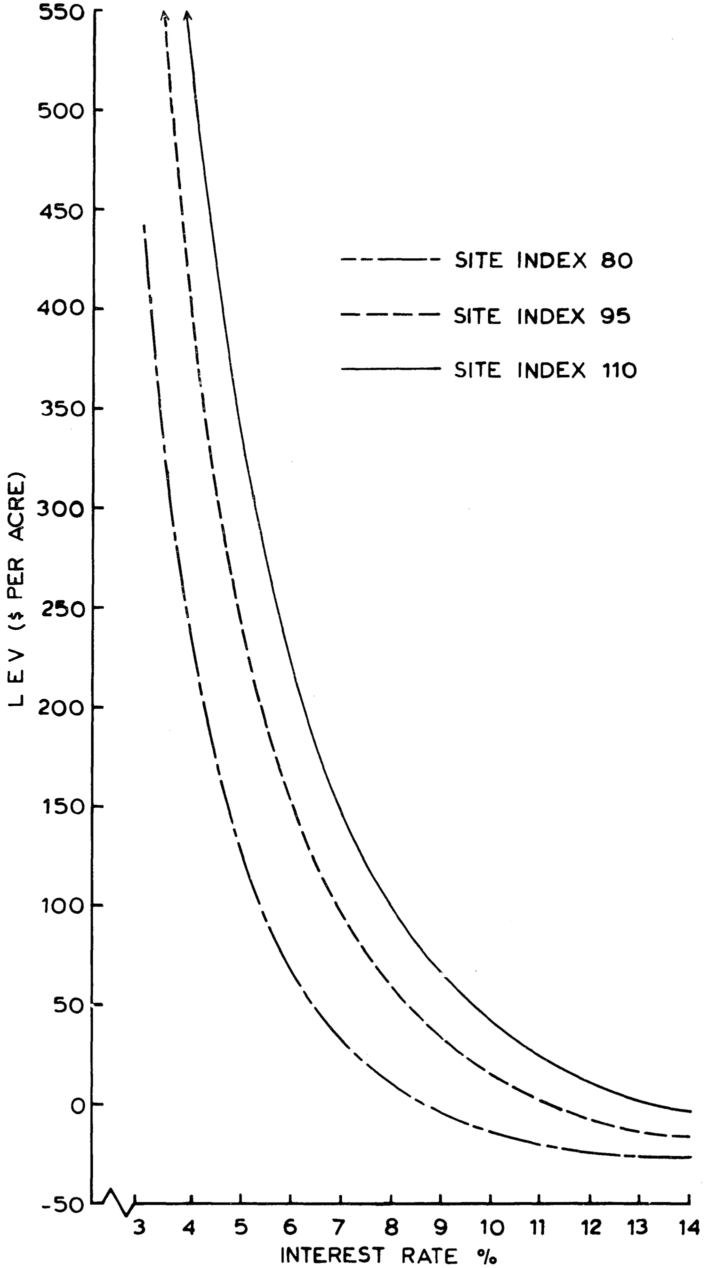

FIG. 1—Land expectation values, including social costs (forest 90 miles from port)

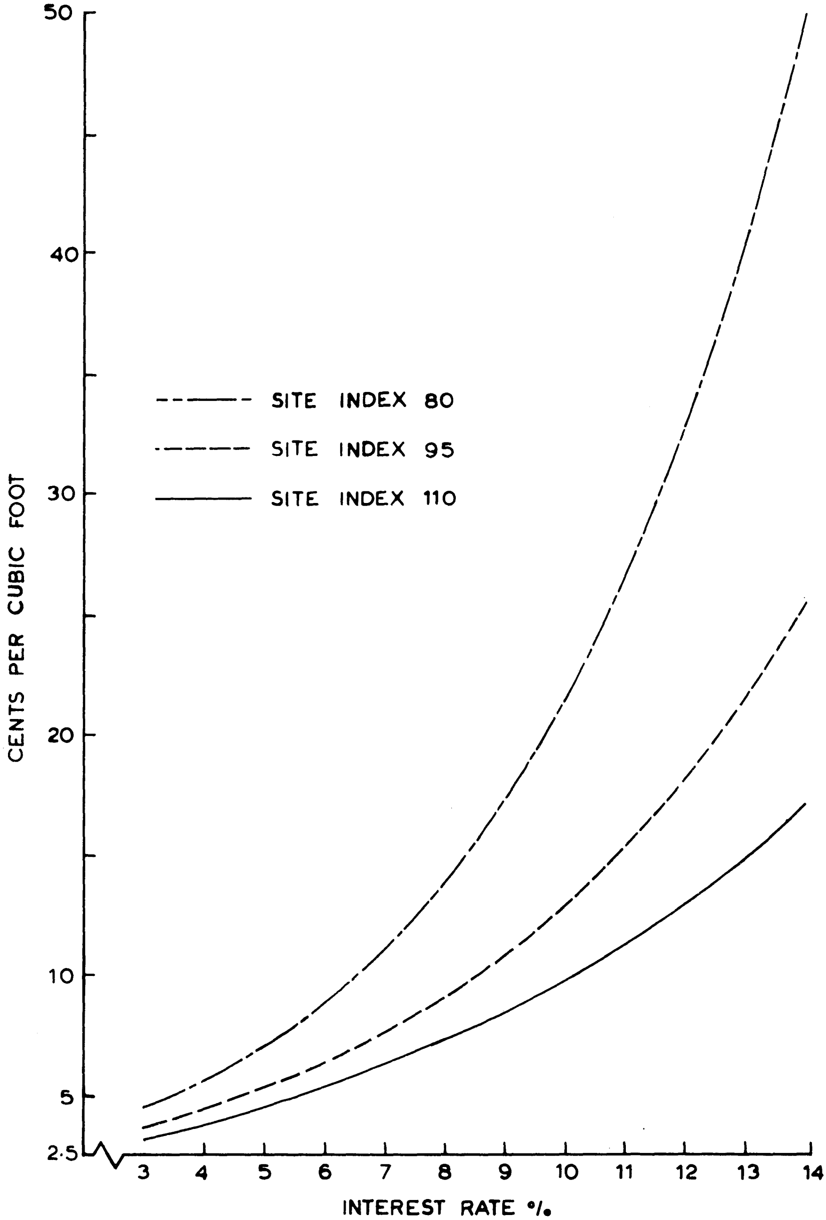

FIG. 2—Break-even costs of production, including social costs

there appear to be no studies of other industries available to allow comparisons of these profit levels.

Not only are profits substantially increased on higher site qualities, but the greater production leads to shortened rotation, greater volume per unit area, and higher production per man (Table 3). It is not possible to quantify the lower degree of

TABLE 4—Effect of lower returns on profitability: LEV in dollars per acre (including social items)

Site Index	Interest Rate % 3	4	5	6	7	8	9	10	11	12	13	14
	1 cent less per cu ft											
80	397	210	113	57	24	3	-9	-17	-23	-26	-28	-29
95	606	354	217	135	83	48	26	9	-2	-10	-15	-20
110	767	462	295	194	130	86	55	34	19	7	-2	-8
	10 cents less per cu ft											
80	43	-2	-23	-34	-39	-41	-41	-40	-40	-39	-38	-36
95	112	44	9	-11	-23	-30	-33	-36	-36	-37	-37	-37
110	169	81	34	7	-8	-19	-26	-29	-31	-33	-34	-34
	18 cents less per cu ft											
80	Negative throughout											
95												
110												

physical (wind, fire), biological (insects, disease), or marketing risk incurred in the shorter rotations on higher quality sites.

When considering the proportion of costs, the effects of longer rotations are to increase the relative importance of early operations, as against the final utilisation costs (Table 5). These effects are accentuated as interest rates increase. For example, logging

TABLE 5—Percentage of costs of operations (to loaded-on-truck). Totals may not add to 100 because of rounding

Operation	Site Index	Interest Rate % 3	4	5	6	7	8	9	10	11	12	13	14
Logging	80	53	48	42	37	32	27	23	20	17	14	12	10
	95	58	54	49	45	40	36	32	29	25	22	20	17
	110	61	57	53	49	45	41	38	35	31	28	26	23
Social	80	10	12	13	15	16	18	19	20	21	22	23	24
	95	9	11	12	13	15	16	17	19	20	21	22	23
	110	9	10	11	12	14	15	16	17	18	19	20	21
Administration	80	18	20	21	22	24	25	26	27	27	28	28	29
	95	15	16	17	18	19	20	21	21	22	23	23	24
	110	13	14	15	16	16	17	18	18	19	20	20	21
Protection	80	6	7	7	8	8	9	9	9	9	10	10	10
	95	6	6	6	7	7	8	8	8	9	9	9	9
	110	5	5	6	6	7	7	7	7	7	8	8	8
Tending	80	6	6	7	7	7	7	7	7	7	7	6	6
	95	6	6	7	7	7	7	7	7	7	7	7	7
	110	6	7	7	7	7	7	8	8	8	8	8	7
Establishment	80	6	8	10	11	13	15	16	18	18	20	22	22
	95	6	7	9	10	12	13	14	16	17	18	20	21
	110	6	7	9	10	11	13	14	15	17	18	19	20

is less dominant in overall costs of 80 than 110, and as a proportion of costs, decreases more rapidly in 80 than 110.

Overall, the highly profitable results should dispel ideas of cheap land for forestry. Against this is the fact that log exports on any scale, are currently excluded from future management targets.

EFFECTS OF LOCATION

Summarised effects of location on LEV are given in Table 6. The net LEV resulting from locating the forest 30, instead of 90 miles from the port, are shown in Fig. 3. If a forest of site index 95 was situated 30 miles from a port, its profitability (as measured by LEV) would be raised to equal that of a forest of site index 110 some 90 miles from a port. Other equivalent levels of profitability showing interactions between the three site indexes, and location are indicated in Table 6.

The LEV figures are primarily measures of profitability and are only part of the answer to location effect, as the annual yield per acre is greater on the higher site indexes. Consideration of location should include the extra haulage (and forest) costs incurred by establishing the greater area of lower quality sites needed to obtain the same volume. This extra area would depend on local circumstances; at its simplest theoretical level an extra 3,750 acres would be needed to produce the same volume from site index 95 as from 25,000 acres (gross) of site index 110.

The absolute mass to be moved in forestry is considerable; the data in Table 7 show the greatly reduced road traffic resulting from a more profitable forest location. Data on road accident rates are not yet available, but presumably accidents are reduced in proportion to the ton-mileage.

EXTERNAL AND INDIRECT EFFECTS; VALUE ADDED CONCEPTS; ECONOMIC CRITERIA

Other effects, common to afforestation, result from the management proposed here. Soil erosion is negligible under exotic forests, though their net effect on total water yield is conjectural. The roading problems resulting from 13 to 19 million ton-miles of traffic per year are proportionately reduced if forests are more strategically located. There is negligible pollution from the log trade, as processing is confined to logging. The biggest external costs are in the high accident rates of the logging industry — by far the most dangerous occupation in the country (Fenton, 1969). The economic severity index (the man-hours lost per 100,000 hours weighted by age for permanent disability or death) for logging was 10 to 15 times the all-industry average for 1963-1966. No later statistics are available. This disadvantage is common to all production forestry regimes.

It is feasible that the land could be used in part for run-off grazing while under predominantly forest use. Recreational use on the actual location would be limited; more pressure and use would presumably come if the forest was situated near an export port with higher urban populations. The differential demand for relatively fit, and almost exclusively male labour could be an extra indirect cost in most circumstances.

The degree of processing that is economically desirable is not discussed at length here. Values of unit output usually increase as further capital inputs are made. This occurs whether the capital is in the form of money as in utilisation plant construction,

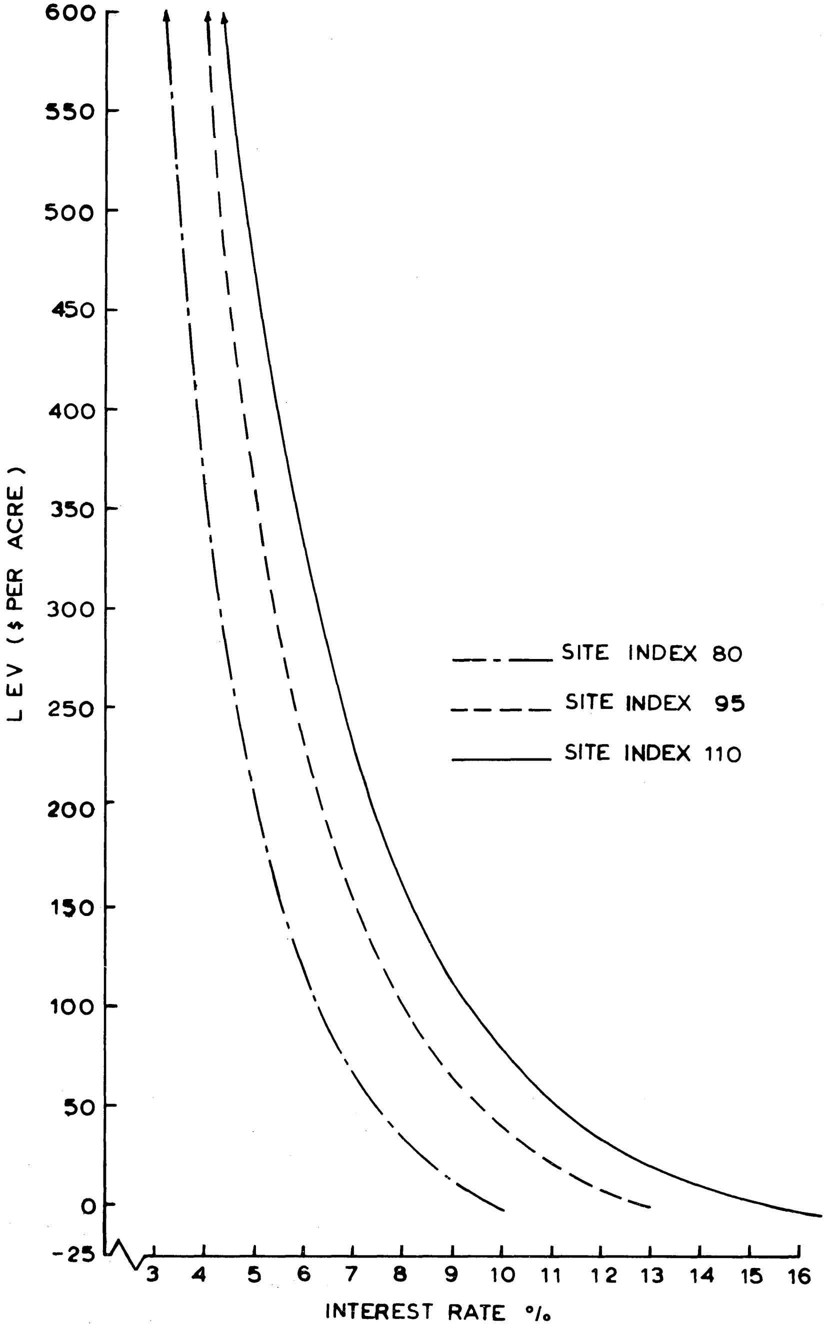

FIG. 3—Land expectation values, including social costs (forest 30 miles from port)

TABLE 6—Location effect on profitability: net LEV in dollars per acre (including social items)

Interest Rate %	Miles from Port 90			70			50			30		
	Site Index			Site Index			Site Index			Site Index		
	80	95	110	80	95	110	80	95	110	80	95	110
3	436	661	832	502	753	944	568	845	1,056	634	937	1,167
4	234	388	504	274	446	575	304	504	647	344	561	718
5	128	240	324	153	279	373	179	318	422	204	357	471
6	67	151	215	84	179	250	101	206	285	118	233	320
7	31	95	145	43	115	171	54	135	197	66	155	222
8	8	57	97	16	73	117	25	87	136	33	102	156
9	-6	32	64	0	43	79	6	54	94	11	65	109
10		14	41	-11	23	53	-7	31	64	-2	39	76
11		2	24		8	33		15	42		21	52
12		-7	11		-2	19		3	26		8	33
13			2			8		-6	14		-2	20
14			-5			-1.5			5			10

TABLE 7—Location effect on load hauls

Site Index	Location - 1-way Haul (miles) 90	70	50	30
	Total Annual Load (in million ton-miles*)			
80	13.285	10.333	7.381	4.428
95	16.750	13.028	9.305	5.583
110	19.270	14.988	10.706	6.423

* At forest normality

or in the form of time as in extending forest rotations. Of course on economic grounds ". . . the costs of a particular processing stage or economic activity have to be evaluated rather than the comparative costs of the final product or even the value added of the product" (World Bank, 1968). The assumption that further processing is desirable for value added reasons has been implicit in many pronouncements on the log trade made in New Zealand in the last decade, but the terms of reference for the Forestry Sector Report of the National Development Conference are for the "desirability of optimum economic processing within the country of New Zealand's forest resources . . ." (Forestry Committee, 1969). Significantly, optimum and not maximum processing is required, and the definition of optimum must include consideration of profitability. The further benefits from processing forest products have sometimes been implied as the justification for forest development, but the costs and profits of processing should be demonstrated. Growing logs for export is highly profitable in its own right and, further, generates a high return of export dollars at a low cost in import dollars (Fenton and Dick, 1972c).

Unlike the pulp and paper industry, the export log trade requires neither tariff protection nor a monopoly position in New Zealand. (Import "control" can be taken as equivalent in effect to a prohibitive tariff). The extent of these benefits to the pulp and paper industry, and of costs to the consumer have apparently not been analysed; they impinge on any assessment of the value added concept. Hence, apart from stressing that the log trade requires no domestic protection and is highly profitable without political interference, a relative case cannot as yet be quantified.

DELIVERED COSTS AND NATIONAL PLANNING

The detailed breakdown of discounted constituent costs presented as an example in Appendix 10 of one of the earlier papers (Fenton and Tustin, 1972) provides a method of calculating costs of production and LEV for other sites. When these are compared a synthesis can be made into a national cost of production schedule. For example, the effect of a complete, instead of a 2%, initial cover of bush can be calculated (assuming the same sequence of operations is followed) for each site index. Details of the calculations are given in Table 8. At 7% interest, for example, the $27 LEV is equivalent to about half the difference in net LEV between site indexes 95 and 110. So, even if 110 were all bush covered, it would still be more profitable to clear it than to plant an easy area of 95. Again the $27 LEV is equivalent to about 20 miles round haul differential; so bush covered land 70 miles from the port is more or less equally profitable to afforest; if it is nearer than 70 miles it is more profitable to clear the bush, for site index 95.

TABLE 8—Cost of afforestation on completely bush-covered sites: LEV in dollars per acre.

Site Index		Interest rate % 3	7	10
80	Original cost*	0.72	0.48	0.36
	Extra cost on 25,000 acres	35.28	23.52	17.64
	Extra cost as a % of total cost (including logging and social)*	9.1	20.3	25.2
95	Original cost**	0.76	0.55	0.44
	Extra cost on 25,000 acres	37.24	26.95	21.56
	Extra cost as a % of total cost**	7.6	17.7	23.6
110	Original cost†	0.79	0.61	0.51
	Extra cost on 25,000 acres	38.71	29.89	24.99
	Extra cost as % of total cost†	7.0	16.9	23.5

* Fenton and Dick, 1972a

** Fenton and Tustin, 1971

† Fenton and Dick, 1972b

Similar calculations can be made for other parameters. For example, if later work shows overall logging costs for steep topography are, say, 30% higher than for the tractor operations evaluated in the studies, then at 7% interest on 110, the total logging cost increases by $24, which is a little less than the effect of a further 20-mile log haul.

Hence, up to 70 miles away, the steep country is still a little more profitable (assuming for the sake of simplicity that other costs are unaltered) than easier country 90 miles from the port. If the country were both steep ($24) and entirely bush covered ($30) it would have to be over 40 miles ($52) nearer to the port to equal the easy topography and light cover of the area actually considered. When the LEV are converted to cents per cu ft, the growing cost of a given volume through time can be calculated. It should be reiterated that the studies are nominative, and some effects are complex, so only approximate answers can be calculated, and only one time sequence has been evaluated, but the order of magnitude and the ranking of the variables should be correct.

The timing of the supply is of great importance to New Zealand, due to the levelling off in the rate of growth of forest products exports in 1980-1995 (Forestry Committee, 1969). Again, there appear to be overestimates of the rotations needed in New Zealand forestry: ". . . New Zealand has become one of the most efficient plantation forest producers in the world. However . . . it takes about 25 to 30 years from planting before significant income can be derived from a new forest . . . this would provide no satisfactory solution to the pressing shorter-run problems facing the farmers and the nation" (New Zealand Economic Council, 1970). As shown in Table 3, rotations for 95 and 110 are 23 yr and 20 yr respectively, and returns begin several years before this. (Pulpwood rotations should be of the order of 8 to 18 yr for the site qualities considered here). Hence the greater profitability of the higher site qualities should be further weighted by their earlier yields. To some extent evaluation at high interest rates has this effect, as it favours regimes which have earlier yields, whether from higher site quality and/or more directed management. But such earlier yields were still grossly more profitable at low interest rates, and by all three profitability criteria used; so unless high interest rates are used as an absolute shut-off, they may not be sufficient to convince decision-makers of the right course of action. Therefore, as wood production is urgent, any management proposals which produce earlier physical yields should receive priority. This reinforces the obvious case to afforest high site qualities.

National planning should ultimately include schedules of delivered costs of different log qualities to utilisation points. The export log trade is the simplest example, where the cost is the sum of growing, logging, haulage, and loading costs. The studies have resulted in nominative growing costs resulting from one pattern of afforestation on each of three site qualities (and require expansion to cover different rates of planting) but serve to show the relative difference in cost on different sites. Logging and haulage costs are largely independent of site quality; clearfelling costs are known, and for a given volume per acre vary approximately ± 15% depending on topography; haulage costs increase as site quality decreases. The main variable cost is then the cost of growing. The final delivered cost is ultimately dependent on the interaction between interest rate, location, site quality, and management regime. The laborious method of budgeting can provide a basis for national planning. In addition to evaluating factors affecting cost of production directly, the land, labour (number and skills) requirements, and capital, both domestic and overseas, required through time can all be expressed. Certainly the qualifications that these are all nominal studies must be constantly remembered, but the first steps in a national cost of production schedule (Hummel and

Grayson, 1962) have now been evaluated, and more sophisticated schedules can be made.

CONCLUSIONS

1. The budget method of evaluation used has the limitation that results are obtained for only one time sequence of operations, but the results are easy to comprehend, are in accordance with the imposed tempo of national afforestation, show where major costs are, and where future work should be concentrated.
2. Results can be amended easily as costs and returns alter.
3. Ranking by LEV; IRR; benefit/cost ratios or cost of production per cu ft; or export dollars earned per import dollar are in the same order for the three site indices; 110 is best, 95 intermediate, and 80 least profitable.
4. The difficulty of deciding the basis for choice of an interest rate remains and interest rate is the dominant influence on all results.
5. All IRR are over 8% and results are profitable throughout.
6. Risks are relatively low, but cannot be quantified on present knowledge. They are of different types, being higher managerially on high quality sites, and higher physically and biologically on low quality sites.
7. The effects of lower yields and prices are considerable.
8. While location greatly affects profit, at 7% interest its effect is generally exceeded by site quality.
9. The ton-mileage to be transported in the log trade is radically reduced by more profitable location nearer the port.
10. Logging is the highest of forest costs, but is exceeded by administration on the lowest site index (80) at 8% interest and over, and at 12% interest and over on site index 95.
11. The more profitable results from the highest site quality are reinforced by the greater volume produced per acre and the earlier yields.
12. The ratio of export dollars earned per import dollar ranges between 8.3 to 1 and 10.8 to 1 at 7% interest (including social costs). Even at 14% interest, the ratios are still 3.3, 5.4, and 6.4 to 1 for the respective site indexes.
13. Market prospects are good.

REFERENCES

CHANDLER, K. C. 1970: Site limitations on pruning and thinning. **In** Pruning and thinning practice. **New Zealand Forest Service, Forest Research Institute Symposium 12, Vol. 2, Papers:** 85-8.

CHANDLER, W. G. 1969: Pine plantations — a private enterprise investment. **Australian Timber Journal, 35 (11) (Congress Issue):** 200-8.

DOWDLE, B. 1962: Investment theory and forest management planning. **Yale University School of Forestry Bulletin 67.**

FENTON, R. 1968a: Silviculture and profitability of plantation forestry in New Zealand. (Thesus lodged in the Australian National University library.)

——— 1968b: The economics of Douglas fir. **New Zealand Forest Service, Forest Research Institute Silviculture Branch Report 82** (unpublished).

——— 1968c: New Zealand's export trade in forest products with Australia. **New Zealand Journal of Forestry 13 (1):** 5-29.

——— 1969: Indirect and secondary economic effects of plantation forestry. **New Zealand Forest Service, Forest Research Institute, Economics of Silviculture Branch Report 10** (unpublished).

——— 1970: Criteria for production forestry. **New Zealand Journal of Forestry 15 (2):** 150-7.

FENTON, R. and DICK, M. MERLE. 1972a: Profitability of radiata pine afforestation for the export log trade—on site index 80. **New Zealand Journal of Forestry Science 2 (1) (this issue):** 99-0.

——— 1972b: Profitability of radiata pine afforestation for the export log trade—on site index 110. **New Zealand Journal of Forestry Science 2 (1)** (this issue): 00-0.

——— 1972c: Import costs and overseas earnings of afforestation models for the export log trade. **New Zealand Journal of Forestry Science 2 (1) (this issue):** 00-0.

FENTON, R., and GRAINGER, M. B. 1965: Economic results from afforestation of the Maraetai Blocks. **New Zealand Forest Service, Forest Research Institute, Silviculture Branch Report 31** (unpublished).

FENTON, R., and TERLESK, C. J. 1971: Aspects of labour in New Zealand forestry. **New Zealand Journal of Forestry 16 (2):** 208-22.

FENTON, R., and TUSTIN, J. R. 1972: Profitability of radiata pine afforestation for the export log trade—on site index 95. **New Zealand Journal of Forestry Science 2 (1)** (this issue): 00-0.

FORESTRY COMMITTEE, 1969: "Report of the Forestry Committee to the Plenary Session of the National Development Conference" (NDC 5). Government Printer, Wellington.

GRAINGER, M. B. 1968: Problems affecting the use of Faustmann's formula as a valuation tool. **New Zealand Journal of Forestry 13 (2):** 168-83.

HIRSHLEIFER, J. 1970: "Investment, Interest and Capital." Prentice-Hall, Englewood Cliffs, New Jersey.

HUMMEL, F. C., and GRAYSON, A. J. 1962: "Production Goals in Forestry with Special Reference to Great Britain." (Paper to Eighth British Commonwealth Forestry Conference.) Forestry Commission, London. 16pp.

JAY, C. 1970: A cost benefit approach to inflation. **Australian Financial Review, 4.12.70:** 8-9.

LEWIS, E. R. 1954: Yield of unthinned **Pinus radiata** in New Zealand. **New Zealand Forest Service, Forest Research Institute, Forest Research Note 1 (10).**

MARTY, R. J. 1964: Analysing uncertain timber investments. **United States Forest Service, Northeastern Forest Experiment Station Research Paper NE-23.**

MacGREGOR, J. J. 1970: New Zealand's exports of wood products with special reference to Japan. **New Zealand Forest Service, Forest Research Institute, Economics of Silviculture Branch Report 29** (unpublished).

NEW ZEALAND ECONOMIC COUNCIL. 1970: New Zealand and an enlarged EEC. **New Zealand Economic Council Report 19.**

NEWPORT, C. A. 1969: The Japanese market for logs and lumber. Session V **in** "The Dynamics of Distribution" (Proceedings of the Fifth Annual Forest Industries Marketing Conference, 1968). (S.U. Rich, Ed.) University of Oregon, Eugene.

TOREN, B. 1961: Comment **in** "Public Finances: Needs, Sources and Utilisation." (J. M. Buchanan, Ed.). Princeton University Press, Princeton.

VAUX, H. J. 1954: Economics of the young growth sugar pine resource. **Californian Agricultural Experiment Station Bulletin 738.**

WALKER, K. R. 1960: The Forestry Commission and the use of hill land. **Scottish Journal of Political Economy 7 (1):** 14-35.

WARD, J. T., and PARKES, E. D. 1966: An economic analysis of large-scale land development for agriculture and forestry. **Lincoln College, Agricultural Economics Research Unit Publication 27.**

WEBSTER, H. H. 1965: Profit criteria and timber management. **Journal of Forestry 63 (4):** 260-6.

WHYTE, A. G. D. 1968: The use of electronic computers as a tool of forest management. **New Zealand Journal of Forestry, 13 (2):** 184-90.

WOOLWINE, P. C. 1969: **In** "Marketing in the Changing World of the 1970s". (Proceedings of the Sixth Annual Forest Industries Marketing Conference). College of Business Administration, University of Oregon, Eugene.

WORLD BANK, 1968: "The World Bank Report on the New Zealand Economy 1968." Government Printer, Wellington.

ZIVNUSKA, J. A. 1967: "United States Timber Resources in a World Economy. Resources for the Future." John Hopkins, Baltimore. 125pp.