

AN ECONOMIC EVALUATION OF AFFORESTATION WITH *RADIATA* PINE ON TAWARAU FOREST

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SYNOPSIS

A full forest management schedule was drawn up for an afforestation project with radiata pine on Tawarau Forest, central North Island, then relevant costs and returns were applied. On the gross area of 5584 hectares, 4872 ha were taken as plantable. Site index was 33 m at 20 years. A short rotation of 25 years managed on a sawlog board regime to produce for the local domestic market of Hamilton was prescribed. Establishment was assumed to be completed in 15 years at 332 ha annual planting, with 100% stocking. Net wood yield per hectare at age 25 was put at 623 m³ — 497 m³ of sawlogs and 126 m³ of chipwood. The forest reaches a sustained yield by year 47 when total yield from a logging coupe of 199 ha is 0.99 million m³ of sawlogs and 0.24 million m³ of chipwood. A staff of 14 and a work force of 43 was required. Buildings and accommodation were minimal, the work force being transported daily from town centres. Costs and returns were taken from a base year of 1968. The economic results derived were favourable. The internal rate of return was 9.8% including social items and 10.8% excluding social items. The present net worth at 7% discount interest rate was \$46.31 including social items and \$55.63 excluding social items. Results indicated that afforestation in the locality would be a profitable venture and could meet the 10% earning rate stipulated by the Treasury. Planting commenced in 1972 and this forest model will provide a valuable yardstick to assess the actual forest profitability.

INTRODUCTION

Tawarau Forest is in the northern King Country area of Waitomo County. It is administered by the Te Kuiti District of the Auckland Conservancy of the New Zealand Forest Service. The forest, of 5584 ha, lies some 37 km north-west by road of Te Kuiti (see Fig. 1). There have been sporadic farming attempts on parts of the block, and minor utilization activity in the past, but it remains the largest single block of undeveloped State-owned land in the locality considered to have any development capability.

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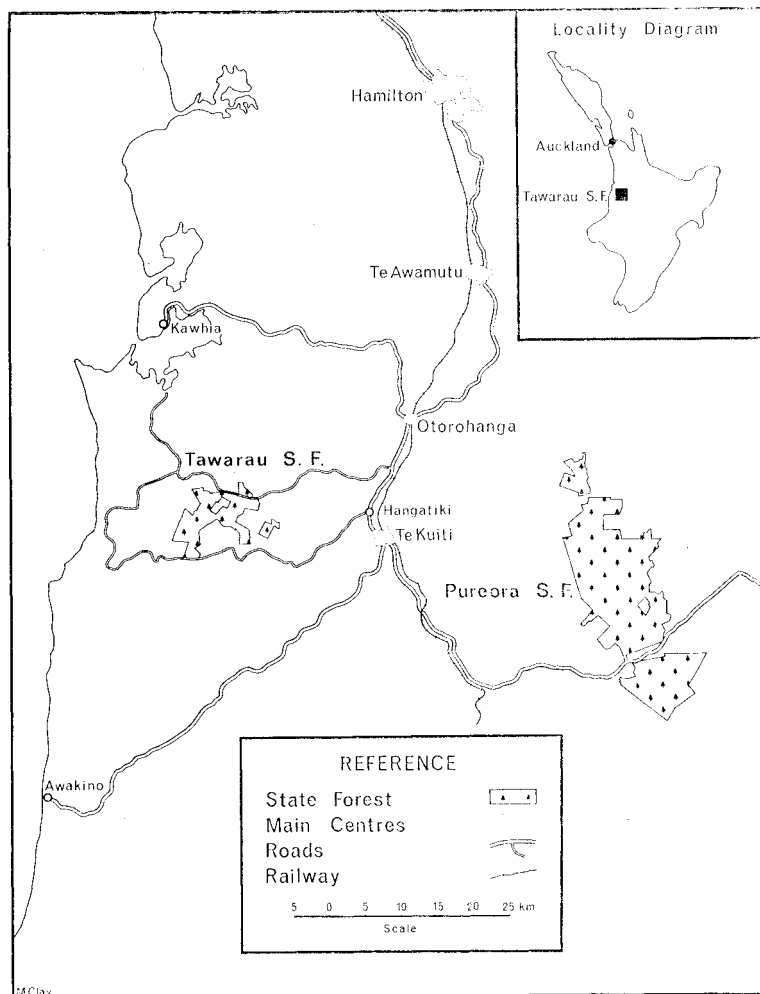


FIG. 1: Location of Tawarau State Forest.

Discussions on the most suitable form of development span more than a decade. A brief report on the exotic afforestation potential was prepared in 1961, which included a proposal to start an afforestation programme in 1965 (Perham, 1961). However, pressure from local farming interests resulted in the recommendation that the block be transferred from the N.Z. Forest Service to the Department of Lands and Survey in 1962 for a farm development and settlement scheme. No development was initiated in the intervening years and in 1969 the N.Z. Forest Service again became interested in an

afforestation scheme for the block. Subsequently a Land Utilization Committee was convened to consider the Forest Service proposal. The committee made a loose recommendation that the land was suitable both for development as farming units and for exotic forest and called for the ultimate decision on the prime use of the land to be made at a higher level.

Because new Government development projects require Treasury approval, comprehensive economic reports on both alternatives were required. The afforestation report was completed in February 1972 and is outlined in summary form in this paper.

OBJECTIVE

The prime objective of the study was to evaluate in economic terms, from the national point of view, the worth of an exotic afforestation scheme for Tawarau Forest. Factors to be determined were present net worth and internal rate of return. To achieve this objective a detailed forest development and management plan was required, and it was intended that this plan would be of practical value should an afforestation scheme proceed.

CHARACTERISTICS

Altitude: From 152 to 396 m a.s.l. The main body of the block, the Mairoa plateau, lies at 213-243 m a.s.l.

Terrain: In the main rolling to strongly rolling, broken in local areas by limestone outcrops, and divided by three main streams.

Climate: Annual rainfall 3030 mm. Long, dry summers with rainfall heavier in the winter and spring months. Moderate winter frosts.

Soils: Free-draining volcanic soils of the Mairoa ash group, classified as silt loam and sandy clay loam, overlying siltstone, sandstone and limestone.

Vegetation: Medium to heavy scrub, with scattered bracken — 3322 ha. Scattered mixed podocarp/hardwood forest of low merchantable volume — 2267 ha.

Boundaries: Well-defined, either by roads or by streams and steep bluffs. Adjoining land is largely in undeveloped indigenous forest and scrub or semi-developed pasture.

THE FOREST MODEL

Plantable Area

Of the total forest area of 5584 ha, some 4872 ha was taken as plantable. The reduction was made by delineating gorge and bluff areas and allowing for roads, power lines and roadside reserves. It was assumed that 100% stocking would be achieved on the 4872 ha.

Site Index

There was no radiata pine growing within the forest and site index was based on height measurements of trees growing adjacent to the forest on the same soil type, using Lewis' alignment chart (Lewis, 1954). After considering site factors, site index was estimated as 33 m at 20 years.

Silviculture

One species, radiata pine, was considered as it clearly offers the greatest profitability as a plantation species. In addition the diminishing indigenous resource in the district needs replacing by an exotic species which can be grown on a short rotation. Fast growth rates and increment response to silvicultural treatment are promised by the indicated high site index. It was decided to adopt a sawlog regime on a short rotation, aiming for maximum clearwood yield. The regime chosen was:

- (1) Each site was cleared and burnt. Gorse (*Ulex europaeus*), bracken (*Pteridium aquilinum* var. *esculentum*), manuka (*Leptospermum scoparium*) areas to be prepared by cultivation.
- (2) Initial spacing to be 3.0×1.8 m — i.e., 1790 stems/ha.
- (3) Blanking — 10% of the annual planting will need blanking in the following year.
- (4) Releasing — first rotation, 80% of former scrub-covered areas and 10% of bush sites will need one release cutting, and 20% of all release-cut areas will need a second treatment. Second and subsequent rotations — 80% of annual area planted.
- (5) Pruning — a first log pruning to be carried out in three stages:
 - 0 to 2.5 m at mean top height (mth) 5.5 m on 740 stems/ha.
 - 2.5 to 4.5 m at mth 8.5 m on 379 stems/ha.
 - 4.5 to 6.0 m at mth 10.5 m on 200 stems/ha.
- (6) Thinning — three thinnings to waste to remove unpruned non-select stems.
 - at mth 5.5 m to 1040 stems/ha
 - at mth 10.5 m to 370 stems/ha
 - at mth 16.5 m to 200 stems/ha
- (7) Clearfelling — at mth 37.5 m; dbh ob 60 cm; age 25 years.
- (8) *Dothistroma* protection — a maximum of five sprayings over the first 15 years of each rotation.

METHODOLOGY

It was decided that the forest budget method developed by the Forest Research Institute (Fenton, 1971) was the most appropriate for the study. The method has been extensively

used by the FRI economics group to carry out research into plantation economics, using the characteristics of the Maraetai block on which to base the forest model chosen. The Maraetai block was a large area of undeveloped Crown land considered in 1962 to be equally suitable for afforestation or agricultural development. Fenton and Grainger (1965) carried out a study of the economics of afforestation on the area. This original study has subsequently been extended to examine the relative profitability of various alternative forest models. As far as was known, it had not been employed as a tool of practical forest management. The method requires precise and detailed programming of the forest development and operations, and a cash flow analysis on an annual basis until the forest model has reached a sustained yield point, or normality. It is best approached as if preparing a forest working plan.

Field Assessment

Before deciding on the management strategy and silvicultural regime, field inspections were made, to become familiar with the area. It was necessary to examine likely vegetative cover classes and ground contours which could necessitate different establishment techniques. Any physical problems associated with establishment, roading and logging were considered. Topographical maps and aerial photographs were an essential aid for these inspections.

Height measurements were taken of radiata pine growing adjacent to the forest to estimate the site index. Forest compartment maps were drawn, and a roading layout planned. Having assembled all the basic data, the forest plan of operations, based on the silvicultural regime chosen, was drawn up.

Management

After deciding on the silvicultural regime, management factors on which the forest development sequence is dependent were examined by considering the relative merits of the alternatives.

- (1) Establishment at an accelerated or normal rate.
- (2) Physical and financial constraints which could limit the size and continuity of the annual establishment programme.
- (3) The necessity to erect a headquarters and village on the forest.

The course adopted is given in the following sections.

Establishment

The plantable area of 4872 ha would be established on a 15-year programme, at 332 ha annually, completing establishment in two-thirds the rotation age of 25 years. Conversion

to normality was necessary to derive an annual cash flow in perpetuity. The related physical schedules detailing year and area for land clearing, establishment, tending, *Dothistroma* spraying, and clearfelling, were drawn up. Normality in terms of areas established and tended was reached in year 35, but full normality was not reached until year 47 when the age class and volume of clearfelling became normal.

Yields

The choice of a heavily thinned short-rotation schedule made growth projections difficult, as such management is a recent concept. The similarity of the regime to that used by Fenton *et al.* (1968a) in Model VF of the Maraetai study series made it possible to use the basic data in that model. The method of Beekhuis (1966) was used to calculate the yield prediction. Gross volume was taken to a 30 cm top on the basis that the heavy early thinning could result in heavy crown branching, resulting in poor grade recovery. It was assumed the top logs would be utilized as chipwood or pulpwood. Net yield per hectare at age 25 was 623 m³, 397 m³ being sawlogs and 126 m³ being chip or pulpwood. Total yield at normality from a logging coupe of 199 ha was 0.99 million m³ of sawlogs and 0.24 million m³ of chipwood or pulpwood.

Total annual staff and labour requirements were then determined, being dependent on the detailed physical schedules. In view of the closeness of Tawarau Forest to the towns of Te Kuiti and Otorohanga, and after examining the cost of the travelling time involved, it was found to be cheaper to transport the work force daily to the site than to erect a complete forest village. When fully developed by year 47, the forest requires a staff of 14 and a total work force of 43 men, consisting of 18 silvicultural workmen, 15 bushmen and 10 miscellaneous workmen. Buildings on the forest itself would consist of 4 houses and 2 batching units for staff, a small office, store, garages, and a maintenance workshop. Maximum use of facilities in Te Kuiti District Office and Pureora Forest would be made.

Schedules were then prepared according to the annual management regime, for annual roading construction and maintenance, vehicles, logging equipment and general equipment, minor capital works and fire equipment.

The forest is already served by 21 km of existing roads. Allowance to construct a further 59 km of Class GII standard over the 15-year establishment period was made, giving a minimum of 1 km of arterial roading to 60 ha. As the forest boundaries adjoin either undeveloped freehold in forest, or Maori land in scrub, no allowance was made for boundary fencing.

FINANCIAL CALCULATION

Basis of Costs and Returns

The present net worth and internal rate of return derived in the study is based on 1968 costs and returns. It was the last

cost-stable year in the national economy before the inflation rate began increasing substantially. A number of the indirect costs required involve considerable tedious work, yet are only a small percentage of the total costs. By using 1968 as the base year, it was possible to use some indirect costs derived by the FRI economics group for use in their afforestation models which had the same base year.

Direct Costs

Selection of the cost data was subjective and was dependent on a careful comparison of the area under study and actual production performance on similar afforestation sites. Direct costs comprise wages, wet time, compensation, holiday pay, travelling time, and transport charges. Supervision and indirect charges are costed separately. It was assumed all work would be carried out by Forest Service work force.

Protection Costs

Allowance was made for a maximum control programme for *Dothistroma* consisting of five sprayings over the first fifteen years of each rotation.

Fire protection costs included vehicles and equipment and an annual charge based on the total exotic area planted.

Indirect Costs

Indirect costs included annual salaries and external overhead charges, general administration, capital repairs and maintenance charges to buildings, services, stores, vehicles and machines. The cost data were taken from Auckland Conservancy cost records but, where not there available, from Model IVF of Fenton *et al.* (1968b).

Social Costs

These comprise the capital and maintenance charge for four houses and two baching units, and the construction and maintenance of 59 km of roading. These items were isolated and listed separately in the results as they are costs which also carry a social benefit. Their full cost might not necessarily be costed as a direct charge on the scheme.

Returns

Net value of the timber, expressed as dollars per cubic metre on forest landing, was used to derive discounted revenue. The value used, derived from a realization study, was \$7.79/m³.

For the sawlog realization, expected timber grade recoveries detailed by Fenton *et al.* (1968a) Model VF were used. No attempt was made to determine value by log height classes as there were insufficient grade data. Timber prices used were from the N.Z. Sawmillers' Federation radiata pine price list of 1.8.68 for Mamaku. It was assumed that a processing

plant would be built at the Hangatiki railhead on the main trunk line 24 km from the forest and that the main market would be Hamilton, 66 km north.

The residual value of top logs and residues for use as chip or pulp wood was minimized by the long haul of 104 km to the closest existing processing plant at Kinleith. A royalty of \$0.56/m³ was allowed.

Profitability Calculation

The purpose of the study was to evaluate two economic factors:

- (1) The present net worth of an afforestation project at stated interest rates, and
- (2) the earning rate an afforestation project would generate.

The present worth of the afforestation scheme is found by subtracting the present value of costs from the present value of returns. Each cost or return item was discounted back to year 1 and divided by the net number of hectares planted to give a net present value per hectare for each item. Simple addition and subtraction followed, to derive the present net worth per hectare.

The discounting calculations were simplified by using the FRI computer programmes FIN 1 and FIN 2. These programmes will derive net present values for up to 100 items for the range of interest rates 3 to 16%. Programme FIN 2 calculates the net present value for semi-permanent capital items which depreciate. The useful service life for each item must be nominated. The programme allows for the replacement of the item at the original cost at the end of its service life and discounts the future cost stream for each interest rate.

The earning rate or internal rate of return of the project was found by graphing present net worth (PNW) for each interest rate. It is that rate of interest at which the present net worth breaks even — *i.e.*, PNW = 0.

It should be noted that the land value was not included in the profitability calculation, the study being carried out from the national point of view. There is also no taxation provision. As the forest is Crown land there is no land purchase cost involved.

Results

The present net worth was calculated for the range of interest rates 5 to 11%. The values are tabulated in Table 1. The break-down of the PNW into cost/return items is self-explanatory. Individual cost items have been summarized into major cost classes — land preparation, establishment, tending, protection, administration, logging, roading and housing.

TABLE 1: PRESENT WORTH BY INTEREST RATE
(\$ PER HECTARE)

Category	Interest Rate (%)						
	5	6	7	8	9	10	11
FORESTS COSTS:							
1. Land preparation	7.49	7.00	6.56	6.17	5.79	5.47	5.17
2. Establishment	9.73	8.37	7.39	6.66	6.08	5.62	5.23
3. Tending	17.32	14.08	11.76	10.02	8.64	7.55	6.65
4. Protection	6.55	5.32	4.42	3.79	3.28	2.88	2.56
5. Administration	30.56	21.70	19.79	16.60	14.20	12.33	10.77
6. Logging	5.15	3.72	2.76	2.09	1.61	1.25	0.99
Total forest costs	76.82	60.20	52.73	45.33	39.60	35.10	31.37
SOCIAL COSTS							
7. Roading	10.21	9.21	8.42	7.86	7.25	6.79	6.39
8. Housing	1.17	1.01	0.90	0.82	0.75	0.69	0.64
Total social costs	11.38	10.23	9.32	8.68	8.00	7.48	7.04
Total costs	88.20	70.43	62.05	54.02	47.60	42.58	38.41
RETURNS							
1. Saw logs	220.25	149.51	104.59	74.84	54.51	40.28	30.12
2. Chip wood	7.68	5.20	3.63	2.59	1.89	1.58	1.15
3. Rents	0.17	0.15	0.14	0.12	0.11	0.10	0.09
Total returns	228.10	154.86	108.36	77.55	56.51	41.97	31.36
PRESENT NET WORTH							
Excluding							
social items	151.28	94.66	55.63	32.21	16.91	6.87	-0.01
Including							
social items	139.90	84.43	46.31	23.53	8.91	-0.61	-7.05

The PNWs at 7 and 10% are of most interest as they are the former and current interest rates set by the Treasury for Government projects. These are shown in Table 2. The earning rate for the project is also shown in Table 2.

TABLE 2: PRESENT NET WORTH AT 7 AND 10%, AND INTERNAL RATE OF RETURN

				Interest Rate (%)	
				7	10
Present net worth:					
Excluding social items	....	....	....	\$55.63	\$6.87
Including social items	....	....	....	\$46.31	-\$0.61
Internal rate of return:					
Excluding social items	....	....	....	10.8%	
Including social items	....	....	....	9.8%	

As returns from agriculture are often expressed as a return per hectare per annum, the present net worth at each interest rate has been expressed as an annuity value in perpetuity in Table 3.

TABLE 3: PNW EXPRESSED AS ANNUITY IN PERPETUITY IN DOLLARS PER HECTARE

			<i>Interest Rate (%)</i>						
			5	6	7	8	9	10	11
Excluding	social	items	9.91	6.15	3.64	2.10	1.09	0.44	—
Including	social	items	9.14	5.50	3.03	1.54	0.57	—	—

The break-even price for sawlogs per m³ for the range of interest rates is given in Table 4.

TABLE 4: BREAK-EVEN PRICE FOR SAWLOGS IN DOLLARS PER CUBIC METRE

			<i>Interest Rate (%)</i>						
			5	6	7	8	9	10	11
Excluding	social	items	2.62	3.03	3.79	4.55	5.46	6.52	7.79
Including	social	items	3.01	3.54	4.46	5.42	6.57	7.91	9.68

CONCLUSION

Apart from the results of afforestation models produced by the economics group at the Forest Research Institute, there are few other comparable studies with which to rank the results. The results must necessarily be judged alone and, on this basis, only values including social items need be considered.

The internal rate of return including social items is 9.8%. It is considered that this figure meets the profitability guideline stipulated by the Treasury.

Normally profitability of alternative land use investment projects is assessed at much lower interest rates. At 5% and 7% discount interest rates, present net worths including social items are \$139.9/ha and \$46.31/ha, respectively, which are equivalent to an annual return of \$9.14/ha and \$3.03/ha. These figures compare more than favourably with returns from farming development of similar country in the locality.

The break-even value for sawlogs of \$4.46/m³ at 7% is within current prices paid for untended logs in log export localities. The break-even price at 10% is \$7.91/m³ and it is not unreasonable to expect that this premium price might be paid for high quality logs.

The results do not reflect maximum profitability of afforestation on Tawarau Forest. Only one management regime was examined and no sensitivity analysis was made of the results, thus an optimum economic result has not necessarily been derived. But the economic evaluation has indicated favourable results and, allowing for the constraints assumed in the forest model, it is considered an afforestation project from the national point of view would be a profitable venture in the locality.

VALUE OF THE STUDY

This forest profitability study has provided good economic support for the proposed afforestation of Tawarau Forest. The apparent favourable characteristics for afforestation have been quantified in economic terms. Results from the agricultural economic study were poor. The internal rate of return was low and the scheme showed a negative profitability after 20 years. Subsequently the Land Settlement Board has approved the release of the block for afforestation purposes and the first planting of the scheme was made in 1972. Basic data compiled and used in the forest model have been a valuable aid in the forest planning. The forest model can be used as a yardstick to assess the actual forest profitability if required.

For the writer the study was a valuable exercise in providing a practical appreciation of the complexity of management factors and decisions to be encountered in forest development.

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