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DIVERSIFICATION OF WAIRARAPA HILL COUNTRY: THE POTENTIAL FOR AGROFORESTRY

J.G. Spall
and
A.D. Meister

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February 1988

Discussion Paper in Natural Resource Economics No.12,
Department of Agricultural Economics and Business,
Massey University, Palmerston North,
New Zealand

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FOREWORD

Falling sheep and cattle product prices and rising on-farm costs have caused a significant decline in real farm income, especially so for hill-country production. Already many new grazing enterprises such as bull beef, goats, and deer have been established. This discussion paper examines the potential contribution agroforestry could make to land use diversification.

Agroforestry has been much in the news over the years. Research carried out by the Ministry of Agriculture and Fisheries and the Forest Research Institute has shown that agroforestry could prove a useful and wise land option for farmers over a wide range of environments. There is now good information on growth characteristics of trees under low planting densities, on performance of livestock under trees and on economic returns. What has been missing thus far is an analysis of agroforestry within a farm system, taking into consideration cash requirements, labour needs, taxation and profitability. In this discussion paper research is described that demonstrates that agroforestry is a viable alternative for hill country diversification.

The research consists of a realistic farm decision making model using a Wairarapa hill country case study farm. The model covers a planning horizon of twenty-one years. Agroforestry was introduced over those years in accordance with cash availability. Although the model concentrates on the financial profitability of agroforestry, some of the intangible aspects of forestry such as erosion control, shelter, aesthetics and shade, contribute further desirable aspects to agroforestry.

This discussion paper is based on post-graduate research undertaken by Mr J. Spall towards his Masters of Agricultural Science Degree. He was supervised by Dr A.D. Meister, Reader in Natural Resource Economics in the Department of Agricultural Economics and Business. The research was funded by the Forest Research Institute.

On behalf of the authors I would like to extend appreciation to all those whose help and cooperation made this research possible. In particular, special thanks are due to:

Staff from the Forest Research Institute, New Zealand Forest Service, Wairarapa Catchment Board, and Plant Material Centre;

Also special thanks is extended to the farmers who contributed to the study, in particular the case study farmers, Jamie and Ricky Strang, who willingly gave their time and data for the linear programming model.

Professor R.J. Townsley
Head, Department of Agricultural Economics and Business

CHAPTER I

INTRODUCTION TO STUDY

1.1 STUDY BACKGROUND AND MOTIVATION

In recent years hill country sheep and beef farmers have experienced a marked decline in real farm income. The costs of inputs have risen sharply while output prices have generally held or more recently have fallen (Taylor, 1984). To counter the impact of this cost-price squeeze, farmers have a number of alternatives. Beyond selling the property these include:

(i) Extensification of Production

Examples include: reducing fertiliser application rates, reducing stocking rates per hectare, and reducing labour. While each of these lower output volumes, by lowering costs it is possible to increase net income. Taylor (1982) suggests that under high rates of inflation of input costs, this may well be a desirable move for the individual farmer but can be undesirable for the national economy because of a lower volume of output. In addition, it may lead to reversion of hill country to secondary growth under more lax grazing pressure.

(ii) Expansion of Production through Land Acquisition

A significant alternative for many farmers has been to expand production through buying or leasing additional land. Amongst one group of hill country farms (Kaplan, 1979) almost half the owners were leasing land additional to that which they owned, while 10 farmers out of 42 (24 %) had bought additional land in recent years. Again, this can be a desirable move for the individual farmer but can have disastrous social effects on a district where it is associated with a population decline.

(iii) Intensification of Production

It is widely recognised that enormous potential exists on hill country for additional output. Such estimates of the potential for increase in stock numbers range between 50 to 300% (Taylor, 1984). For example, it has been estimated that if the 1980-81 stocking rates were improved to the "top" farmer levels over the whole of the North Island, total stock units would increase by 128%.

Economically successful intensification results where the additional revenue from the extra output more than compensates for the higher overheads and variable costs that may be required. In contrast to the first two options an improvement in technical and economic efficiency provides benefits not only to the farmer, but also to the district through the additional inputs purchased and income generated and also to the nation through additional export receipts. A key feature of successful intensification is the management input in all its facets through planning, implementation, and control.

(iv) Diversification of Production

A fourth approach to falling profitability is to try alternative forms of production. Diversification shares with intensification the potential to benefit the district and the nation. It requires skillful management but, unlike intensification, it demands entirely new knowledge and skills of the farmer and can be both costly and risky.

It is this last alternative that this study focuses on and in particular the issues involved for farmers diversifying into trees for timber production. Two basic objectives were considered:

1. Is agroforestry in general likely to be a profitable investment for Wairarapa hill country farmers?

2. What factors influence the feasibility of farmer investment in agroforestry?

The study was conducted using a case study farm located in the Wairarapa district occupying the south-eastern area of the North Island of New Zealand.

In chapter 2 the methodology used for the study is described. Primary emphasis is on the development of a whole farm economic model that incorporates both existing agricultural activities and agroforestry alternatives. The optimal feasible strategy for the case study farm indicated by the model is outlined in chapter 3. The results of experimentation with the model to provide solutions for the study objectives are detailed in chapter 4.

In chapter 5 attention is drawn to some of the limitations of the methodology used and some of the broader issues of project evaluation.

Finally, in chapter 6 the implications of the research are discussed with respect to the study's two basic objectives.

CHAPTER 2

METHODOLOGY

2.1 THE METHODOLOGY APPLIED

The choice of methodology depends on the properties of the system under review and the objectives of the study. A key feature of the agroforestry system is the time dimension. Trees planted today will probably not be harvested until 28-30 years from now. Therefore, to study the impact of agroforestry on the farm enterprise (its profitability, labour demand and cashflows) the methodology for analysis must be able to incorporate this time dimension. The methodology should also allow optimisation of goals so that the best farm plan can be determined.

A form of model which appears to best meet the requirements of the study is the intertemporal linear programme, particularly those versions with a multiple objective function. Intertemporal linear programming enables the solution of several production periods simultaneously (for a description see Throsby 1962, Rae 1977, Olsson 1971, and Mendoza et al 1986). Such models not only provide solutions for optimum resource use but also consider fully feasibility aspects, the fact that when an investment is made it has liquidity and capacity effects on the farm for a long period of time (Olsson, 1971). If a multiple objective function is used, consideration can be given to the use of agroforestry systems to meet social, ecological and other economic goals beyond profit maximisation (Mendoza et al, 1986).

2.2 FEATURES OF THE INTERTEMPORAL MODEL

Linear programming problems consist of three quantitative components: an objective, alternative methods or processes for obtaining the objective, and resource or other restrictions (Heady and Candler, 1960). In mathematical terms linear programming is used to determine a vector 'X' composed of a series of values xj which maximises (or minimises):

$$Z = cjxj$$

subject to	aij	< = bi	for	i= 1,2......, m
	x	> = o	for	j= 1,2......, n

where	aij	= technical coefficients reflecting demand for resource i by activity j,
	xj	= activity j,
	cj	= cost/revenue coefficient associated activity j,
	bi	= quantity of resource i available.

In an intertemporal linear programme land, labour and capital are available in different years. While there is no formal difference between intertemporal and normal linear programming there are some distinguishing features:

(i) Each activity and each restriction must be dated in a certain period of time.

(ii) Incoming and outgoing payment flows occur within the model.

(iii) For each activity dated in a certain period of time, there is given not only the link between this activity and the restrictions in the same period, but also the possible link with restrictions in other periods. Thus the central feature of the model is the transfer of resources and monetary capital between periods (Olsson, 1971).

2.3 STRUCTURE OF THE MODEL

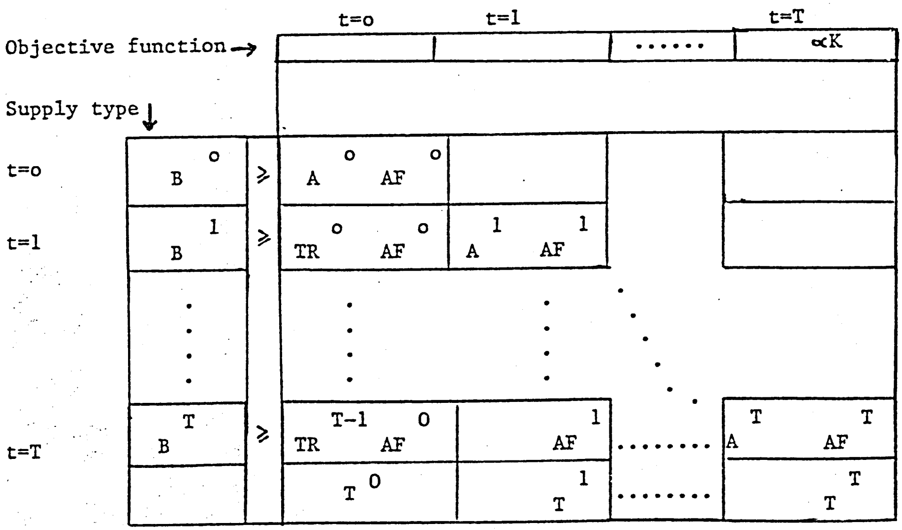
An outline of the major features of the model is given in figure 2.1. Three major types of activities are included in the model.

(i) Agricultural and other annual activities (At) including sheep, cattle, cropping, livestock activities associated with cropping, and hire of labour.

(ii) Agroforestry activities (AFt) initiated in time t and still present at time T.

(iii) Activities to transfer resources and monetary capital between periods (TRt).

Figure 2.1



2.3.1 Cash Flow in the Model

Figure 2.2 (page 25) illustrates the flow of cash through the model. After-tax cash is initially transferred from the previous year to be available at the start of the next year. From this the model deducts all fixed costs for the year including the farmer's consumption requirements. All variable production costs are also paid out at the beginning of the year.

If a cash surplus is apparent at this stage, it is invested off the farm in a bank account and carries interest. The interest earned contributes to the revenue during the year while the basic sum invested is available at the start of the following year. In the event of a deficit, cash may be borrowed and is paid back at the start of the following year together with the interest charge.

Revenues are received at the end of each year and from this taxation payments are calculated and deducted to provide a cash sum available for the following year.

2.3.2 The Objective Function and the Length of the Planning Period

In constructing any whole-farm model it is important to formalise the goals in as correct a manner as possible as this will help determine both the alternatives provided in the model and the optimal solution (Olsson, 1971). As farmers normally have a number of objectives which they wish to achieve, the hierarchical approach adopted by Olsson (1971), Rae (1977) and others is considered to provide the most realistic approach. Expressed in the form of a utility function in the general sense:

$$U = f(q1G1, \ldots\ldots qnGn/L1 \ldots\ldots Lm)$$

Where: q1...qn are weights applied to the objectives G1...Gn,

L1...Lm is a set of separate objectives, the achievement of which is compulsory (Rae, 1970).

In this model the profit motive is assumed to be of primary interest and the "G" objectives comprise after-tax cash and asset values at the end of the planning horizon. By setting q1, the tax-free cash weight equal to one, and parametrically varying q2 (the asset value weight), the efficient set of capital budgets is derived.

For this model the production cycle of 28 years for the agroforest was considered to be the appropriate length for the planning horizon as this utilised all the available information and was within the length of time for which an interested farmer may run his business. However, in the event it was only possible to run the model over 21 years due to limitations in the linear programming package used. Comparisons with models of shorter length suggested that this limitation was unlikely to have significantly affected the result.

2.3.3 The Constraints

The major constraints included in the model can be grouped as follows:

Land constraints
Cropping and associated feed transfer constraints
Labour constraints
Livestock reconciliation constraints
Financial constraints
Final asset and cash constraints.

Land constraints

There is a set of constraints to model each land class on the property. Associated with each land class is a stock carrying capacity and a permissible range of possible activities. These are summarised in table 2.1.

Table 2.1 Land Class Uses

Land Class	Carrying Capacity (SU/ha)	Possible Uses Sheep	Cattle	Cropping	Agrfor.
IIw	13.8	yes	yes	yes	no
IIIs1	15.8	yes	yes	yes	no
IVe4	11.8	yes	yes	no	yes
Vc1	12.8	yes	yes	no	no
VIe4	11.8	yes	yes	no	yes
VIIe2	8.8	yes	yes	no	yes

Cropping and associated feed transfer constraints

A minimum crop area of 12 hectares was defined to meet the farmer's wish for a summer greenfeed crop for lambs. Feed transfer constraints allowed for the transfer of feed to either sheep or cattle activities from the crop rotations.

Labour constraints

Two labour constraints are contained in the model, both referring to the period June, July and August when it was assumed a peak demand for labour by the agroforestry activities would occur. The first constraint limited the total amount of farm labour available by the farmer while the second calculated farm labour used by agroforestry activities.

Livestock reconciliation constraints

The model also has a set of constraints to account for changes in sheep and cattle numbers and therefore the effect on cashflow and taxation.

Financial constraints

Four financial constraints are incorporated into the model to assist in the determination of the cashflow and taxation. These are:

(i) A constraint to limit total expenditure to no more than cash available at the start of the year plus borrowings.

(ii) A "tax deductions" constraint to sum all tax deductible expenditures.

(iii) A "revenue" constraint which summed all pre-tax cash receipts and from which all-tax deductible expenditures were subtracted.

(iv) A constraint to sum all "cost of bush" forestry expenditure.

Final asset and cash constraints

The final asset and cash constraints appear in the final year of the model and are used to determine:

(i) Final asset values of all activities at the end of the planning period.

(ii) The final after-tax cash position at the end of the planning period.

2.3.4 The Bounds

Bounds are introduced to reduce the length of the model. Bounds are used to determine:

- an upper bound on the amount of borrowing on overdraft permitted
- an upper bound to indicate the limits on assessable income at which marginal tax rate changes.

These are:

up to 9,500	15 cents in the $
9,500 - 30,000	30 cents in the $
30,000 plus	48 cents in the $

- an upper bound to indicate the permissible limit for "cost of bush" deductions, the current standard being $7,500 per year.

2.3.5 The Activities

The major activities included in the model and repeated in each year can be placed in the following categories:

Sheep and cattle activities on open pasture
Cropping and associated livestock activities
Agroforestry activities
A hiring of labour activity
Activities to account for changes in sheep and cattle numbers
Borrowing and lending activities
Cash and asset transfer activities (final year only).

<u>Sheep and cattle activities on open pasture</u>

For each of the six land classes both a sheep and cattle activity is defined with costs and returns adjusted to suit the carrying capacity of the land class.

<u>Cropping and associated livestock activities</u>

As the primary emphasis is to examine agroforestry, crop rotations are formulated to simplify the model and thereby reduce the matrix size. A choice of two rotations is available for each of the land classes IIwl and IIIsl, only one of which utilised labour in the winter period.

To use feed produced by the crop rotation, either sheep or cattle activities are available.

Agroforestry activities

Agroforestry is considered a possible land use for classes IV, VI and VII. Appropriate silvicultural regimes are formulated for each land class before incorporating an agricultural activity based on sheep. Again to limit matrix size it is possible to consider only one regime incorporating one agricultural activity for each land class.

Hiring of Labour

Hiring of labour for silvicultural work only is provided by this activity. It is assumed that existing farm labour will be sufficient for agricultural activities.

Activities to account for changes in sheep and cattle numbers

These activities adjust revenue and tax for changes in non-agroforestry sheep and cattle numbers. Adjustments to revenue and tax as a result of changes in stock numbers carried underneath trees are handled within the agroforestry activities.

Borrowing and lending activities

These provide opportunities to either borrow on overdraft or alternatively invest money off the farm for a one year period.

Taxation and financial activities

A tax deductions transfer activity allows a sum equal to the tax deductible expenditures for a year to be subtracted from the gross income and transferred to the supply of cash available at the start of the following year. Taxation can then be calculated on the amount remaining and the residual again transferred to the supply of cash available at the start of the following year using the taxation activities.

Two activities are necessary to model forestry taxation. One allows for forestry expenditure up to the available limit to be a tax deductible item. The second permits forestry expenditure not treated as tax deductible to be carried forward to the final asset row.

Cash and assets transfer activities

In contrast to the other activities, these appear only in the final year and act to transfer the value of final assets and cash to the objective function.

2.4 THE DATA USED IN THE MODEL

2.4.1 Selection of a Case Study Farm

To identify and select a cash study farm, 19 farmers names were solicited from the Wairarapa Catchment Board, Forest Service and Ministry of Agriculture and Fisheries to represent as wide a range as possible of districts and land types. From the list five farmers were identified in consultation with the Forest Service as having an interest in farm forestry. Individual visits to three of these properties then took place and a final selection made. Factors influencing this choice were:

(i) The particular property was not atypical of farms in that district with respect to land type, farm policy, and performances.

(ii) The property contained six different land classes from class II to VII which fitted the requirements of a model aimed at examining land use.

(iii) The farmer had already initiated an agroforestry block, had good records, and was enthusiastic about the objectives of the study.

In two subsequent visits to the property, a large quantity of data was collected including five years of accounts to assist in deriving matrix coefficients.

2.4.2 Derivation of Matrix Coefficients

In this section the derivation of the more significant coefficients in the model is outlined. These are:

Land use and stocking rates for different land classes
Agricultural performances and returns
Forestry yields and returns
Agroforestry data
Labour
Fixed costs
Final asset values

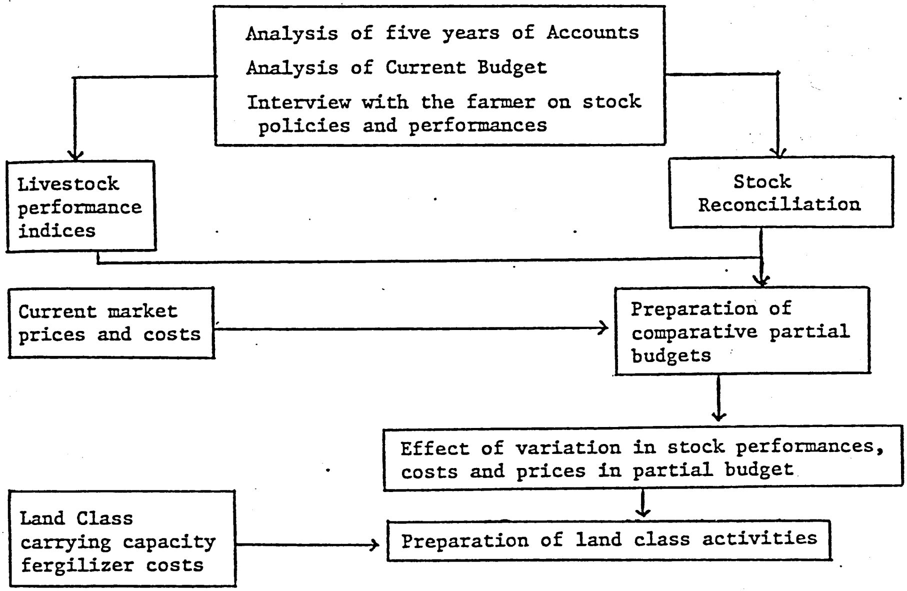
<u>Land use and stocking rates</u>

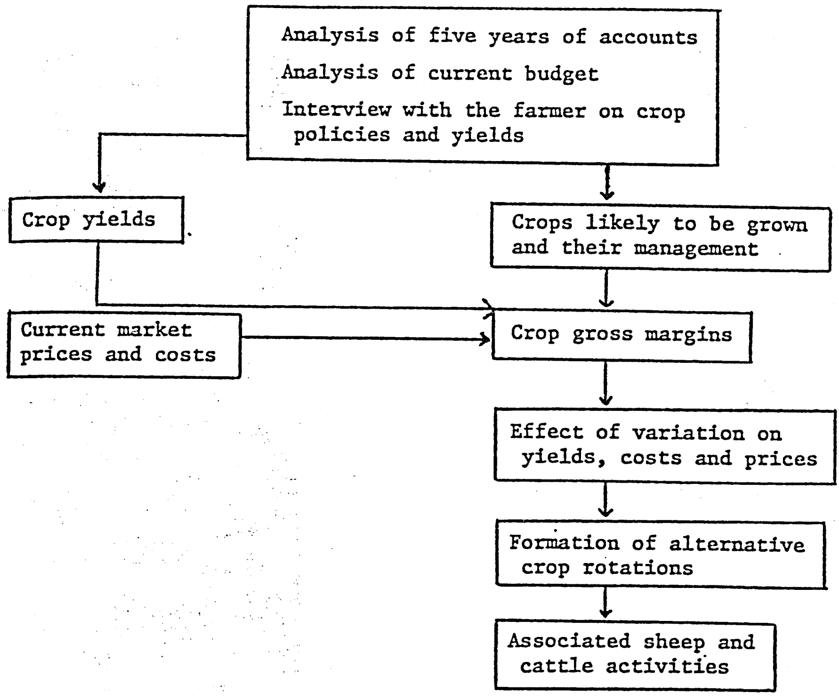
The property had a recent Soil Conservation Farm Plan prepared by a Wairarapa Catchment Board Soil Conservator. This gave detailed maps indicating land capabilities and soil types with additional details on their areas and properties. From this and further discussion with the farmer and Forest Service it was possible to identify appropriate land uses for each capability unit.

To determine stocking rates, published data (Water and Soil Miscellaneous Publication No. 74) were available estimating present average carrying capacity for each land use capability unit. Using the farmer's representative stock numbers it was a straightforward task to adjust the published data to fit the case study farm. While on-farm information on the relative carrying capacity of the land use capability units would have been preferable, the figures used were in accord with the farmer's subjective beliefs.

<u>Agricultural performances and returns</u>

Preparation of appropriate agricultural activities for each land class followed a systematic process. For the sheep and cattle activities this was:





Analysis of five years of accounts
Analysis of current budget
Interview with the farmer on crop policies and yields
Crop yields
Crops likely to be grown and their management
Current market prices and costs
Crop gross margins
Effect of variation on yields, costs and prices
Formation of alternative crop rotations
Associated sheep and cattle activities

Several features deserve comment:

(i) The performance figures used, for example wool weights and lambing percentages, represent the average of the previous five years. In contrast current stock numbers and policies, adjusted for any abnormalities, formed the basis of the stock reconciliations. It was felt this combination gave the best representation of the base year.

(ii) 1986 costs and prices were used in the formation of the comparative partial budgets. Subsequently the effect of variations in these was examined.

(iii) In preparing land class activities any direct costs associated with a particular land use were considered. On the case study farm fertiliser was the only cost in this category, although in other situations weed control could be a significant item.

With respect to cropping and associated livestock activities, a slightly different procedure was adopted.

This process resulted in two alternative crop rotations for each of the land classes 2 and 3. Each crop activity utilised 6 ha and provided feed for either sheep or cattle activities.

Forestry yields and returns

Deriving appropriate matrix data for the forestry component involved close liaison with the Forest Service and Forest Research Institute. To determine appropriate site indexes (i.e. mean top tree height at age 20 years) a visit to neighbouring farms was made with the local forestry extension officer. Measurements were taken of existing wood lots to develop a height for age curve.

Subsequently appropriate regimes for the three different land classes, considered suitable for agroforestry, were developed with the assistance of forestry extension officers and using the SILMOD simulation model. The information generated by the runs with SILMOD, including silvicultural treatments, harvesting costs, and gross timber returns, were then incorporated into the agroforestry activities.

Agroforestry data

To develop full agroforestry activities required the combination of the forestry data generated above with appropriate agricultural indices. In the absence of any data from the Wairarapa it was necessary to review existing research evidence. Of particular concern was the likely carrying capacities and stock performances under the regimes that had been developed.

Data from four principal trial sites in New Zealand was available; Whatawhata, Tikitere, Invermay and Akatore. After a review of the site conditions under which the trials had been conducted, it was thought the Whatawhata results would be most applicable. This was the only site representative of North Island hill country.

A technique was required to allow for reduced livestock performance underneath trees. After discussion with N. S. Percival, MAF Rotorua, the formula used by Arthur-Worsop (1984) was used. This determined a carrying capacity (Adj. CC%) that was adjusted by a livestock performance index:

$$\text{Adj. CC\%} = 0.75\ (\text{CC\%}) + 0.0025(\text{CC\%})^2$$

It was then a straightforward matter to take the carrying capacities applicable for each land class and determine actual and adjusted carrying capacities for each year of the rotation.

Selection of the above formula meant that a sheep rather than cattle policy was required for grazing under the trees as the formula was derived from sheep performance measurements. The existing sheep policy was considered suitable for use in an agroforestry system, and hence the appropriate sheep land class activities, modified by the above formula, provided the basis for the agricultural component.

The only further modification made was to allow for a reduction in fertiliser use under an agroforestry regime. In the absence of information on the nutrient requirements for an agroforestry system the existing assumption made by Arthur-Worsop (1984), that fertiliser is required every second year during the period years 0-15, applied at the same rate as open pasture, was used.

Account needed to be taken of taxation as it applies to agroforestry. Under the proposed forestry taxation from 1 April 1987, four categories of forestry expenditure will be recognised:

(i) Costs of a capital nature where the value added is reflected in the asset, and therefore, will be neither depreciable or deductible, e.g. land purchase, initial consultancy fees relating to the feasibility of a forestry project.

(ii) Costs of a capital nature expended on an asset with a limited life which will be depreciated against current income, e.g. land preparation, temporary and permanent fences, roads, firebreaks, and shelter and erosion control plantings.

(iii) Costs directly related to the tree crop which will be transferred to a cost of bush account and which will become deductible when revenue is earned from the sale or harvest of the forest, e.g. planting and silvicultural costs.

(iv) Costs incurred in the maintenance of the forestry business which will be deductible in the year incurred from income from any source, e.g. rents, rates, interest on borrowed monies, pest control and repairs and maintenance costs. Deductible expenditure also includes costs incurred in felling, transporting, and milling timer.

For the purposes of the model categories (iii) and (iv) were particularly relevant and it was necessary to divide agroforestry costs between cost of bush and deductible expenditure. With reference to the livestock component all direct costs associated with the livestock are deductible. However, allowance for categories of expenditure that relate to both the agricultural and forestry components was also required, in this case fertiliser. The percentages of expenditure that are generally accepted as relating to agriculture are:

Age of tree crop	
0 - 5 years	70%
5 - 10 years	50%
10 - 15 years	35%
15 and above	25%

The above percentages were used to allocate fertiliser costs. Costs of bush accounts are permitted to operate in three ways:

(i) Stand Basis - separate cost of bush accounts for each stand distinguished according to the year of planting, location, type of tree and projected use.

(ii) Annual Planting Basis - the taxpayer may pool together all cost of bush expenditure on stands of forest planted in a specific year into an annual cost of bush account.

(iii) Total Forest Basis - small forestry businesses with 40 hectares or less of total forest plantings are permitted to allocate all cost of bush expenditure into a single cost of bush account.

For the purposes of the model, where an area greater than 40 ha could be planted in trees, the annual planting basis was used. It was assumed that each \$1 of cost of bush account would result in a saving of 48c, the maximum tax rate. As the cost of bush values could only be deducted in the year in which each annual planting was harvested, it was necessary to discount the tax savings back to the 21 year period in which the model operated. Thus:

$$AVCOBt = 0.48 * a_t/(1+i)^{(7+t)}$$

Where AVCOBt = the asset value for a cost of bush account relating to year t

i = discount rate

a_t = cost of bush in year t

Labour

Information on the total labour availability and requirements of the agricultural activities was obtained by interviewing the farmer. Total available labour was defined as the hours of farm labour available in the three months June to August after making allowance for that required for repairs and maintenance, administration and other non-direct agricultural activities. Labour requirements for the sheep and cattle activities were determined by identifying each operation carried out over the period concerned and the hours required. By dividing the base number of stock units the hourly requirement per stock unit could be determined and subsequently the hours required by each sheep and cattle activity.

A necessary simplifying assumption was that of an assumed linear relationship between stock units and hourly requirements. This is not strictly true with respect to all operations, for example shifting and checking stock, where economies of size are apparent. Thus for a drop in stock units below the base level the model may have slightly underestimated labour requirements and conversely overestimated them for increases in stock units above the base levels.

With respect to cropping the only operation of concern over this period was ploughing for wheat in August, an operation requiring 5 hours per hectare.

Labour requirements for the agroforestry activities were obtained by using data from the New Zealand Forest Service (Cost of Establishing and Managing Radiata Pine Plantations, 1985). The low tree stocking regimes used in this study were outside the database provided, and had to be calculated by extrapolating the data. As straightline relationships were involved these estimates were considered to be relatively accurate. Information for the labour requirements of the associated sheep activities was determined by multiplying the carrying capacity for each year by the hourly requirement per stock unit. No allowance was made for any increase in mustering time of sheep under trees as at low tree densities any differences have not been significant (Percival, Hawke, et al, 1984).

An hourly wage rate for forestry labour was determined from current (27.2.86) Forest Service costings including an allowance for travel time expenses.

Fixed costs

Fixed costs, including tax deductible overheads, were determined from the results of an examination of five years of accounts and the construction of a full budget and cash flow for the base year using 1986/87 costs and returns. To preserve confidentiality, mortgage costs were calculated on a per stock unit basis using the most recent MAF monitoring report representative farm details for North Island Hill Country (Farm Class 4) (November, 1986).

Final Asset values

To formulate the objective function it was necessary to determine final asset values. For the annual activities including sheep, cattle, cropping, associated livestock activities and labour hire, the net returns (or costs in the case of labour hire) were capitalised:

$$\text{capitalise } NRj = NRj/r$$

The NPV of all such activities was therefore given by:

$(NRj/r)Yj$

where Yj = the level of the jth activity in the 21st year of the programme.

For the agroforestry activities it was necessary to firstly determine the amortised present value over the optimum production cycle of 28 years. This was given by:

$$A = \sum_{t=1}^{n} NR_j^t/(1+i)^t \times i(1+i)^t/((1+i)-1)$$

where NRj = net revenue of the jth activity in the t-th year

i = discount rate

Asset values for each agroforestry activity were then derived from the equation:

$$AV_j^t = NR_{n+1}/(1+i) + NR_{n+2}/(1+i)^2 + \ldots\ldots + NR_{n+m}/(1+i)_n + (A/i)/(1+i)^{n+1}$$

where AV_j^t = the asset value of activity j,initiated in year t

NR_n = net revenue of the activity in year n

n = age of the trees in year 28

m = 28

A = amortised present value of activity j

An important factor in determining final asset values was the choice of discount rate. The accepted procedure is to use a firm's cost of capital: the rates of return expected by those parties contributing to the financial structure of the firm. It is normally calculated as a weighted average of the costs associated with each type of capital included in the financial structure of the business.

In the case of a farm the weighted average cost of capital (d) may be calculated using the following equation:

$$d = k(e)*We + K(d)\ (i-t)*Wd$$

where	K(e)	=	after-tax rate of return on equity capital
	We	=	the long run proportion of equity used to operate the firm
	K(d)	=	the interest rate on debt
	Wd	=	the long run proportion of debt that will be used to operate the firm
	t	=	the marginal tax rate.

To determine the after-tax rate of return on equity capital the following equation is applicable:

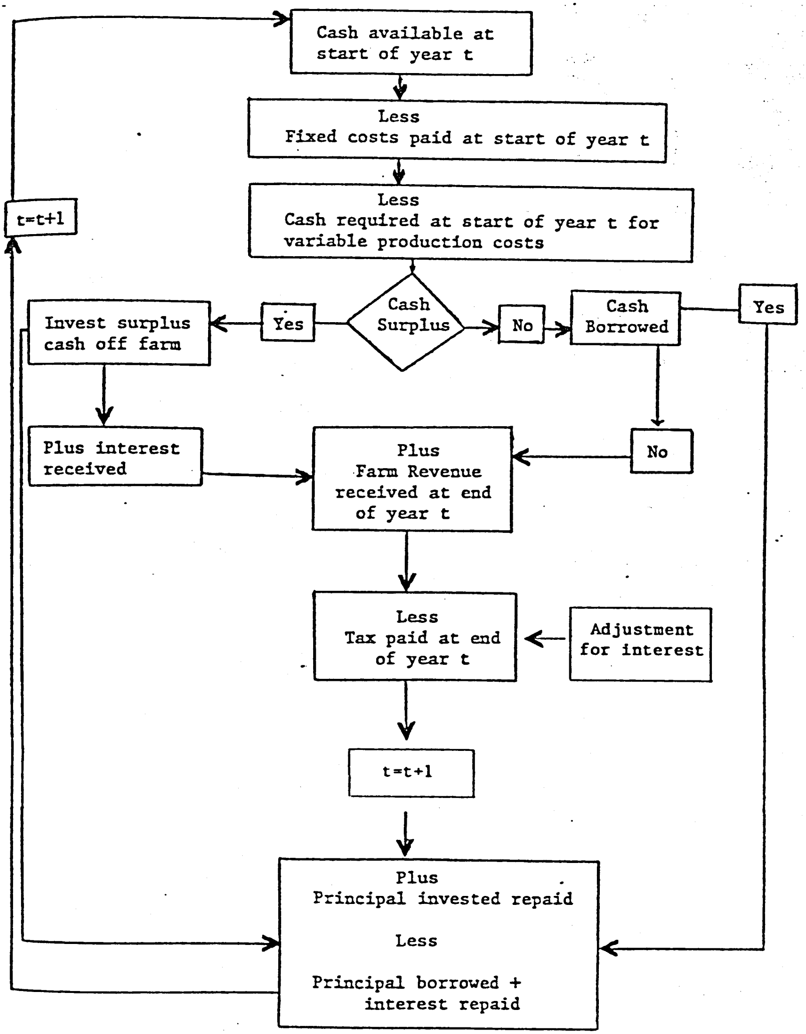
$$K(e) = K(ce)*(1-t) + K(ne)*(1-tG)$$

where	K(ce)	=	cash return on equity capital
	K(ne)	=	increase in market value of assets
	G	=	proportion of non-tax return subject to tax

In the absence of localised information, the findings of Leathers and Gough (1984) were used to provide estimates of K(ce) and K(ne). Over the period 1960 to 1980 they found the real rate of return to farming averaged 8 percent, made up of 3.4 percent annual cash earnings and 4.6 percent real capital gains.

The discount rate used of 10% was within the range determined by these calculations, and while higher than normally used by forestry interests, was considered a realistic rate from the point of view of a private investor.

Figure 2.2 Cash Flow in the Model



CHAPTER 3

A LINEAR PROGRAMMING ANALYSIS OF AGROFORESTRY

3.1 INTRODUCTION

In this chapter the results of the agroforestry model (A.F.) are discussed by means of comparing them with the results of a benchmark model (B). The benchmark model was used to represent the status quo of the farm business and was the intertemporal linear program (I.L.P.) without the agroforestry activities. The results of both the the B model and the model incorporating agroforestry (A.F.) were discussed with the farmer and where possible compared with other results. The farmer felt that the results were an accurate representation of his situation and added weight to some of his own beliefs. The discussions and comparisons indicated that the model could be used to analyse the integration of agroforestry into a hill country farm.

Because terminal values were expressed on a "before tax" basis, while the quantity of cash accumulated at the end of the period was net of tax payments, a weighting of 0.52 was assigned to the "terminal value" activity. This assumed that 48 percent of each post horizon annual taxable income would be paid out in tax.

3.2 DESCRIPTION OF RESULTS

3.2.1 Structural Changes

The structural changes in farm enterprises are summarised in tables 3.1 for the A.F. model and may be compared with the results for the B model in Table 3.2.

Table 3.1 Agroforestry Model - Physical Programme

YEAR	AGROFORESTRY PLANTINGS AF4	AF6	AF7H	TOTAL /YR	ACCUM. TOT	PROPN UT.AREA	SHEEP SU	CATTLE SU	AGROFOR. SU AF4	AF6	AF7	SUB TOT	TOTAL SU	CROPPING SCROP	ROTN W2
BASE							7086	1412	0	0	0	0	8498	2	2
0	35.02	18.56	0	53.58	53.58	7.82	7355	482	0	0	0	0	7837	2	2
1	26.27	3.57	0	29.84	83.42	12.18	7355	130	83	44	0	126	7611	2	2
2	6.70	2.73	0	9.43	92.85	13.55	7355	18	227	96	0	323	7696	2	2
3	1.54	0	0	1.54	94.39	13.78	7355	0	499	214	0	713	8068	2	2
4	0	0	0	0	94.39	13.78	7355	0	665	240	0	905	8260	2	2
5	5.47	0	0	5.47	99.86	14.58	7290	0	706	255	0	961	8251	2	2
6	0	3.07	0	3.07	102.93	15.03	7254	0	727	255	0	982	8236	2	2
7	0	5.88	0	5.88	108.81	15.88	7184	0	740	263	0	1002	8186	2	2
8	0	4.20	0	4.20	113.01	16.50	7135	0	770	284	0	1054	8189	2	2
9	0	10.08	0	10.08	123.09	17.97	7016	0	787	333	0	1120	8136	2	2
10	0	6.97	0	6.97	130.06	18.99	6934	0	754	377	0	1131	8065	2	2
11	0	14.59	0	14.59	144.65	21.12	6761	0	685	418	0	1103	7864	2	2
12	0	13.70	0	13.70	158.35	23.12	6600	0	612	497	0	1110	7710	2	2
13	0	9.25	0	9.25	167.60	24.47	6491	0	538	576	0	1114	7605	2	2
14	0	0	0	0	167.60	24.47	6491	0	471	687	0	1158	7649	2	2
15	0	0	0	0	167.60	24.47	6491	0	397	763	0	1160	7651	2	2
16	0	0	0	0	167.60	24.47	6491	0	355	805	0	1160	7651	2	2
17	0	0	18.10	18.10	185.70	27.11	6331	0	334	791	0	1125	7456	2	2
18	0	9.59	14.67	24.26	209.96	30.65	6082	0	318	778	32	1128	7210	2	2
19	0	0	16.72	16.72	226.68	33.09	5942	0	305	773	90	1168	7110	2	2
20	0	16.80	9.50	26.30	252.98	36.93	5615	0	292	767	193	1251	6866	3.83	3.83
TOT	75	118.99	58.99												

Table 3.2 Benchmark Model - Physical Programme

YEAR	SHEEP SU	CATTLE SU	TOTAL SU	CROPPING SCROP2	ROTNW2
BASE	7086	1412	8498		
0	8468	0	8468	2	2
1	8468	0	8468	2	2
2	8468	0	8468	2	2
3	8468	0	8468	2	2
4	8468	0	8468	2	2
5	8468	0	8468	2	2
6	8468	0	8468	2	2
7	8468	0	8468	2	2
8	8468	0	8468	2	2
9	8468	0	8468	2	2
10	8468	0	8468	2	2
11	8468	0	8468	2	2
12	8468	0	8468	2	2
13	8468	0	8468	2	2
14	8468	0	8468	2	2
15	8468	0	8468	2	2
16	8468	0	8468	2	2
17	8468	0	8468	2	2
18	8468	0	8468	2	2
19	8468	0	8468	2	2
20	8424	0	8424	3.83	3.83

Over the 21 year period of the A.F. model a marked change in land use is evident with all land considered suitable for agroforestry eventually planted. Planting commenced on classes 4 and 6 (with planting proceeding at a much faster rate on class 4). For the first 6 years the mean area planted per year was 12.5 ha/year for class 4 and 4.1 ha/year for class 6. Planting continued on class 6 for the remainder of the planning period. On class 7 country planting did not commence until year 17. Cumulative agroforestry plantings with time are indicated in figure 3.1.

Associated with the adoption of agroforestry were corresponding changes in stock units (Figure 3.2). While total stock units eventually declined with time, this was not continuous as available grazing increased under agroforestry plantings between years 0 - 3 after planting. The low density regimes used, particularly for land classes 4 and 6, meant that considerable grazing was available under the agroforestry regimes for the entire 21 year period. Thus in year 10, 94% of initial stock units were still being carried with 21% of the property in agroforestry regimes. Even by year 20, 80% of initial stock units were still being carried with 37% of the farm in agroforestry. At this time the agroforestry area was expected to provide feed for 19% of the farms stock units.

The pattern of available feed, as indicated by stock units carried, under the three agroforestry regimes is indicated in Figure 3.3. From year 5 the total number of stock units carried under trees was very stable. This indicated that the increase in feed provided by additional agroforestry areas (after the first year) tended to match the decline in feed in the earlier plantings as the trees grew.

Both the A.F. and B model showed a change in stock policy with a phasing out of cattle and a corresponding increase in sheep. In the A.F. model a gradual transition over a three year period occurred, with the reduction in cattle corresponding to an initial increase in sheep and subsequent tree plantings. In the B model cattle are sold and replaced by sheep in the first year of the planning horizon. After the initial changes a stable sheep policy is maintained in both models.

Both the A.F. and B model had similar cropping programmes. With the exception of the final year of the planning horizon, cropping is constant at the minimum permitted area of 12 hectares. The rotation incorporating wheat is adopted with its associated sheep activity on land class 2. The expansion of cropping to the entire land class 2 area in the final year is likely to be an artifact of the model. In latter results it was found that expansion of cropping in year 20 was related to the availability of cash; under conditions of greater capital restrictions than the standard A.F. and B model, cropping remained at the minimum permitted level. This suggests that an expansion of cropping in the final year was related to the need to minimise tax.

Figure 3.1 Agroforestry Plantings

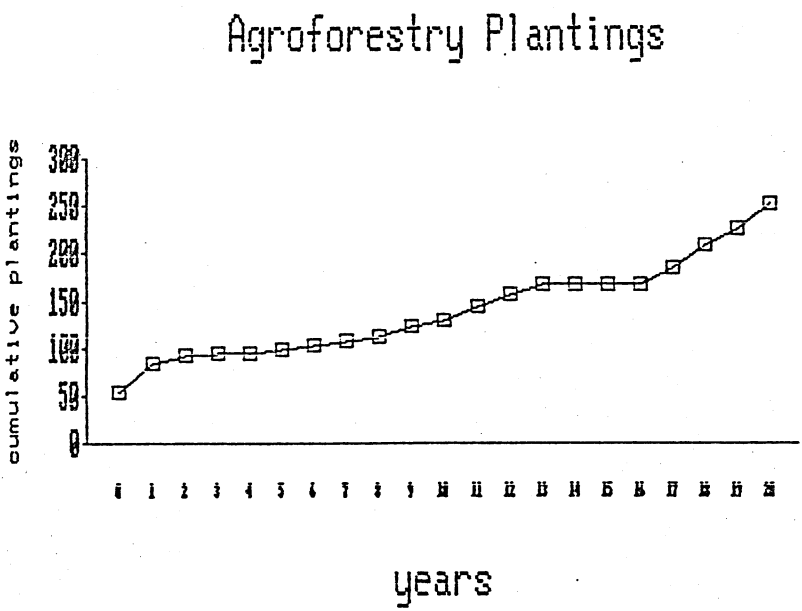


Figure 3.2 Total Stock Units

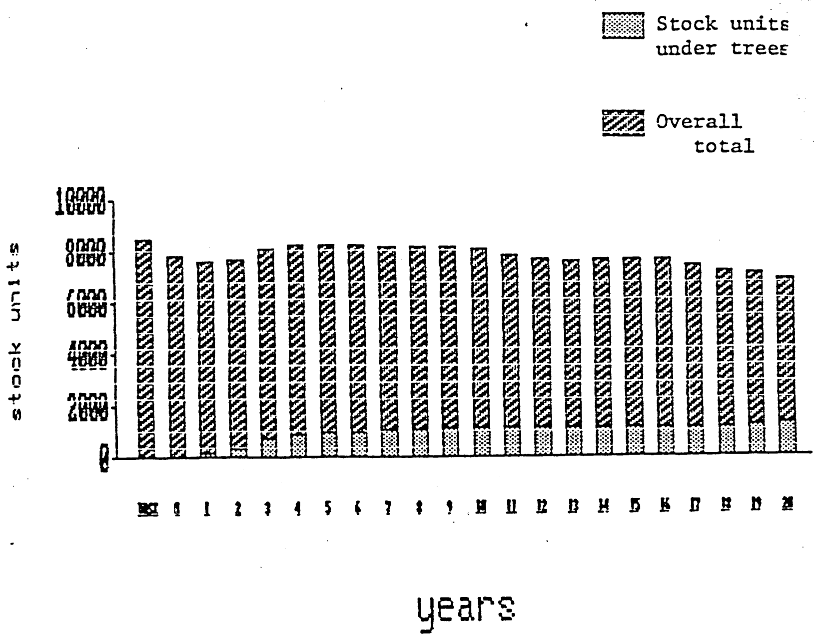
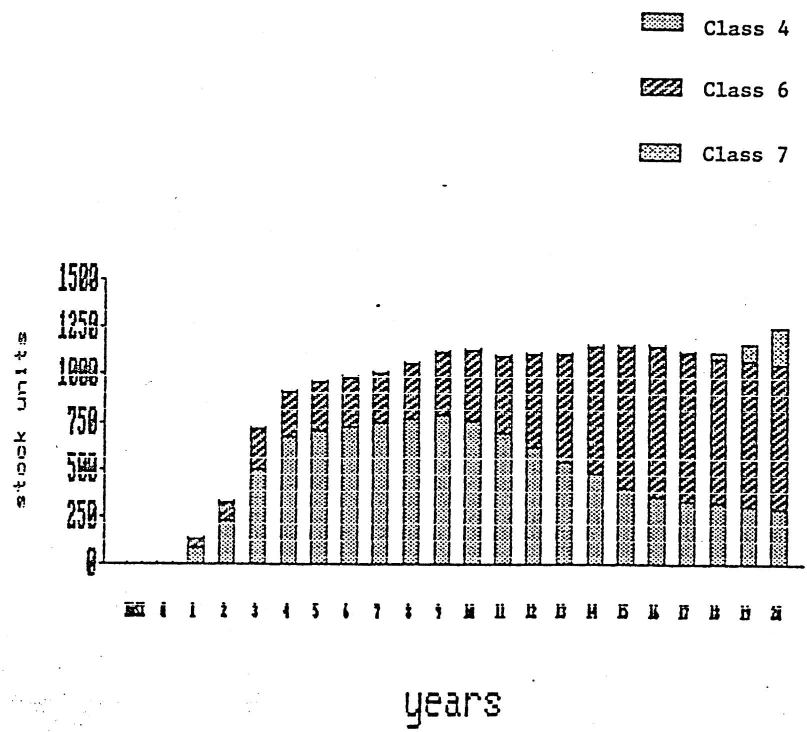


Figure 3.3 Agroforestry Stock Units



3.2.2 Labour

The adoption of agroforestry on the scale specified in A.F. substantially alters the labour profile for the property. Table 3.3 summarises these changes.

In the B model a substantial surplus of labour, 354 hours, was forecasted over the winter period, or 40% of total labour available. In contrast in the A.F. model surpluses of labour only occurred in years 0 - 2. In all other years agroforestry effectively utilised all surplus labour (Figure 3.4). In five of the years additional labour is hired, with a peak of 556 hours in year 4. This would approximately equate to hiring a full-time forestry worker for the entire three month period.

Over the 21 year planning horizon on-farm labour provided 84% of the total labour requirements for agroforestry.

3.2.3 Cash Flow

Cashflows for both A.F. and B models are presented in Tables 3.4 and 3.5 respectively.

These tables reflect the pattern of cash flow described in Section 2.3.1. Thus for the B model (Table 3.5) in year 0, $60,000 is available after meeting fixed costs paid at the start of the year. As $75,091 is required to meet variable production costs at the start of the year, $15,091 is borrowed to make up the shortfall. Gross farm income of $309,677 is received at the end of the year and from this tax of $22,272 must be deducted. The remaining amount of $287,405 is available at the start of the following year, less of course, the principal borrowed and interest repaid.

Figure 3.5 indicates the predicted differences in variable farm costs between the A.F. and B models. For much of the planning horizon variable costs are lower in the A.F. model, particularly from year 11 onwards. These differences reflect:

(i) The lower number of stock units carried;

Table 3.3 Labour Profiles for the Benchmark and Agroforestry Plans

YEAR	SURPLUS LABOUR BENCHMARK	SURPLUS LABOUR AGROFORESTRY	LABOUR USED FOR AGROFORESTRY FARM LABOUR	LABOUR USED FOR AGROFORESTRY HIRED LABOUR	LABOUR USED FOR AGROFORESTRY TOTAL
			0	0	0
0	354.03	41.74	320.23	0	320.23
1	354.03	31.27	367.84	0	367.84
2	354.03	242.83	156.02	0	156.02
3	354.03	0	378.06	449.42	827.48
4	354.03	0	367.07	555.72	922.79
5	354.03	0	367.76	49.44	417.20
6	354.03	0	368.90	0	368.90
7	354.03	0	371.62	0	371.62
8	354.03	0	371.72	0	400.79
9	354.03	0	376.25	228.23	604.48
10	354.03	0	377.52	127.06	504.58
11	354.03	0	389.12	0	389.12
12	354.03	0	408.59	0	408.59
13	354.03	0	406.62	0	406.62
14	354.03	0	404.70	0	399.50
15	354.03	0	400.79	0	415.28
16	354.03	0	399.50	0	432.47
17	354.03	0	415.28	0	432.47
18	354.03	0	432.47	0	434.50
19	354.03	0	441	0	434.50
20	338.28	0	434.50	0	434.50
TOTALS	7418.88	315.84	7955.56	1409.87	9449.48

Figure 3.4 Agroforestry Labour Use

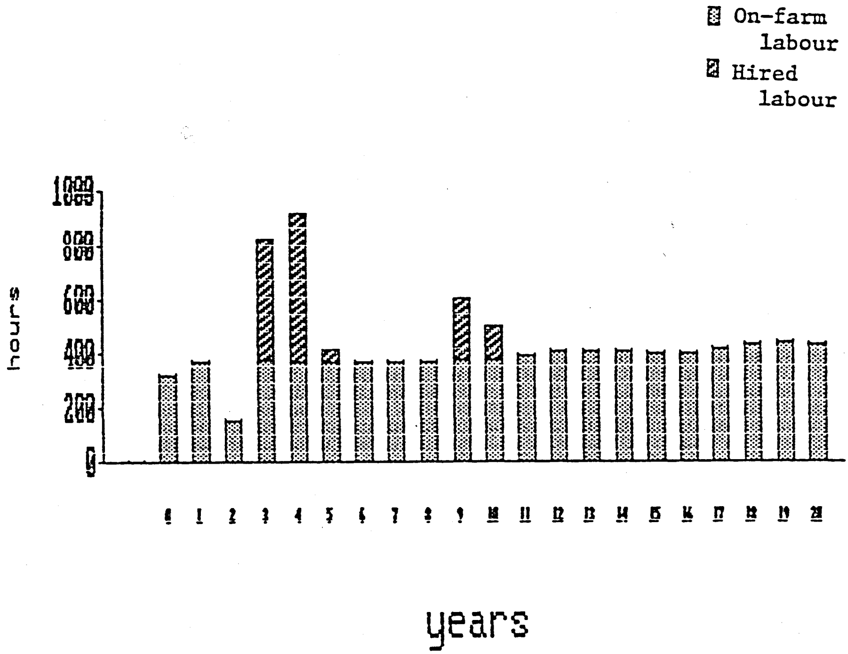


Table 3.4 Agroforestry Model - Cash Flow

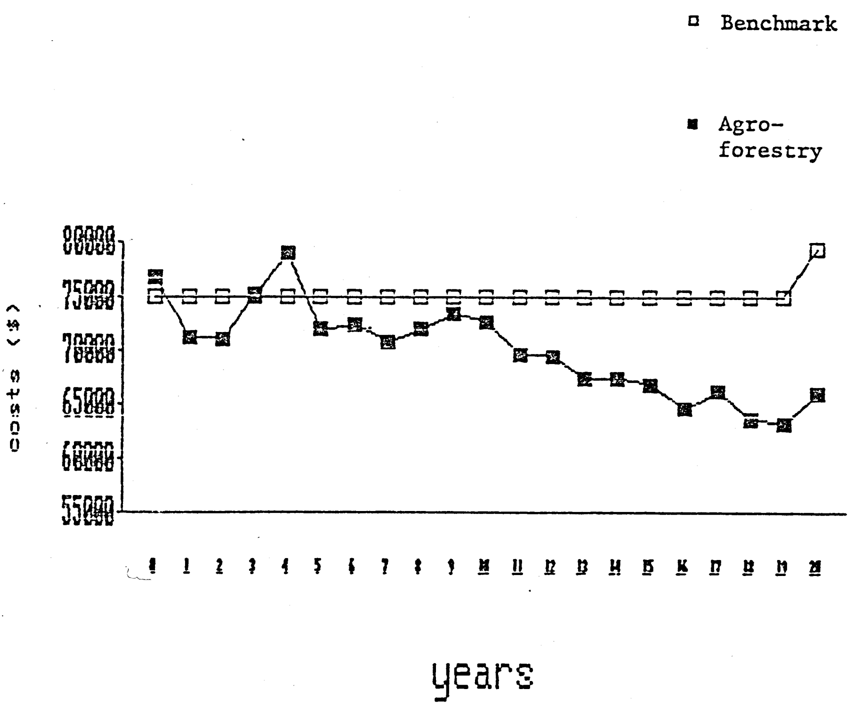
OPENING CASH BAL	PLUS BORROWING	PLUS LENDING REPAID	LESS CASH FIXED COSTS	CASH FLOW LESS CASH FARM COSTS	LESS BORROWING REPAID (INCL INT)	LESS LENDING	PLUS GROSS FARM INCOME	LESS TAX PAID	AMOUNT TRANSFERRED	BANK BALANCE	YEAR
60000	16741	0	0	76741	0	0	277001	9541	267460	267460	0
267460	0	0	142964	71170.21	19921.79	33404	235975	7998	227977	261381	1
261381	0	33404	142964	71068	0	47349	221592	7758	213834	261183	2
261183	0	47349	142964	75145	0	43074	223342	9048	214294	257368	3
257368	0	43074	142964	78961	0	35443	226495	8639	217856	253299	4
253299	0	35443	142964	71914	0	38421	227633	10425	217208	255629	5
255629	0	39421	142964	72396	0	40269	227437	10425	217012	257281	6
257281	0	38421	142964	70822	0	43495	226832	10425	216407	257902	7
257902	0	40269	142964	71931	0	45007	226888	10231	216607	261614	8
261614	0	43495	142964	73328	0	45322	226039	9273	216766	262088	9
262088	0	45007	142964	72521	0	46603	223996	8945	215051	261654	10
261654	0	45322	142964	69639	0	49051	219442	7894	211548	260599	11
260599	0	46603	142964	69410	0	48225	214657	6690	207967	256192	12
256192	0	49051	142964	67337	0	45891	210890	6464	204426	250317	13
250317	0	48225	142964	67445	0	39908	210167	5851	203316	243624	14
243624	0	45891	142964	66705	0	33555	209278	6750	202528	236083	15
236083	0	39908	142964	64600	0	28519	208495	7115	201380	229839	16
229839	0	33555	142964	66119	0	20816	203123	4220	199902	219719	17
219719	0	28519	142964	63598	0	13157	195333	2333	192940	205037	18
205037	0	20816	142964	63133	0	0	190335	1415	188920	188526	19
188526	20000	13157	142964	65956	0	0	189253	27	169926	189926	20

Table 3.5 Benchmark Model - Cash Flow

CASH FLOW

OPENING CASH BAL	PLUS BORROWING	PLUS LENDING REPAID	LESS CASH FIXED COSTS	LESS CASH FARM COSTS	LESS BORROWING REPAID (INCL INT)	LESS LENDING	PLUS GROSS FARM INCOME	LESS TAX PAID	AMOUNT TRANSFERRED	BANK BALANCE	YEAR
60000	15091	0	0	75091	0	0	309677	22272	287405	287405	0
287405	0	0	142964	75090.71	17958.29	51392	236163	13287	222876	274268	1
274268	0	51392	142964	75092	0	56212	236982	13680	223302	279514	2
279514	0	56212	142964	75091	0	61459	237874	14109	223765	285224	3
285224	0	61459	142964	75091	0	67169	238845	14574	224271	291440	4
291440	0	67169	142964	75092	0	73384	239901	15082	224819	298203	5
298203	0	73384	142964	75090	0	80149	241051	15634	225417	305566	6
305566	0	73384	142964	75090	0	87512	242303	16234	226069	313581	7
313581	0	80149	142964	75092	0	95525	243665	16888	226777	322302	8
322302	0	87512	142964	75091	0	104247	245148	17600	227548	331795	9
331795	0	95525	142964	75091	0	113740	246762	18375	228387	342127	10
342127	0	104247	142964	75090	0	124073	248518	19218	229300	353373	11
353373	0	113740	142964	75091	0	135318	250430	20135	230295	365613	12
365613	0	124073	142964	75091	0	147558	252511	21134	231377	378935	13
378935	0	135318	142964	75092	0	160879	254775	22221	232554	393433	14
393433	0	147558	142964	75090	0	175379	257240	23404	233836	409215	15
409215	0	160879	142964	75091	0	191160	259923	24692	235231	426391	16
426391	0	175379	142964	75091	0	208336	262843	26094	236749	445085	17
445085	0	191160	142964	75091	0	227030	266021	27619	238402	465432	18
465432	0	208336	142964	75091	0	247377	269480	29279	240201	487578	19
487578	0	227030	142964	79488	0	265126	277315	30750	246565	511691	20

Figure 3.5 Direct (variable) costs



(ii) The relatively low costs of the agroforestry regimes used;

(iii) The high proportion of on-farm labour used for the agroforestry regimes (on-farm labour is treated as a fixed cost).

The latter point is particularly significant. If on-farm labour had not been available the total labour cost over the planning horizon would have been $105,834 as opposed to the actual cost of $15,791, a difference of $90,043.

Figure 3.6 indicates the predicted differences in gross farm income between the A.F. and B models. The high initial income in year 0, particularly for the B model is due to the sale of the cattle. Under the stable sheep policy adopted for the B model income slowly increases as funds available for lending progressively accumulate and earn interest. In comparison the income pattern for the A.F. model reflects the underlying changes in total stock units carried (see Figure 3.2). While farm income is generally lower in the A.F. model, up until year 10 the differences are relatively small in keeping with the small decline in stock numbers.

The combined effect of these changes together with differences in taxation are reflected in net farm income (Figure 3.7) and the end of year bank balance (Figure 3.8). The widening gap between the A.F. and B models in the latter part of the planning horizon reflects the higher net income generated by the B model as a result of higher stock numbers. The effect is also magnified by the current interest rates used in the models, (19% for borrowing, 17% for lending) which are at historically high levels.

Figure 3.6 Total Farm Revenue

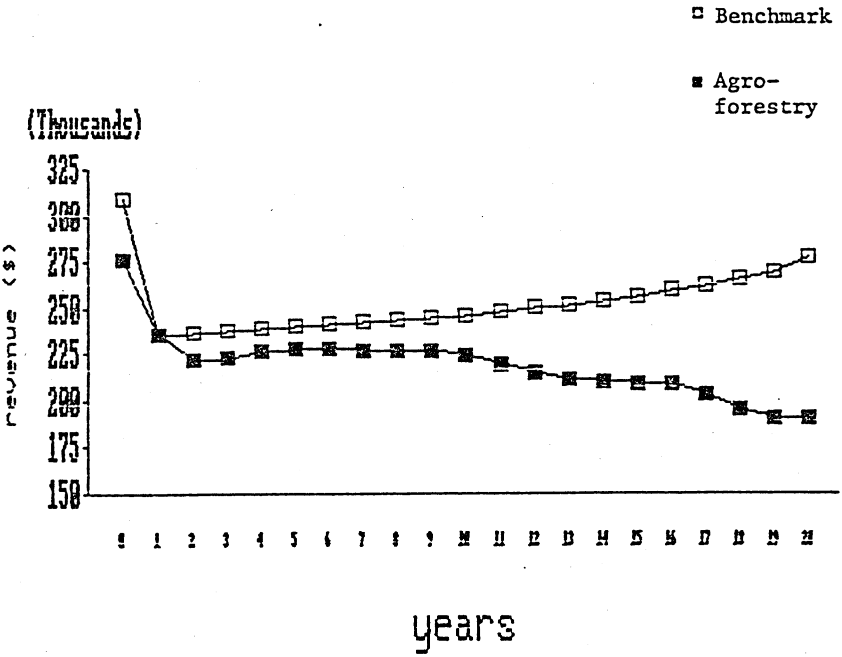


Figure 3.7 Net Farm Revenue

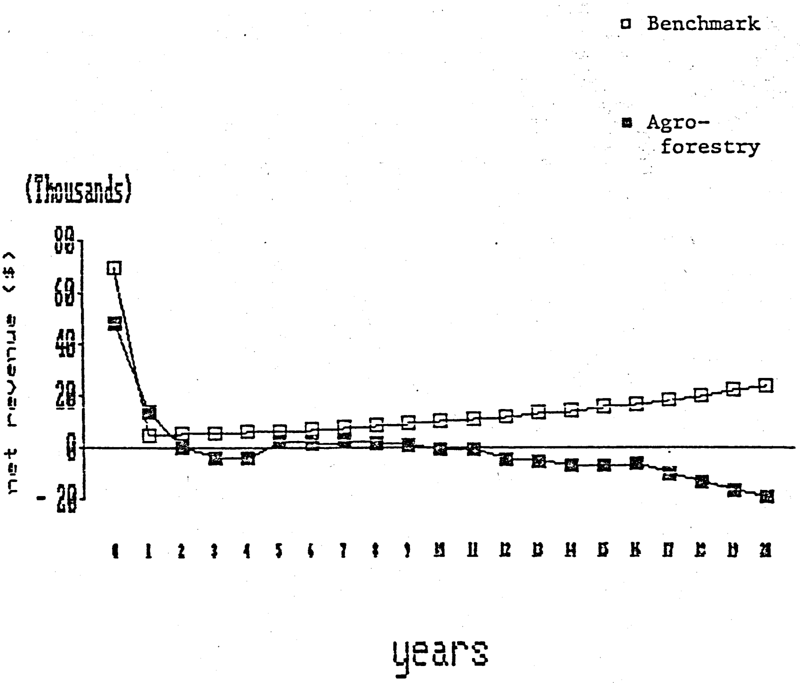
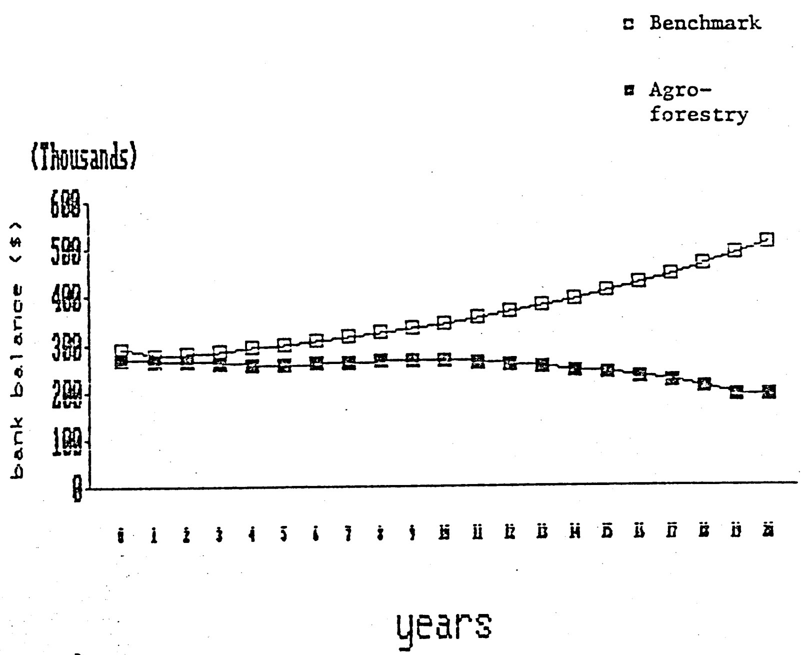


Figure 3.8 Cumulative Cash Balances



3.2.4 Objective Functions

Table 3.6 summarises the difference in objective function values between models B and A.F.

Table 3.6

	Model B	Model A.F.
Values at the end of the planning horizon		
Final Cash Balance	386,727	41,162
Value of Future Income Discounted from Infinity X 0.52 weighting factor.	793,639	1,749,691
Objective function	1,180,366	1,790,853
Present Values (10% discount rate)		
Final Cash Balance	52,246	5,561
Future Income	107,221	236,383
Objective function	159,467	241,944

The results clearly indicate the A.F. model to be more profitable than the B model where the objective is to maximise the net present value of future incomes. In contrast to the B model, by far the greatest value of the A.F. model occurs beyond the end of the planning horizon when timber income will be realised. This contrasts markedly with the picture within the planning horizon where the A.F. model realises a significantly lower final cash balance.

The present value figures help to place the very large future values in perspective.

3.3 SHADOW PRICE OF RESOURCES AND OPPORTUNITY COST OF ACTIVITIES

3.3.1 Resource Valuations

The marginal value product (shadow price) of resources used in the model provides further insight into the optimum solutions.

In the case of a resource used at limit level the value of one extra unit of the resource is specified; for resources not fully used the penalty incurred by changing one unit of the resource is identified.

Land

Figure 3.9 illustrates the shadow price of land class 2 for both A.F. and B models with time. The pattern shown is representative of the other land classes. (Note: All land was fully utilised). As would be expected, the marginal value product of land generally declines with time until terminal values are attached to land using activities in the final year of the planning horizon. The inclusion of agroforestry activities in the A.F. model substantially raised the value of all land classes.

The inclusion of agroforestry activities also altered the relative values of different land classes. Thus in the B model, land classes 2 and 3, with their higher stocking rates in comparison to other land classes, had higher shadow prices at both the beginning and end of the planning horizon (Figures 3.10, 3.11). In contrast, in the A.F. model, land classes 4 and 6 had the highest shadow prices at the end of the planning horizon (Figure 3.11). Both land classes 4 and 6 had agroforestry as a permitted land use. While land class 7 had the lowest value in both A.F. and B models, the inclusion of agroforestry in the A.F. model raised its relative value in comparison to those land classes where agroforestry was not permitted.

Figure 3.9 Shadow Prices (Land Class 2)

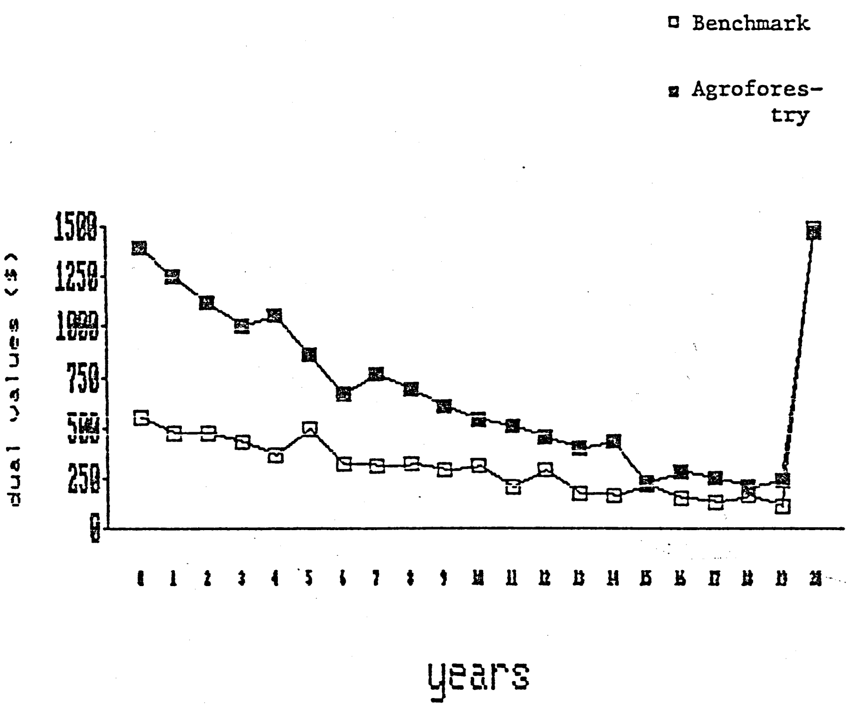


Figure 3.10 Shadow Prices of Land Classes (yr 0)

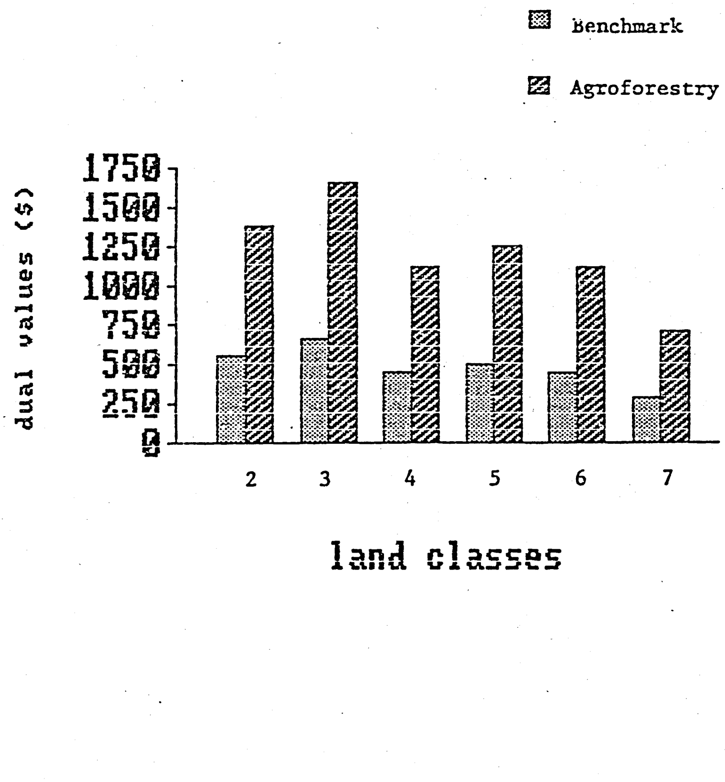
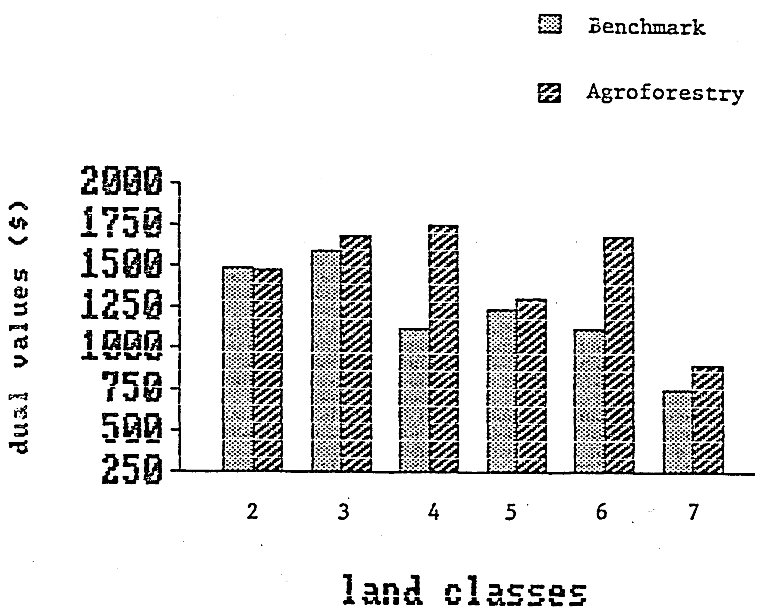


Figure 3.11 Shadow Prices of Land Classes (yr 20)



Labour

The marked differences in labour profile between the A.F. and B models have already been commented on. Figure 3.12 suggests that altering the availability of on-farm labour would alter the profitability of agroforestry. At the peak value of labour in year 4, for example, changing the level of labour by one hour would alter the objective function by $75. This applied over a wide range, from 851 to 942 hours of on-farm labour (if it had been available). Table 3.7 summarises the ranges over which the shadow prices apply.

Tax-Free Cash

Table 3.8 indicates the shadow price of tax-free cash and the ranges over which these apply in year 0.

Table 3.8 Shadow Price of Tax-Free Cash

	Model B	Model A.F.
Value	5.98	12.29
Range	55,091 - 75,091	59,792 - 60,117

These imply that, within the ranges specified, each dollar's difference in opening cash would alter the objective function by $5.98 for Model B and $12.29 for Model A.F. Another way of expressing this is in terms of an expected rate of return - the interest rates that will discount these value to $1 in year 0. For B this is 8.9 percent and for A.F. 12.7 percent. While the B model shows a very modest after-tax return reflecting current low profitability levels for sheep farming, the A.F. model demonstrates a good, if not spectacular, after-tax return.

Figure 3.12 Shadow Prices of Labour

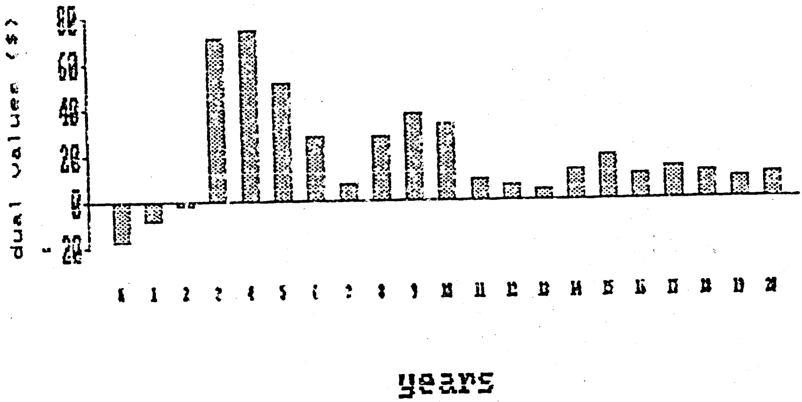


Table 3.7 Ranges Applicable to Shadow Prices for Labour

YEARS	LOWER LIMIT	UPPER LIMIT
0	834	834
1	841	845
2	633	634
3	840	896
4	851	942
5	837	905
6	858	886
7	856	903
8	866	886
9	808	919
10	799	924
11	872	883
12	867	935
13	769	880
14	873	902
15	858	879
16	872	910
17	870	880
18	868	879
19	868	950
20	855	878

3.3.2 Activity Valuations

The shadow prices indicate:

(i) For those activities in the plan the change in objective function that would result if their level was altered

(ii) for excluded activities their opportunity cost in terms of the value of other activities that would have to be given up.

Cattle

Figure 3.13 illustrates the shadow price for cattle on land class 2 for both A.F. and B models with time. The pattern is representative of shadow price change with time for the other cattle activities. In comparison to the sheep policy the cattle policy had both higher capital values and labour requirements per stock unit (Table 3.9).

Table 3.9 Comparative Returns for Sheep and Cattle

	Sheep Policy	Cattle Policy
Capital ($1 SU)	13.68	64.94
Net return (after 19% opportunity cost on capital) ($1 SU))	18.82	15.59
Labour requirement (hr/SU)	0.059	0.12

These figures indicate why sheep rather than cattle activities were specified in both models. The generally higher opportunity costs for cattle in the A.F. model reflected competition for both capital and labour with the agroforestry activities.

Cropping

Figures 3.14 and 3.15 illustrate the changes in objective function that would result if the crop rotation on land class 2 was reduced or increased. The results indicate that increasing the crop area would markedly reduce the objective function. As well, with the exception of year 21, savings would result if the minimum crop constraint was removed. As noted for cattle, generally higher opportunity costs apply in the A.F. model if the crop activity was to be expanded. Again this reflected competition for capital and labour with agroforestry activities.

Agroforestry on Class 7

Figure 3.16 emphasises the high opportunity costs associated with introducing agroforestry on to class 7 country during the early years of the planning horizon. While the opportunity cost of agriculture was lower on this class of land agroforestry also had significantly lower returns than on other land classes. This was a result of higher establishment, tending and harvesting costs.

Borrowing

A clear difference in the shadow price of borrowed funds was evident between the A.F. and B models (Fig. 3.17). For the entire planning horizon the A.F. model could afford to pay more for each dollar borrowed in comparison to the B model. The difference was most marked in the early years of the planning horizon. Clearly this difference is a consequence of the higher profitability of the A.F. model.

Figure 3.13 Shadow Cost of Cattle (Land Class 2)

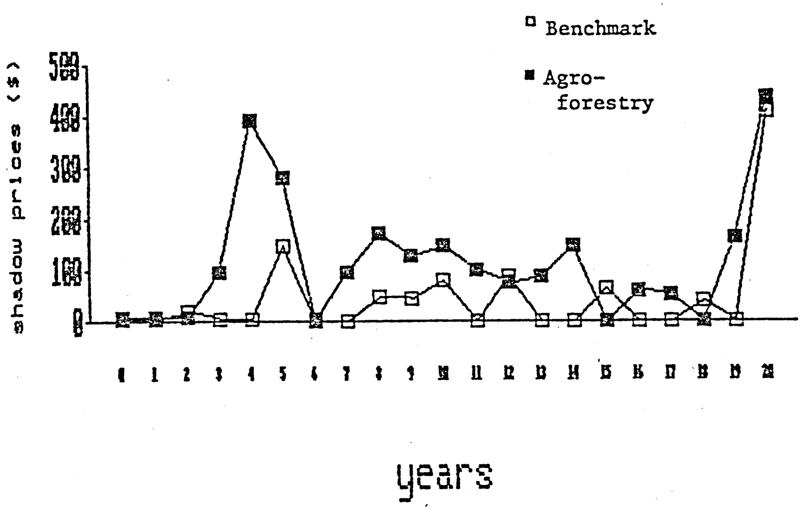


Figure 3.14 Savings from Reduction in Crop Area

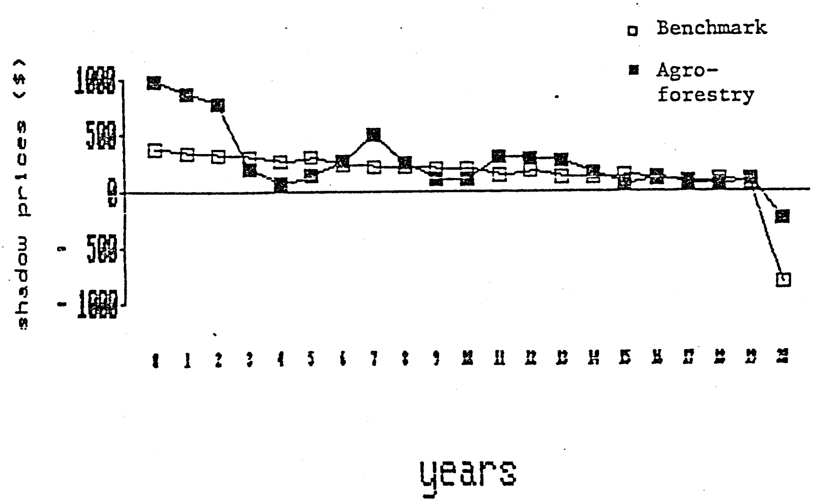


Figure 3.15 Cost of an Increase in Crop Area

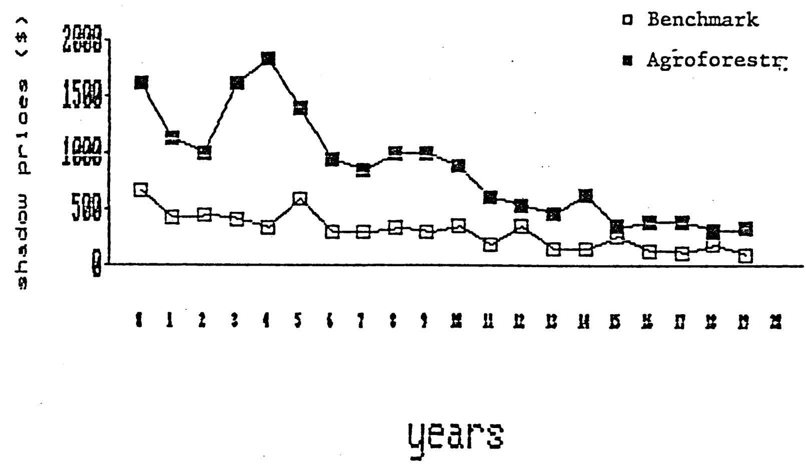


Figure 3.16 Shadow cost of Agroforestry on Land Class 7

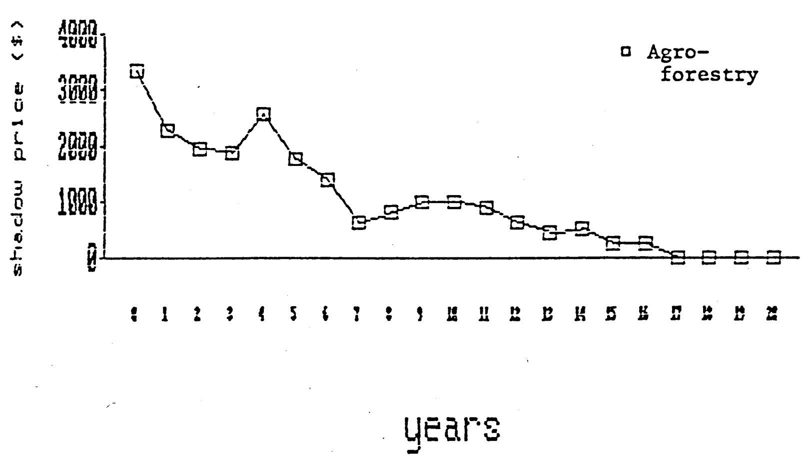
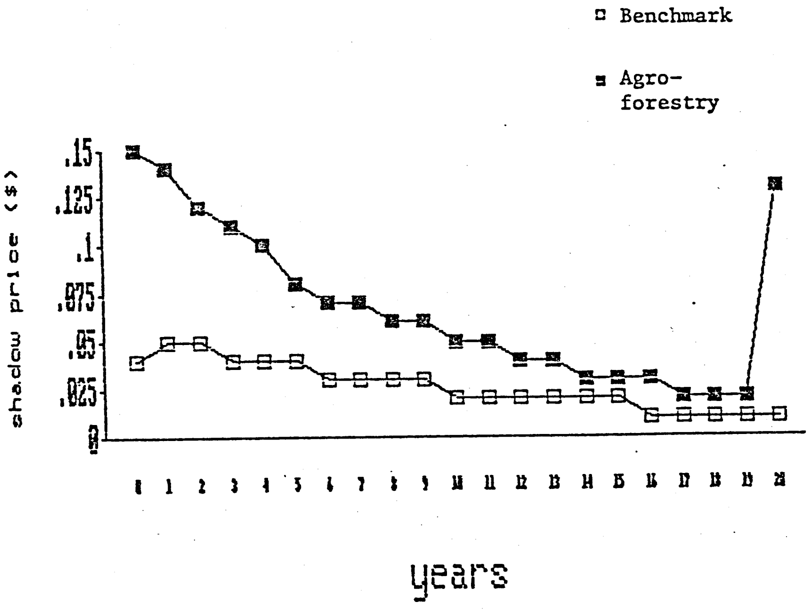


Figure 3.17 Shadow Price of Borrowing



Forestry Tax Deduction

In periods 0 and 4 the permissable forestry tax deduction limit of $7,500/year was reached. Table 3.10 indicates that extending the limit would improve the profitability of the A.F. model.

Table 10 Shadow Price for Extending Forestry Tax Deductions

Year	Upper Activity	Shadow Price
0	7,699	0.48
4	8,037	1.05

The effect would have been more pronounced under circumstances of a higher annual rate of planting.

3.5 SUMMARY

The results of the study indicate that agroforestry is both a profitable and economically viable development option for the case study farm. The optimal farm plan specified a continuous planting programme, commencing with land classes 4 and 6. Planting of class 7 land was delayed until the latter years of the planning horizon. Shadow prices indicated a marked reduction in profitability if planting on class 7 had commenced earlier. In comparison to agroforestry on land classes 4 and 6, agroforestry on class 7 had higher labour and capital requirements as well as lower final returns.

While over one-third of the property was planted by year 20, 80% of the farms initial stock units were still being carried. This was a result of the continuous planting programme and the high level of grazing under the agroforestry regimes specified. For both the benchmark and agroforestry models a change from a mixed sheep and cattle policy to an all sheep policy was indicated.

A key feature of the agroforestry model was the marked increase in labour requirements and its effective utilisation of surplus winter labour. An examination of shadow prices suggested that any reduction in the availability of on-farm labour would reduce the profitability of agroforestry.

Marked differences were apparent in cashflows between the benchmark and agroforestry models. Within the planning horizon the agroforestry model had lower direct costs but also a lower gross farm income. From year 3 net farm income was consistently lower in the agroforestry model, and from year 12, negative. As a result differences in end of year bank balances progressively grew larger. The real value of the agroforestry model occurred after the end of the planning horizon. As a result, while both models were profitable, the agroforestry model had a markedly higher objective function value.

To extend the results of the analysis, the succeeding chapter examines the effect on the agroforestry model of altering some of the parameters.

CHAPTER 4

A SENSITIVITY ANALYSIS

4.1 INTRODUCTION

In the preceeding chapter several factors likely to affect investment in agroforestry were identified, for example labour supplies and tax deductibility of forestry. As well, the heterogenous nature of farms and farmers in the Wairarapa limits the applicability of the results of one case study. This chapter seeks to investigate the significance of some of these factors and extends the applicability of the results to a wider range of circumstances.

4.2 ON FARM FACTORS

4.2.1 Capital Restrictions

The level of debt servicing is a crucial factor in the continuing viability of farms and markedly affects investment opportunities. Accordingly, the level of debt servicing was varied from \$2 - 7 per SU based on initial stock units of 8,498. (Note: the standard plan was solved for a debt servicing level of \$6.78/SU). Farms also vary widely in their liquidity and again this is recognised as an important consideration in affecting investment opportunities. The opening level of cash was varied from \$40,000 to \$70,000, the standard plan having been solved for an opening cash level of \$60,000. As the pattern of results was very similar for varying both types of capital restrictions, those obtained for varying the level of debt servicing only are summarised here.

The primary physical effect was to alter the rate of tree planting (Figure 4.1). It is noteworthy that even under relatively high levels of debt servicing, all of the area available for agroforestry was eventually planted. It is probable that extending the length of the planning horizon would have reduced the high planting rates indicated in the later years as by year 20 the peak overdraft limit of $20,000 had been reached in the $7/SU plan.

Table 4.1 indicates the pattern of planting under low and high levels of debt servicing. In all plans the rate of planting is initially highest for class 4 and lowest for class 7, reflecting the relative profitability of agroforestry in the different land classes. Even with little capital limitation, planting on the class 7 land did not commence until year 7.

Corresponding changes in total stock units carried are indicated in Figure 4.2. As would be expected higher initial planting rates were associated with more marked drops in stock numbers. However, from years 5 to 14 total stock units were similar for different plans. This again reflected the high level of grazing available from agroforestry activities after the initial planting phase. From years 14 to 19 greater differences were apparent between plans, corresponding to:

(i) a decline in available pasture in plans with higher initial planting rates and therefore older trees;

(ii) a lull in planting for the high debt servicing plan.

By year 20 total stock units were very similar for the different plans as by this time planting of class 7 land had reduced available grazing in the high debt servicing plan.

For all plans a change from a mixed sheep and cattle to an all sheep policy was specified, with all cattle sold by year 4. Lower levels of debt servicing and corresponding faster planting rates, were also associated with a faster transition period from cattle to sheep.

Figure 4.1 Agroforestry Plantings - Effect of Debt Servicing

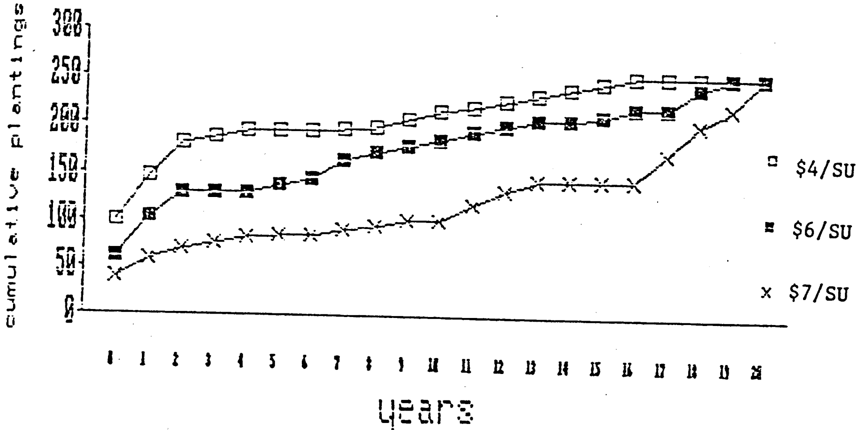


Figure 4.2 Total Stock Units - Effect of Debt Servicing

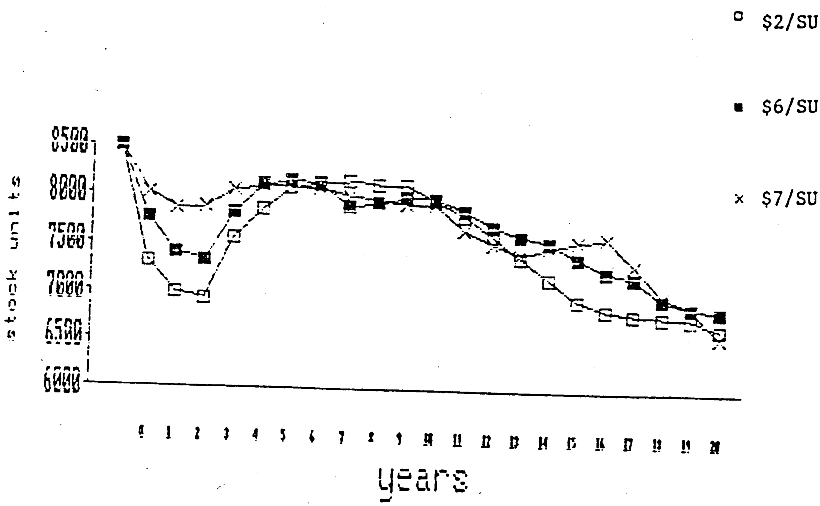


Table 4.1 Effect of Debt Servicing on Planting Pattern

YEAR	DEBT $2/SU			DEBT $7/SU		
	AF4	AF6	AF7H	AF4	AF6	AF7H
0	72.87	34.38	0	28.93	9.39	0
1	2.13	50.91	0	16.08	4.14	0
2	0	33.67	0	11.13	0	0
3	0	.04	0	5.92	0	0
4	0	0	0	7.24	0	0
5	0	0	0	1.82	0	0
6	0	0	0	0	0	0
7	0	0	10.85	0	5.71	0
8	0	0	4.95	3.89	.43	0
9	0	0	3.55	0	6.08	0
10	0	0	7.21	0	.89	0
11	0	0	4.02	0	17.45	0
12	0	0	6.96	0	14.08	0
13	0	0	10.12	0	10.40	0
14	0	0	6.35	0	0	0
15	0	0	4.99	0	0	0
16	0	0	0	0	0	0
17	0	0	0	0	0	30.05
18	0	0	0	0	16.96	11.40
19	0	0	0	0	0	17.56
20	0	0	0	0	33.48	0
TOTALS	75	119	59	75.01	119.01	59.01

Cropping entered the solution at the minimum permitted area of 12 ha., with the exception of the final year, for debt servicing plans of $6/SU or less, when all of land class II was specified for cropping. As previously observed this expansion in cropping is likely to be an artifact of the model. While the rotation specifying wheat with its associated sheep activity was normally chosen, plans with low levels of debt servicing substituted barley for wheat in the early years of the planning horizon. This occurred inspite of a lower return from barley and reflected competition for labour and capital with agroforestry activities during these periods.

As would be expected, low debt-servicing plans with faster planting rates had higher total and peak labour requirements. This was reflected in increased requirements for hired labour, (Figure 4.3) both in total and proportionally. For example, at a debt servicing figure of $4/SU, hired labour provided 38% of total agroforestry requirements; at $7/SU the equivalent figure was 8%.

Cumulative cash balances for three of the plans are summarised in Figure 4.4. The results indicate that a decline in cash balances only occurs with relatively high levels of debt servicing. At $6/SU debt servicing and below, an increase in cumulative cash balance occurs inspite of extensive development of agroforestry. All plans specify borrowing in year 0 with further borrowing only specified for $7/SU debt servicing in years 19 and 20.

Figure 4.3 Agroforestry Plantings - Effect of Timber Values

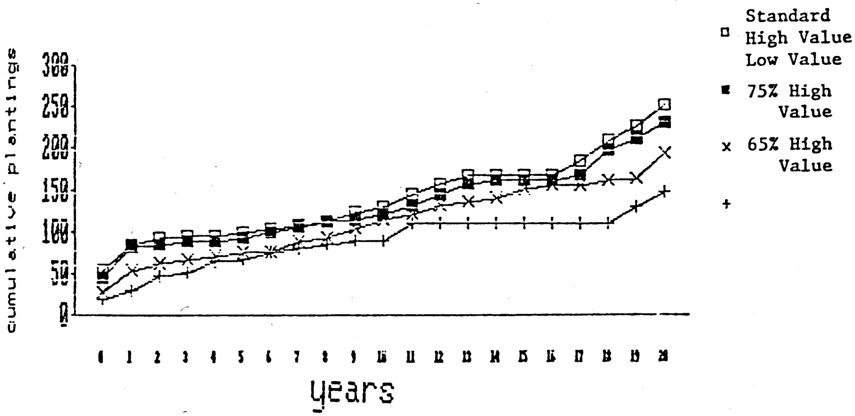


Table 4.2 summarises the differences in objective function between plans.

Table 4.2 Effect of Debt Servicing on Objective Function

	Plans (Debt Servicing)			
	$2/SU	$4/SU	$6/SU	$7/SU
Values at the end of the planning horizon				
Final Cash Balance	1,173,654	600,992	190,785	34,592
Value of future income	2,300,120	2,260,634	1,992,034	1,613,982
Objective function	3,473,774	2,861,626	2,182,819	1,648,574
Present value (10% discount rate)				
Final Cash Balance	158,561	81,194	25,775	4,673
Future Income	310,746	305,412	269,124	218,049
Objective Function	469,307	386,606	294,899	222,722
Proportional change relative to standard objective function at $6.78/SU	1.94	1.60	1.22	0.92

One aspect of interest provided by varying opening cash is the effect on the shadow price of opening cash. This shadow price, gives the marginal productivity of additional cash and is another measure of profitability. Table 4.3 indicates these as well as the expected rates of return (in terms of the annual compound growth rate, g, in the equation \$1 $(1+g)^{21}$ = shadow price).

Table 4.3 Shadow Price of Opening Cash

Level of Opening Cash	Shadow Price	Rate of Return
40,000	54.74	21%
50,000	27.36	17.5
60,000	12.29	12.5
70,000	10.69	11.5

As would be expected the marginal productivity of additional cash increases with decreasing supplies. Over the range examined the model incorporating agroforestry indicates good after-tax returns.

4.2.2 Timber Value

The results discussed so far relate to a standard set of prices, costs, and performances for each activity. As these vary markedly from farm to farm and from one year to another on the same farm, it is essential to gain some indication of their effect on the optimal plan. In the event it was not possible to examine the effect of varying agricultural performances and returns because of the time required to alter these in each of the 21 periods.

It would have also been desirable to examine the effect of varying parameters with respect to the agroforestry regimes, for example, site indices, and distance from a mill. Again this was prohibited by the lack of available time. Instead, a crude estimate of the robustness of the model was obtained by varying final timber values. Thus, the standard model was solved using default high values for clear timber. Sawlog stumpages for regimes on class 4, 6 and 7 were \$79, \$77, and \$57/m^3 respectively. Additional plans were prepared and solved using the default low value for clear timber as well as plans based on 75% and 65% of high values respectively.

The effect of lower timber value was to reduce both the rate and extent of tree planting (figure 4.5). The least profitable agroforestry regime, i.e. planting on land class 7, was reduced first followed by planting on class 6. Table 4.4 summarises the different pattern of planting between the plan with high timber values and values at 65% of the high value.

Thus the results suggest plans specifying agroforestry to be relatively robust, but that agroforestry profitability, as influenced by site, is a very important determinant.

Table 4.4 Effect of Changing Timber Values on Planting Pattern

YEAR	HIGH VALUE AGROFORESTRY PLANTINGS					65% HIGH VALUE AGROFORESTRY PLANTINGS				
	AF4	AF6	AF7H	TOTAL/YR	ACCUM TOT	AF4	AF6	AF7H	TOTAL/YR	ACCUM TOT
0	35.02	18.56	0	53.58	53.58	19.90	0	0	19.90	19.90
1	26.27	3.57	0	29.84	83.42	10.88	0	0	10.88	30.78
2	6.70	2.73	0	9.43	92.85	16.15	0	0	16.15	46.93
3	1.54	0	0	1.54	94.39	4.74	0	0	4.74	51.67
4	0	0	0	0	94.39	13.85	0	0	13.85	65.52
5	5.47	0	0	5.47	99.86	.23	0	0	.23	65.75
6	0	3.07	0	3.07	102.93	9.07	0	0	9.07	74.82
7	0	5.88	0	5.88	108.81	.18	3.69	0	3.87	78.69
8	0	4.20	0	4.20	113.01	0	4.95	0	4.95	83.64
9	0	10.08	0	10.08	123.09	0	4.75	0	4.75	88.39
10	0	6.97	0	6.97	130.06	0	0	0	0	88.39
11	0	14.59	0	14.59	144.65	0	21.06	0	21.06	109.45
12	0	13.70	0	13.70	158.35	0	0	0	0	109.45
13	0	9.25	0	9.25	167.60	0	0	0	0	109.45
14	0	0	0	0	167.60	0	0	0	0	109.45
15	0	0	0	0	167.60	0	0	0	0	109.45
16	0	0	0	0	167.60	0	0	0	0	109.45
17	0	0	18.10	18.10	185.70	0	0	0	0	109.45
18	0	9.59	14.67	24.26	209.96	0	0	0	0	109.45
19	0	0	16.72	16.72	226.68	0	21.01	0	21.01	130.46
20	0	16.80	9.50	26.30	252.98	0	17.27	0	17.27	147.73
TOTALS	75	118.99	58.99			75	72.73	0		

The effect on objective function values is indicated in Table 4.5.

Table 4.5 Effect of Changing Timber Values on Objective Function

	Plans			
	Standard	Low Value	75% High Value	65% High Value
Values at the end of the planning horizon				
Final Cash Balance	41,162	83,618	186,079	241,139
Value of future income	1,749,691	1,508,227	1,179,151	984,972
Objective Function	1,790,853	1,391,845	1,365,230	1,226,111
Present Value (10% discount rate)				
Final Cash Balance	5,561	11,297	25,139	32,578
Future Income	236,383	203,761	159,302	133,070
Objective Function	241,944	215,058	184,443	165,648
Proportional change relative to standard	1.0	0.89	0.76	0.68

Clearly, future timber values will have a marked effect on the profitability of plans incorporating agroforestry.

4.2.3 Other

Other internal factors examined included variation in labour availability, proportions of different land classes, and changes in objective function. The latter was simulated by solving the model with a constant final cash value of 1 but with weights on final asset values of 0, 0.2, 0.4, 0.6, 0.8, and 1.0.

The primary physical effect of a reduction in labour was to reduce the planting rate of agroforestry. However a significant reduction in both permanent and hired labour had a minor effect on profitability. It should be noted, however, that farm labour provided the bulk of agroforestry requirements in all cases. With further restrictions, particularly in farm labour, a more marked reduction in profitability would have occurred.

The case-study farm had a relatively small proportion of class 6 and 7 land. In this respect it was atypical of many hill country farms in the Wairarapa. Accordingly a plan with 75% of area consisting of class 6 and 7 hill country was simulated. With a lower carrying capacity it was necessary to reduce debt servicing to $5/SU (based on initial stock numbers) in order for the plan to be feasible. However, agroforestry was still embarked upon with results consistent with those already observed. Thus class 4 and 6 land was planted initially, with planting on class 7 only commencing in the latter years.

As with changes in labour availability, the primary physical effect of a change in objective function values was to alter the rate of planting. It is noteworthy that a weight of only 0.2 on final asset values was sufficient for agroforestry to be included in the plan. At this level, as well as a reduction in planting rate, only limited planting of class 7 land was specified. Weights of 0.6 and above specified identical plans. Differences in cumulative cash balances reflected the different weights put on final asset values. Thus the plan with the weight of 0.2 on final asset values combined an extensive planting programme with an increase in cash balance. Plans with weights higher than this ultimately indicated a decline in cash.

4.3 OFF-FARM FACTORS

4.3.1 Interest

Interest rates used in the model are at historically high levels. With the long duration of the planning horizon, and the effect of high interest rates on generating significant levels of off-farm income, it was felt prudent to examine the effect of interest rate on the optimum farm plan.

Interest rates for borrowing of 10, 15 and 20% with lending rates 2% below these were examined. Figure 4.6 indicates that higher interest rates were associated with a faster rate of planting. At the lowest interest rate of 10%, 8.3 ha of class 7 land remained unplanted at the duration of the planning horizon. A second major change was specified in livestock policies. With lower interest rates the profitability of cattle, relative to sheep activities, improved so that cattle increasingly entered the solution (Table 4.6). Nevertheless, even at low interest rates, cattle numbers were gradually reduced and replaced by sheep and agroforestry.

As would be expected, changes in interest rate had a marked effect on the pattern of borrowing and lending. At low interest rates borrowing rather than lending was generally specified; the converse applied at higher interest rates. The additional income generated by lending activities at higher interest rates would have facilitated the faster planting rates.

While profitability, as determined by objective function values, was lower at lower interest rates the effect was comparatively small.

Figure 4.6 Agroforestry Plantings - Effect of Interest Rate

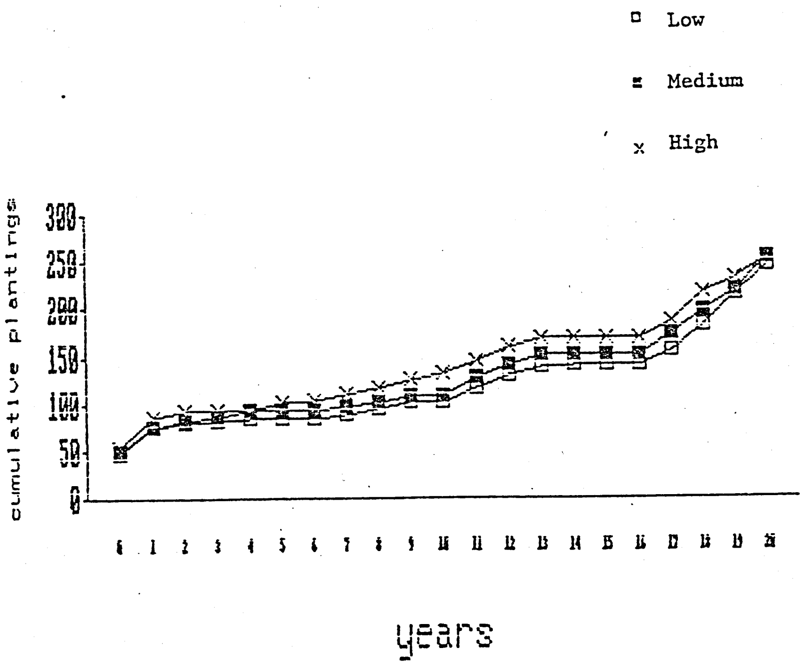


Table 4.6 Effect of Interest Rate on Livestock Policies

LOW INTEREST		MEDIUM INTEREST		HIGH INTEREST	
SHEEP SU	CATTLE SU	SHEEP SU	CATTLE SU	SHEEP SU	CATTLE SU
7086	1412	7086	1412	7086	1412
6478	1412	7246	678	7364	473
6436	1134	7246	342	7364	95
6436	1088	7246	267	7364	0
6436	1065	7246	205	7364	0
6436	1035	7246	135	7364	0
6411	1060	7246	135	7285	0
6411	1060	7246	135	7238	0
6366	1058	7191	127	7160	0
6366	972	7191	75	7104	0
6366	906	7191	0	6997	0
6366	906	7191	0	6913	0
6189	906	6971	0	6751	0
6146	802	6809	0	6592	0
6146	698	6682	0	6482	0
6146	675	6682	0	6482	0
6146	675	6682	0	6482	0
6146	675	6682	0	6482	0
6146	527	6497	0	6324	0
6142	270	6167	83	5979	0
6087	0	6059	0	5847	0
5733	0	5668	0	5615	0

4.3.2 Forestry Tax Deductions

The present permissable limit for tax-deductible forestry expenditure is $7,500 per year. Given the relative ease with which this figure could be changed by future Government Policy the effect of different limits was simulated. These were $0 (i.e. no tax-deductible forestry expenditure), $2,500/year and $12,500/year.

The effect of raising the limit was to slightly increase the rate of planting. However, it is noteworthy that even with no tax-deductible forestry expenditure, all land suitable for agroforestry was planted. Overall, changes in the tax deductible limits had relatively minor effects on profitability.

4.4 SUMMARY

The results in this chapter suggest that the optimum plan incorporating agroforestry is relatively stable. The main effect of variation in both on and off-farm factors was to alter the rate of agroforestry development, rather than change the ultimate development of agroforestry.

Factors of major significance to the rate of development and profitability were shown to be capital availability and timber values. Other variables, including labour availability, weights placed on final asset values, interest rates, and tax deductibility also affected the rate of development and profitability but to a lesser extent.

When factors acted to restrict the rate of agroforestry development, the least profitable agroforestry (land class 7) was always the first to be removed from the solution.

CHAPTER 5

MODEL LIMITATIONS AND FURTHER ASPECTS OF AGROFORESTRY

5.1 MODEL LIMITATIONS

By definition models are limited in how far they can include all variables and influences. It is worthwhile to identify and suggest the implications of some of these limitations.

5.1.1 Model Type

The linear programming model used was static in that costs, prices, and measures of productivity were taken as being constant. In addition present day technology was assumed. Clearly this is a major limitation in a model that covers a 21 year planning horizon. Further parametric programming, for example examining the effect of different livestock profitability levels, would have provided some limited but not complete insight, as it is impossible to portray the future.

One aspect of the static nature of the model was the high rate of planting possible, where an optimum programme could be specified with complete certainty. Under "real" conditions slower planting programmes may be more realistic. For example, the diminishing terms of trade faced by farmers in recent years was left out of the model. If included, cash balances in latter years of the model results would have been reduced, and therefore cash limitations may have acted to restrict the rates of planting below those indicated.

These considerations emphasise the main role of the model in suggesting the optimum programme in the first year of the planning horizon rather than in 2, 5 or 10 years time. Relative returns, weather patterns, personal circumstances, etc. are all subject to change and will of course influence the optimum farm programme. It also suggests the need for revision as new information becomes available.

The special postulates of linear programming of linearity, divisibility, additivity, and finiteness generally fitted the situation. An exception was the labour requirements for stock (see Section 2.4.2.) but this did not seriously compromise the model.

5.1.2 Calculation of Benefits in the Model

Benefits from the agroforestry regime were confined to the direct returns from livestock grazing underneath the trees and final timber value. No account was taken of the other benefits possible, including soil and water conservation, shelter for pasture and stock, economic stability, and aesthetics. To this extent, the results are a conservative estimate of the value of agroforestry.

A fuller consideration of these benefits may have altered some of the conclusions with respect to both profitability and feasibility. For example, the inclusion of other benefits may have placed less emphasis on final timber value as a determinant of profitability. Another feature of significance is that a decline in livestock performance for livestock grazing underneath the trees was assumed. On a farm scale, where livestock would normally only spend part of their time in agroforestry grazing, such a decline in livestock performance may not occur. In practice an improvement in overall livestock performance could well eventuate, particularly from a reduction in stock losses following shearing and during lambing in the variable Wairarapa climate. Such an improvement, if it occurred, would offset the predicted decline in net farm income predicted in the later years of the planning horizon.

Another aspect of significance, is that the relative profitability of agroforestry for different land classes may have altered if other benefits had been considered. For example, land class 7 has a high priority for planting if soil and water conservation needs are considered.

5.1.3 Model Information

In developing the model many assumptions were necessary, particularly in relation to the agroforestry activities. The data base for the low density regimes used in the study is still limited, and information available for the Wairarapa was also very limited. Some aspects of importance to the accuracy of the model predictions include:

(i) Final timber yield estimates.
In addition to concern over the accuracy of SILMOD predictions at low tree densities, there was some concern that on exposed sites in a windy location, such as the Wairarapa, trees at low densities would be subject to distortion, reducing the value of the timber.

(ii) Assumptions on stock carrying capacities.
The existing agroforestry trials are still only part-way through their rotations while information for the Wairarapa is non-existent. While the most applicable information was used, the stock carrying capacities assumed for the model are only best estimates. Changes from these are likely to have a relatively small effect on profitability, but could have a more marked effect on the feasibility of the A.F. model. This is particularly true in the latter years of the planning horizon when changes in net income are primarily determined by stock carrying capacity.

(iii) Logging Costs.
Again while an attempt was made to use the best estimates available, the harvesting production and cost estimator used in SILMOD is not considered suitable for use on small forest woodlots (Blundell, 1985). For "limited scale logging", where production is restricted and manpower and machinery cannot be used to optimum efficiency, costs tend to be higher than those suggested by the estimates in SILMOD. As logging costs form a very significant part of total forestry costs, changes from those assumed could have a marked effect on profitability.

5.1.4 Model Activities

A limited range of activities were included in the analysis. Livestock activities were confined to sheep and cattle breeding and agroforestry to P. radiata under regimes designed to maximise clearwood production. Financing of the agroforestry programme could only be undertaken from funds generated on the farm or from a limited amount of lending.

Clearly this restricted the scope of the analysis. As has already been suggested, alternative land use activities may have been more profitable than those included in the model. Alternative livestock activities, for example, would compete for land use with agroforestry. However, where grazing underneath trees was possible, the profitability of the agroforestry activities would have also been increased.

Special purpose species in particular, were left out of the model through a lack of quantitative information. In some situations these may have proved more suitable than the P. radiata activites. The Wairarapa Catchment Board and individual farmers such as J. Pottinger, have experienced considerable success with the establishment and growth of eucalypt species on steep erosion - prone hill country.

Joint ventures were not examined in the model. The results indicate that they are not a necessary factor for the successful development of agroforestry. Nevertheless, given the importance of capital availability, joint ventures could be expected to increase the potential rate of agroforestry development.

5.2 STUDY LIMITATIONS

The primary emphasis in this study has been on the development of a whole-farm planning model that incorporates agroforestry. In Chapter 1 it was pointed out that this forms only part of a project evaluation. Of particular concern must be the implementation of an agroforestry system.

The model assumes:

(i) A high standard of management

The regimes used in the model assume that all silvicultural work is carried out on-time. This presupposes that the farmer and all labour employed for forestry work will have the knowledge, skills and commitment to ensure this is the case of a 20+ year period. Over the same period of time, the farmer needs to maintain the productivity of his livestock if the farm is to remain viable. Finally, skills in financial management are assumed, with adequate provision for a possible future decline in net farm income.

It is suggested that few individuals combine all of the above qualities. The use of consultants to provide advice and, if necessary, organise planting and silvicultural work may be a necessary precondition for many farmers contemplating extensive agroforestry. In such cases provision within the model for such supervision costs should be made.

(ii) A market for the timber

In reality a ready market for the timber in 28 years time cannot be guaranteed. It is suggested that potential growers, at the bare minimum, need to give thought to, and make some arrangements for, the disposal of their crop. This may mean contacting existing processors in the district (e.g. to provide adequate volumes to attract processors to purchase); it may also mean linking up with other forestry owners to form a marketing group. It also means clearly identifying appropriate regimes, in the light of likely future market needs.

CHAPTER 6

CONCLUSIONS AND IMPLICATIONS FOR THE WAIRARAPA

6.1 INTRODUCTION

In the preceeding two chapters preliminary conclusions were drawn on the results of the study. In this chapter the implications of the research are discussed with respect to the study's two basic objectives:

1. Is agroforestry in general likely to be a profitable investment for Wairarapa hill country farmers?

2. What factors influence the feasibility of farmer investment in agroforestry?

The wider implications for the Wairarapa district are also briefly discussed.

6.2 PROFITABILITY AND FEASIBILITY

The study indicated that agroforestry is likely to be a profitable investment for Wairarapa hill country farmers. When tested under a range of circumstances the primary effect was to alter the rate of development rather than the choice of agroforestry as an investment. Table 6.1 summarises the objective function values for various changes (in present value terms).

Table 6.1 Summary of Objective Function Values

Plan	Objective Function	Proportional change from standard
Standard Agroforestry	241,944	1.00
Benchmark	159,467	0.66
Debt Servicing:		
$2/SU	469,307	1.94
$4/SU	386,606	1.60
$6/SU	294,899	1.22
$7/SU	222,722	0.92
Opening Cash:		
$40,000	167,458	0.69
$50,000	217,363	0.90
$70,000	257,445	1.06
Labour:		
Less Permanent	231,567	0.96
Hired Labour Limit 400 hr	241,500	1.00
Hired Labour Limit 300 hr	240,789	1.00
Timber Value:		
Low	215,058	0.89
75% High Value	184,443	0.76
65% High Value	165,648	0.68
Interest Rate:		
Low	225,639	0.93
Medium	230,871	0.95
High	244,698	1.01
Forestry Tax Deduction:		
Limits		
$0	227,230	0.94
$2,500	236,385	0.98
$12,500	242,061	1.00

While a dramatic change in land-use was specified in the optimal plan, agroforestry appeared to integrate well with existing hill country farming systems as the impact on them was limited. In the case study by year 20, with over one-third of the farm in trees, 80% of the original livestock were still being carried. A continuous planting programme together with a high level of grazing underneath the trees, ensured that fluctuations in livestock numbers were minimised. Surplus winter labour was effectively utilised by the agroforestry programme.

Some key factors were shown to influence both the profitability and feasibility of the programme. With respect to profitability, choice of planting site and ultimate timber value was very important. Sites with good access and relatively easy contour had higher planting rates than steeper more inaccessible sites. In the case study farm, sites in the former category corresponded to class 4 and 6 land, and sites in the latter to class 7. Reductions in timber value reduced both planting rates and profitability.

The implications for farmers are as follows:

(i) If the primary objective is to maximise returns at felling then preference should be given to planting easier contoured and accessible farm sites. In doing this both growing costs, including labour, and extraction costs will be minimised. At the costs and prices used in the model, opportunity costs of lost agricultural production appeared to be of lesser significance. This is in contrast to the results of Arthur-Worsop (1984) which indicate lower agroforestry returns as stocking rates increase. The essential difference with the present study is that a combination of factors, rather than just stocking rate, are considered in evaluating site profitability.

(ii) The model assumed optimum silvicultural programmes which produced a high proportion of clear timber. If tending was neglected there would be a corresponding fall in the profitability of the programme.

(iii) The farmer needs to consider his location relative to sawmills. Other studies have identified the significance of transport costs in influencing profitability. The case study farm was only 16 km from the nearest sawmill on a sealed road.

With respect to feasibility, cash-flow considerations are of overriding significance. In comparison to the benchmark model variable costs were lower in the agroforestry model. However, particularly in later years, gross farm income was also lower primarily as a result of the reduction in stock numbers carried. As a result net farm income was negative from year 11. It was not surprising that changes in cash availability had a marked effect on the rate of development of agroforestry.

The implications for farmers should be clear. A farmer contemplating agroforestry requires information on:

(i) The long term effect of an agroforestry programme on overall stock numbers

(ii) The likely effect on net cash flow, particularly of a reduction in livestock numbers.

Other factors were also shown to influence both the profitability and feasibility of an agroforestry programme. Within the ranges studied changes in labour availability had a relatively minor effect on the programme. However, in a situation where on-farm labour was not readily available for agroforestry, it is likely that more significant changes would have occurred.

Inspite of considerable debate over the effects of taxation changes on farm forestry profitability, this study suggests that changes in the tax-deductibility limits for forestry expenditure have a relatively small effect.

6.3 LAND USE

The majority of Wairarapa hill country farms have a range of land classes varying widely in their physical attributes, productivity, and potential use. Much past and present farm management practice, however, pays scant regard to this. Identical stock policies are normally practised across all land classes, while inputs such as fertilizer are often applied at a uniform rate. This is inspite of the fact that each land class will have its own unique set of production functions.

A feature of the model used in this study was that differences between land classes were explicitly recognised, with different activities available for each land class. Further development of the model could have highlighted these differences even further. An "All-Wool" activity, for example, may have been a more appropriate land use for some of the land classes in the model than the existing sheep breeding policy. With respect to an input such as fertilizer, a constant maintenance level was assumed for all land classes. This is unlikely to be true when land classes range from high fertility flats to steep, erosion prone hill country.

It is suggested that many farmers would benefit from an appraisal of both:

(i) appropriate land use
(ii) the level of inputs applicable to different land classes on their property.

Where available, soil and water conservation plans prepared by the Wairarapa Catchment Board with detailed land use capability surveys, would provide a useful starting point.

It is also suggested that this could be a fruitful area for farm management research; particularly as a focus for integrated studies.

6.4 IMPLICATIONS FOR THE WAIRARAPA DISTRICT

6.4.1 District Benefits and Costs

The development of on-farm agroforestry, as suggested by the results of this study, would bring obvious potential benefits to the Wairarapa district. It could:

(i) Lessen the dependence of the district on sheep and beef production by augmenting the already established timber industry.

(ii) Expand production without the marked loss in agricultural production and rural depopulation implied by conventional forestry.

(iii) Provide additional employment, both directly for workers in the timber industry and indirectly through multiplier effects.

(iv) In the longrun potentially improve the viability of much of the district's hill country.

While the Wairarapa is considered a low priority area for afforestation by the New Zealand Forest Service because of its isolation, its possession of one of the first pruned forests to mature gives it a comparative advantage for the production of quality timber products. With high transport costs, it may be to the district's strategic advantage to concentrate on the high value products that can be produced from clear timber.

An additional cost to the district of further forestry development, is the heavier demands on rural roads made by logging as opposed to farming vehicles. It has been estimated that over the course of a 28 year forest rotation, only dairying generates more trips per thousand hectares per year than forestry (Clough, P, 1987). A point of difference of course is that with forestry, peak traffic flows are concentrated during the years of harvesting, compounding roading problems.

6.4.2 Development of Agroforestry

No matter how potentially suitable or profitable agroforestry is, it will not have a significant impact on the Wairarapa unless adopted by a large number of farmers. The adoption by farmers of forestry and as a special case, agroforestry, to date has been low.

Three main types of factors are recognised as affecting the outcome of the adoption-decision process:

(i) The characteristics of the potential adopters.
(ii) The manner in which the innovation is communicated to them.
(iii) The nature of the innovation itself (Raintree, 1983).

As with all populations, hill country farmers vary widely in their rate of adoption of new techniques, ranging from the innovators to the slow adopters. Currently, many are under severe financial pressure and this is acting to restrict development options. Raintree (1983) suggests that the most effective strategy for promoting change is to develop technology applicable to the broad majority of farmers, rather than just the innovators and early adopters. Use may be made of the latter to demonstrate new technologies.

With respect to the extension process, there is considerable evidence that two-way models that involve farmers in developing the technology have a far greater likelihood of adoption than "those handed down from on high" (Raintree, 1983).

Ultimately, the rates of adoption of a new technology will depend on its attributes. Rogers and Shoemaker (1971) identify five main technology attributes associated with higher adoption rates:

- Relative perceived advantage
- Compatability with the local culture
- Low technical complexity
- Trialability
- Observability.

With agroforestry the long production period tends to reduce the perceived economic advantage and makes trialability, and observability more difficult. However, Raintree (1983) outlines strategies that can be devised to offset these constraints. These include:

(i) Use of the existing land-use system as a base. In the Wairarapa the extensive conservation plantings by the Wairarapa Catchment Board could well be a starting point for further agroforestry plantings.

(ii) Use of a problem solving approach to design. This makes the assumption that a technology is more likely to be adopted if it solves perceived problems. In the Wairarapa benefits from shelter, for example, could be emphasised as an intermediate benefit from agroforestry systems.

(iii) Profitability and feasibility. Farmers require quantitative information on the likely profitability and feasibility of an agroforestry investment. In this respect, the results of this research could be a basis for further appraising agroforestry.

It is axiomatic that any extension programme requires a suitable organisation to carry it out. A primary recommendation of this study is that the Wairarapa United Council investigate the feasibility of setting up a District Forest Association. This would comprise a grouping of forestry owners, processors, and relevant local bodies such as the Wairarapa Catchment Board. Its first function would be to pool local forestry knowledge and develop a forestry strategy for the Wairarapa.

Ultimately such a district association could develop along similar lines to those in Finland. It could:

Co-ordinate local farm forestry development and marketing; provide a comprehensive extension and management service to producers; either provide, or act as a vehicle, for joint venture developments.

It is suggested that the long term nature of agroforestry will require a district initiative if widespread development is to occur.

6.5 FURTHER MODEL DEVELOPMENT AND USE

The model developed in this study could be regarded as the first stage in developing more comprehensive whole farm economic models incorporating agroforestry. The Forest Research Institute has developed an agroforestry model and places a high priority on developing a whole property model (Knowles, 1987). It is suggested that the agroforestry model could be readily incorporated into this whole-farm model. With further development this would provide:

(i) A focus for stimulating interaction between researchers.

(ii) Provide the basis for developing a consulting service and extension tool.

For the latter, development of a "user-friendly" package would be essential, together with skilled personnel with a good knowledge of the use and limitations of linear programming.

A second line of development for this model could be for investigating land use options. Examples include: the effect of soil conservation programmes on farm profitability and feasibility, other livestock activities such as goats and deer, and changing fertilizer programmes. Again this could provide a focus for interaction between researchers and ultimately the development of consultancy services.

To conclude, a quote from Robert F. Kennedy might be appropriate: "Few of us have the greatness to bend history itself, but each of us can work to change a small portion of events, and in the total of those acts will be written the history of this generation".

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