Diversification of Wairarapa Hill Country : the Potential for Agroforestry.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

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The usual caveat applies to all those mentioned above.

ABSTRACT

The purpose of this study was to investigate the potential for agroforestry on Wairarapa Hill Country farms. It was set against a background of a marked decline in real farm income on hill country sheep and beef farms in recent years.

A broad perspective on project evaluation was taken with a review of the system components presented; covering hill country farming in New Zealand, the Wairarapa, Forestry in New Zealand, and Agroforestry.

The results of an intertemporal linear programming model covering a 21 year period, suggest that agroforestry can be both a profitable and feasible investment for Wairarapa Hill Country farmers. Profitability is shown to be strongly influenced by the suitability of planting sites and final timber value. With respect to feasibility, cash-flow considerations are of overriding importance. Together with factors considered outside the model, particularly the management of an integrated livestock and agroforestry property, the need for individual evaluation of each circumstance is stressed.

It is recommended that significant development of agroforestry in the Wairarapa will require some form of District Association to co-ordinate planting and marketing, and provide suitable extension and management services.

Further development of the model for both agroforestry and land use evaluation is suggested.

CHAPTER 1

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, 1984a). 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 a reduction in labour. While this lowers 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 additional land 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. A smaller population can reduce many rural services "telephone, roads, schooling, mail service, places to have social life and meet with others, stores, cartage, agricultural extension services, etc. all deteriorate and the distances people must travel to fulfill their family and farm needs increase greatly" (Kaplan, 1979).

(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, 1984b). 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. That intensification can be profitable, is well illustrated by a recent analysis of hill country farms by the N.Z.M.W.B.E.S. (1982). This indicates that farmers who had lifted output per hectare significantly over the 10 year period concerned kept their incomes ahead of inflation (Figure 1.1).

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. Already many hill country farmers have successfully implemented new grazing enterprises including bull beef, goats, and deer. In selected areas, for example the Mangamahu Valley near Wanganui, new horticultural ventures have been successful.

Diversification shares with intensification the potential to benefit the district and the nation. It requires skilful 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 thesis focusses on and in particular the issues involved for farmers diversifying into trees for timber production. Special emphasis is placed on the integration of trees into sheep and beef farms under agroforestry systems. Such production systems have the potential to increase the total productivity of plant and animal from a given area and are particularly suitable for "marginal" land (Nair, 1984).

The study was conducted in the Wairarapa district occupying the south-eastern area of the North Island of New Zealand (Figure 1.2). The district is broadly representative of a very large area of hill country with considerable areas of "marginal" land.

Several studies in New Zealand have indicated that agroforestry can be profitable from both a farm and national viewpoint (Jackman and Knowles, 1973; Arthur-Worsop, 1984; Walker, 1984). However relatively little work has been done on the economic feasibility of agroforestry for hill country farmers.

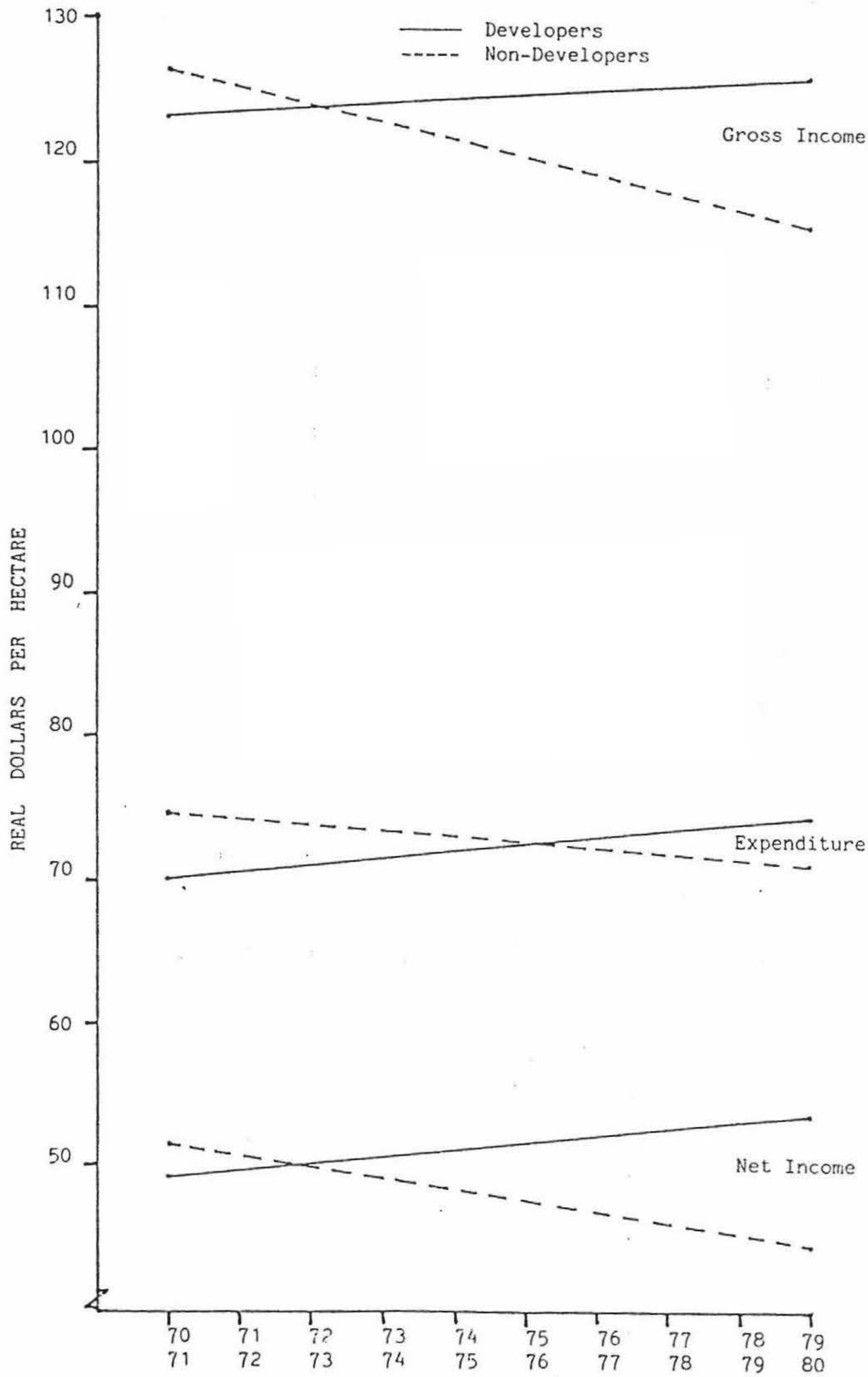


Figure 1.1 North Island Trends in Income and Expenditure (Real Terms 1975/76) 1970/71 - 1979/80

Source: N.Z. Meat and Wool Board's Economic Service (1982)

Figure 1.2 District and Farm Location

Source: Department of Lands and Survey, N.Z.M.S. 265 North Island Edition 2

1.2 PHYSICAL AND ECONOMIC FEATURES OF HILL COUNTRY FARMING SYSTEMS IN NEW ZEALAND

1.2.1 The Significance of Hill Country Farming

Hill country represents a resource of major importance to the economy of New Zealand. Of the 13m ha of pastoral land in New Zealand (N.Z. Agr. Stats, 1985) about 4.5m ha can be classed as "predominantly non-ploughable land" or hill country (Brougham, 1973). This carries an estimated 45% of the nations stock units of 105m (NZMWBES, 1982) while half of all sheep and beef farms are on hill country (Taylor, 1984b).

In the North Island, hill country represents about 54% of the total area and this alone is estimated to carry 25% of New Zealand's stock units (Scott, 1981). In 1984/85 pastoral farming products contributed $m5706 or 50% of New Zealand's export receipts (New Zealand Agr. Stats, 1986).

While the direct contribution of hill country to New Zealand's economy is clear, hill country also makes an indirect contribution through its role as a supplier of sheep and beef to downland farms (Hight, 1976). Hill country farms employ more than 15,000 people and indirectly provide many more jobs for the servicing sector.

1.2.2 Physical Aspects

The title "hill country" covers a wide variety of land types differing in climate, soil, topography, and vegetation. Often a distinction is drawn between farms in wet or dry areas, the former constitutes approximately 3.6m ha and receives an annual rainfall of between 1000 - 2500 mm, the balance of 0.9m ha receives between 350 - 1000 mm per annum (Brougham and Grant, 1976). This difference in rainfall has led to an average carrying capacity for dry hill country of about 4 SU/ha and wet hill country of 10 SU/ha.

Such a broad band disguises the marked differences in climate and microclimate experienced in hill country, often in very short distances, as a consequence of steep slopes and changing aspects. In all parts of the country however, the climate permits in situ grazing and this has been a key factor in developing New Zealand's low cost grazing systems.

Soils also vary markedly with many hill farms having mixtures of hill soils (those on slopes from 18 - 30 degrees) and steepland soils (soils on slopes > 30 degrees) (Gillingham, 1982). Commonly these soils are shallow, prone to erosion in its various forms, and require fertiliser to maintain present levels of production.

With markedly different climates, soils, and states of development pasture composition and production is also highly variable (Table 1.1).

Table 1.1 General Groupings of Pasture Plants in Hill Country

	Summer-dry		Summer-wet
		LEGUMES	
High Fertility	White Clover Barrel medic Clustered clover Suckling clover Lotus annuals		Red Clover Lotus major Suckling clover
		GRASSES	
Low Fertility	Perennial ryegrass Kikuyu Cocksfoot Poa annua Browntop Sweet Vernal Carpet grass Chewings fescue Ratstail Danthonia Hairgrass		Perennial ryegrass Kikuyu Poa Trivialis Browntop

(Source: Sheath, 1982)

Hight (1976) mentions that up to 9000 kg DM/ha have been recorded on dry hill faces and up to 13,000 kg on wet hill faces, with highest recorded carrying capacities of 18-20 SU/ha.

In many areas the presence of perennial weeds such as gorse and blackberry as well as reversion to native scrub impose extra costs in maintaining pastures.

1.2.3 Historical Aspects: The Development of Hill Country.

The development of hill country farming in the North Island dates from the 1850's with the felling and burning of the original forest cover. Development peaked between 1890 and 1914 to the extent that by the latter date the initial clearance of bush for farming was largely complete (O'Connor, 1970).

A technological breakthrough, the development of refrigeration, provided the key for this development. With the first shipment of frozen beef from New Zealand in 1882 came the progressive realisation that it would be possible to successfully ship perishable products overseas, primarily the United Kingdom. Other factors acted to facilitate the pace of development, among them;

- the presence of settlers who wished to develop farms.
- a Liberal Government which acted to ensure land was available for such development.
- the development of railway routes and roads that opened up the country.

Of particular importance was that all of this coincided with a period of rising prices in world markets for this produce. In 1912 a Government appointed commission on the cost of living in New Zealand calculated that between 1890 and 1912 export prices rose by some 40% while the cost of imported goods went up no more than 3-4% (O'Connor, 1970).

By the 1920's the present system of hill country farming had been developed. Both cattle and sheep were normally carried with the cattle having a primary role of keeping as much secondary growth as possible from establishing itself. Store lambs and surplus sheep and cattle found a ready market among downland farms. Initially the Lincoln breed of sheep proved the most suitable for foraging amongst charred forest remains and keeping regrowth down. However once over the development period, the Romney breed proved superior so that by 1913 it had become the most important breed.

In the early 1920's economic conditions changed with a severe fall in price of most primary products and this culminated in even lower returns during the Depression in the early 1930's. At the same time the initial boost of fertility was declining and this was followed in turn by lower grass growth and a lower stock carrying capacity. In places the land started to revert to its natural state while erosion also started becoming a problem. Once the stumps and roots of the original forest rotted away, slip and gully erosion commenced, threatening the stability of not only the hill country farms but also farms on the flood plains of rivers having their catchment areas in eroded hill country.

On downland farms intensive pasture management techniques started to be applied in the 1930's. Lime and fertiliser use increased dramatically, improved pastures were sown and mechanisation started having an impact. In contrast, little technological change was possible on hill country farms. This had to wait until the late 1940's when, in particular, aerial topdressing with superphosphate commenced. It now became possible to arrest the decline in fertility: as well aerial spreading of new weedkillers, rabbit and possum poisons, and seeds all contributed to the development of hill country.

As with the first phase of development a new generation of farmers were ready to commence farming, particularly returned servicemen and again the Government of the day acted to ensure land was available for development. A further point of commonality with the first phase were the rising prices for produce, particularly wool in the early 1950's.

The 1950's and 1960's constituted a period of relative stability for hill country farmers. There was an assured market for their produce and farmers were not under undue cost-price pressures. New machinery and equipment particularly tractors and four wheel drive vehicles served to increase the productivity of farm labour (Milne, 1969) while modifications continued to be made to farming systems. These included higher stocking rates, second shearing, and the use of cross breeds. Perhaps the most evident factor of this period was a steady increase in sheep and cattle numbers. Associated with this was a marked increase in flock size per farm. From 1956 to 1966 the average flock size per owner increased from 1650 sheep to 1994 sheep (Milne, 1969).

This period also saw soil conservation commence, primarily through the action of various Catchment Boards under the auspices of the Soil and Water Conservation Organisation. This work has had a significant impact in not only helping to stabilise large areas of hill country but in influencing farm development and production increases (King, 1982). In terms of the research topic, this marked the first widespread reintroduction of trees into hill country following its clearance.

At the end of the 1960's the steady increase in stock numbers tapered off. Several reasons have been advanced for this and were summarised by McLean (1978) as;

- Climate: several poor seasons in the early 1970's.
- Economic: lower farm incomes led to lower investment by farmers.
- Behavioural: lack of confidence by farmers and disillusionment at lack of support by the community.
- Technical: fewer major technical advance than in the past.

In response to the economic problems, the Government introduced the Livestock Incentive Scheme and Land Development Encouragement Loan Scheme to help stimulate output in the face of falling farm incomes. Both schemes gave a considerable impetus to growth in stock numbers and output. In June 1981 sheep and beef cattle units had increased to 86m compared to 76m in June 1971. At the same time, continued technological advancement enabled higher stocking rates to be carried, particularly in the field of fencing. This occurred in tandem with grazing management changes that saw significant numbers of hill country farmers start to manage pastures with the same intensity as the dairy farmer four decades earlier.

The late 1970's and 80's have also seen significant development in diversification commence on hill country farms. To date primary interest has centred on livestock activities such as deer and goats (Table 1.2).

Table 1.2 Deer and Goat Statistics, 1986 ('000 head)

	1982	1983	1984	1985*
(est)				
Female deer (1 year and over)	70.9	95.7	128.6	174
Total deer	151.0	195.6	258.7	335
Female goats (1 year and over)	57.9	90.0	145.1	225
Total goats	72.4	150.4	230.4	360

* estimated

Source (Agr. Stat)

Currently all pastoral farmers are experiencing a severe downturn with low returns and a marked increase in costs, particularly debt servicing. As a result livestock numbers are falling as many hill country farmers retrench and seek to reduce their level of debt.

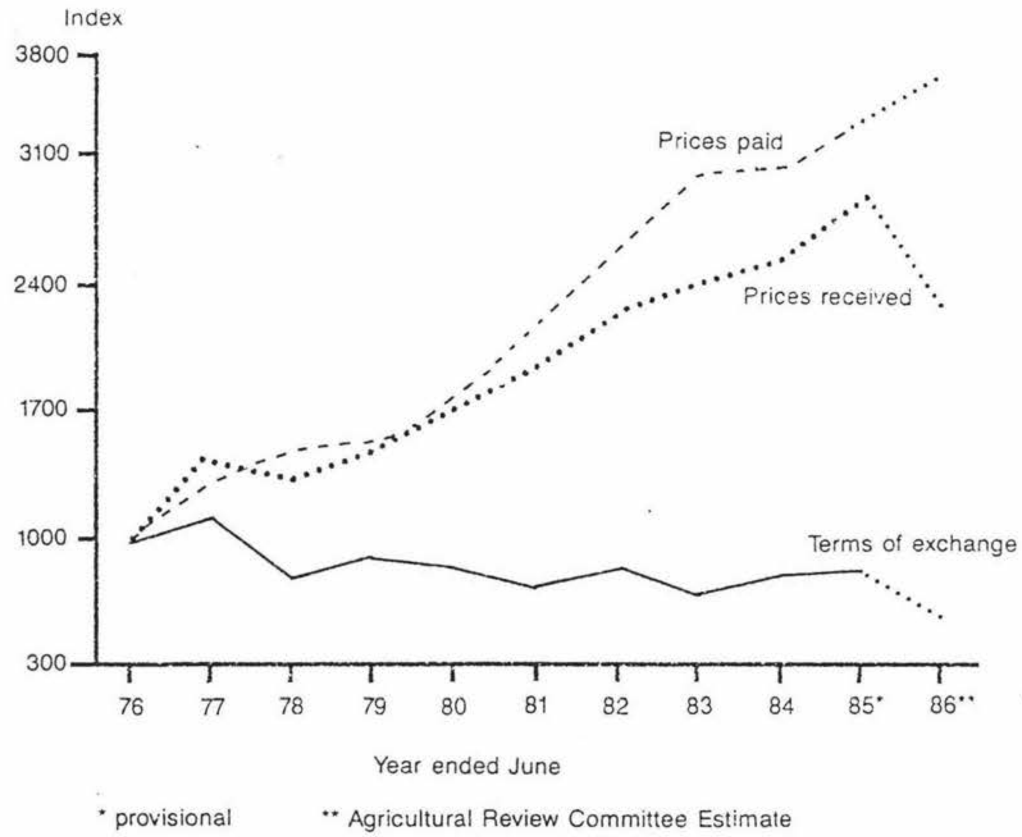
This brief summary of hill country serves to indicate two basic points. Firstly, that under appropriate economic circumstances hill country farmers have intensified their farming systems and have in more recent years demonstrated a willingness to try new production systems. Secondly, and associated with this, has been a willingness to adopt new technology.

1.2.4 Current Economic Features of Hill Country

Hill country farming today is under severe economic pressure. The terms of exchange at the farm gate have continued to deteriorate in response to a high level of inflation and interest rates in New Zealand (Figure 1.3). Taylor (1984b) points out that if New Zealand had rates of inflation equal to OECD rates in the five years from 1977/78, even without subsidised prices our terms of exchange would have risen by 9.7%.

Other factors have also acted to exarcerbate current problems. The substantial lift in production in the mid 1970's encouraged by Government assistance measures, coincided with contracting traditional markets and led to a downward pressure on prices (Durbin, 1985). Initially Supplementary Minimum Prices and the Meat Income Stabilisation Account helped to maintain farmers' incomes. However these assistance measures effectively ceased at the end of the 1984/85 season and significant falls in prices paid to producers resulted. Even before this recent fall, in 1984 it was estimated that net incomes had in real terms fallen to a level only 53% of those in the mid 1970's (Taylor, 1984b).

Figure 1.3 Sheep and Beef Farm Terms of Exchange



Source: State of Agriculture (1985-86)

As a consequence of the above changes farmers in general have become increasingly dependent on outside sources of funds for both current and development expenditure. This contrasts with the 1950's and the 1960's where much development was undertaken from retained profits. In addition, in the current economic climate interest rates have risen substantially. As a consequence interest rates now form a relatively large proportion of farm costs at around 18% for sheep and beef farmers (Brook and Crengle, 1985). While average indebtedness is not high serious problems are likely when high debt servicing is associated with lower output per stock unit (Taylor, 1984b).

Not surprisingly, reinvestment in hill country is now at a low level. A key indicator of this is shown in fertiliser use, estimated to have fallen 52% between 1984/85 and 1985/86 for the all classes average sheep and beef farm.

It is highly likely that current stocking rates will not be maintained while recently developed country will revert. As in the past, the problem is most acute on the more remote and difficult country with low stocking rates and comparatively low returns.

Under these circumstances there is considerable debate on the appropriate land use for hill country. These range from variations to traditional policies, for example all wool farming as opposed to breeding, through other grazing alternatives, to agroforestry and forestry. Clearly modifications to existing policies and new strategies will be required if hill country farming is to remain viable.

1.3 NEW FARMING SYSTEMS AND THE FARM MANAGEMENT PROCESS

The consideration and possible adoption of an entirely new production system forces a farmer into a learning situation with many aspects to consider and act upon. It is therefore instructive to consider the nature of farm management and the farm management process, and the insight it may provide for considering new production systems.

1.3.1 Management

If we consider what is meant by management then it is clear that management can be defined in many ways and mean different things to different people. Three basic views can be distinguished (Osburn and Schneeburger, 1983). They are:

- management as a job; the idea of being paid for performing the tasks of running a business.
- management as a resource, the awareness that the human factor is crucial to the performance of a business.
- management as a procedure; the act or manner of controlling the process of executing a given policy (Cary, 1980).

In this context the third view is most relevant as it draws our attention to the underlying processes of management rather than simply the tasks as in the first view or the product of management as is implied by the second. We can consider management as a process because it involves a systematic series of actions which are directed towards some end (Parker, 1984). In management literature this is referred to as the problem solving or decision making process. Eight main steps or activities are normally recognised by management texts. These are:

1. Formulation of goals and objectives of the firm.
2. Recognition and definition of problems and opportunities.
3. Gathering and organisation of facts.
4. Analysis of alternative sources of action.
5. Decision making based on sound criteria.
6. Implementation: acting on the decision.
7. Acceptance of responsibility for the decision regardless of the outcome.

8. Evaluation of the outcome of the decision.
(Osburn and Schneeberger, 1983).

In some definitions the first and last step are omitted (e.g. Johnson, 1976) and may be treated as part of a separate process. Scoullar (1975) for instance, hypothesises that the management process is in fact two processes - the problem solving process and the goal achievement process. Such a view highlights the suggestion that management involves not only decisions about means to achieving ends, but also decisions about the ends themselves. The problem solving process is concerned with recognising a problem and selecting the best alternative to overcome the problem (Scoullar, 1975) while the goal achievement process could be seen as "a dynamic cycle of setting goals, achieving or not achieving goals, evaluating goal achievement, and perhaps establishing further goals or modifying goals" (Cary, 1980). In practice the two processes cannot be separated; actions are influenced by what an individual thinks the situation should be like and what he can do about it, while goals are influenced by his perception of what he can do.

The problem solving process may be seen as the link between reflection and action; as such it is a fundamental human activity and in fact is synonymous with the learning process (Kolb et al, 1974). While the steps are listed in a systematic order, problem solving is in fact an interactive process with feedback loops between all the steps, while the steps are not always in the same order. This serves to emphasise that the problem solving process is really only a model of reality, albeit a very useful one.

Using the problem solving process as a basis for considering management confers a number of advantages. These include:

(i) Placing a broad perspective on management through not specifying the functions that managers need to undertake for "effective" management behaviour.

(ii) Providing a suitable framework from which to draw on theories or activities. These are only drawn on if they are relevant to the problem solving process.

(iii) Recognising that management is a form of human behaviour rather than a science or an art (Cary, 1980).

1.3.2 Farm Management

In defining farm management, we need to reflect the special characteristics of farm versus other forms of management (Parker, 1984). A definition which accomplishes this more accurately than most has been provided by Dillon (1980) who defines farms management as: "the process by which resources and situations are manipulated by the farm manager in trying with less than full information to achieve his goals." This definition captures the decision making process of management as well as some of the characteristics applicable to farming. These include:

- the dynamics of the farm system and its environment.
- the need for a farmer to handle situations as well as resources.
- the active role of manipulation as opposed to the more passive role of organising and controlling.
- the uncertain nature of the farmer's decisions, so objectives are attempted rather than necessarily attained.

Within such a definition we can then outline the possible functions of farm management. Three basic functions of management have been defined as planning, implementation, and control (Barnard and Nix, 1973). Planning has been conceived by Ackoff (1970) as "the design of a desired future and of effective ways of bringing it about", and defined in more pragmatic terms by Barnard and Nix (1973) as "the allocation of resources in a manner which best satisfies the objectives of the individual."

Implementation or organising, involves selecting the best alternative and taking action to put the plan into operation (Kay, 1981). Putting the plan into operation may involve both acquiring the necessary resources and then managing them over time as they are being used.

The third function, that of control, provides for observing the results of the implemented plan to see if the specified goals and objectives are being met as well as making the necessary adjustments if they are not (Kay, 1981).

While useful to distinguish conceptually, in reality the functions of farm management overlap and may be difficult to distinguish in practice (Barnard and Nix, 1973).

1.3.3 Strategic Planning and New Production Systems.

Farm management textbooks and farm management research provide considerable information on the economic principles and budgeting techniques that assist a farmer with the question "what to produce?" However, little assistance is given in the selection of enterprises that a farmer should consider in any particular circumstances beyond the time honoured ones of considering his resources of land, labour, capital, and his own personal qualities, in relation to the resource requirements of different enterprises.

In contrast management research and practice at firm and particularly corporate level has been concerned with developing strategic (corporate) planning; "The formal process of developing objectives for the corporation and its component parts, evolving alternative strategies to achieve these objectives and doing this against a background of a systematic appraisal of internal strengths and weaknesses and external environmental changes" (Irving, 1970 as cited by Hussey, 1982). Strategic planning has been described more succinctly as "preparing todays business for the future" (Drucker, 1977). In one sense strategic planning as defined can be treated as the complete management process.

In the present context it is taken as the application of the decision making process to the planning function of management.

The factors that led to this management discipline have been noted by Taylor and Wills (1971) as including:
Rapid decline of traditional markets with changing patterns of consumption and distribution;
Products rendered obsolete by new developments in technology;
Invasion of home markets by foreign producers.

Similar marked and rapid changes have also occurred in agriculture; for example in the context of New Zealand hill country recent changes include:
A decline in red meat consumption in western countries;
Changing markets for meat and wool;
Increased competition by white meat alternatives;
Severe competition in traditional markets, particularly for meat by the EEC;
The challenge of synthetics to wool; etc.

While the primary factors for success in a business must be the skill, judgment, and ability of the manager, there is considerable evidence that corporations practicing stratetic planning have significantly outperformed those that did little or no formal planning (Hussey, 1982). While it is not clear that a similar strategy may also assist the small business such as the family farm, elements of strategic planning could well be applicable. Like all businesses, farmers need to consider such basic questions outlined by Drucker (1977) as:
What is the business?
What will it be?
What should it be?

It is only very recently that the concepts of strategic planning have begun to be applied to the small business (Curtis, 1983). It has been claimed, but not yet researched, that applying the principle of strategic planning to the small business may:

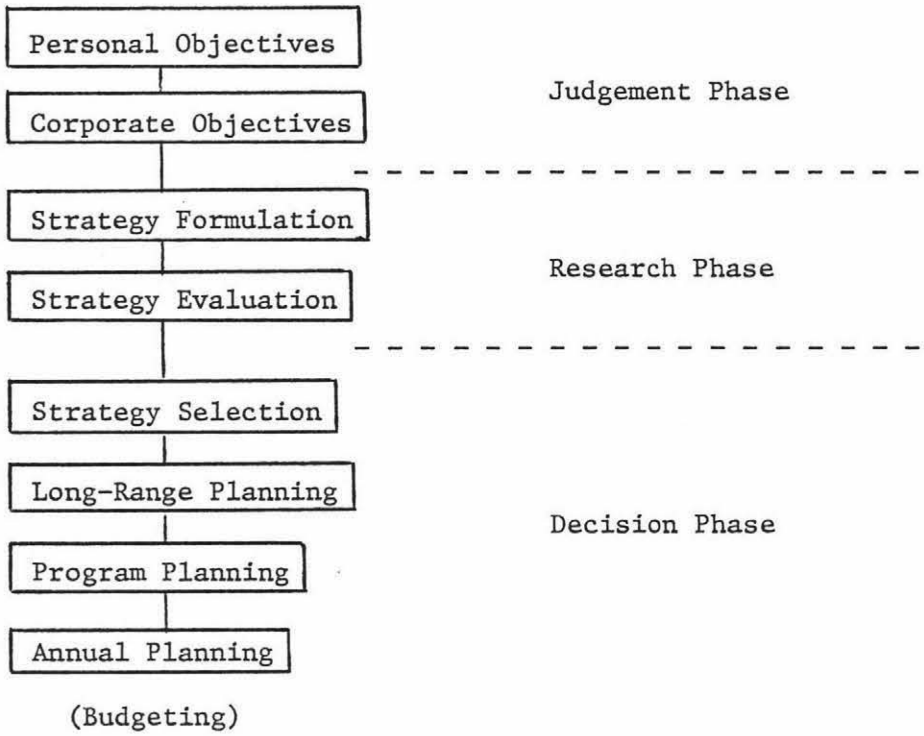
Improve profitability;

Increase satisfaction from using the firm as a vehicle to achieve personal ambitions;

Help the manager in knowing how to assess threats and opportunities, and how to change the business to meet the new conditions (Curtis, 1983).

If we accept the proposition that "planning is one of the most complex and difficult intellectual activities in which man can engage" (Ackoff, 1970) then a formalised process which assists in this is at least worth examining. The elements of the strategic process as they might apply for a smaller firm such as a farm are indicated in Figure 1.4.

Figure 1.4 The Strategic Planning Process for Smaller Businesses



From Curtis, 1983

In particular the strategic planning process allows for the consideration of new production systems in a formalised and comprehensive manner.

1.4 OBJECTIVES AND OUTLINE OF THESIS

1.4.1 Objectives

In this chapter some of the background to a real need to lift the long term profitability of farming in hill country has been presented. With evidence that agroforestry can be both an appropriate and profitable land use, this study considers 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?

Primary emphasis in the study is on the development of a whole farm economic model that incorporates agroforestry alternatives. However, the proceeding discussion would serve to emphasise that this represents only part of the evaluation of strategic alternatives by the farmer. The use of optimisation models for the broader task of strategic planning is still in its infancy (Naylor and Thomas, 1984). No attempt is made to examine the complete strategic planning process as it might apply to a hill country farmer. However attention is drawn to some of the broader issues of project evaluation not met by the whole farm model. These include:

(i) An analysis of a hill country farm,

(ii) An overview of the hill country physical and economic environment including future markets for timber,

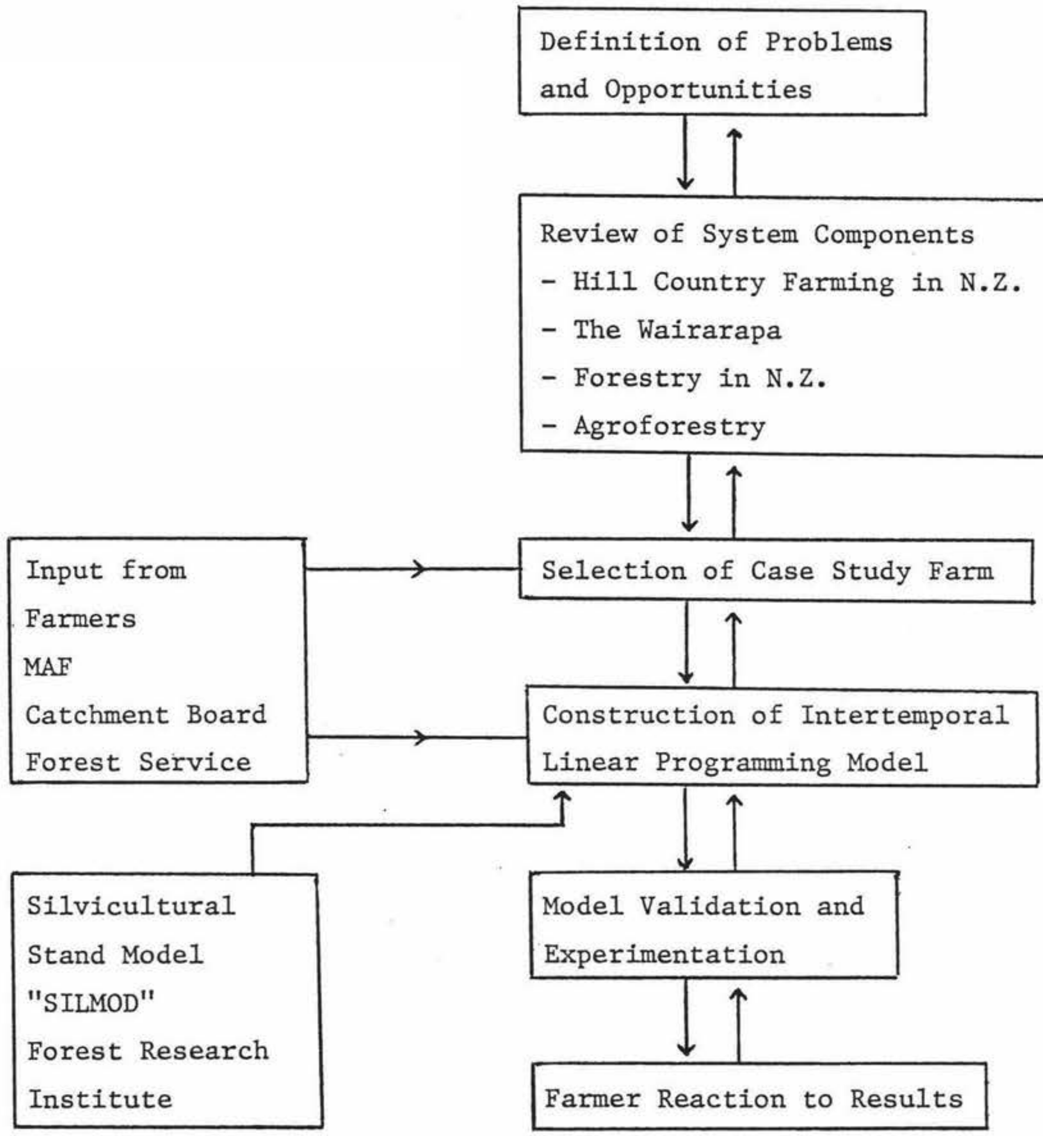
(iii) Agroforestry as an investment;
   - farmer objectives
   - returns
   - effect on farm cash flow
   - integration with existing enterprises
   - management requirements
   - marketing strategies

(iv) Implementation of agroforestry systems.

1.4.2 Thesis Research Methodology

An outline of the methodology to be used is indicated in Figure 1.5. It represents an application of the decision making process to meet the particular context and objectives of this study.

Figure 1.5 Outline of Thesis Research Methodology



The first phase of defining problems and opportunities has been initiated in this chapter. The second phase also started, will further this process and provide a review of all the major components of the system under study. This includes:

- an appreciation of the factors influencing the development of hill country farming systems (Chapter 1);
- the physical and farm system characteristics of the Wairarapa district (Chapter 2);

- forestry in New Zealand (Chapter 3);
- agroforestry as a production system (Chapter 4).

The third and fourth phases of case study farm selection and model construction are covered in chapter 5. Use of a case study farm provides an opportunity for early interaction with a farmer and will provide "real" information for model construction. Assistance and information will be sought from the Ministry of Agriculture and Fisheries, Wairarapa Catchment Board, New Zealand Forest Service, and farmers during this process.

The purpose of the model will be to develop an optimal feasible strategy for the case study farm incorporating both existing agricultural activities and agroforestry alternatives (Chapter 6). In addition to inputs from the above sources, the Silvicultural Stand Model developed by the Forest Research Institute will be used to provide data for the forest component.

Once constructed, validation and experimentation with the model will be carried out to provide solutions for the study objectives (Chapter 7). The "final" phase of the study will seek informal reactions from the farmer. It is thought that both the results and discussion will generate further insight into the problems and opportunities for hill country farmers investing in agroforestry (Chapter 8). The double headed arrows linking each phase of the study indicate the interactive nature of the methodology to be used.

CHAPTER II

THE WAIRARAPA

2.1 DEVELOPMENT OF THE WAIRARAPA

The Wairarapa district is bounded on the west by the Tararua Ranges and on the south and east by the sea. The northern boundary runs east from the Tararua Ranges through the area south of Pahiatua to the sea on the west. Prior to European settlement much of the region was covered in indigenous forest, scrub, fern, and swamp vegetation. The open character of the lower Wairarapa Valley with its cover of fern and coarse grass led to the establishment of New Zealand's first two sheep stations in 1844. Within a year 12 more stations were occupied (Bagnall, 1971) and development since that date has primarily been associated with the growth of pastoral farming.

Initially development was tied to the clearance of the bush with milling constituting a major activity in the latter part of the 19th century. However by the 1920's indigenous timber in quantity, was virtually exhausted (Bagnall, 1971). The dominance of pastoral farming is indicated by the extent of grassland (Table 2.1).

Table 2.1 Areas of Dominant Vegetation Groups for the Southern Hawkes Bay - Wairarapa Region

Vegetation Group	Area (ha)	Percent of Region
Grassland	1,202,940	84.6
Cropland	5,880	0.4
Scrubland	121,630	8.5
Forest	65,180	4.6
Weeds, Herbs	3,870	0.2
Area not mapped (rivers, lakes, urban area) etc	24,120	1.7
Total	1,422,620	100.00

Source (Noble, 1985)

Masterton is the main centre with a population of 19,700 with the smaller towns being Featherston, Martinborough, Greytown, Carterton and Eketahuna. Most of the towns developed during the early days as small subdivisions, some dating from the 1850's. With improved roads and transport some of the smaller towns have found it difficult to progress (Booth and Gibbs, 1969).

Compared to other districts within New Zealand the Wairarapa is still relatively isolated with no effective coastal ports, while the local airfield has only recently been sealed. In hill country areas many roads are still narrow and torturous. Servicing industries however are well established with saleyards in main centres, a freezing works at Waingawa, fertiliser works at Mangatinoka and Waingawa and lime works at Mauriceville, Masterton, and Martinborough. Sawmills located in the Wairarapa at present have a cutting capacity of 81,000m3/per annum and handle local wood production without difficulty.

2.2 PHYSICAL FEATURES

2.2.1 Physiography

Three natural physiographic regions can be identified in the Wairarapa (Noble, 1985).

(i) Axial mountain ranges and foothills. Only the eastern side of the Ruahine Ranges are included in the region. They are steep and rugged with peaks rising to over 1500 m asl.

(ii) Central Lowlands. These consist of a central trough of plains, terraces and low hill country formed from very young sedimentary rocks. The major river system, the Ruamahanga river, together with numerous other rivers with headwaters in the Tararua Ranges have built up broad fertile plains.

(iii) Eastern hill country. This comprises rolling to steep hill country to the east of the central lowlands, below 600m asl and formed of Cretaceous and tertiary sedimentary rocks. Steeper mountain ranges are also included in this area and include the Waewaepa Range (760m asl), the Puketoi Range (800 m asl) and the Aorangi mountains (980m asl).

A significant feature is that part of the region is contained within the "East Coast Fold Belt." This includes the Wairarapa Fault which runs from Palliser Bay in a north-easterly direction along the eastern side of the Rimutaka and Tararua Ranges to east of Woodville. There are many parallel faults with a NE-SW alignment including some that are presently active (Noble, 1985). These often have wide crush zones associated with them which are particularly susceptible to severe mass movement erosion.

2.2.2 Rock Types

Rock types in the Wairarapa region are sedimentary and form a very complex pattern. Thus the river terrace systems are comprised of recent gravels and alluvial flood plain deposits. The majority of hill country, especially in eastern parts of the region, comprises tertiary sediments of sandstone, siltstone, mudstone or limestone. However, part of the region is covered by loessial deposits overlying these sediments. The four most extensive rock types comprising 53 percent of the Southern Hawkes Bay-Wairarapa region are loess, jointed mudstone, greywacke, and alluvium.

The exial mountain ranges as well as the Aorangi, Waewaepa, and Wakarara Ranges and areas of the coastal "taipo" country are formed of greywacke.

2.2.3 Soils

The variety of rock materials as well as changes in the local conditions of formation have led to soils of the Wairarapa differing widely in their texture, structure, nutrients, drainage and other properties (Booth and Gibbs, 1969). In turn agricultural production from these soils varies immensely.

The area of the land use capability classes for the Southern Hawkes Bay - Wairarapa Region are shown below (Table 2.2).

Table 2.2 Land Use Capability Classes

LUC Class *)	Area (ha)	Percent of Region
I	18,000	1.3
II	74,810	5.2
III	217,170	15.3
IV	101,830	7.1
V	29,640	2.1
VI	620,480	43.6
VII	285,620	20.1
VIII	50,950	3.6
Areas not mapped	24,120	1.7
Total	1,422,620	100.0

*) For a full description of each of the Land Use Classes see Appendis I, (Source Noble, 1985)

2.2.4 Climate

The Wairarapa climate is generally noted as being hot and dry in summer and cold and wet in winter. Summer temperatures frequently rise above 25 degrees Cent. in sheltered inland areas and may exceed 32 degrees Cent., while winter frosts may be as low as -9 C. However another feature is the highly variable nature of the climate; seasons tend to be unpredictable with, for example, in some autumns a very quick change from hot and dry to cold and wet (Booth and Gibbs, 1969). Like other regions east of the main ranges, the Wairarapa can experience short and sudden changes in temperature (Thompson, 1982).

There is considerable variation in rainfall recorded throughout the region ranging from about 800 mm in the Wairarapa Valley to more than 2000 mm on the Ruketoi Range and the Aorangi Mountains and over 4000 mm recorded on the summit of the Ruahine Range (See Figure 2.1).

Most of the eastern coastal hill country has an annual rainfall between 1000 - 1400 mm. However much of this rain occurs during winter from easterly and southerly winds. Very little rain comes from the west as a result of the rainshadow effect of the Ruahine and Tararua Ranges. Further, the eastern hills are exposed to persistently strong westerly winds during the spring and autumn equinoxes, depleting soil moisture reserves and retarding pasture growth. The coastal ranges cause a rainshadow effect in inland areas from S-SE rain, and have an important orographic effect in localising rainfall.

It is usual for the Wairarapa region to experience a dry period each year, especially in summer when rainfall is least and temperatures highest. During the period 1884 to 1981 there were 87 periods of 15 consecutive days when there has been no measurable rainfall and 151 dry spells (at least 15 consecutive days, none of which has 1 mm or more rain) in the Masterton Borough area (Thompson, 1982). The variability in seasonal and annual rainfall in the Wairarapa is similar to other East Coast districts in New Zealand and generally higher than many western areas. Further, the rainfall is more variable in summer than winter and becomes more variable the further away the location is from the western ranges (Thompson 1982).

While there are some sheltered areas in the Wairarapa, on the whole it is a windy location. The prevailing westerly winds over New Zealand are modified by the orography of the Wairarapa, in that Cook Strait and the Manawatu Gorge have the effect of funnelling airstreams, resulting in north-westerlies and south-westerlies prevailing east of the Manawatu Gorge and the Rimutaka and Tararua Ranges respectively. Easterly and southerly winds usually bring rain and colder temperatures and are more frequent in winter. Westerly winds, which predominate during the spring and autumn equinoxes, are occasionally of fale force and frequently strong enough to significantly effect plant growth through the rapid depletion of soil moisture.

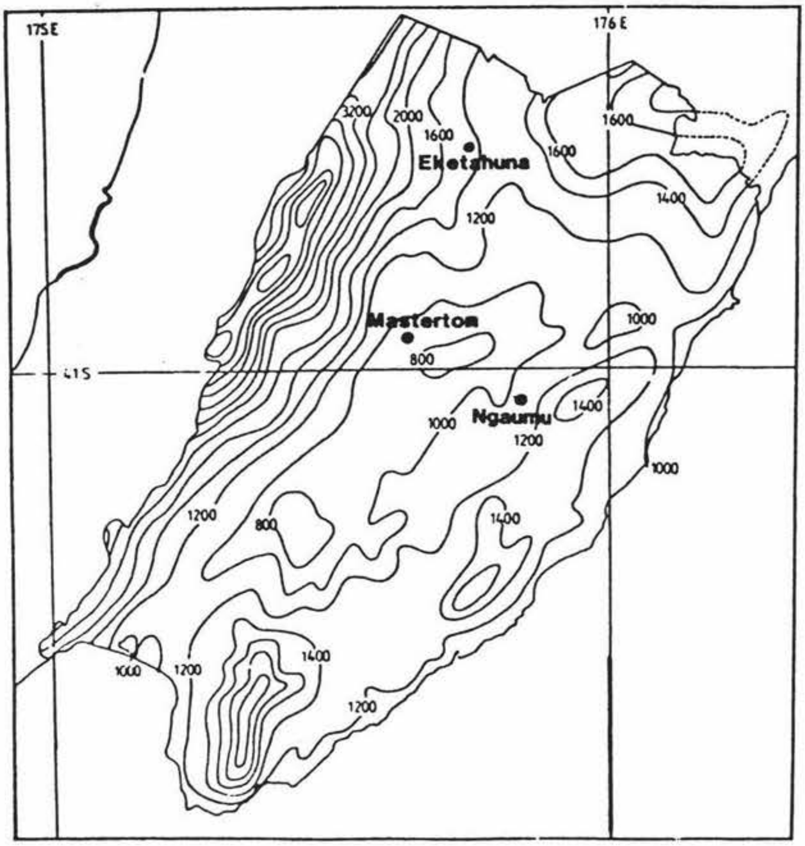
A feature of the eastern hill country is the modifying effect of topography on microclimate. North and north-westerly slopes and ridges are more severely dessicated than lower slopes while south-westerly slopes are more sheltered and subject to far less moisture variation (Noble, 1985).

2.2.5 Pasture Production

No detailed information on the pattern of seasonal pasture growth in the Wairarapa was published until 1975. At that time Radcliffe (1975) published the results for 5 years of measurements on a site 8 km south of Masterton on the Wairarapa plain (Figure 2.2). The seasonal pattern of growth indicated that spring growth began in mid August, and had a very marked spring peak when nearly half the annual growth was produced. The onset of spring growth is associated with a rise in soil temperature and continues until November when moisture levels are beginning to decline. Both summer and autumn growth was variable and reflected "the severe limitations on pasture growth imposed by warm temperatures and moisture stress" (Radcliff, 1975). The seasonal proportion of yields indicated about 16% of annual pasture production is produced in the winter, 46% in spring, 11% in summer and 22% in autumn.

Further measurements since then have produced similar patterns of pasture production in other dryland locations in the Southern Hawkes Bay - Wairarapa area (Figure 2.3). Significant differences are observed in higher altitude areas where spring growth occurs later, but with more reliable December rainfall, often continuing into January. Autumn production also tends to be higher but with colder soil temperatures reducing winter pasture production.

Figure 2.1 Mean Annual Rainfall (mm) 1941-70 for the Wairarapa Region



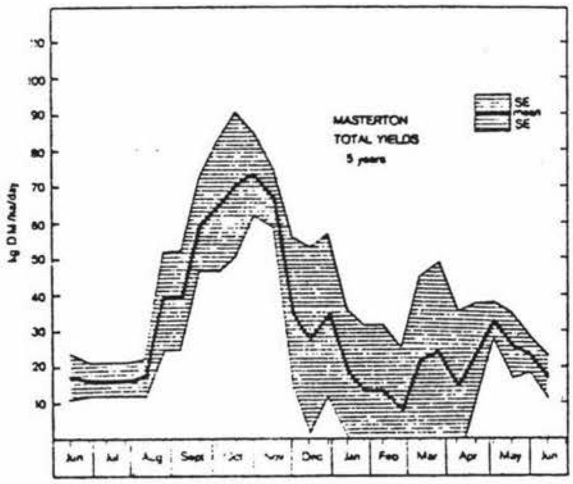
Source: Thompson 1982

An aspect of pasture production is the marked variation in productivity between sites. Thus Parker (1984) observes pasture production on the easier improved hill country pastures as about 10500 kg DM/ha and between 7000 - 8000 kg DM/ha on steeper improved pastures, while on unimproved low fertility ones it could be less than 5000 kg DM/ha. Land capability units recorded in the Wairarapa indicate carrying capacity for "average" use as ranging from 1 to 15 SU/ha (Noble/ 1985). Factors contributing to differences in pasture production include soil fertility and water holding capacity, slope, aspect, fertilizer history and pasture management.

2.2.6 Soil Erosion

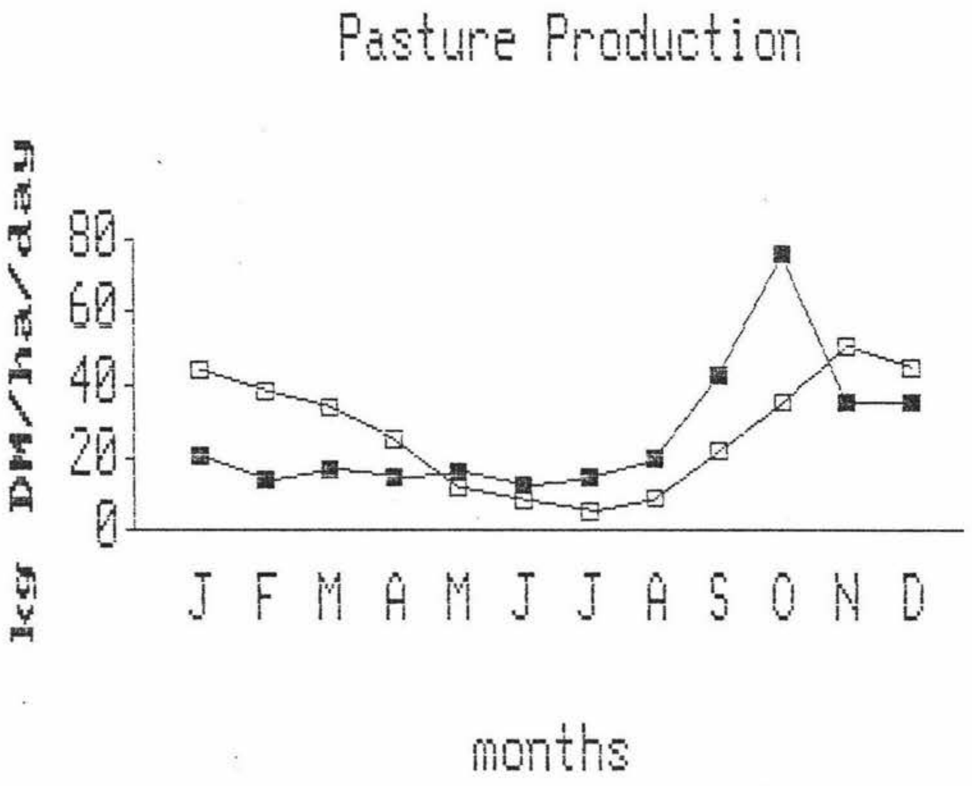
A feature of the East Coast of the North Island in general is the extent and diversity of erosion. For the Southern Hawkes Bay Wairarapa region a large proportion of the area is affected by erosion in various forms (Table 2.3). Major damage was caused in the 1964 and 1977 floods with minor events in between.

Figure 2.2 Masterton - Seasonal Distribution of Pasture Growth Rates and Standard Errors



Source: Radcliffe, 1975

Figure 2.3 Effect of Location on Pasture Production



□ Marima - wet zone

■ Rawhiti - dry zone

Source: Ministry of Agriculture and Fisheries, Masterton.

Table 2.3 Areas of Map Units Affected by Erosion

Erosion type	Area of Map Units Affected (ha)
Soil Slip	525,370
Earthflow	418,770
Sheet	213,880
Gully	143,030
Tunnel Gully	120,640
Scree	90,800
Wind	84,280
Streambank	61,500
Debris Avalanche	27,860
Deposition	14,700
Slump	13,950
Earth Slip	520
Hill	110
No Erosion Recorded	463,770

Note: The total area affected by erosion is different from the sum of the individual types, because up to 3 types can be recorded in a map unit. (From Noble, 1985)

The erosion problem is contributed to by the faults and crush zones previously described, soil properties, slope characteristics, vegetation cover, and climatic conditions. Soils derived from mudstone and argillite in particular, are characterised by widespread erosion problems. Erosion problems are aggravated by the highly variable Wairarapa climate with a tendency to either excessive wetness or drought. An additional factor is the removal of rough protective vegetation from water courses and steep slopes on a topography originally stabilized under forest cover (King, 1969).

King (1969) observes that apart from soil loss by sheet erosion, the most common form of erosion is down-cutting and gully erosion in water courses; this in turn leads to slope instability typified by massive slump movements, lateral gullying and slip movements.

To control erosion, the Wairarapa Catchment Board has instituted eight catchment control schemes covering the Owahanga, Mataikana, Whakataki, Whariama, Homewood, Maungaraki, Awhea-Opouawe and Kaiwhata catchments and the Lower Wairarapa Valley. This represents a significant proportion of the Wairarapa Hill Country, with expenditure primarily on fencing and tree planting (King, 1982).

2.3 FARMING SYSTEMS IN THE WAIRARAPA HILL COUNTRY

2.3.1 Introduction

Sheep and beef cattle predominate in the Wairarapa, particularly in the hill country. While the total land area of 707,582 ha constitutes only 3.3% of the New Zealand land area the Wairarapa contains 4% of the country's beef cattle and 5% of the sheep population (184,686 beef cattle and 3,585,369 sheep respectively; N.Z. Agr. Stats, 1984). More recently diversification into goats and deer has commenced. Apart from cash crops occasionally grown on valley floors the other farming systems in the Wairarapa are located in the Central Lowlands. This includes: Dairying in flatter areas which border the Tararua and Rimutaka Ranges and where rainfalls are generally over 1200 mm per annum; horticultural production around Masterton, Carterton, Greytown and Martinborough, with major crops including vegetables; berryfruits, pip and stone fruit and grapes; and cropping of wheat, barley, ryegrass and clover seeds, potatoes and oats.

In common with the majority of sheep and cattle systems in New Zealand, pasture provides the primary feed input throughout the year. On flat and easier country summer crops (predominantly rape for lambs) and winterfeed are still quite commonly grown, partly to renew pastures.

Sheep policies normally centre on the keeping of breeding ewes and rearing of replacement hoggets. In recent years a greater proportion of lambs have been sold to the freezing works rather than as store stock to farmers on the flat and easy country in the Wairarapa and other districts (Baker, 1984). The majority of farms (23 out of a sample of 30 in Parker, 1984) also run cattle in addition to sheep. As with sheep, breeding policies predominate with the main cattle policy involving breeding, rearing replacement heifers, and selling off surplus weaners as stores. Again, as with sheep, there has been a move to fatten surplus stock selling steers and surplus heifers to the freezing works (Baker, 1984).

2.3.2 Farmers

Two recent surveys provide some information on farmers and farm characteristics in the Wairarapa. These are a survey of 108 hill country farms by Field, Clark and Brougham (1982) throughout the Wairarapa and of 30 farms in the North-East Wairarapa Hill Country by Parker (1984). The results from Parker (1984) indicated an average period of farm ownership of 12 years, in some cases the third generation was farming the same property. Owner-operated farms predominated (26 out of 30) while the average age of farmers was 41 years. Only 4 of the farmers held qualifications higher than secondary school level, although farmers wives tended to be more highly qualified.

On average 3380 stock units were looked after per labour unit but this ranged from 1470:1 to 6241:1.

In the Field et al (1982) study, information was sought on the main factors motivating farmers or acting as disincentives. While the main incentive was primarily financial (35%) others included enjoyment (26%), challenge (19%), status (12%), and a variety of other motivating reasons. The primary disincentive was also seen as financial, particularly inflation and a poor and uncertain return on investment (Total 72%). A range of other limitations were also indicated including markets, climate, locality, topography, etc. Interestingly, particularly in the context of this study, only three farmers listed an inability to diversify as their greatest disincentive.

2.3.3 Farm Areas and Topography

The survey by Field et al (1982) revealed a mean farm size of 701 ha while in the smaller sample of Parker (1984) mean size was 692 ha. Farm sizes vary greatly and in the latter survey ranged from 161 ha to 1496 ha. As in the study by Kaplan (1979) a significant proportion of farmers had increased their farm size, in this case 9 farmers out of 30 in the previous 5 years.

In terms of topography Parker (1984) found the average farm in his survey had 69% steep or non-cultivatable hill, 24% rolling to moderate hill country and 7% flats. However, these proportions varied greatly between farms with, for example the proportion of steep ranging from only 10% to 95% of the farm. Nearly two thirds of the properties had more than 70% steep hill country.

2.3.4 Farm Improvements

Parker (1984) noted a considerable increase in subdivision in the previous five years. Much of this was associated with the development of improved electric fences and recognition of the importance of improving pasture utilization. While sheep handling facilities were observed to be good by Parker (1984), 25 out of 30 farmers were making or planning improvement to stock water supplies. At the time of the survey the Wairarapa had experienced a low rainfall winter and summer and a windy spring.

Application of phosphate fertilizer is recognised as having a crucial role in maintaining pasture productivity (O'Connor and Mansell, 1982). Some 65% of soil samples from the Wairarapa over the one year period 1979-80 had soil test levels for phosphate below 10-12, a level considered necessary to sustain high levels of pasture and animal production (O'Connor and Mansell, 1982). The above authors suggest that where phosphate status is low, stopping fertiliser use for 1-2 years is likely to reduce pasture production 11-12%. They also indicate the likely change in seasonal production with lower fertility-type grasses producing proportionally less in winter and early spring. Evidence to support the importance of phosphate to production was found by Field et al (1982) where wool production per hectare was found to increase with the application of phosphorus containing fertilisers.

Baker and Todd (1983) observed that over the previous three years fertilizer use by their clients had dropped in excess of 50%. Fertilizer usage has continued to decline since that date in line with the decline in hill country profitability.

2.3.5 Farm Productivity

Indices of productivity show a marked variation between farms. For example Parker (1984), found a mean stocking rate/effective ha at 30th June 1982 for his sample of farms of 11.3; however the range was from 7.7 to 15.6. Similarly, average lambing percentage in the survey farms for the three seasons prior to the survey was 95% but this varied from 67-130%.

Three major factors can be identified as contributing to this variation: The effect of different physical environments;
The effect of different seasons;
The effect of management.

Data from the Wairarapa Catchment Board (1984) illustrates this. From records of the farm production from a large number of hill country farms, the Board derives an index of the properties production. This is called the Unit Production Assessment (UPA) and is derived from the formula: (A + B) x C x 10 / D

Where A = Total stock units;

B = Natural increase (lambs docked plus calves marked x 4);

C = Wool per sheep stock unit;

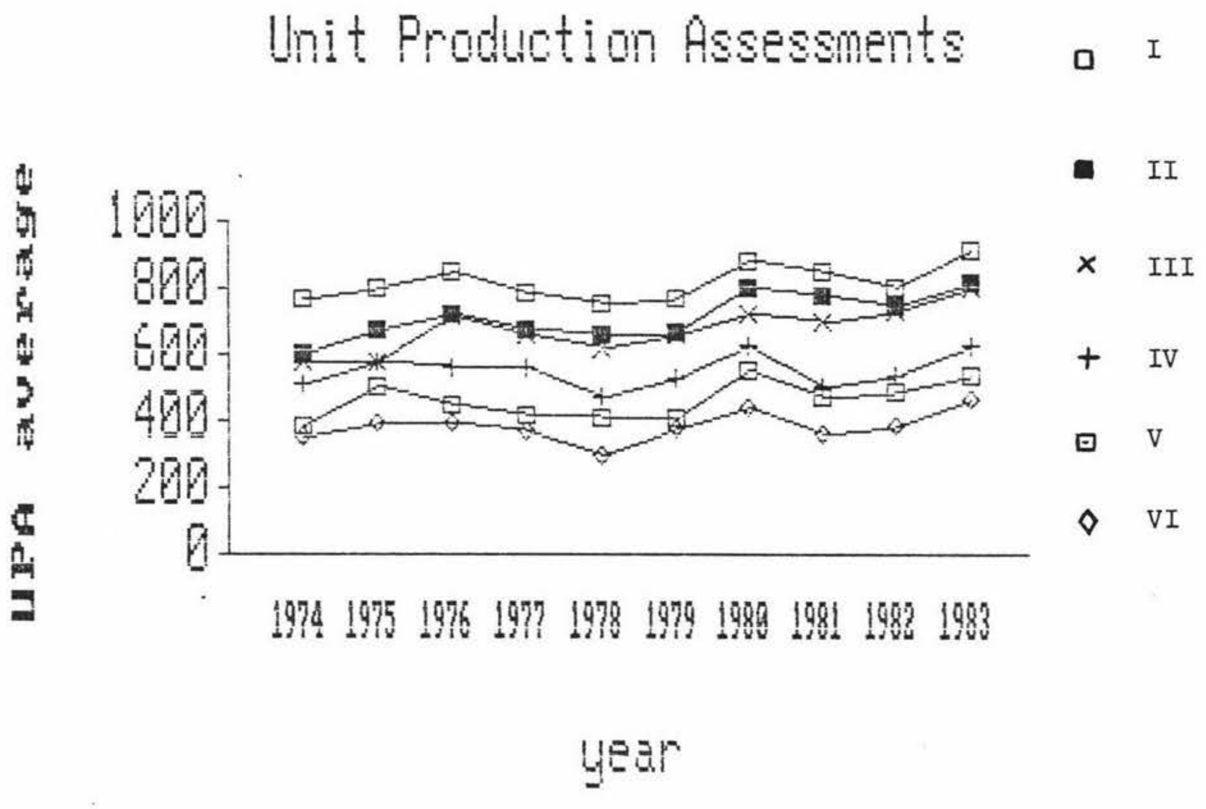
D = Area in hectares (King, 1982).

Properties are classified for comparison purposes into six soil groups as follows:

Soil Group	Natural Fertility	Rock Types
I	High	Siltstone Mudstone Limestone
II	Predominately High	80% Group I
III	Medium	Sandy Siltstone Loess Sandstone alluvium
IV	Predominately Medium	80% Group II
V	Medium to Low	Greywacke Sandstone Conglomerate
VI	Low	Argillite

The results for the 10 year period 1974-1983 are shown in Figure 2.4. Note that differences in performance are apparent between the six soil groups for most years, while considerable year to year variation is also apparent. Table 2.4 serves to illustrate variation as a result of management differences (From King, 1982).

Figure 2.4 Unit Production Assessments for soil groups



Source: Wairarapa Catchment Board Unpublished Data (1984)

Table 2.4 Variation in Unit Production Assessments

Soil Group	I	II	III	IV	V	VI
Lowest Farm	607	381	381	189	225	199
Highest Farm	1109	915	1056	1101	573	767
Average UPA	767	664	659	526	407	373

It is evident from this that top producing farms are achieving very similar results from classes I - IV, in marked contrast to the lower group.

Field et al (1982) divided farms into six groups; a division into two groups depending on soil and three groups depending on rainfall. Again significant differences in productivity were apparent, both as a result of soil type and rainfall difference. Parker (1984) found highly significant differences between districts and seasons in lambing percentages and between districts for sheep liveweights. The extent of seasonal variation is indicated by an improvement in lambing percentage of 18% and wool per sheep SU by 25% in 1982/83 following a drought year. (Wairarapa Farm Improvement Club Figures, Todd and Baker, 1984).

2.3.6 Economic Features of Hill Country Farms in the Wairarapa

A brief overview of current economic conditions has already been presented. Information from recent Farm Monitoring Reports provide further detail on recent economic conditions in hill country. Two classes recognised in the reports are applicable to Wairarapa Hill Country:

Hard Hill Country North Island (Farm Class 3) running breeding ewes and breeding cows where a high proportion of stock are traditionally sold as stores.

Hill Country, North Island (Farm Class 4) running breeding ewes plus a wide range of cattle policies and regularly selling a considerable proportion of stock to the freezing works.

Tables 2.5 and 2.6 indicate recent changes in income and expenditure for these classes of farms. In 1984/85 gross farm incomes for both classes were a considerable improvement over the preceding year. This was a result of improved stock performance, income from stock replaced in 1983/84 following the 1982/83 drought and improved prices following a major devaluation of the New Zealand dollar in July 1983. Farmers generally took the opportunity to apply maintainance levels of fertilizer as well as significantly lift other areas of farm working expenditure.

In contrast the preceeding two years were markedly affected by a severe drought during 1982/83 in the Wairarapa and other east coast areas. In that season capital stock were sold or not replaced, supplementary feed costs were increased fourfold and fertilizer programmes were reduced by 20-40% to compensate for the reduced incomes. Below maintainance applications of fertilizer were also applied during 1983/84.

In the 1985/86 year a severe drop in income to levels less in nominal terms than 1982/83 was experienced. For hard hill country (class 3) and hill country (class 4) drops of 32 and 23% in gross income occurred. The immediate cause of this was the removal of support prices at a time of low world commodity prices in general. In the current 1986/87 year a modest improvement in gross income of 13 and 12% for class 3 and 4 respectively is projected.

The response of farmers has been to minimise farm expenditure in all areas. For example in the "All Classes Average" farm fertilizer applied in 1985/86 was the equivalent of 7.8 kg/Stock unit. This compares with applications averaging 15 kg/stock unit over the previous 5 years and an average of 20 kg/stock unit in the 1970's (State of Agriculture Report, 1986). With a decline in inputs, particularly fertilizer, stock units are falling. On class 3 hill country 1987 closing stock units are projected to be 6% lower than the opening stock units in 1984/85 (MAF Monitoring Report Sheep and Beef November, 1986).

Table 2.5 Farm Class 4 Hill Country, N.I. Sheep and Beef

$/Farm Class 4	1984/85	% Change 1984/85 to 85/86	1985/86	% change 1985/86 to 86/87	1986/87
Sheep Sales	39029	-48	20436	13	23032
Cattle Sales	45912	-17	37935	12	42548
Wool Sales	46480	-10	42010	6	44629
Milkfat Income	0	0	0	0	0
Crop Sales	0	0	0	0	0
Other	903	67	1513	-6	1422
Less Sheep Purchases	1521	-13	1316	-43	757
Cattle Purchases	17026	-21	13427	-3	12969
Gross Farm Income	113777	-23	87150	12	97905
Wages	4381	-40	2637	-17	2190
Animal Health	3903	-4	3747	-0	3732
Breeding Expenses	0	0	0	0	0
Dairy Shed Expenses	0	0	0	0	0
Crop Expenses	147	12	165	13	187
Electricity	964	22	1179	21	1430
Feed	2264	-12	1998	-8	1834
Fertilizer	14105	-67	4625	131	10675
Lime	790	-100	3	-59	1
Seed	340	-39	206	-18	170
Freight	4395	-1	4371	13	4940
Shearing	7363	-7	6858	2	7004
Weed and Pest Control	1235	-49	629	-15	533
Vehicle Expenses	6882	-6	6469	11	7174
Repairs and Maintenance	5914	-39	3620	0	3624
Administration	5793	19	6871	9	7512
Other	1075	7	1147	-2	1124
Farm Working Expenditure	59549	-25	44527	17	52132
Cash Farm Balance	54228	-21	42624	7	45773
Personal Drawings	13464	-3	13088	9	14228
Tax	6747	6	7128	-45	3911
Total Personal	20211	0	20216	-10	18138
Principal Repayments	4885	6	5162	5	5396
Interest	13763	28	17593	7	18773
Total Financial Charges	18648	22	22755	6	24169
Balance for Reinvestment	15369	-102	-346	-1101	3465
Development	4042	-88	491	-41	291
Capital Purchases	6963	-93	492	21	593
Other	300	-95	14	2081	303
Total Development and Capital	11305	-91	997	19	1188
Plus New Finance	660	-76	162	-51	80
Current Account Balance	4724	-125	-1181	-300	2357

Source: MAF Farm Monitoring Report (December 1986)

Table 2.6 Farm Class 3 Hard Hill Country, N.I. Sheep and Beef

$/Farm Class 3

	1984/84	% Change 1984/85 to 85/86	1985/86	% Change 1985/86 to 86/87	1986/87
Sheep Sales	51607	-53	24378	1	24559
Cattle Sales	41764	-29	29810	22	36269
Wool Sales	64054	-19	51968	14	59083
Milkfat Income	0	0	0	0	0
Crop Sales	0	0	0	0	0
Other	1523	27	1928	8	2090
Less Sheep Purchases	2119	-43	1198	-18	988
Cattle Purchases	1518	25	1902	3	1959
Gross Farm Income	155311	-32	104984	13	119054
Wages	10852	-32	7401	-8	6844
Animal Health	5541	-7	5170	-1	5121
Breeding Expenses	0	0	0	0	0
Dairy Shed Expenses	0	0	0	0	0
Crop Expenses	0	0	0	0	0
Electricity	1902	-14	1636	16	1898
Feed	1732	-58	735	15	842
Fertilizer	14684	-94	900	97	1772
Lime	162	-95	8	-100	0
Seed	41	5	43	-80	9
Freight	6442	-22	5023	-2	4943
Shearing	12724	-6	11959	-3	11574
Weed and Pest Control	8669	-74	2226	72	3827
Vehicle Expenses	8559	-15	7434	19	8634
Repairs and Maintenance	7566	-48	3972	10	4368
Administration	7511	15	8635	9	9381
Other	2985	7	3186	42	4516
Farm Working Expenditure	89371	-35	58129	10	63729
Cash Farm Balance	65940	-29	46855	18	55325
Personal Drawings	15989	-13	13833	1	13988
Tax	7113	-32	4820	-32	3257
Total Personal	23102	-19	18653	-8	17245
Principal Repayments	6245	-6	5840	5	6151
Interest	20616	16	23891	0	23943
Total Financial Charges	26861	11	29731	1	30094
Balance for Reinvestment	15978	-110	-1530	-622	7986
Development	4402	-87	571	33	760
Capital Purchases	7289	-57	3141	34	4208
Other	0	0	25	729	209
Total Development and Capital	11691	-68	3737	39	5177
Plus New Finance	0	0	574	-100	0
Current Account Balance	4287	-209	-4693	-160	2809

Source: MAF Farm Monitoring Report (December 1986)

A feature of farm expenditure has been the increasing proportion of financial changes. For both class 3 and 4 hill country total financial changes are likely to account for 25% of gross income on the representative farm. The December (1985) farm monitoring report notes that hard hill country farms are particularly vulnerable to an increase in interest rates with considerable development work undertaken through the Land Development Encouragement Loan Scheme.

Wairarapa Hill Country farmers have been particularly affected by the economic downturn. Average per head performances for sheep in the Wairarapa have been lower than the North Island Hill Country average as a result of the climatic extremes experienced in the district. Thus for the last five years lambing percentages have been 5% lower and wool 0.4 kg per sheep stock unit lower (MAF Masterton, 1985). In addition, a considerable amount of development expenditure has occurred over the last 10 years with an expansion of sheep and beef cattle stock units by 9%. For example from 1977-1980, 18,800 ha of hill country in the Wairarapa was cleared and developed under the Rural Banking and Finance Land Development Encouragement Loan (MAF Masterton, 1985).

Currently, development and capital expenditure are at very low levels with farmers primary concerns the implementation of survival tactics.

2.4 FORESTRY IN THE WAIRARAPA

In marked contrast to the large proportion of land in the region covered by grassland, forest comprises only 4.6% of the Southern Hawkes Bay - Wairarapa region. As at the 30th June 1984, 19,591 ha of exotic forest were located in the Wairarapa district; this represents 1.9% of New Zealand's total exotic forest resource of 1,041,079 ha. Table 2.7 indicates the breakdown of private and public afforestation in the Wairarapa.

Table 2.7 Afforestation Area in the Wairarapa

District	Total Area	Private Afforestation	Public Afforestation
Eketahuna	78251	318	
Featherston	207903	1677	
Masterton	214308	6854	8828
Wairarapa South	203235	1914	
Totals	703697	10763	8828

Source: N.Z. Agr. Statistics (1984)
Forest and Forest Industries Statistics (N.Z.) (1960-82)
N.Z. Forest Service, Wellington.

Private afforestation represents 55% of exotic forestry in the Wairarapa while the majority of public forestry is represented by Ngaumu Forest. Table 2.8 indicates that soil conservation plantings form a significant part of the private afforestation. Much of this is directly attributable to the soil conservation work of the Wairarapa Catchment Board. Pinus radiata species predominate, forming 94% of private plantings and almost 100% of state plantings.

Table 2.8 Private Plantations - Purpose and Species

Purpose	P.Radiata	Douglas Fir	Species Corsican Pine	Other Softwood	Eucalypts	Other Hardwoods	Other	Total
Production	4307	6	17	7	7		1	4345
Forest Grazing	12							12
Production and Protection	4045	9		56	107	51	307	4575
Shelter	54			1	2		1	58
Protection	387					2	25	414
Total	8805	15	17	64	116	53	334	9404

While exotic forest forms only a small part of the Wairarapa's land use and an even smaller part of New Zealand's total exotic forest resources, forestry makes a significant contribution to the region's economy. In recent years production from Ngaumu Forest has increased significantly from 9000 m3 in 1981/82 to 34,000 m3 in 1983/84 (Rockell, 1984). This supply will continue to increase, the extent depending on the cutting option chosen. Table 2.9 indicates the likely production increases under one of these options.

Table 2.9 Predicted Production from Ngaumu Forest

Year	Volume Available Annually State	Private	Total
1984-86	30,000 m3	20,000	50,000
1987-91	80,000	45,000	125,000
1992-95	175,000	46,000	221,000
1996-2000	175,000	112,000	187,000
2001-2005	175,000	238,000	413,000

Source: Rockell, 1984.

At present there is a cutting capacity of 81,000 m3/annum for sawmills in the Wairarapa region (assuming single eight hour shifts rather than dual shift mills) so that clearly additional capacity will be required in future years.

A point of significance is that Ngaumu is one of the first pruned forests to mature. Thus currently stands from Ngaumu are getting about 25% of their volume as pruned logs over 20 cm in diameter and 74% as unpruned sawlogs. With the price differential between pruned and unpruned logs ($90/m3 and $39/m3 respectively) approximately 44% of the value of produce comes from the pruned logs and 55% from the unpruned logs. In the mid 1990's however some stands due for utilization will have only unpruned logs, as they were not pruned and were thinned to a lesser degree. Rockell (1984) observes however that from the mid 1970's all stands have been intensively tended so that stands due for utilization after the year 2000 will produce a third of their volume as pruned logs.

Considerable potential exists for expansion of forestry in the Wairarapa, particularly of the "smaller scale, lower cost clearwood regimes on better quality and more accessible sites" advocated in the "CNIPS" (1983) report. However expansion is limited by both the high transport costs to extract timber from more isolated areas and the distance from deep water ports. As a result the Wairarapa is considered a low priority area for afforestation by the New Zealand Forest Service.

CHAPTER III

FORESTRY IN NEW ZEALAND

3.1 THE DEVELOPMENT OF EXOTIC FORESTRY

Exotic forest trees were planted in New Zealand from the early days of European settlement. For example the earliest known P. Radiata plantation was planted in 1856 and felled in 1876 (Sutton, 1984). It wasn't until the 1920's and 30's however, that planting commenced on a major scale. This followed a Royal Commission report in 1913 which indicated that unless an immediate planting programme was started, New Zealand's indigenous forests would be exhausted by 1965 (Sutton, 1984).

These recommendations were excepted and vigorously put into effect by the newly established Forest Service, aided by the unemployment relief scheme. In fact the self sufficiency goal was exceeded, so that in 1932 the goal was extended to produce an exportable surplus. By 1935 over 300,000 ha of exotics had been established, most of it P. Radiata (Sutton, 1984). However, by this stage it was decided that further extension of exotic forests for the export of timber and other products could not be justified on economic grounds. Bunn (1981) summarised the economic thought of the time as "it seems that apart from Australia, Europe was considered to be the most likely market, and that New Zealand would be unable to compete there because of its higher freight costs, dearer electricity, higher capital investment, higher wages and more costly engineering and chemical supplies."

For the next 25 years from 1936 to 1960 the primary emphasis was on developing and establishing markets for the resource that had been established. Sutton (1984) observed that New Zealand had become the first country to create a plantation resource before it was required. While the initial estimates of future wood use by the 1913 Royal Commission and the Forest Service were close to what was actually used, the indigenous forest continued to supply more wood than expected while the exotic plantations, especially radiata pine, grew faster than expected.

This over-supply of wood had two major consequences:
It was necessary to develop profitable techniques for processing fast grown knotty pine into an acceptable product in a market "dominated by cheap readily available high quality indigenous coniferous timber."
It was difficult to justify expensive tending to improve quality. In any case the outbreak of World War II meant there was hardly sufficient manpower to protect the forest, let alone to thin and prune it (Entrican, 1960).

The first problem was largely overcome with the development by the Forest Service of proven methods of conversion, grading, seasoning and preservation, followed by the progressive development of other radiata pine products (e.g. pulp, plywood, fibreboard, and particle-board) by private enterprise. By the late 1950's export markets for sawn timber, logs, newsprint, and kraft pulp and paper had been established (Bunn, 1979).

However the lack of any tending meant that timber from trees planted during this period yielded an insignificant proportion of clear and defect clear grades, limiting its possible end uses and restricting export opportunities for sawn timber. The overcrowded stands provided ideal conditions for an epidemic of the accidentally introduced Sirex noctilio wood wasp. This caused considerable mortality with the original 1500 stems/ha reduced to 300 stems/ha by age 35 years. In effect Sirex effectively thinned the old plantations (Sutton, 1984).

It wasn't until 1960 that a new policy was decided upon, that of expanding the forest resource with the aim of increasing the surplus of new forest material for export. This followed an extensive policy review in 1959 which indicated that the current levels of planting would be unable to meet future demand. The new policy that was accepted by the Government in 1960 had three targets:

(i) The export target was increased from 1,400,000 to 4,250,000 m3, a threefold increase.

(ii) Exotic forest estate targets of 800,000 ha by the year 2000 and 1,200,000 ha by 2025 were set.

(iii) The national annual planting rate was increased to 8,000 to 12,000 ha in order that the higher export target could be achieved (Bunn, 1979).

Subsequently the national annual planting target has been increased three times (to 23,000 ha in 1969, 28,000 ha in 1972, and the unattained limit of 55,000 ha of 1975), all with the aim of increasing forestry's contribution to total export earnings. Actual planting rates over this period are shown in Table 3.1. By June 1984 exotic forest area had reached 1,041,000 ha. More recently planting rates have declined dramatically as a result of changes in forestry taxation. Nevertheless a dramatic increase in production will occur; between 1991 and 2000 production will double and then increase by a further 75% between 2000 and 2015 (Kibblewhite and Levack, 1982). Figure 3.1 indicates this increase in log production by type.

Some of the factors associated with this second wave of planting include:

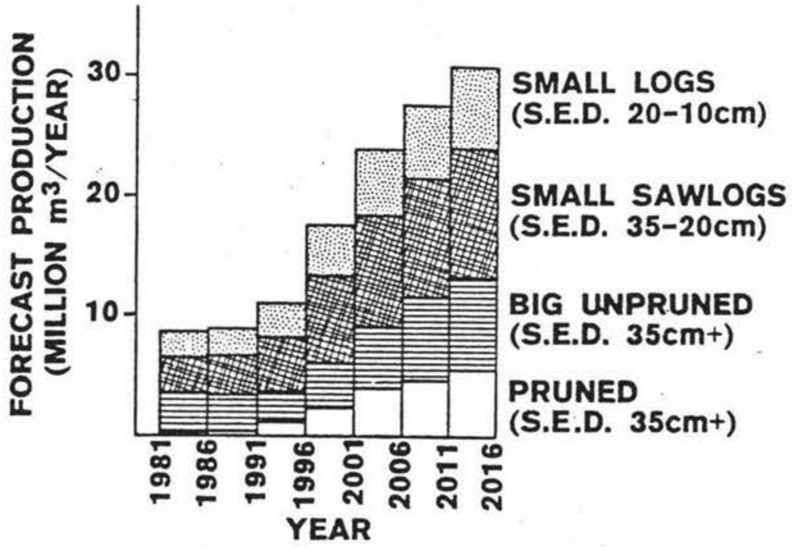
(ii) Increasing competition between agriculture and forestry for land use. Whereas the first wave of planting was on land not used for agriculture, later plantings have been on regenerating scrublands, traditionally regarded as available "as of right" for agricultural expansion. More recently planting has been on farmland itself. This has challenged what Le Heron and Roche (1984) call the "Doctrine of Agricultural Primacy," the web of economic and social relations and events which has emphasised agriculture over alternative land uses in New Zealand. There has been continued pressure to expand agricultural production while the forest sector has been engaged in its massive afforestation venture. Inevitably this has lead to competition for land and conflict. Conflict has also arisen with environmental groups over the planting of cut-over native forest.

Table 3.1 Exotic Planting Statistics 1960-1982

Year Ended 31st March	New Area Planted (000 ha)			Net productive stocked area (000 ha)			Annual net increase in total stocked area (000 ha)
	State	Private	Total	State	Private	Total	
1960	3	2	5	195	157	352	0
1961	4	2	6	199	159	358	6
1962	5	2	7	213	149	362	4
1963	6	3	9	220	152	372	10
1964	7	4	11	228	156	384	12
1965	9	5	14	235	160	395	11
1966	8	5	13	241	163	404	9
1967	9	5	14	235	160	395	10
1968	10	7	17	257	172	429	15
1969	13	8	21	270	177	447	18
1970	15	8	23	283	182	465	18
1971	15	11	26	294	189	483	18
1972	13	16	29	306	202	508	25
1973	17	16	33	323	215	538	30
1974	21	23	44	343	234	577	39
1975	21	23	44	343	234	577	39
1976	22	23	45	385	272	657	41
1977	22	27	49	406	299	705	48
1978	20	19	39	425	324	749	44
1979	21	22	43	449	350	799	50
1980	18	26	44	467	379	846	47
1981	17	21	38	484	404	888	42
1982	22	21	43	505	434	939	51

Source: (Forest and Forest Industries Statistics N.Z. 1960-82
N.Z. Forest Service)

Figure 3.1 Exotic Log Production by Type

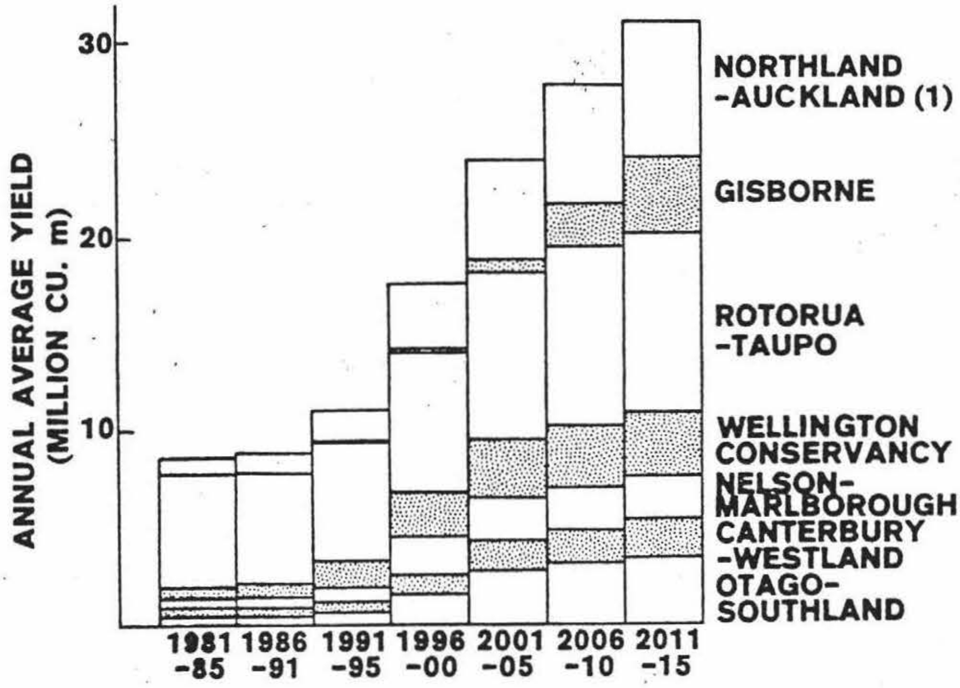


Source: Kibblewhite and Levack, 1982

(ii) Increasing geographical spread of production (Figure 3.2). While the Rotorua-Taupo area will continue to be the most important supply region, and will have an annual yield in 2001-15 almost 50% greater than in 1980, it will represent a quarter of the total resource because of the increased contribution of other regions (Kibblewhite and Levack, 1982).

(iii) A further feature of much of the plantings since the 1960's is their location on steep, often isolated areas, in contrast to the early planting on easily contoured pumice land. For example 35% of plantings in the 1-15 year age class have been on steep country, while only 13% of the 30+ age class has been on this type of country (Bourke, 1982). This has meant higher establishment and tending costs and will markedly increase logging and transport costs compared to plantings on easier contour (Fenton, 1965).

Figure 3.2 Total New Zealand Exotic Supply Forecasts by Region



Source: Kibblewhite and Levack 1982

Table 3.2 Predicted production of Clear Grades and Factory Grade Sawn Timber

TABLE 1 - Predicted production of Clear grades and Factory grade sawn timber

Period pruned	Predicted defect core	Period clearfelled	Log d.b.h. (cm)	Assumed conversion[1] (%)	Grade index [2]	Predicted % of log volume outturned		Potential production in Clears and Factory grades		
						Accumulated Clear grades[3]	Factory grade	Pruned butt logs[4] (000 m^3)	Accumulated Clear grades[3] (000 m^3)	Factory grade (000 m^3)
1961-65	32	1981-85	55	52.5	.90	18.2	11.4	261	47	30
1966-70	29	1986-90	50	52.5	.91	18.6	12.4	380	71	47
1971-75	29	1991-95	50	55.0	.95	20.5	12.9	1198	246	154
1976-80	29	1996-00	50	55.0	.95	20.5	12.9	2335	479	301
1981-85	25	2001-05	50	57.5	1.15	28.5	12.4	3961	1129	491

(1) Conversions adjusted down from original analysis (Forestry Council 1981) to include straight and swept logs.

(2) Park 1980.

(3) Aggregated data for No. 1 and No. 2 Clears and No. 1 Clear Cuttings (Whiteside 1982) ignore effects of defects such as resin pockets.

(4) Pruned butt logs greater than 35 cm s.e.d. only.

Source: Kibblewhite and Levack, 1982

In the future it is likely that new afforestation will increasingly shift from extensive estates on marginal hill country to smaller scale, better quality, more accessible sites, i.e. areas at present occupied by agriculture.

(iv) Changes in timber quality. The most significant of these will be increasing proportions of pruned trees: by 1990 up to 20% and by 2000 over 50% of the trees utilised could be pruned (Kibblewhite and Levack, 1982). As a consequence of both this and better pruning, an increased proportion of clear grades will be obtained (Table 3.2).

(v) Expanded afforestation will mean enlarged processing and consumption of forest products. The main resource, P. Radiata, has proven to be very versatile as a species, capable of supplying the raw material for a range of solid and reconstituted wood and fibre products. There is general acknowledgement on the need for effective sector and industry planning, so as to realise the full benefits of the increased forest resources (Bourke, 1982).

(vi) Much of the increased production will need to be exported. In a study of the future (New Zealand) market for sawn timber and panel products, Maughan (1986) concluded that there was "no possibility that an increase in domestic demand will make significant inroads into the supply of timber forecast to come on to the New Zealand market in the 1990's." Presently exports represent 49% of current production (by volume) or 4.9m m3. Bourke (1982) suggests a likely exportable surplus of 11 million m3/year by 2000 and 22 million m3/year by 2015 representing 61 and 71 percent of production by volume.

Clearly the rapid increase in exotic forest area, as well as the increase in production, will continue to have a marked effect on the New Zealand economy. The 1981 Forestry Development Conference had an objective of expanding forestry export earnings till they amounted to 20-25 percent of the national total. Corson (1982) predicts the forest industry will have a dominating influence on the economy as it will "involve massive long-term allocations of wood, energy, and capital resources and potentially earn a major share of the foreign exchange."

3.2 MARKET OUTLOOK

The rapid increase in exotic forest area in New Zealand has been designed to take advantage of a forecasted world shortage of wood by the end of this century. The extent of this shortage, if any, and the wood products in which it will occur is, however, subject to considerable debate.

3.1.1 The Significance of Wood as a Commodity

Wood is recognised as one of man's most important commodities reaching an annual world consumption of 3000 million tonnes in 1980 (Bourke, 1982). To place this in perspective the consumption of wood parallels that of oil but is greater than the combined production rates of steel, cement, plastics and aluminium as well as the combined production of all major food items (Table 3.3).

Table 3.3 Total World Annual Production (million tonnes)

Construction Materials		Food Products	
Steel	530	Wheat	350
Cement	460	Rice	340
Aluminium	13	Maize	320
		Potatoes	280
		Barley	150
		Raw Sugar	80

Source: (Sutton, 1980)

1600 million tonnes of wood is used as fuel, emphasising its role as the primary energy source for a majority of the world's population. The remainder is used by the forest industries, 79 percent of whom are located in the developed regions (Bourke, 1982). The production and relative proportions of various products are shown in Table 3.4.

Table 3.4 Production and Grade by Selected Product Groups, 1980

	Production			Exports		
	N.Z. (mill.)	World	Prop'n (%)	N.Z. (mill.)	World	Prop'n (%)
Total roundwood (m3)	9.9	3020.3	0.3	1.4	115.8	1.2
Indust. roundwood (m3)	8.8	1393.5	0.6	1.4	113.6	1.2
Sawlogs and Veneer logs (m3)	5.2	841.5	0.6	1.0	69.8	1.4
Sawn timber and sleepers (m3)	1.9	428.7	0.4	0.6	80.0	0.8
Pulp (tonnes)	1.0	126.8	0.8	0.5	21.7	2.3
Paper-total (tonnes)	0.6	174.8	0.4	0.3	35.1	0.9
Newsprint (tonnes)	0.3	26.2	1.0	0.2	12.4	1.9

Source: (F.A.O. 1982a in Bourke, 1982)

Table 3.4 also illustrates the very small proportion of world production and trade at present contributed by New Zealand.

3.2.2 Future Wood Supply

Many studies have been conducted to project future supply and demand prospects for forest products (Bourke, 1982). However, Sutton (1981) suggests these have tended to concentrate on demand rather than supply potential. Estimates of supply based on the biological potential of the world's forests suggests ample supplies of timber will be available, even if demand doubles over the next 20 years (Sutton, 1981). King (1978) reviewed estimates of the potential sustainable production of the world's forests and these ranged from 7,000 million m3 to 19,000 million m3; F.A.O.b,s tentative estimate was 12,000 million m3. However these estimates are subject to considerable debate. Bourke (1982) suggests both the methodology and the data used are subject to question. Existing forest resources and harvesting levels are very uncertain in many countries, while forecasts of future annual production depend on assumptions about sustainable yields; the level at which the total volume of wood felled in any one period does not, on average, exceed the maximum increase in wood growth over the whole forest, within that period. In many instances assumptions on sustainable yields have been on an arbitrary basis, often influenced by economic needs (Bourke, 1982).

In a review of prospects for sustained wood supply in major world regions, Sutton (1981) concluded there was limited scope for increasing yields or even sustaining current wood supplies.

The apparent discrepancy between this analysis and estimates based on biological potential was interpreted to mean considerable over-estimates of sustainable yield. In particular Sutton (1981) identified a failure to manage and re-establish most of the world's forests, especially those in the tropics.

A change in wood quality is also predicted by Sutton (1980). He suggests that the most desirable, best quality, old growth stands have been felled and that regeneration that follows produces trees of smaller size and poorer quality. As well, Sutton (1981) concludes that most of the world's plantations have not been managed for high quality wood production.

3.2.3 Future Wood Demand

Estimates of future demand are even more difficult than those of supply as estimates must be made on economic growth rates, the extent of the development of substitute products, changes in consumer preferences, and population growth (Bourke, 1982). A summary of recent projections for the year 2000 are shown in Table 3.5.

Table 3.5 Year 2000 Projections of Future World Wood Demand

Authority	Projected Demand (in millions m^3)		Total
	Fuelwood	Industrial Wood	
MADAS (1974)	1000-1200	3170-3770	4170-4970
KING (1978)			5220-6410
FAO (1979)	1280	2085	3365
EIU (1981)	1900	1800	4700
Actual 1979 Values for Comparison (FAO 1981)	1600	1420	3020

Source (Sutton, 1981)

While all the above estimates indicate an increase in individual wood demand there is no agreement on future demand for fuelwood. FAO estimates (FAO, 1982b) suggest that world usage of industrial wood will rise from the 1980 level of 1470 million m3 to 2086 million m3 by 2000, a 1.6% growth rate per annum.

To assist with future planning it is necessary to know not only overall growth rates but the likely demand for individual products. Figures from FAO (1982b) suggest that greatest absolute growth in usage will occur for pulp products, followed by sawn timber and panel products, particularly reconstituted panels. Of particular significance is the conclusion that demand will be constrained by supply, supporting the conclusion of researchers such as Sutton (1981). For softwoods severe contraints of both sawnlog and fibrelog material are suggested, while for hardwoods sawlogs are projected to be short supply with fibrelog supply contrained by economies and quality limitations rather than physical supply.

A further factor of significance to consider is the regional nature of any deficits or surpluses. The USA, Western Europe, and Japan are all forecast to be deficit areas for sawn timber and pulp.

3.2.4 New Zealand's Future Market Position

Even with a marked increase in production New Zealand will still remain a minor producer of forest products in the world. However, Bourke (1982) suggests that this is of greater significance when world trade and particularly specific products and market areas are considered. Table 3.6 illustrates this.

Table 3.6 Production and Trade in 2000

	Production N.Z. (1)	Production World (3)	%	Exports N.Z. (2)	Exports World (3)	%	Imports W. Pacific Basin (3)	N.Z. Exports Proportion % 2000 (1980)
Pulp (000t)	4693	243,900	1.9	3393	29,100	11.7	6500	52.2 (33.8)
NewsP (000t)	360			105				
SawnT (000m3)	7718	542,500	1.4	3718	54,500	6.8	5600	66.4 (24.0)
Solid Wood Panels (000m3)	2070	69,500	6.0	2004	12,600	15.9	3200	61.6 (6.6)

(1) Processing Options Working Party Scenario I
(2) Production less estimated domestic consumption
(3) Estimated from FAO 1982 b; West Pacific Basin refers to Japan, Oceania, Far East, and centrally planned Asian countries.

Source (Bourke 1982)

Far from being "a price taker on the margins of world trade" (Prickett, 1984) New Zealand has the potential to become a dominant force in regional trade.

There is general agreement that whatever product mix New Zealand produces, it will have to be sold on the international market in the face of strong competition (Corson, 1982). The extent to which this is successful will depend on both developing a viable set of processing options and then promoting the products produced. Bourke (1982) stresses the dominating effect future market needs must play in this. He identifies information required as including: What are the prospects for given products in an individual market?
What advantages (if any) do the New Zealand products possess?
Can New Zealand firms take advantage of these opportunities profitably?
What measures (if any) will enhance the prospects and/or profitability of exports?

To date there is a strong belief that New Zealand should concentrate on regimes producing a maximum volume of clearwood. Factors influencing this choice include:

(i) The view that New Zealand has no real comparative advantage for the production of pulp and paper, framing timber or log export regimes (Sutton, 1978). However, against this New Zealand producers of pulp and paper have found that their relatively small flexible operations can have the advantage of being selective in the marketing of their products (Glucina, 1982).

(ii) Recognition of New Zealand's ability to produce pruned logs of high quality with very short rotations by world standards (Sutton, 1978).

(iii) The forecasted short supply of clearwood. Other countries with the ability to produce large areas of radiata pine have generally chosen not to prune their stands (Sutton, 1978).

Bourke (1982) suggests that while this may well be a desirable strategy other factors need to be considered including the present preference of buyers for other species, likely price margins for clearwood in future markets, rather than present levels, and whether increased supplies of clearwood will lead to decreasing prices.

Clearly more research could provide at least partial answers to some of these questions. To a large extent the present tree planting and tending regimes must be seen as an act of faith as no one is so technically proficient so as to accurately predict the world scene in 30 years.

3.3 SPECIAL PURPOSE SPECIES

3.3.1 Introduction

At present pinus radiata occupies close to 90% of the present area of softwood plantations. It does so for a variety of reasons including "the relative ease with which it can be established, its fast growth rate, its silvicultural plasticity, its relative resistance to disease, its tolerance of a wide range of sites and its wide acceptability (within New Zealand) as a superior general purpose timber." (NZFS, 1981). However its timber properties are not well suited to some demanding end-uses where higher standards in decorative features dimensional stability, and surface hardness are required. Examples include furniture and cabinet work, turnery, handles, ladders, some exterior joinery items, decorative veneer and plywood, poles, cross-arms, strip and parquet flooring and panelling. Species able to produce timbers with properties capable of meeting such end-uses are termed "special purpose species."

Within both the New Zealand Forest Service and forest industry generally, there is a recognition of the need for such species. Reasons advanced for this include:

- a need to provide a substitute for a declining indigenous cut of quality timbers;
- offset the need for imports of quality timbers;
- enable the export of a wider range of quality timber products.

(NZFS, 1981).

3.3.2 Future Supply and Demand

Predicting future supply and demand of special purpose species is fraught with the same difficulties in predicting global timber supplies and demand. Nevertheless the forest service predicts the following. (Table 3.7)

Table 3.7 Supply Projections by Species for Sawlogs (000 m3/year)

Species	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Eucalyptus	58.4	68.8	79.1	76.7	80.6	180.6	483.2	461.2
Cypresses	4.6	4.7	4.7	4.7	4.7	4.7	4.8	5.3
Indigenous	530.8	263.7	191.7	184.1	184.1	132.7	57.7	57.7
Total	593.8	337.2	275.5	265.5	269.4	318.0	545.7	524.2

Source: (NZFS 1981)

This assumes a 3100 ha annual new planting programme and 30 year rotations for exotics, both of which may change with more knowledge.

Again, projecting future levels of demand is difficult as demand will be influenced by such factors as; the supply of indigenous timbers, the price and availability of imported timbers, population and per capita consumption trends, and by the substitution of high grade P.Radiata or non-wood products for some of the non-demanding end uses. However, if current demand is used a tight-resource situation is apparent.

Table 3.8 Supply and Demand for Sawlogs (Volumes in 000 m3/year)

	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2000-2010	2010-2015
Supply	593.8	337.2	275.5	265.6	269.4	318.0	545.7	524.2
Demand	588.5	588.5	588.5	588.5	588.5	588.5	588.5	588.5
Net Surplus/ Deficit	+5.3	-251.3	-313.0	-323.0	-319.1	-270.5	-42.8	-66.3

Source: (NZFS, 1981)

With a reducing indigenous cut there is a serious special purpose timber deficit until 2006-10 when the eucalypt sawlog supply increases significantly. Clearly if demand was to rise, substantial deficits would continue well into the twenty-first century.

On the world scene competition for speciality timbers is intense. At present levels of demand this will increase still further as resources are depleted. For example, FAO figures suggest tropical hardwood forests are being destroyed at 20 million hectares a year, while it is estimated the supply of tropical hardwoods will dwindle almost to nothing in 20-25 years (Chavasse, 1982).

Not all writers believe there will be the famine of hardwoods projected. Maclaren (1984) raises the possibility of substitutes that could fulfill the present uses of special purpose species: "If furniture can be made from P.Radiata so that it needs a wood scientist with a microscope to distinguish it from mahogony, what status is to be had from possessing the genuine article?" Nevertheless it would seem unwise for foresters to concentrate solely on P.Radiata.

3.3.3 Species and Their Requirements

The main exotic species possessing wood properties considered suitable for special purpose uses are detailed below.

Table 3.9 Main Exotic Special Purpose Species and Uses

Species	Uses
Acacia melanoxylon	Furniture and cabinet work turnery
Cupressus macrocarpa	Exterior joinery, boat building
C lusitanica	Exterior joinery, boat building
Eucalyptus botryoides	Furniture and cabinet work
E delagatensis	Turnery and veneers
E fastigata	Furniture and cabinet work, turnery, handles, and veneers
E regnans	Furniture and cabinet work
E saligna	Furniture and cabinet work, turnery and veneers
Juglans nigra	Furniture and cabinet work, turnery and veneers

Source (NZFS, 1981)

These species all vary in their site, silvicultural, and utilisation requirements. Thus deep well drained fertile soils are required for Juglans nigra (Black Walnut) and are desirable for cupressus macrocarpa (FRI, 1979). In contrast to P.Radiata there is no single eucalypt species suited to a wide range of sites. Eucalypt species must be matched to particular conditions of climate and topography (See Table 3.10).

Table 3.10 Choice of Eucalypt Species

Climatic region	Decorative Timber	Specialised uses requiring strength and/or natural durability	Fuelwood
Region 1. Warm temperate areas Annual rainfall 750-2000 mm Maximum frost -8 degrees C Mean annual temp. 10-12.5 degrees C	E saligna E botryoides E muellerana E fraxinodes E obliqua E sieberi	E saligna E botryoides E muellerana E pilularis E globoidea E microcorys	E saligna E botryoides E nitens
Region 2. Cool temperate areas Annual rainfall 750-2000 mm Maximum frost -10 degrees C Mean annual temp. 10-12.5 degrees C	E regnans E fastigata E fraxinodes E obliqua	E fastigata E obliqua	E nitens E fastigata
Region 3. Cold temperate areas Annual rainfall 750-2000 mm Maximum frost -14 degrees C Mean annual temp. 10-12.5 degrees C	E regnans E fastigata E delegatensis E nitens	E fastigata	E nitens E fastigata

Source (FRI "What's new in Forest Research" No. 124, 1984)

Much of the Wairarapa hill country would fall within the region (2) classification. While acacia melanoxylon (Blackwood) may be grown on a wide variety of soils from swampy to skeletal, it requires shelter and/or side shading to encourage erect tree growth, a factor of particular significance for a windy district like the Wairarapa.

Silvicultural regimes need to be formulated to produce high quality knot-free timber. The NZFS stresses that special purpose species are not as "forgiving" as P.Radiata requiring more specific site selection, more careful seedling handling and establishment, more precise silvicultural treatment, and so on. In contrast to P. Radiata, suggested regimes are based on a more limited research base, while very limited information is available on growth rates and yields for a range of sites (Bunn, 1971).

Utilization experience for many of these species is also limited, particularly for specimens which have received optimum silvicultural treatment. In the case of ash eucalypts quarter rather than flat sawing is required. Such species have a high tangential shrinkage which, in flat-sawn boards, causes substantial surface checking and abnormally high shrinkage because of the collapse of cells during drying (FRI No 122, 1984). Special equipment for log turning and handling is required. For this reason a large enough resource is required to justify a medium sized sawmill; Forest Service figures suggest an annual cut of 45 ha on a 1600 ha working circle to sustain a sawmill of 20,000 m3 annual capacity (NZFS, 1984).

In contrast to sawing experience for timber, utilization of a variety of exotic species for veneer production is well understood (NZFS, 1981).

3.3.4 Current Policy on Special Purpose Species

The New Zealand Forest Service has produced a policy document (The N.Z. Forest Service Policy on Exotic Special Purpose Species, Sept., 1981) and provides research and advisory services. In the policy document a clear need for a planting programme to meet future needs was recognised. It was suggested that private planting of Juglens nigra and Cupressus macrocarpa be encouraged, as the high quality soils required for these species are in private tenure. For other species with less exacting requirements, particularly eucalypts, it was envisaged the Forest Service would be able to establish significant areas of forest as the nucleus for special purpose timber industries.

While the report concluded there could be scope for exporting speciality timbers in the longer term, it was considered prudent to proceed with an establishment programme designed to produce not more than double the domestic demand because of a lack of marketing information. Planting programmes were suggested as being on a population basis so as to locate resources in reasonable proximity to possible domestic markets (Table 3.11).

Table 3.11 Annual Planting Programmes for State and Private Ventures

	Cupressus(ha)	Eucalyptus(ha)	Other(ha)	Total(ha)
Auckland	150	290	50	490
Rotorua	150	300	10	460
Wellington	180	280	40	500
Nelson	20	100	10	130
Westland	100	190	10	300
Canterbury	-	-	10	10
Southland	70	130	10	210
Total	670	1290	140	2100

Source (NZFS Policy on Exotic Special Purpose Species, 1984)

A relatively high rate of planting is envisaged for the Wellington region, which includes the Wairarapa District.

To date the planting targets suggested have not been met. In 1983/84 only 1159 ha was planted in Special Purpose Species; of this area 552 ha was planted by the state and most of the rest by major companies. The contribution by farmers to the establishment of a special-purpose timber resource has been negligible (Prickett, 1984). Prickett (1984) believes the financial and psychological realities of a lead time of 40-50 years means that most farmers will not contemplate investment in forestry in the establishment phase. He suggests that in common with the radiata-based industry of today it will be necessary for the State to take the initiative with planting and funding.

3.4 FARM FORESTRY IN NEW ZEALAND

The development of the forestry industry in New Zealand has primarily been from plantings undertaken by the New Zealand Forest Service or large forestry companies. However at times there has been considerable emphasis on farm forestry plantings.

In 1960 Entrican proposed that farm forestry provide 50% of the new plantings with the State undertaking the remainder. Assistance towards this end was given by the removal of farm plantations from death duty regulations in 1960, while in the same year a national Farm Forestry Association was formed to provide a forum for interested parties and a means of broadcasting the organizations policies. Again in 1981 the Working Party on Afforestation to the Forestry Conference concluded that small growers should increase their contribution to 24% of the national total exotic forest area by 1990 (Le Heron and Roche, 1984). This would mean an annual planting by the small growers of 12,000 to 16,000 ha. Currently small growers only contribute approximately 12% of the national exotic forest area (Estimated from McKenzie, 1987).

By emphasising the role of the small grower in this way Le Heron and Roche (1984) suggest three objectives of the state could be achieved.

(i) The planting of optimally located "agricultural lands" on sites of relatively easy contour close to port facilities.

(ii) Reduction of the share of the resource base controlled by the forest utilization companies.

(iii) To promote diversification in agriculture at a time when sector returns are declining.

Actual planting rates shown in Table 3.12 indicate that small grower plantings have not kept pace with projected targets. Many reasons have been advanced for this including:

(i) Lack of technical knowledge.

(ii) Lack of time.

(iii) Lack of finance.

(iv) Difficulty in selecting a woodlot.

(v) Difficulty in growing trees and livestock together.

(vi) The hazards of predicting government policy.

(vii) Lack of scientific and technical backup.

(viii) Hazards of handling and predicting marketing methods 30 to 40 years ahead, possibly involving the next generation.

(ix) The influence of a woodlot, and of contractual issues associated with it, on the marketability of the land.

(Malloy, 1985)

Table 3.12 Tree Planting Rates

Type of Grower	1 Target Annual Area 1981-85 (ha)	2 Actual Area to Yr End 31/3/83 (ha)	3 Percentage (2) % (1) Achieved (%)
State	16,050	19,243	120
Large Grower	17,200	27,121	158
Small Grower	10,550	2,860	27
Total	43,800	49,224	112

Source (Ogle, 1984)

A recent survey of 200 woodlot owners indicated that these people planted trees for a wide variety of purposes including shelter, erosion control and aesthetics; in fact it appeared financial aspects were of secondary importance for the majority of respondents (Smaller and Meister, 1983). Only 34% of respondents had plans for future plantings, reasons for not planting are summarised below (Table 3.13).

Table 3.13 Reasons for not planting

Reasons for Not Planting	Number	%
Insufficient Time	1	2.9
Limited Knowledge	0	-
Limited Finance	2	5.9
Uncertain Markets	4	11.8
Uncertain Returns	13	38.2
Shortage of Labour	0	-
Other	14	41.2

Note: "Other" included:
(a) Respondents who considered themselves too old to gain any benefit from further plantings of trees.
(b) Respondents stated that land was already in its most productive use, that is grazing, and any change would be unprofitable.

Source (Smaller and Meister, 1983)

These results highlight the uncertain nature and long term investment required for forestry. Another factor which may have strongly influenced farmer attitude towards farm forestry is the widely held belief previously discussed, which identifies agriculture as the primary land use and progress as the conversion of idle lands to pasture, rather than pasture to forestry (Le Heron and Roche, 1984). The comment made in reference to agroforestry in Australia could be directly translated to New Zealand "At present few private landowners agree that agroforestry is either practical or economic for them. Most view it as a long-term commitment, beset with unfamiliar problems, yielding dubious returns and requiring greater labour inputs." (Batini, Anderson and Moore, 1983).

CHAPTER IV

AGROFORESTRY

4.1 DEFINITION AND ROLES

Agroforestry has been defined as "a collective name for land-use systems and technologies, where woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals, either in some form of spatial arrangement or temporal sequence. In agroforestry systems there are both ecological and economical interactions between the different components" (International Council for Research in Agroforestry, 1982). Many other definitions have been offered but frequently they confuse the definition with the aims and potentials of agroforestry, for example, presuming it to be a successful form of land use, when in fact like any other land use it may fail (Editorial, Agroforestry Systems, 1982).

Such a definition covers a wide variety of names for agroforestry systems such as: multi-tier farming or three dimensional farming; agrisilviculture or silvi-pasture systems; forest farming and the taungya system (The intercropping of young tree plantations with staple crops). In one sense agroforestry is a new concept, particularly in western cultures where agriculture and forestry have developed as separate forms of land use and science. However agroforestry is also recognised as one of the oldest and more widely practiced land use systems, but perhaps amongst the scientifically least studied ones (Nair, 1984).

Five commonly stated goals are recognised for agroforestry systems (Reid and Wilson, 1985);
Economic stability of the long term
Complementary production
Environmental protection and control
More economic use of poor land
Aesthetics.

4.1.1 Economic Stability

This refers to the diversification in farm production provided by tree products. Tree products are particularly useful in this respect as time of harvest is frequently flexible, while different markets are supplied compared to conventional agricultural crops. This is particularly evident currently in New Zealand, where pastoral products are experiencing a marked downturn while timber prices remain buoyant.

4.1.2 Complementary Production

This refers to the production of fodder for stock to offset deficiencies in pasture production, for example, in the Wairarapa context the provision of additional feed during summer droughts. In New Zealand research is being conducted on the possibilities of tagasaste (tree lucerne) as a livestock fodder (Reid and Wilson, 1985).

4.1.3 Environmental Protection and Control

This aspect is of particular significance in hill country areas such as the Wairarapa and represents to date the most compelling reason for planting trees in this district. Recent work in the Wairarapa hill country has emphasised the lost pasture production as a result of soil slip erosion (Trustum et al, 1984).

It was found that although slips revegetated rapidly over the first 20 years to within 70-80% of uneroded productivity, further recovery was slow. The evidence suggested that once ground was eroded it may never regain the same potential for agricultural production under a pasture regime. Further, the greatest depressions in pasture production occurred in mid-winter and mid-summer, in times of the year when pasture growth rate are at their lowest and farmers have the highest risk of major feed deficits.

This increased rate of erosion followed the removal of native forest and would suggest that tree planting would be necessary to prevent further deterioration. In a review of soil conservation work in the Whareama Catchment on the East Coast of the Wairarapa, retirement of land from grazing plus open planting of trees was found to contribute to production by preventing further loss of land due to erosion (Blackmore, 1984).

In addition to soil and water conservation, trees are often planted to provide shelter. Exposure affects animals directly and also indirectly, through its effect on pasture growth and feed supply which influences livestock fertility and performance.

Compared to low country, pasture on hill country faces greater exposure and harsher conditions. King and Sturrock (1984) suggest it would be logical to expect the detrimental effects of wind and associated weather parameters on growing plants, including moisture stress, temperature reduction, and physical damage to be accentuated on hill country. The evidence available suggests this is indeed the case; Malloy et al (1980) summarising a large number of trials in New Zealand showed that dry matter production, especially its seasonal and annual variability, was decisively influenced by climate, especially rainfall variability but also by temperature and wind.

In the hill country environment the interaction of temperature, rain, and wind contribute to the "effective temperature" and produce the worst type of exposure hazards. These effects can be particularly severe on new born lambs and recently shorn sheep. In an investigation of prenatal lamb mortality in a flock of 1400 ewes in the Wairarapa 40% of lamb deaths were the result of starvation and exposure (Duff et al, 1980).

While a need for increased shelter is widely recognised it is very difficult to realistically assess the economic value of shelter with present data. For example, laboratory based studies cannot take account of either the animals ability to seek natural shelter outside planted shelter belts or the existence of potential stock management problems associated with the use of shelter (Holmes and Sykes, 1984).

In hill country little is known about the principles for determining the need for, or location of shelter (King and Sturrock, 1984). It is thought that up to 20 percent or more of the total area may need to be in trees to provide adequate shelter compared to 3 percent on the plains. This of course ties in well with agroforestry regimes and the need on many properties for erosion and water conservation plantings.

4.1.4 Better Use of Poor Lands

It is suggested that agroforestry regimes may be more economic than conventional grazing only on some land classes. Within New Zealand several studies indicate that agroforestry returns can exceed those from grazing only (Knowles and Percival, 1983), (Arthur Worsop, 1984), (Walker, 1984), (Clark, 1985).

Arthur-Worsop (1984) in a comprehensive study of agroforestry from the national viewpoint compared the returns to agroforestry under different stocking rates (Table 4.1).

Table 4.1 Agroforestry Returns as Affected by Stocking Rate

	Net Benefit to Agroforestry NPV	($/ha)
Low	(7.5 su/ha)	420
Standard	(9.0 su/ha)	300
High	(11.0 su/ha)	147

These results reflect a lower opportunity cost of agriculture under lower stocking rates.

Examples exist of properties where agroforestry now occupies a significant area but where agricultural production has remained constant or increased. For example on a 415 ha hill farm in Hawkes Bay a 38% decrease in grazing as a result of tree planting was accompanied by only a 5 percent decrease in livestock numbers and an improvement in livestock performance (Aitken, 1978).

4.1.5 Aesthetics

Many farmers plant trees with a view to beautification. In doing so the aim is to grow trees in such a way as to develop a landscape which does not offend, but pleases the senses. Generally agroforestry can succeed in this with wide tree spacings and understory pasture creating a park-like landscape.

4.2 DEVELOPMENT IN NEW ZEALAND

4.2.1 Research History

Within New Zealand the impetus for the development of agroforestry has principally come from the forestry sector. In the late 1960's work at the Forest Research Institute suggested that considerably wider spacings for the tree crop would, in association with timely pruning, yield much higher returns from the final crop than the standard regimes (Fenton and Sutton, 1968). In 1972 Fenton et al presented a radically different tending regime which proved considerably more profitable than all existing regimes (Table 4.1).

Table 4.1 Tending Schedule "Direct Regime"

Mean Height Crop Trees	Operation
	Plant 1500 items/ha (Spacing approximately 3.7 x 1.8 m
5.0	Prune the best 740-620 stems/ha 0-2.4 m and thin all others (no yield)
8.0	Prune the best 370-320 stems/ha 2.4-4.5 m (If incorporate grazing, thin all others)
11.0	Prune the best 200 stems/ha 4.5-6.0 m and thin all other (no yield)
13.5	Prune 200 stems/ha (multinodels) 6.0-8.5 m
17.0	Prune 200 stems/ha (multinodels) 8.5-11.0 m
36.0	Clearfell

Source (Fenton et al, 1971)

Prior to this, research had shown that under New Zealand conditions production thinning was unlikely to be profitable (Sutton, 1984). Research and experience suggested that thinned logs were expensive to extract and saw, had poor yields and grades, and were only suitable for pulp. Other costs were also incurred: there was stem damage on remaining trees, a loss of productive area because of extraction tracks and truck loading sites, a loss in diameter growth on final crop trees compared to what was possible if thinning had been earlier, increased risk of wind damage, and the removal of previously pruned trees as thinnings (Sutton, 1984). In addition, it was shown that as the first two log lengths (bottom 11m) of the final harvest tree contain 60% of the volume and over 70% of the gross value, final crop selection could be made once trees reached 11m. This was much earlier than the then current practices.

At this stage it was already apparent that widely spaced early and heavily thinned and pruned trees would result in a flush of ground vegetation which could be grazed. A series of joint MAF/FRI experiments aimed at establishing trees on pasture, and grazing livestock among young trees were established from 1970 at Whatawhata, Rukuhia, and in the Rotorua district (Kirkland, 1985). More complex trials were subsequently established, to measure tree growth and understory livestock and pasture production, between 1971 and 1975 at Whatawhata, Tikitere, Putaruru, Invermay, and Otago Coast Forest (Kirkland, 1985).

Within the New Zealand forestry industry Sutton (1984) observed that acceptance of their findings was slow. Factors contributing to this included: doubts by management about yield and wood quality, especially of logs above the ground butt log; It was difficult to "prove" a regime that only existed, at that stage on paper; The limited data base suggested lower tree stocking would result in lower total volume production, at a time when low stumpages and non-existent or small quality differentials favoured high volume producing regimes.

By the mid 1970's however, most New Zealand State Forests and some forest companies were thinning early to the final crop stocking and had no production thinning, primarily because of a poor thinning market. Final crop stockings were still much higher than the 200 stems/ha proposed and ranged from 250 to over 400 (Sutton, 1984). A wide diversity of regimes were in fact practiced.

In the late 1970's it became apparent to researchers at FRI that it was becoming increasingly difficult to analyse all the information that was available as complex interactions occurred. In Sutton's view research tended to increase rather than narrow silvicultural options so that it was possible to justify almost any regime (Sutton, 1984). As a result it was decided to develop a simulation model, incorporating the large data base already developed, which would simulate the whole growing, harvesting and conversion process. At the same time a Radiata Pine Task Force was set up to provide a better basis for determining and rationalising silvicultural regimes. Fortuitously the two needs coincided and led to the development of SILMOD, a simulation model which grows one hectare of tended radiata pine and simulates the harvesting, transporting, and sawing of that stand. As a result it allows various sites, management, and utilization options to be evaluated for P.Radiata throughout New Zealand (See Figure 4.1 for an outline of SILMOD). The components of SILMOD have been progressively validated while the model has been extended and improved to include a greater range of options, processing alternatives, and pricing assumptions.

Some of the principal results from both SILMOD and MAF/FRI agroforestry trials include:

(i) Site productivity is the most important determinant of profitability. For example, trees on farm sites with a history of topdressing and pasture development, produce up to 40% more diameter growth during the first 10-15 years than trees growing on adjacent unimproved sites (Kirkland, 1985).

(ii) Farm sites can also be more profitable because they are often better located, more free of weeds, more stable, on easier terrain, are often roaded, and carry lower annual overheads than much of the new crop radiata pine (Kirkland, 1985).

(iii) For any site the most important decision is the final crop stocking. Rather than the 200 stems/ha indicated by the direct regime, optimum stockings may be nearer 100 stems/ha with lower volume yields and larger branches resulting from the lower stocking more than compensated for by lower growing, harvest and processing costs (Sutton, 1984).

(iv) Timing and intensity of pruning and thinning are essential; Sutton (1984) and other researchers strongly believe that tree quality is largely determined by the early silvicultural treatments. Further, with severe pruning any loss of increment is compensated for by an improvement in quality.

From mid-1983 an agroforestry project team was set up to extend

SILMOD where necessary, to cover trees growing at low stocking on farm sites, and to include, in conjunction with MAF, agricultural inputs and outputs based on the research trials. The team was also to cover the introduction of an agricultural component into existing exotic forests (Kirkland, 1985).

4.2.2 Current Extent of Agroforestry

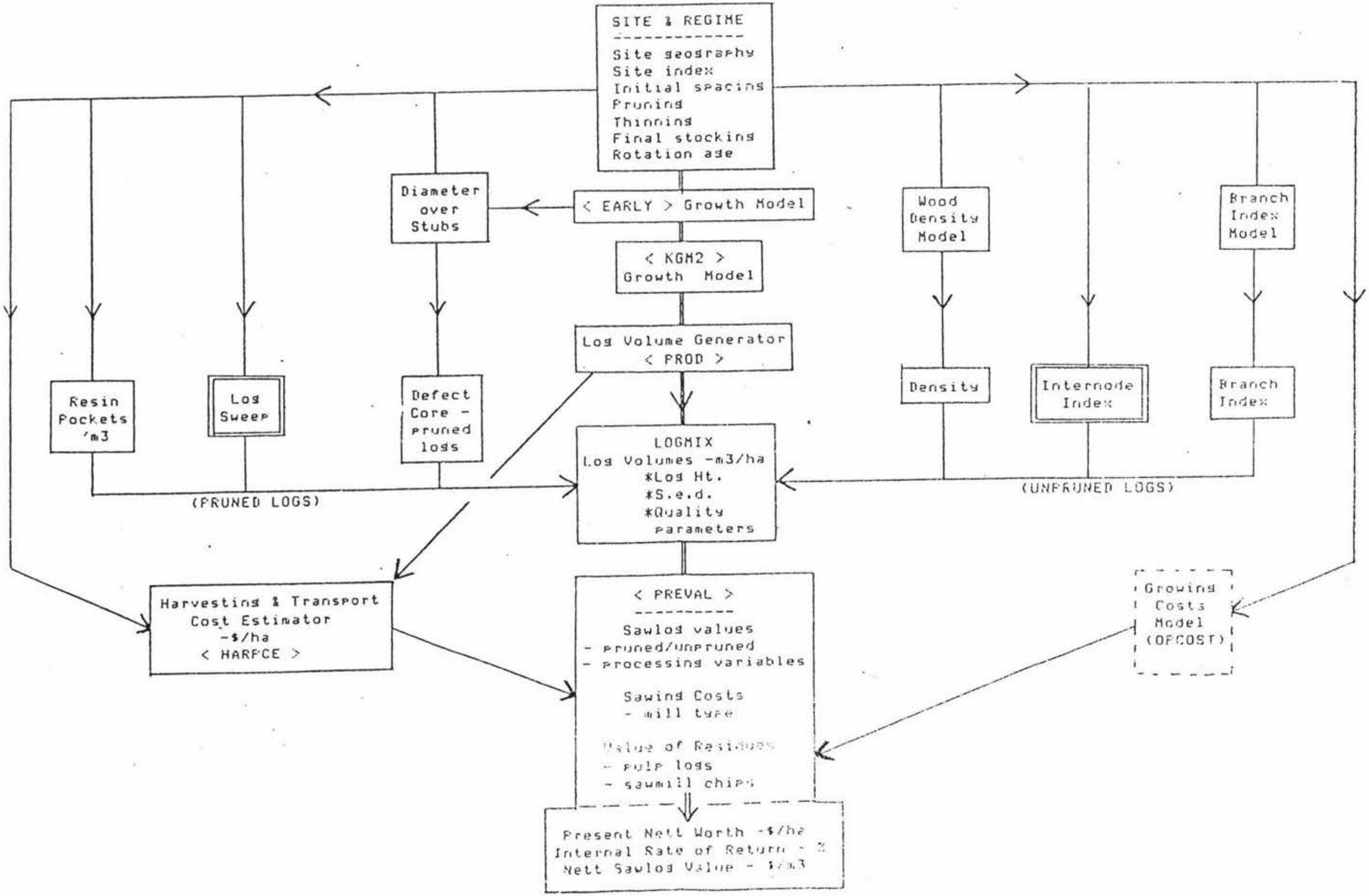
At present there are an estimated 56,000 ha of state and 46,000 ha of private forest where grazing is carried out (Kirkland, 1985). This ranges from runoff grazing to intensively managed agroforests.

On farmland 200,000 ha has been open planted for erosion control, principally with poplar varieties. A further 2,300,000 ha has been estimated as requiring such planting (Kirkland, 1985). While shelterbelts are widespread an extensive national survey would be required to obtain accurate information on this resource (Kirkland, 1985).

Agroforestry, as envisaged by the research findings, is estimated to have been adopted by only 200 farmers (Kirkland, 1985). A considerably greater area has been established by forest companies and joint New Zealand Forest Service and Land and Survey projects.

However further expansion of agroforestry is taking place, often, as a result of leasing and joint ventures between forest companies and landowners.

Figure 4.1 Outline of Radiata Pine Task Force Silvicultural Stand Model ("SILMOD")



Source: (Radiata Pine Task Force Cilvicultural Stand Model "Silmod" Appreciation Seminars, 1982)

4.3 RESOURCE REQUIREMENTS

4.3.1 Land

For agroforestry to succeed several requirements that relate to the land must be met. These include:

Farm location

This is important with respect to obtaining labour, log cartage costs, and growth rate of trees. Knowles (1975) suggests that as most farm forestry contractors are married and prefer to live at home, a farm may need to be within an hours travelling time to obtain this service.

Log cartage costs are particularly significant in the overall profitability of agroforestry; principally because 1 ha of trees produces approximately 4.0 times more weight of produce over 25 years than a hectare used for pastoral farming (Knowles, 1975). In an economic study of agroforestry from the national viewpoint, increasing the distance from the forest to the mill from 80 km to 150 km decreased the net benefit from $405 per 1 ha to $216 per 1 ha (Arthur-Worsop, 1984). This occurred for haulage costs based on Class 1 roads whereas many agroforests are serviced by Class 11 roads and hence would face even greater costs.

Tree growth rate also has a marked effect on profitability. Commonly, tree height growth potential is measured on a scale called site index, which predicts the mean top height of trees on any site at 20 years (Burkhart and Tennant, 1977). A common value for North Island hill country is 28 m with values over the range 18 to 35 m due to changes in factors such as soil depth, rainfall, altitude, exposure, aspect, and latitude (Knowles and Percival, 1983). Each extra 1 to 1.5 m of height growth saves one year in the rotation.

Farm site

Within a farm, choice of suitable sites is significant with respect to pasture and tree productivity, existing vegetation, slope and access. Ideally the most suitable sites are those areas with relatively low pasture productivity because of aspect, slope, soil type, or a combination of factors. Farm foresters in New Zealand such as Neil Barr and John Aitken have demonstrated that sites of low pasture productivity can often be quite suitable for trees. Using such areas, minimises the opportunity costs arising from lost production as a result of shading.

Areas with woody perennial weeds such as gorse, bracken, and blackberry are generally considered less suitable for agroforestry because of the cost of weed control. In such cases plantations with a higher density of planting may be more suitable or alternatively a species such as acacia melanoxylon which requires shading.

Slope is important with respect to both silvicultural costs and particularly logging costs. As a general rule in New Zealand skidders are used on slopes up to 10 degrees, crawler tractors up to 20 degrees and haulers on steeper slopes. SILMOD studies indicate a marked decrease in present net worth with increasing slope although this is far less significant at low agroforestry stocking rates (Knowles and Percival, 1983).

Access is required for both silvicultural operations and harvesting; roading costs to extract a probable 600 tonnes per ha of timber may significantly reduce the profitability of agroforestry.

4.3.2 Labour

Labour requirements for intensive agroforestry systems can form the major cost in the production process. However these can be minimised by low tree stocking rates, pruning and thinning systems adopted to this type of tree growing, the use of on-farm labour during "slack" periods, and the relatively easy access available on most farms.

Tree stocking rate and access

The effect of tree stocking rate and operation conditions is illustrated by Table 4.2. This demonstrates the marked reduction in labour costs achieved with lower tree stocking rates and the easy to straightforward conditions normally considered for agroforestry. By planting 450 stems/ha as against 1500 stems/ha, for example, it is estimated that by the time the trees have had their final pruning \$1200 to \$1400 in costs will have been saved (Barr, 1985).

Lower planting rates have been encouraged still further by the development of improved tree strains. These can be multiplied by small cuttings or tissue culture and have the advantage of a known tree form (Barr, 1985).

Pruning and thinning

The development of agroforestry regimes has led to radical changes in silviculture methods for P. Radiata. Under open conditions this species, left untended, produces large branches and therefore timber of low quality. To produce a large amount of clearwood it is necessary to minimise the size of the defect core (the cylinder containing pith, branch stubs and occlusion scars) and maximise the final log diameter (Koehler, 1984). To achieve this it is necessary to prune and thin trees as early as possible so that the knots are contained in a thin defect core surrounded by a large clearwood zone (Barr, 1985). As pruning results in a loss in growth a balance is therefore required between minimising the size of the central defect core and maintaining tree growth.

Table 4.2 Operation Value Guide

October 1985

OPERATIONS	Stems Per Hectare (s.p.h.a.)	CONDITIONS				
		Easy	Straightforward	Moderate	Difficult	Very Difficult
		Dollars per hectare				
Felling for land clearing		263	450	634	821	1006
Hand felling regeneration		150	313	476	639	802
Hand line cutting		163	238	313	388	464
Spot spray before planting		60	103	145	188	230
Hand fertilising		53	83	113	143	173
Hand planting (exotics)	800	56	93	129	165	202
	1000	68	108	143	187	227
	1200	79	125	172	213	264
	1400	90	137	183	229	276
	1600	103	153	202	252	301
Hand planting (indigenous)	400	64	124	184	243	303
	600	88	155	222	289	356
	800	113	185	257	329	401
	1000	135	215	294	374	453
Marram digging (Dollars per tonne)			119			
Marram hand planting			250			
Blanking	200			25		
	400			44		
	600			63		
	800			81		
Pruning (First lift)	500	232	259	287	315	342
	600	278	311	345	378	410
	700	324	363	402	441	480
Pruning (Second Lift)	200	94	118	142	165	190
	300	141	177	213	249	284
	400	188	236	284	332	379
Pruning (Third Lift)	200	120	151	182	212	243
	300	179	226	272	318	364
Thin to waste (stems removed) (1st thin)	400	69	89	107	125	145
	600	95	118	141	164	186
	800	121	150	179	209	238
	1000	147	180	217	252	287
	1200	173	214	254	295	336
Thin to waste (2nd thin)	200	52	63	72	83	93
	400	89	102	116	130	144
	600	124	141	156	174	190

Note: Costs/ha for blanking, pruning lifts 1, 2, 3 and thinnings-to-waste are for exotic species only.

Source (N.Z.F.S., 1985)

Conventionally, three lift pruning has been used with potential crop trees pruned in three stages at ages 5, 7 and 9 years. However this results in large branch sizes, costly to remove and a large DOS (diameter over stubs). More recently the practice of fixed lift pruning has been used where all trees, irrespective of their height are pruned to the same height. However research results from the FRI (Koehler, 1984) indicate that variable lift pruning (varying the pruned height in accordance with the individual tree height and nodel branching habit) is a much more effective method of containing the DOS. It does this by ensuring all trees receive similar pruning severities and also allows a more flexible scheduling of pruning. Rather than just three lifts the trend under agroforestry conditions has been towards annual lifts.

Variations on variable lift pruning exist. Aitken (1984) advocates diameter related pruning whereby trees are pruned to a predetermined DOS. Claimed advantages for this system include: maintainance of a small defect core; high tree growth rates by ensuring sufficient green branches are left; less physically demanding work as branches are pruned while they are still small.

Early thinning is also necessary under agroforestry regimes, particularly if pasture production is to be maintained at high levels and the effect of flash minimised (Percival and Knowles, 1984). Other advantages to early thinning include: a reduction in competition for light, water, and nutrients, between trees and therefore higher growth rates; minimisation of the cost and effort of pruning trees that will be cut out; and improved wind firmness (Ward, 1984).

Barr (1985) believes plantations should be reduced to their final density when trees reach a height of 6 m if not before. Aitken (1984) has found that a high percentage of faults that prevent a tree being considered as a final crop tree occur in the first two years.

Timing of operation

Agroforestry has the potential to utilize labour at a relatively quiet period on sheep and beef farms, winter. Nearly all operations are carried out during the winter months, prior to lambing and calving and following tupping. Surprisingly the most significant disadvantage of woodlots in a recent survey was the amount of work involved in a woodlot operation (Smaller and Meister, 1983). Over 60% of farmers considered that labour needs for the woodlot activity conflicted with other farming activities. This may well reflect however, the labour input under traditional high density regimes.

4.3.3 Finance

The availability of finance and alternative methods of funding an agroforestry project are crucial to both the projects viability and profitability. In many cases finance availability will put an upper limit on the size of an agroforestry project.

Until 1984 the Forestry Encouragement Events Scheme was a major source of finance for forest growers. However this was abolished in the 1984 budget and replaced by a system of tax deductions. Currently, alternative sources of finance include: On farm from other farm enterprises including eventually the sale of timber; National Water and Soil Conservation Authority Grants; joint ventures; leases; and finance houses.

On-farm financing

On many farms on farm financing of agroforestry is possible. This allows the farmer to retain complete control over the growing of the crop and flexibility in its ultimate sale. In comparison to conventional woodlots there are marked savings in establishment and tending costs with an agroforestry regime. (Table 4.3)

Table 4.3 Annual Establishment and Tending Cost ($/ha) of Woodlots and Agroforestry on Low Fertility Soils

Year	Woodlot	Agroforestry
0	385 preparation	58
1	363 planting/fertilizer	304 planting/fertilizer/fence
2	110 releasing	36 releasing
3	0	0
4	0	0
5	363 thinning/pruning	121 thinning/pruning
6	165 pruning	61
7	264 fertilizer	77
8	363 thinning/pruning/health	379 fertilizer/pruning
9	0	0
10	0	0
11	0	0
12	0	0
13	264 fertilizer	0
14	0	264 fertilizer
15	0	0
Total	2277	1300

Source (Clark, 1985)

Table 4.3 also illustrates how the majority of costs (apart from harvesting) occur in the initial years of a crop rotation. Returns of course do not occur until 25+ years following establishment. With on-farm financing it is therefore essential to ensure the farm can meet the requirement for development funds while the trees are growing (Clark, 1985). For this reason a progressive approach to planting is normally recommended to minimise the risk of limiting operations because of a lack of on-farm finance (Clark, 1985).

National Water and Soil Conservation Authority Grants

With the abolishment of the Forestry Encouragement Grant Scheme, these are the only grants now remaining. Their primary function is to provide protection to soil and water rather than to promote the growing of timber (Lewis and McKenzie, 1984). The protection grant has been widely used in the Wairarapa Hill Country through the work of the Wairarapa Catchment Board and may meet up to 70 percent of a project cost.

Joint ventures

A Forestry Joint Venture is an agreement between an interested investor and a private landowner to develop an area of land into a productive forest (Lewis and McKenzie, 1984).

Ultimate revenue from the tree crop is normally divided in proportion to the agreed contributions between the two parties. Hence this is normally: Farmer: Use of land; payment of rates; costs of fencing; access. Investor: Finance for forest development and management; labour; equipment.

To date the majority of joint venture investors have also been timber processing companies who have acted to provide a guaranteed market at the end of the rotation. For a farmer such a joint venture provides a means of financing and managing a tree crop at very little cost, while the investor is saved the cost of land acquisition. However, this must also be weighed against some loss of management control and lower final returns.

Leases

Under a lease the right of occupation and land use passes to a lessee for a predetermined number of years. In return the landowner generally receives an annual rental and may, in some instances, receive a share of the profit, or percentage on the sale of the produce (Lewis and McKenzie, 1984). In this case management of both the land and forest is in the hands of the lessee.

Finance houses

A farmer may also consider finance from the Development Finance Corporation, Rural Banking and Finance Corporation and other finance houses. Current high interest rates however have prevented most farmers from considering these sources.

Taxation

Within New Zealand numerous taxation changes have been made with respect to forestry; Downey (1987) notes that a typical mature P. Radiata has had thirteen different tax treatments. The most recent taxation policy is discussed in section 5.4.2.

4.3.4 Management

In order to produce high value logs in an agroforest situation, a high standard of management is required. Failure to prune and thin trees on time in an agroforest quickly results in large defect cores and a reduced amount of grazing available under the trees (Percival and Knowles, 1983).

In the past tree planting on farms has tended to follow cycles of activity and neglect (Malloy et al, 1980). In respect to farm shelter Hosking (1978) reported that in the North Island shelterbelts are mostly old, unmanaged, decayed and damaged by winds, with little or no timber value.

Clearly for agroforestry to be successful a change in existing knowledge, skills, and attitudes towards farm forestry will be required. The advisory services of the New Zealand Forest Service are seeking to achieve this through; agroforestry demonstrations; development of extension packages in agroforestry; extension programmes to those areas likely to give a high level of return; further development of SILMOD and its availability for informed decision making (Kirkland, 1985).

4.4 INTEGRATION WITH PASTORAL FARMING

Any farmer considering agroforestry needs to know the likely effect of trees on his agricultural system. In New Zealand quantitative data is now available indicating the effect of P.Radiata on pasture and stock production under a range of conditions. Very little data is available for other tree species, inspite of the potential of many of them for agroforestry.

4.4.1 Effect of Pinus Radiata on the Pasture Component

Information on the effects of tree age and density on pasture production and composition have come from long-term studies on a range of sites in New Zealand including:

Tikitere (near Rotorua)
Waratah (near Putaruru)

Whatawhata

Invermay

Akatore (50 km south of Dunedin)

Pasture Growth

As would be expected pasture growth was found to decrease with higher tree density and generally increase with age of trees (Percival et al, 1984). The latter did not always occur however, and this was attributable to pruning and thinning operations either holding or reducing the competition effect of the trees on pasture growth.

The seasonal distribution of pasture growth was also examined (Table 4.4).

Table 4.4 Seasonal Distribution of Pasture Growth Under P.Radiata (% of annual yield averaged over tree ages 4, 5 and 8 years)

	Tree Stocking Regime (stems/ha)					
Period	0	50	100	200	400	S.E.
Jan-April	28	30	31	31	35	1.7
June-August	8	9	7	8	7	0.9
Oct-Dec	52	49	50	49	46	1.1

Source (Percival et al, 1984).

As livestock carrying capacity is usually determined by the ability to feed stock during winter, present indications are that agroforestry does not lower this more than would be indicated by annual yields.

At both Tikitere (Percival and Knowles, 1983), Invermay and Akatore (Cossens, 1984) a close relationship has been found between relative annual pasture yields (expressed as a proportion of open pasture) and the tree canopy green crown length (GCC = Number of trees per ha x mean green crown length per tree). This has been used to predict future livestock carrying capacities (Cossens, 1984).

Pastoral availability to livestock

The net quantity of pasture available to livestock is the result of not only reduced pasture growth as a result of tree competition, but also the restricted grazing area from thinning and pruning debris (Plate 4.1).

At Tikitere tree density had a predominate effect with, for example, a 50% loss after final pruning in the 400 stems/ha treatment but only 25% maximum loss at 100 stems/ha. Overall, from ages 4 to 10 years, pasture availability was around 85%.

Percival et al (1984) noted that the rate at which slash decays depends on the size of material and time of year, but that little slash will remain at Tikitere by tree age 14 years. With annual silviculture, and lower planting rates of superior form trees less slash can be expected.

Pasture composition

Marked changes in botanical composition have been measured at Tikitere. The largest effect of increased tree stocking was a reduction in ryegrass content with a similar but smaller effect on white clover. Such a decline in white clover has implications for both feed quality and nitrogen fixation. These were replaced by annual grasses such as poa spp., sweet vernal, and goose grass.

Plate 4.1 Slash under trees as a result of recent thinning and pruning
Palmerston North City Corporation, Gordon Kear Forest.

There was little change in the proportion of browntop but yorkshire fog was greater with increasing tree density and also increased greatly during tree establishment. By tree age 5 years pine needle litter greatly increased.

Care needs to be taken in interpreting these results as much of the hill country envisaged as suitable for agroforestry already has very little ryegrass and white clover. Pasture compositions may change little with agroforestry and might even improve with a reduction in exposure. Trials with a range of pasture species at Tikitere indicated no clear production advantage between some commonly available grasses.

4.4.2 Effect of P.Radiata on Livestock Production

The same long term trials also provided information on the effect of P.Radiata tree age and density on animal production. A summary of the results is presented here.

Livestock carrying capacity

At Tikitere mobs of sheep were allocated to different treatments, the size of the basic flock being determined annually, and based on such factors as pasture and stock performance in the previous year, expected changes in the pruning and thinning debris, tree competition, and the grazing policy objective. The latter included similar pasture utilisation (years 5-9) or similar ewe bodyweight (year 10 onwards) (Percival et al, 1984).

As could be expected the number of livestock at each tree stocking was determined by the net pasture available. Hence as tree stocking rate increased livestock numbers decreased. A similar decline was expected as the trees got older; however between years 5 and 8 there was no overall reduction in livestock numbers as a consequence of a steady reduction in tree stocking from thinnings and reduced competition from remaining trees as a result of pruning (Table 4.5).

Table 4.5 Effect of Density and Age of P.Radiata on Livestock Carrying Capacity (relative to livestock carried on open pasture)

Site	Tree Age (years)	Tree Density (stems/ha) Nil	50	100	200	400	100 twin rows
Tikitere	5	100	96	89	67	30	91
	6	100	78	67	53		71
	7	100	86	70	53		71
	8	100	92	79	61	34	78
	9	100	96	78	49	21	78
	10	100	85	68	40	15	71
Waratah	9	100			57		
	10	100			56		
	11	100			42		
	12	100			29		
	13	100			21		
	14	100			17		
	15	100			28		
	16	100			23		

Source (Percival et al, 1984)

These results have highlighted the need for low tree densities in order to maintain a significant agricultural component, as well as the need for timely silviculture. Livestock carrying capacities have been projected forward over a while rotation for different tree densities based on expected pasture growth in relation to expected tree growth (Figure 4.2).

At Akatore and Invermay the indicated carrying capacities in the 30th year at 400 and 200 sph were 2 percent and 11 percent of open pasture respectively compared to 30 percent at 100 sph (Cossens, 1984). Caution is needed in interpreting these results however, as at lower stocking rates the effects of size and shape of the tree canopy are largely unknown (Percival and Knowles, 1983).

Caution is also required in transferring results from these trials to other classes of country. Thus on steep summer dry hill country at Whatawhata it was thought probable that trees at age 9 - 10 and spaced at 100 sph, imposed relatively little limitation on stocking rate (Gillingham, 1984).

Sheep liveweight

Sheep liveweights were monitored regularly at both Tikitere and Waratah. As tree density increased sheep liveweight was lower although the effects were minor at 100 sph. It appeared that while there was evidence for stocking rates being too high on some tree plots, in other cases some other factors appeared to be responsible for the lower liveweights. Suggestions included:

- lower legume content
- pine needle intake
- gastro-intestinal parasites
- vitamin D deficiency
- changes in structural carbohydrates for pasture in low light

The first three factors are thought to be the most significant (Percival et al, 1984).

Wool weight and quality

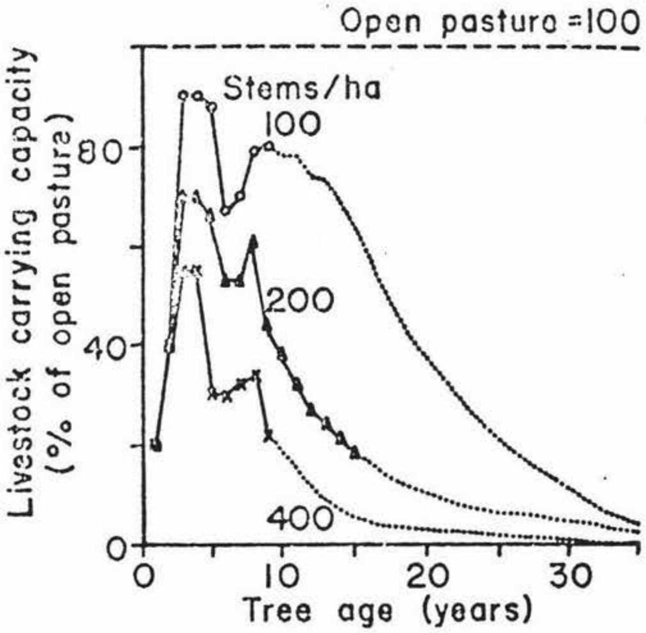
Again, as with liveweight, wool weights were observed to decrease as tree density increased. The overall effect was:

50 stems/ha -8 percent
100 stems/ha -12 percent
200 stems/ha -16 percent

Under older trees at Waratah, the average loss was 25 percent.

A very close relationship between wool weight and sheep liveweight led the researchers to suggest that the effect on wool weight could be accounted for by sheep liveweight changes.

Figure 4.2 Predicted Effects of tree age and stocking on livestock carrying capacity



Source (Percival and Knowles, 1984)

Wool quality changes were minor and economically insignificant.

Lambing percentages and lamb growth rates

The data available from Tikitere indicated that lambing percentage, as measured by lambs born to ewes tupped, was unaffected by the trees with the exception of year 9. It was suggested that a lower ewe liveweight at tupping was responsible for this. Further, there was no evidence of abortion as has occurred with cattle grazing under P.Radiata (Knowles and Dewes, 1980).

At Tikitere lamb survival from birth to docking was similar for all flocks, as there were no severe storms to test the shelter value of trees. However, where agroforestry has been designed to act as a lambing haven, as on P.Smails property at Hororata in Canterbury, significant reductions in lamb losses have been claimed (Reid and Wilson, 1985).

Liveweight gains for lambs between docking and weaning are shown in Table 4.6.

Table 4.6 Liveweight gain between docking and weaning of lambs grazing under P.Radiata (g per lamb per day).

Site	Tree Age			Tree density (stems/ha)			
	(years)	Nil	50	100	200	400	SED
Tikitere	7	219	217	220	237		5
	8	189	189	184	160	156	5
	9	182	175	170	167	133	8
	10	185	164	151	157	7	
Waratah	11	141			112		
	12	194			196		
	14	133			109		

Source (Percival et al, 1984)

The figures in the table above indicate poorer lamb growth rates under the trees, particularly as the tree component becomes more dominant.

Gastro-intestinal parasites

Trials with anthelmintics resulted in small but significant increases in ewe liveweight. As the trials were not accompanied by faecal egg or pasture larval nematode studies, the only conclusion that could be reached was that there was a possibility of higher worm numbers in spring at higher tree densities. Even then, this only occurred in some years.

Mustering times of sheep

The presence of trees was shown to increase mustering time, particularly as tree density increased. However at 50 and 100 stems per ha the differences were not significant.

4.4.3 Effect of P.Radiata on Soil Fertility

The addition of trees to pasture creates a very complex system with nutrients entering from the atmosphere, the weathering bedrock, fertilizers and stock movements, and leaving by the removal of tree and agricultural products, leaching and erosion. Trees are said to improve the cycling by continually bringing nutrients to the surface and replenishing the topsoil with their litter for the agricultural crop (Reid and Wilson, 1985). However tree species vary greatly in their effect on the nutrient cycle. For example, litter from eucalypts and deciduous hardwoods has a low nutrient status while litter from nitrogen fixing trees is generally high in nitrogen.

With P.Radiata, results to date are limited by the age of the trees at Tikitere and Waratah. To date the major effect observed has been a decrease in nitrogen availability with increasing tree density (Percival, Gee and Steele, 1984). It is suggested that this was associated with the decline in white clover and that nitrogen fixation by other legumes may become more important as tree competition increases. The above authors have insufficient information to determine whether the combined nutrient requirements of P.Radiata trees and pasture are greater than conventional agriculture.

4.4.4 Effect of P.Radiata on Microclimate

One of the objectives of an agroforestry regime is to ameliorate the climate for pasture and livestock. Results to date at Tikitere and Waratah are limited by the lack of site replication (Percival, Hawke, Andrew, 1984). However some consistent differences were observed.

Major effects were observed on wind-run and grass minimum temperatures. Wind-run was substantially reduced with trees; this would have the effect of raising the equivalent temperature by several degrees. Grass minimum temperatures were also higher for all seasons under trees. To date however the temperature differences have not altered pasture growth patterns while, contrary to expectation, facial eczema spore numbers were greater on open pasture than under trees.

4.4.5 Effect of the Agricultural Component on P. Radiata

The agricultural component also has a marked effect on tree growth. Once established basal area growth of trees on farmland is up to 40% better than comparable forest sites although height growth is similar (West, 1983). However, in the establishment and even later stages grazing management needs to avoid excessive damage to the trees.

During establishment it is normal not to graze for 6-8 months after planting to avoid excessive tree damage. On some larger blocks with less intensive management, livestock are often excluded for two years. More recently attempts have been made with modified planting patterns and electric fencing to allow uninterrupted grazing following tree planting. Results with grazing indicates stock class, feed utilisation, and the degree to which stock are accustomed to grazing amongst trees are all important factors in influencing tree damage. Thus, beef cattle are preferred to dairy cattle and mature sheep to hoggets. High utilisation of pasture is not recommended until the trees are above 1.2 m (Hawke, Percival and Knowles, 1983). Stock accustomed to grazing amongst trees generally cause considerably less damage.

Once established stock can still damage trees through bark stripping. Cattle, for example, can cause bark stripping damage on trees 8-10 years old (Hawke, Percival and Knowles, 1983). This generally occurs in late winter and early spring and requires stock removal to avoid further damage.

Experience with red deer and goats indicates that pines need to be nine to 10 years old to avoid damage. However, other deer species, for example fallow and sika, have been observed to cause very little damage (Treeby, 1986).

4.5 MARKETING

The existing literature on agroforestry gives scant accord to appropriate marketing strategies for timber by small growers. However, practising farm foresters frequently identify marketing arrangements to be of critical importance. Aitken (1984) suggests that marketing arrangements must exist so that farmers will be confident of future returns. This is particularly relevant when it is considered:
farmers have little or no experience in valuing and selling wood.
stumpages in the past have often been low.

Five alternatives briefly reviewed by Whyte and Kippenburger (1983) include:

Private Sale
Log Exchange
Marketing Agencies
Co-operatives
Joint Ventures.

Private sale has been the most frequent method used in New Zealand to date. While this gives the owner control over the sale of his produce it may entail considerable work on his part including a valuation, advertisement of the sale to take advantage of a competitive market, and accurate measurement of the standing trees or produce being sold. Advertisement of a woodlot for tender may be of little value if there is only one saw miller in the district and therefore a lack of competition.

A log exchange may overcome some of these problems by creating both a larger supply of logs and a larger pool of buyers. With more competition among both growers and processors a fully effective market place may be created (Malloy, 1985).

In the case of a marketing agency three parties are involved, the grower, agency and buyer. Use of an agency, for example a forest consultancy, helps ensure that returns from the sale of timber will be optimised at a cost to the grower of a commission.

The last two alternatives rely on economic co-operation for the sale of timber. In the case of co-operatives the grouping together of producers may lead to greater bargaining power, the possibility for reducing costs, and the opportunity to pool knowledge and expertise. However a co-operative structure may be at a disadvantage if input is not available from future processors on future volume and quality requirements as dictated by market requirements. Joint venture arrangements with processing companies such as the Tuki Tuki Valley venture (Aitken, 1987) may overcome the latter problem in addition to their obvious role in providing finance. Malloy (1985) warns of the dangers however of joint ventures with processing companies solely interested in a low cost source of timber.

Clearly each of these alternatives may have a role to play. The lack of experience in New Zealand suggests that methods used in other countries should be examined for their applicability here. In particular Aitken (1979) believes that the economic co-operation practised in Finland between forest farms has been crucial to the success of forestry in that country. In implementing the Tuki Tuki Valley joint venture, the Finland model has been adopted where each district has its own forest management association. The main function of the associations is to make forestry as profitable as possible by pooling the collective knowledge of owners, companies, and beneficiaries (Aitken, 1987). Such district associations control the rate of extraction of timber, negotiate a floor price for all grades of timber, and provide a comprehensive advisory and management service to the producers (Aitken, 1979).

CHAPTER V

THE INTERTEMPORAL LINEAR PROGRAMMING MODEL

5.1 THE METHODOLOGY ADOPTED

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 its multidimensional nature, both temporal and spatial. Any model should explicitly consider both time and the changing interactions between the tree and agricultural components as the trees grow. To fully meet the study's objective of investigating both the profitability and feasibility aspects of agroforestry, an optimising routine is also highly desirable.

Previous economic studies of agroforestry in New Zealand have relied on discounted cash-flow techniques (for example McRae 1981, Knowles and Percival 1983, Smaller and Meister 1983, Arthur-Worsop 1984, Walker 1984, and Clark 1985). These studies used net present value (NPV) to indicate the profitability of agroforestry and thus accounted for the time aspect of growing trees. However only the latter two studies emphasised the distinction between the profitability and feasibility of agroforestry, that is, the need to maintain a financially viable farm in the years between planting and harvesting. In both cases a whole-farm budgeting approach was taken but with arbitrary assumptions on the rate and area of agroforestry planting. Further, all the analyses were carried out in pre-tax terms. Walker (1984) recognises this limitation and suggests, for example, that the taxation implications of fluctuating livestock numbers could have considerable effects on the profitability and feasibility of agroforestry.

Overseas, partial budgeting has been extensively used for the economic analysis of agroforestry systems (e.g. Nelliat (ed) 1978, Trenbath 1976). However these have generally been restricted to single period studies. More recently a multi-component, multi-time period budgeting package for use on microcomputers has been developed and applied (Etherington, Matthew 1983). This adequately considers the multidimensional aspects of agroforestry while the use of a microprocessor enables many alternatives to be quickly analysed. The primary limitation of this approach is the absence of an optimising routine.

Overseas literature also contains examples of the use of linear programming models to investigate the profitability of farm forestry (Coutu and Ellertsen 1960, Sinden 1970). These models considered both forest and non-forest activities in whole farm situations and determined the most profitable plan for varying resource restrictions of land, labour and capital. However only single periods were analysed with forestry costs and returns discounted and converted to an annual basis by the use of annuities. Thus intertemporal relationships such as the optimal rate of planting and the flow of capital from one period to the next were neglected.

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).

Examples of the use of intertemporal linear programming models in agriculture include Jensen (1968) - pasture improvement, Willis and Hanlon (1976) - selecting an optimum mix of apple varieties, Abalu (1975) - selecting perennial crops, Oppenheim (1978) - orchard development and Verinumbe et al (1984) - leguminous tree crops.

5.2 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

$$aij \leq bi \quad \text{for } i = 1,2\ldots\ldots, m$$
$$x \geq o \quad \text{for } j = 1,2\ldots\ldots, n$$

where

aij = technical coefficients reflecting demand for resource i by activity j,

xj = activity j,

cij = cost/revenue coefficient associated activity j,

bi = quantity of resource i available.

In an intertemporal linear program 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).

Extending the general linear programming model to the intertemporal case gives:

$$\text{Maximise } z = \sum_{j=1}^{n} cj^{1}\, xj^{1} + \sum_{j=1}^{n} cj^{2}\, xj^{2} + \ldots\ldots + \sum_{j=1}^{n} cj^{T}\, xj^{T}$$

$$\text{subject to } \sum_{j=1}^{n} aij^{1}\, xj^{1} \leqslant bi^{1}$$

$$\sum_{j=1}^{n} aij^{2}\, xj^{1} + \sum_{j=1}^{n} aij^{2}\, xj^{2} \leqslant bi^{2}$$

$$\vdots \qquad \vdots \qquad \ddots$$

$$\sum_{j=1}^{n} aij^{T}\, xj^{1} + \sum_{j=1}^{n} aij^{T}\, xj^{2} + \ldots\ldots + \sum_{j=1}^{n} aij^{T}\, xj^{T} \leqslant bi^{T}$$

$$xj^{t} \geqslant 0$$

for $j = 1,2,\ldots\ldots\ldots,n$
$i = 1,2,\ldots\ldots\ldots,T$

where cj^{t} = the contribution per unit of activity xj initiated in period t

xj^{t} = the level at which activity xj is initiated in year t

aij^{t} = the per unit requirement of activity xj for resource bi in period t

bi^{t} = the supply of resource i in period t

5.3 STRUCTURE OF THE MODEL

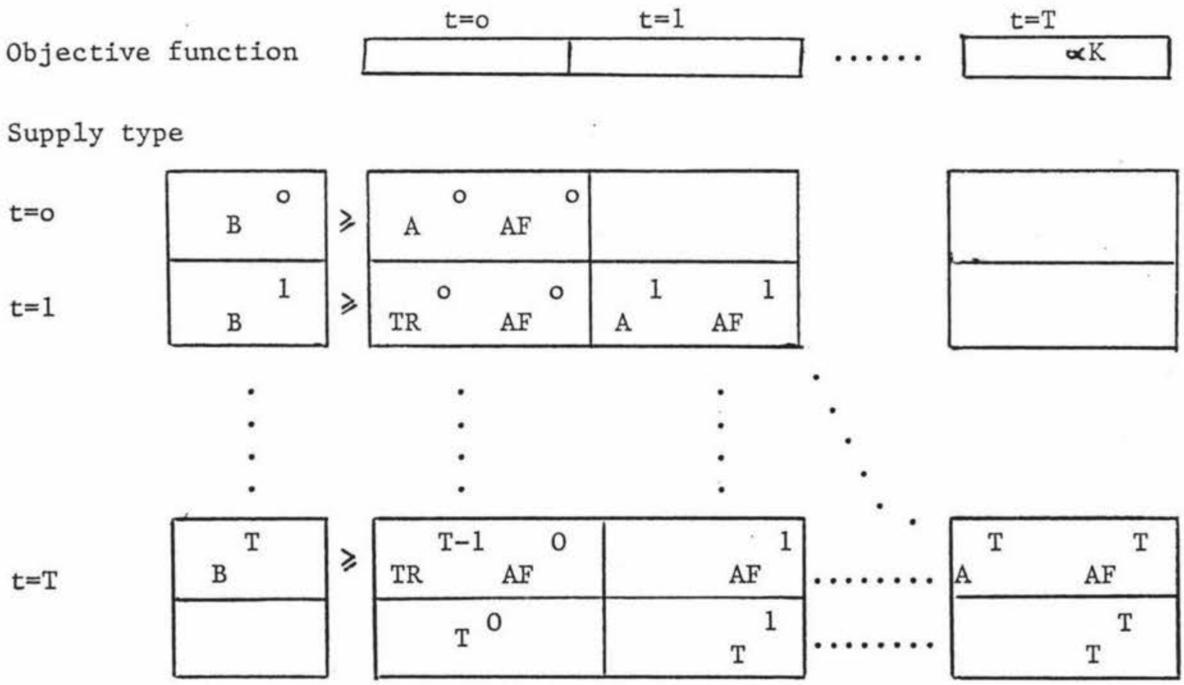
An outline of the major features of the model is given in Figure 5.1. Three major types of activities are included in the models.

(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 5.1



Where A^t = submatrices of coefficients for activities and transactions functioning within year t

AF^t = submatrices of coefficients for agroforestry activities initiated in year t, with a resource requirement in time t

TR^t = submatrices of coefficients for transfer of resources from year t to year t+1 or T

T^t = vector of coefficients of final asset values of activities initiated in year t

B^t = vector of resources and restrictions in period t

αK = a vector of objective function coefficients corresponding to the weights attached to the final q goals

for $t = 1,2,\ldots\ldots,T$
$K = 1,2,\ldots\ldots,q$
$t = 1,2,\ldots\ldots,T$

A simplified part of the matrix of year 0 and 1 is presented in page 142 to provide more detailed information.

5.3.1 Cash Flow in the Model

Figure 5.2 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.

5.3.2 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, 1972). As farmers normally have a number of objectives which they wish to achieve, the hierarchical approach adopted by Olsson (1972), Rae (1977) and others is considered to provide the most realistic approach. Expressed in the form of a utility function in the general sense:

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

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 will be derived.

Secondary "L" objectives include:

1. Consumption levels by the farmer's family.
2. Restrictions to borrowing on overdraft to limit indebtedness and allow the farmer to operate flexibly.

In determining the length of the planning horizon, several views need to be considered. Olsson (1972) suggests that the planning horizon should not be further in time than is of interest to the decision maker. In this case the maximum length of time was the period for which the farmer was running his business. Boussard (1971) argues that "long-run plans are not necessarily made up in order to be carried out, but only to utilise all the available information in making the best possible decision for the present period." In this instance it is suggested that Modigliani's definition of the planning horizon is appropriate: the time within which it is necessary to plan in order to make a decision for the first period.

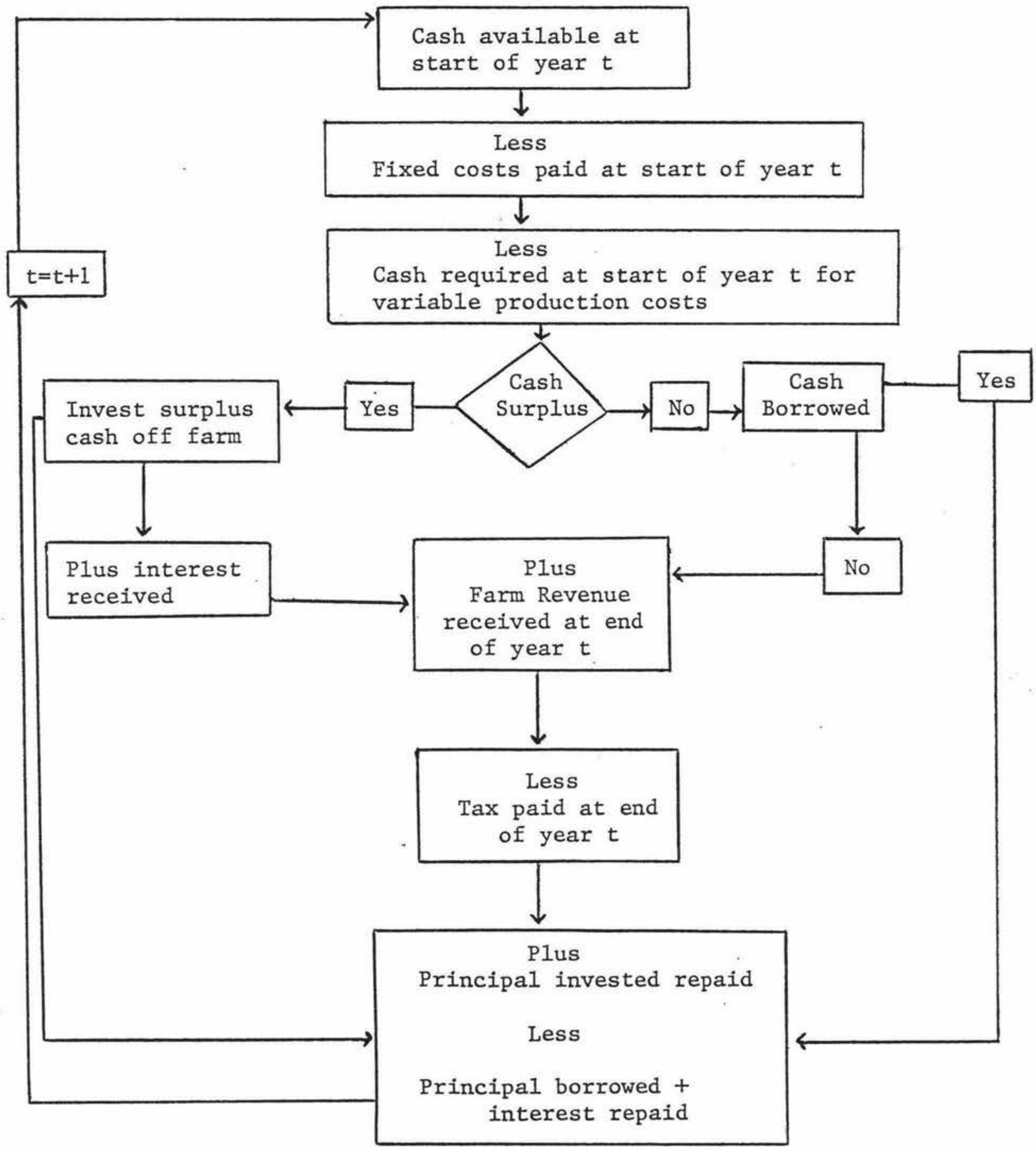
For this model the production cycle of 28 years for the agroforest was considered appropriate as this utilised all the available information and was within the length of time for which an interested farmer may run his business. However, in the event it was only possible to run the model over 21 years 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.

5.3.3 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.

Figure 5.2 Cash Flow in the Model



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 5.1

Table 5.1 Land Class Uses

Land Class	Carrying Capacity (SU/ha)	Sheep	Cattle	Possible Uses Cropping	Agroforestry
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 is defined to meet the farmer's wish for a summer greenfeed crop for lambs. Feed transfer constraints allow 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 is assumed a peak demand for labour by the agroforestry activities will occur. The first constraint limits the total amount of farm labour available by the farmer while the second calculates 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 sums all pre-tax cash receipts and from which all-tax deductible expenditures are 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.

5.3.4 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.

5.3.5 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).

Sheep and cattle activities on open pasture

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.

Cropping and associated livestock activities

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 utilises 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.

5.4 THE DATA USED IN THE MODEL

5.4.1 Selection of a Case Study Farm.

In identifying and selecting the particular farm used in the study, several factors were considered:

(i) Survey data of Wairarapa hill country farms (see chapter 2) reveal a very heterogeneous group of farms and farmers. This variation extends from underlying physical characteristics such as land classes and climate, indices of productivity and profitability, through to differences in managerial ability, capital availability and objectives.

(ii) The agroforestry system under review, with a low density of plantings was virtually non-existent in the Wairarapa.

(iii) The large amount of detail required for the model and its usefulness would be very dependent on the enthusiasm and co-operation of the personnel concerned.

(iv) A primary purpose of the study was to provide information that would be of value to Wairarapa hill country farmers and their advisors rather than say, the implications of alternative government policies.

(v) The time available.

Two alternative ways to analyse groups of farms are the representative farm and cash study approach, neither of them necessarily mutually exclusive. The use of representative farms has been reviewed by Carter (1963), Day (1963), Plaxico and Tweeten (1963) and others.

The representative farm approach has tended to be most useful in policy studies, for example aggregate production requirement studies and the implications of alternative policies. Representative farms have been far less useful in providing guidance to individual farmers particularly where there is a wide variation in resources and management between farms. In addition most representative farm studies are carried out in a static framework, effectively ignoring the constantly changing conditions that farmers operate in.

Some of these limitations can be partially overcome by stratifying the population under study into more homogeneous groups (See ElAdeemy and MacArthur, 1969). This at least ensures that the results of a study will be partially applicable to more than just the farm studied.

Given adequate time, the latter approach would have best suited the circumstances and purposes of the study. However this would have necessitated the gathering of a great deal of data to both identify representative farms and then construct linear programming models for such properties. Instead a case study approach was adopted but with an emphasis on parametric programming so as to analyse different problem situations.

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 performance.

(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. Plates 5.1 - 5.8 illustrate the different land classes on the case study farm and aspects of their properties.

5.4.2 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

Relevant farm details are contained in Appendices 1 and 2.

Land use and stocking rates

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 (Noble, 1985) 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

Plate 5.1 View of homestead sites
Middle foreground Land Classes II and II
Distance: Class IV rising to Class V

Plate 5.2 Foreground: Land Classes III and II following wheat crop.
Background: Land Class VI (in bush)

Plate 5.3 View north towards Masterton.
Land Classes V and IV visible

Plate 5.4 Land Class IV

Plate 5.5 Land Class V. Note rocky limestone outcrops.

Plate 5.6 Two year old pine tree on Class V showing effects of drought, competition, and possible manganese deficiency.

Plate 5.7 Land Class VI - recent slump erosion to be stabilised by tree planting

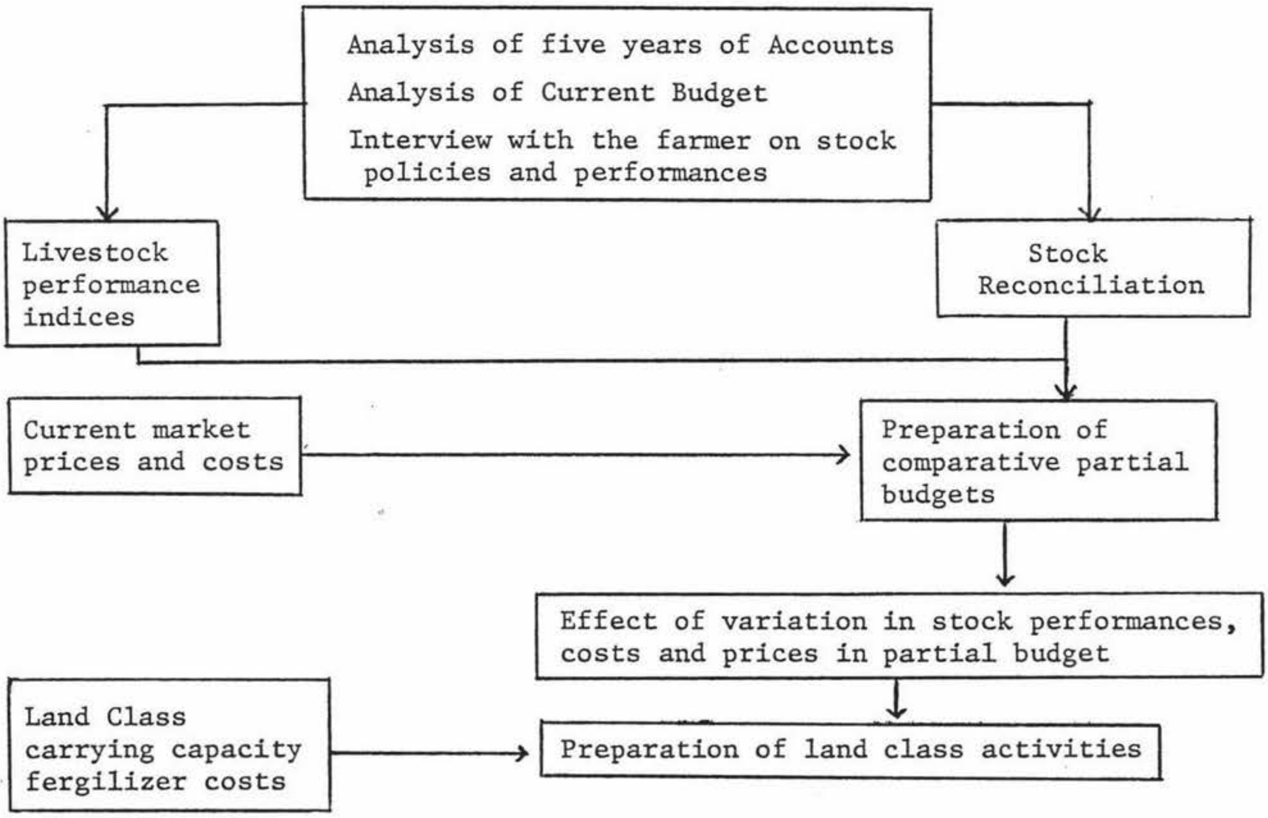
Plate 5.8

Land Class VII. Note soil and water conservation on plantings of P.Radiata and poplars by Wairarapa Catchment Board.

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.

Agricultural performances and returns

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



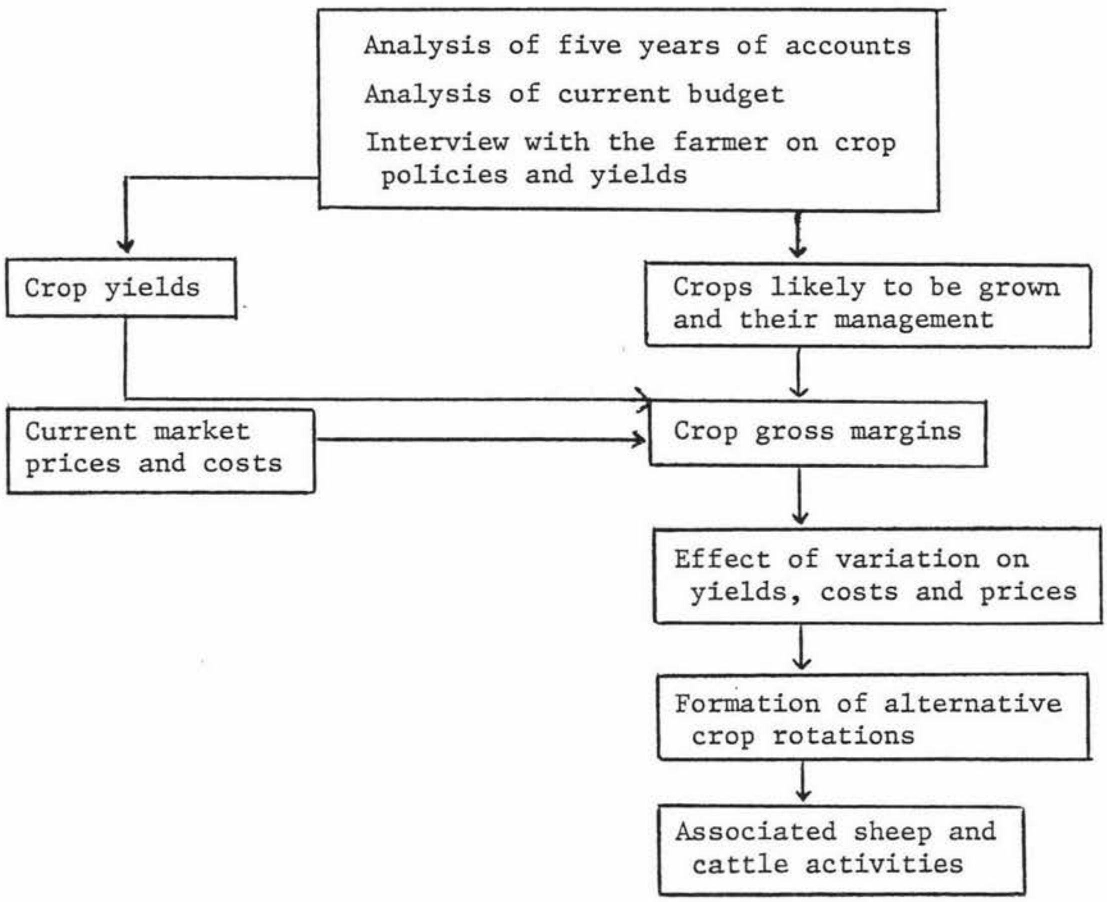
Several features deserve comment:

(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 fertilizer 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 (Appendix 3).

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. This had the advantage of a more comprehensive data base on which to rely. 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 timber.

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:

$$AVCOBt = 0.48*a/(1+1) \quad (28-t)$$

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

i = discount rate.

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, 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:

$$A = \sum_{t=1}^{n} \frac{NRj^{t}}{(1+i)^{t}} * \frac{i(1+i)^{t}}{(1+i) - 1}$$

where NRj^{t} = 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:

$$AVj^{t} = \frac{NRn+1}{(1+i)} + \frac{NRn+2}{(1+i)^{2}} + \ldots.., \frac{NRn+m}{(1+i)^{n}} + \frac{\frac{A}{i}}{(1+i)^{n+1}}$$

where AVj^{t} = the asset value of activity j, initiated in year t

NRn = 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 firms 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:

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

where K(e) = after-tax rate of return on equity capital

K(d) = the long run proportion of equity used to operate the firm

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.

Details of these calculations are contained in Appendix 5. 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.

5.5 SUMMARY

In order to give a more detailed examination of the model the first two years are detailed in Table 5.2. To assist in interpreting the matrix the following legend should be used:

Abbreviations	Explanation
Constraints	
OBJFN	objective function
LAND2	land class IIw
LAND3	land class IIIs1
LAND4	land class IVe4
LAND5	land class Vc1
LAND6	land class VIe4
LAND7	land class VIIe2
TFEED1	transfer of feed from crop rotations on LAND2
TFEED2	transfer of feed from crop rotations on LAND3
CROPM	minimum crop area
LABT	total farm labour supply June-August
LABAG	farm labour used by agroforestry activities
SCHGE	sheep livestock reconciliation
CCHGE	cattle livestock reconciliation
OCASH	cash available at the start of the year
REV	farm revenue
TAXD	tax deductions
COBT	cost of bush transfer
Activities	
S2-S7	sheep: land classes 2-7
C2-C7	cattle: land classes 2-7
SCROP2	sheep associated with crop on LAND2
CCROP2	cattle associated with crop on LAND2
SCROP3	sheep associated with crop on LAND3
CCROP3	cattle associated with crop on LAND3
ROTNW2	wheat based rotation on LAND2
ROTNW3	wheat based rotation on LAND3
ROTNB2	barley based rotation on LAND2
ROTNB3	barley based rotation on LAND3
AF4	agroforestry on land class 4
AF6	agroforestry on land class 6
AF7H	agroforestry on land class 7
HIRE LABOUR	hire of labour for silvicultural work
INCREASE /DECREASE SHEEP	change in sheep
INCREASE/ DECREASE CATTLE	change in cattle
BORROW	borrowing
LEND	lending

TAXT1	tax transfer at 15 cents in the $
TAXT2	tax transfer at 30 cents in the $
TAXT3	tax transfer at 48 cents in the $
TAX DEDUCTION TRANSFER	transfer of tax deductible expenditures
FORESTRY TAX DEDUCTION	allowance for forestry expenditure to be tax deductible
COST OF BUSH ACCOUNT	carrying forward of non tax deductible forestry expenditure to final asset row

The model was solved using the SCICONIC/VM Mathematical Programming Package on the Massey University Prime 750 computer.

Table 5.2 First Two Years of Model Matrix

CONSTRAINT	RHS	SHEEP -LAND CLASSES 2-7						CATTLE -LAND CLASSES 2-7						SHEEP AND CATTLE ASSOCIATED WITH CROP				CROP ROTATIONS				AGROFORESTRY				STOCK RECONCILIATION						TAXATION TRANSFERS					
		S2	S3	S4	S5	S6	S7	C2	C3	C4	C5	C6	C7	SCROP2	CCROP2	SCROP3	CCROP3	ROTNW2	ROTNW3	ROTNB2	ROTNB3	AF4	AF6	AF7H	HIRE LABOUR	INCREASE SHEEP	DECREASE SHEEP	INCREASE CATTLE	DECREASE CATTLE	BORROW	LEND	TAXT1	TAXT2	TAXT3	TAX DEDUCTION TRANSFER	FORESTRY TAX DEDUCTION	COST OF BUSH ACCOUNT
OBJFN																																					
LAND2	23	1						1										6		6																	
LAND3	52		1						1										6		6																
LAND4	75			1						1												1															
LAND5	357				1						1																										
LAND6	119					1						1											1														
LAND7	59						1						1											1													
TFEED1														58.50	51.40			-58.50		-58.50																	
TFEED2																63.50	56.40		-63.50		-63.50																
CROPM	12																	6	6	6	6				-1												
LABT	876	.81	.93	.70	.76	.70	.52	1.66	1.90	1.42	1.54	1.42	1.06	3.45	6.17	3.75	6.77	10	10			4.80	8.20	11.80	1												
LABAG																						-4.80	-8.20	-11.80		-1	1										
SCHGE	7086	13.80	15.80	11.80	12.80	11.80	8.80							58.50		63.50												-1	1								
CCHGE	1412							13.80	15.80	11.80	12.80	11.80	8.80		51.40		56.40													-1	1						
OCASH	60000	108	116	100	104	100	89	95	101	89	92	89	80	230	152	250	167	2816	2816	2733	2733	140	140	155		12	-3	70.50	-70		-.20	1	1	1	1		
REV		-360	-413	-308	-334	-308	-230	-426	-488	-365	-395	-365	-272	-1530	-1587	-1661	-1742	-3185	-3185	-2920	-2920	-35	-35	-26		8.40	8.40	45	-45	-.22					1	-1	
TAXD	121648	-108	-116	-100	-104	-100	-89	-95	-101	-89	-92	-89	-80	-230	-152	-250	-167	-2816	-2816	-2733	-2733	-99	-99	-74	-11.20											1	1
COBT																						-140	-140	-155													
LAND21	23																																				
LAND31	52																																				
LAND41	75																					1															
LAND51	357																																				
LAND61	119																						1														
LAND71	59																							1													
TFEED11																																					
TFEED21																																					
CROPM1	12																																				
LABT1	876																					3.20	5.70	.10													
LABAG1																						-3.10	-5.60														
SCHGE1		-13.80	-15.80	-11.80	-12.80	-11.80	-8.80																														
CCHGE1								-13.80	-15.80	-11.80	-12.80	-11.80	-8.80	-58.50	-51.40	-63.50	-56.40													1.22	-1	-.85	-.70	-.52	-1		
OCASH1	-133688																					7	7	6													
REV1																						-42	-42	-32													
TAXD1	121648																					12	12	9													
COBT1																																					

CONSTRAINT	SHEEP -LAND CLASSES 2-7						CATTLE -LAND CLASSES 2-7						SHEEP AND CATTLE ASSOCIATED WITH CROP				CROP ROTATIONS				AGROFORESTRY				STOCK RECONCILIATION						TAXATION TRANSFERS					
	S21	S31	S41	S51	S61	S71	C21	C31	C41	C51	C61	C71	SCROP21	CCROP21	SCROP31	CCROP31	ROTNW21	ROTNW31	ROTNB21	ROTNB31	AF41	AF61	AF7H1	HIRE LABOUR1	INCREASE SHEEP1	DECREASE SHEEP1	INCREASE CATTLE1	DECREASE CATTLE1	BORROW1	LEND1	TAXT11	TAXT21	TAXT31	TAX DEDUCTION TRANSFER1	FORESTRY TAX DEDUCTION1	COST OF BUSH ACCOUNT1
OBJFN																																				
LAND2																																				
LAND3																																				
LAND4																																				
LAND5																																				
LAND6																																				
LAND7																																				
TFEED1																																				
TFEED2																																				
CROPM																																				
LABT																																				
LABAG																																				
SCHGE																																				
CCHGE																																				
OCASH																																				
REV																																				
TAXD																																				
COBT																																				
LAND21	1						1										6		6																	
LAND31		1						1										6		6																
LAND41			1						1												1															
LAND51				1						1																										
LAND61					1						1											1														
LAND71						1						1											1													
TFEED11													58.50	51.40			-58.50		-58.50																	
TFEED21															63.50	56.40		-63.50		-63.50																
CROPM1																	6	6	6	6																
LABT1	.81	.93	.70	.76	.70	.52	1.66	1.90	1.42	1.54	1.42	1.06	3.45	6.17	3.75	6.77	10	10			4.80	8.20	11.80	-1												
LABAG1																					-4.80	-8.20	-11.80	1												
SCHGE1	13.80	15.80	11.80	12.80	11.80	8.80							58.50		63.50										-1	1										
CCHGE1							13.80	15.80	11.80	12.80	11.80	8.80		51.40		56.40											-1	1								
OCASH1	108	116	100	104	100	89	95	101	89	92	89	80	230	152	250	167	2816	2816	2733	2733	140	140	155						-1	1						
REV1	-360	-413	-308	-334	-308	-230	-426	-488	-365	-395	-365	-272	-1530	-1587	-1661	-1742	-3185	-3185	-2920	-2920	-35	-35	-26		12	-3	70.50	-70		-.20	1	1	1	1		
TAXD1	-106	-116	-100	-104	-100	-89	-95	-101	-89	-92	-89	-80	-230	-152	-250	-167	-2816	-2816	-2733	-2733	-99	-99	-74		8.40	8.40	45	-45	-.22					1	-1	
COBT1																					-140	-140	-155	-11.20											1	1

CHAPTER VI

A LINEAR PROGRAMMING ANALYSIS OF AGROFORESTRY

6.1 INTRODUCTION

In this chapter the results of the agroforestry model are discussed by means of comparing them with the results of a benchmark model. Both models are assumed to commence with the 1986/87 year, with the latter model representing the farm business without agroforestry activities.

Before presenting the results, section 6.2 discusses model validation and the development of the benchmark model.

6.2 MODEL VALIDATION

Model validation can be regarded as comprising two components, testing and evaluation. France and Thornley (1984) characterise these as follows:

> Testing - refers to checking for methodological correctness, e.g. the mathematical equations must correctly represent the stated agricultural and biological assumptions, the equations must be self-consistent and dimensionally homogenous; any algebra and analysis must be free from error; the computer coding must be correct and so on.
>
> Evaluation - concerned with aspects such as appropriateness to objectives, plausibility, goodness-of-fit, elegancy, economy, simplicity and utility.

Thus, while testing is an objective process, evaluation is essentially subjective and in the case of linear programming involves running through repeated cases to see whether it meets the "test of believability" (McCarl, Nuthall, 1982). A further point is that validation is a continuous process and needs to occur at each step in model development including:

(i) Model structure, including its biological and economic assumptions.

(ii) Mathematical expression of (i) and any further mathematical analysis.

(iii) The solutions of the equations derived in (ii).

(iv) Examining and interpreting the predictions of the model (France and Thornley, 1984).

In Chapter 5 the model's structure and mathematical expressions used were described and discussed. Further discussion on some of the internal limitations of the model is covered in Chapter 8. The usual postulates in linear programming of linearity, divisibility, additivity and finiteness also apply.

The solutions to all equations used to generate data for the model were checked carefully while accuracy of input data was assisted through the use of a spreadsheet package on a microcomputer. Results generated by the model for a range of circumstances were carefully examined for consistency. The cashflow was checked by hand to ensure that this aspect had been correctly modelled.

To evaluate the predictions of different model solutions, a benchmark (B) was used to represent the status quo of the farm business. This was the intertemporal linear program (I.L.P.) without the agroforestry activities. The results of both 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. For example, the farmer had already concluded that his cattle policy was less profitable than his sheep, that surplus labour would be available for agroforestry operations and that capital availability would help determine planting rates: all features of the model. Previous economic studies of agroforestry, e.g. Walker (1984), Clark (1985), had also highlighted some of the findings of this study such as the need to maintain financial feasibility under circumstances of reduced annual cash inflows with agroforestry. 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.

6.3 DESCRIPTION OF RESULTS

6.3.1 Structural Changes

The structural changes in farm enterprises are summarised in tables 6.1 for the A.F. model and may be compared with the results for the B model in Table 6.2

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 6.1

Table 6.1 Agroforestry Model - Physical Programme

YEAR	AGROFORESTRY PLANTINGS						SHEEP	CATTLE	AGROFORESTRY SU				TOTAL	CROPPING	
	AF4	AF6	AF7H	TOTAL/YR	ACCUM TOT	PROPN UTIL AREA	SU	SU	AF4	AF6	AF7	SUBTOTAL	SU	SCROP2	ROTNW2
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	82.65	43.80	0	126.45	7611.45	2	2
2	6.70	2.73	0	9.43	92.85	13.55	7355	18	227.29	96.03	0	323.32	7696.32	2	2
3	1.54	0	0	1.54	94.39	13.78	7355	0	499.46	213.90	0	713.37	8068.37	2	2
4	0	0	0	0	94.39	13.78	7355	0	664.71	240.16	0	904.87	8259.87	2	2
5	5.47	0	0	5.47	99.86	14.58	7290	0	705.53	255.31	0	960.84	8250.84	2	2
6	0	3.07	0	3.07	102.93	15.03	7254	0	726.98	255.31	0	982.29	8236.29	2	2
7	0	5.88	0	5.88	108.81	15.88	7184	0	739.89	262.56	0	1002.45	8186.45	2	2
8	0	4.20	0	4.20	113.01	16.50	7135	0	770.25	283.68	0	1053.93	8188.93	2	2
9	0	10.08	0	10.08	123.09	17.97	7016	0	786.71	333.23	0	1119.94	8135.94	2	2
10	0	6.97	0	6.97	130.06	18.99	6934	0	753.53	377.11	0	1130.64	8064.64	2	2
11	0	14.59	0	14.59	144.65	21.12	6761	0	685.41	417.63	0	1103.04	7864.04	2	2
12	0	13.70	0	13.70	158.35	23.12	6600	0	612.45	497.45	0	1109.90	7709.90	2	2
13	0	9.25	0	9.25	167.60	24.47	6491	0	538.03	576.36	0	1114.39	7605.39	2	2
14	0	0	0	0	167.60	24.47	6491	0	470.84	687.34	0	1158.18	7649.18	2	2
15	0	0	0	0	167.60	24.47	6491	0	397.32	762.92	0	1160.24	7651.24	2	2
16	0	0	0	0	167.60	24.47	6491	0	354.68	804.88	0	1159.56	7650.56	2	2
17	0	0	18.10	18.10	185.70	27.11	6331	0	333.78	790.74	0	1124.51	7455.51	2	2
18	0	9.59	14.67	24.26	209.96	30.65	6082	0	318.32	777.54	31.86	1127.72	7209.72	2	2
19	0	0	16.72	16.72	226.68	33.09	5942	0	304.83	773.40	89.53	1167.76	7109.76	2	2
20	0	16.80	9.50	26.30	252.98	36.93	5615	0	291.70	766.71	192.56	1250.97	6865.97	3.83	3.83
TOTALS	75	118.99	58.99												

Table 6.2 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

Figure 6.1 Agroforestry Plantings

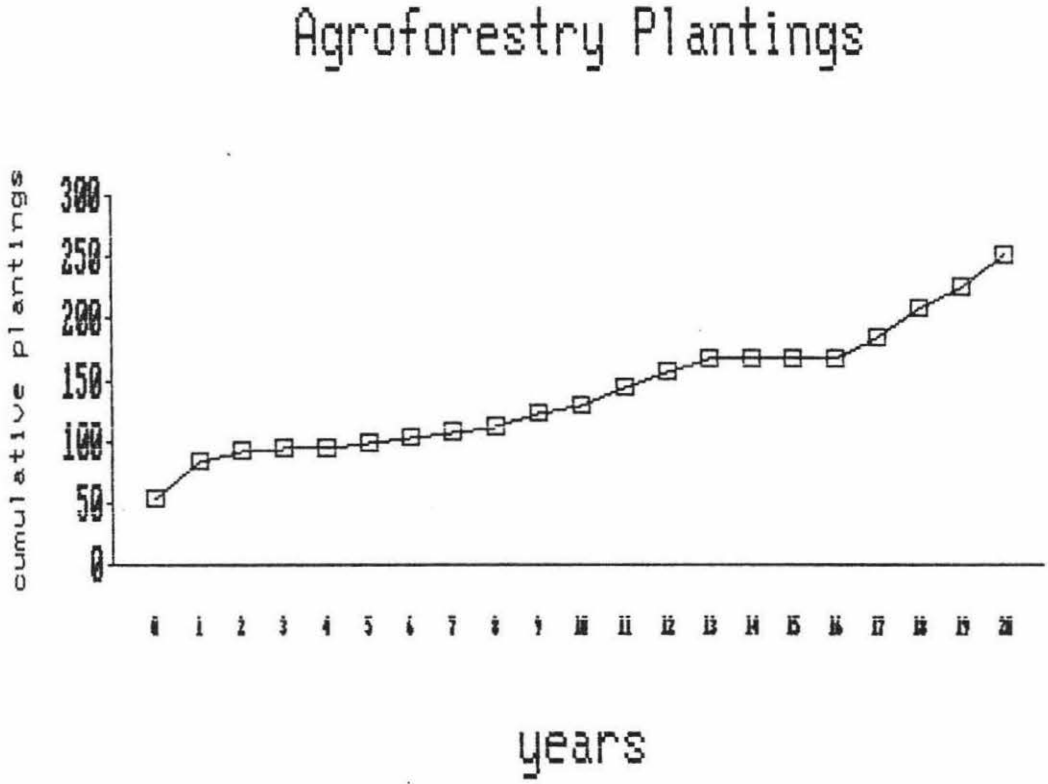
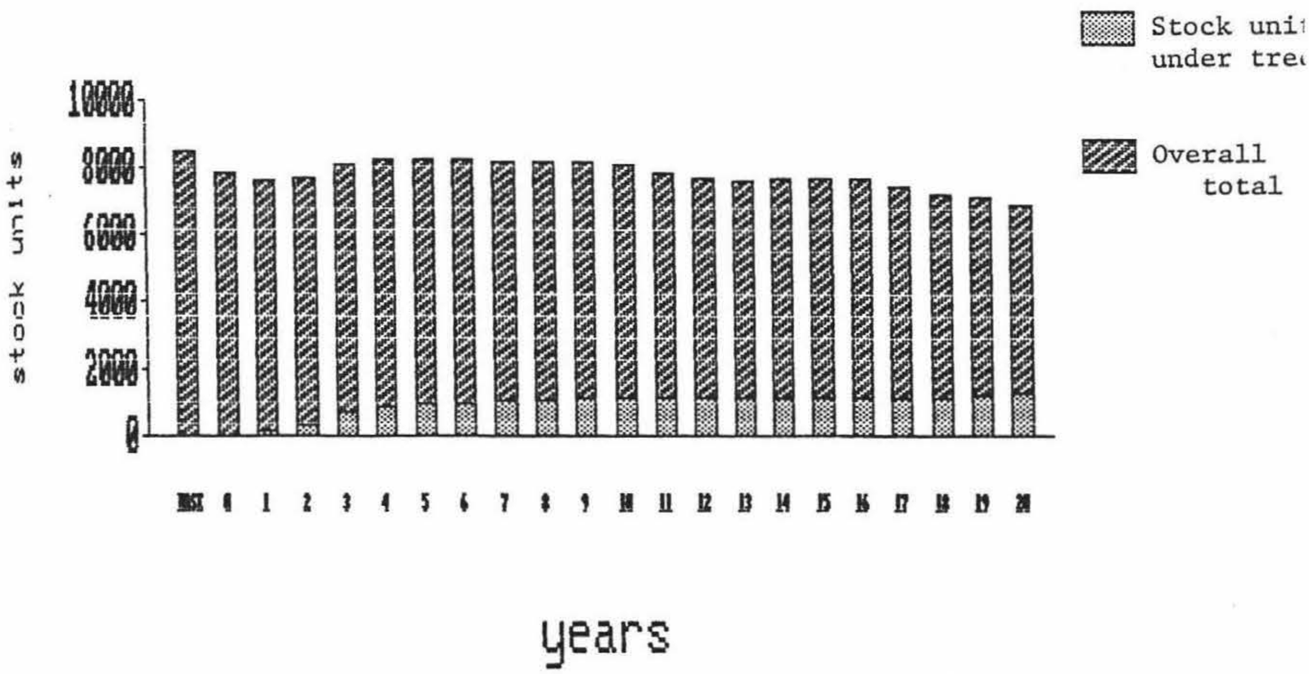


Figure 6.2 Total Stock Units



Associated with the adoption of agroforestry were corresponding changes in stock units (Figure 6.2). 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 6.3. 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 artefact 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.

6.2.2 Labour

The adoption of agroforestry on the scale specified in A.F. substantially alters the labour profile for the property. Table 6.3 summarises these changes.

Figure 6.3 Agroforestry Stock Units

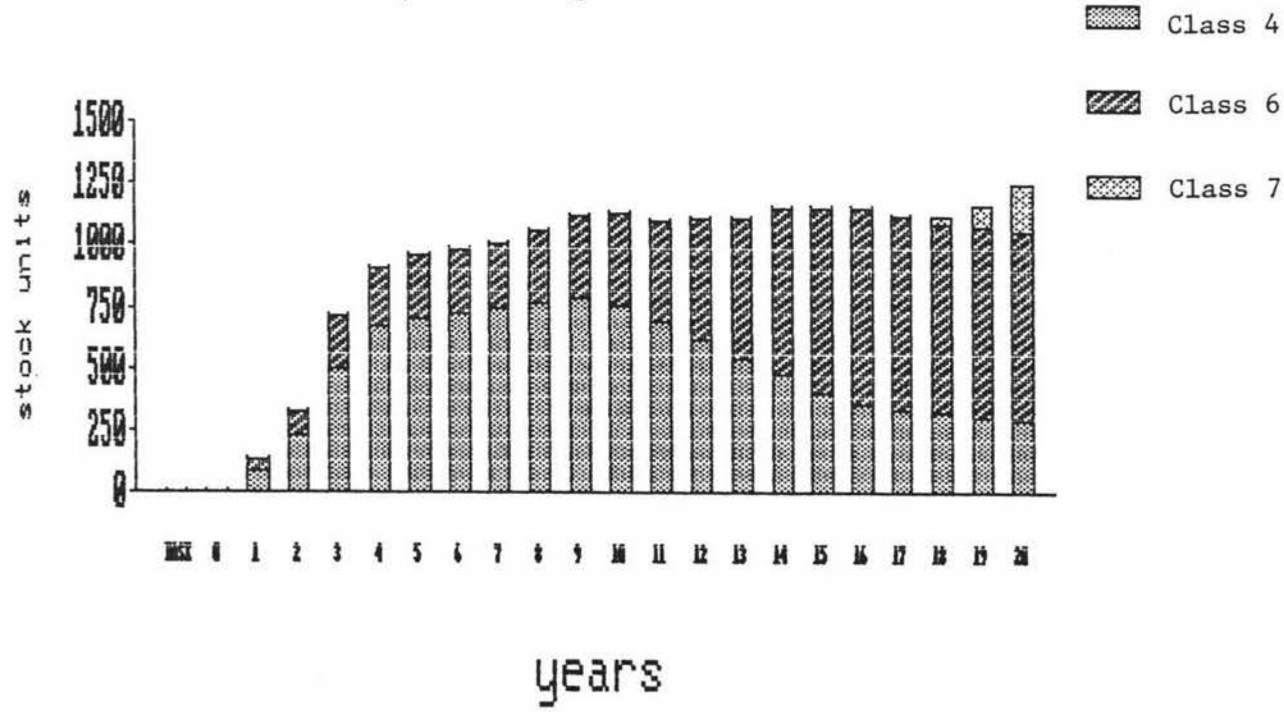


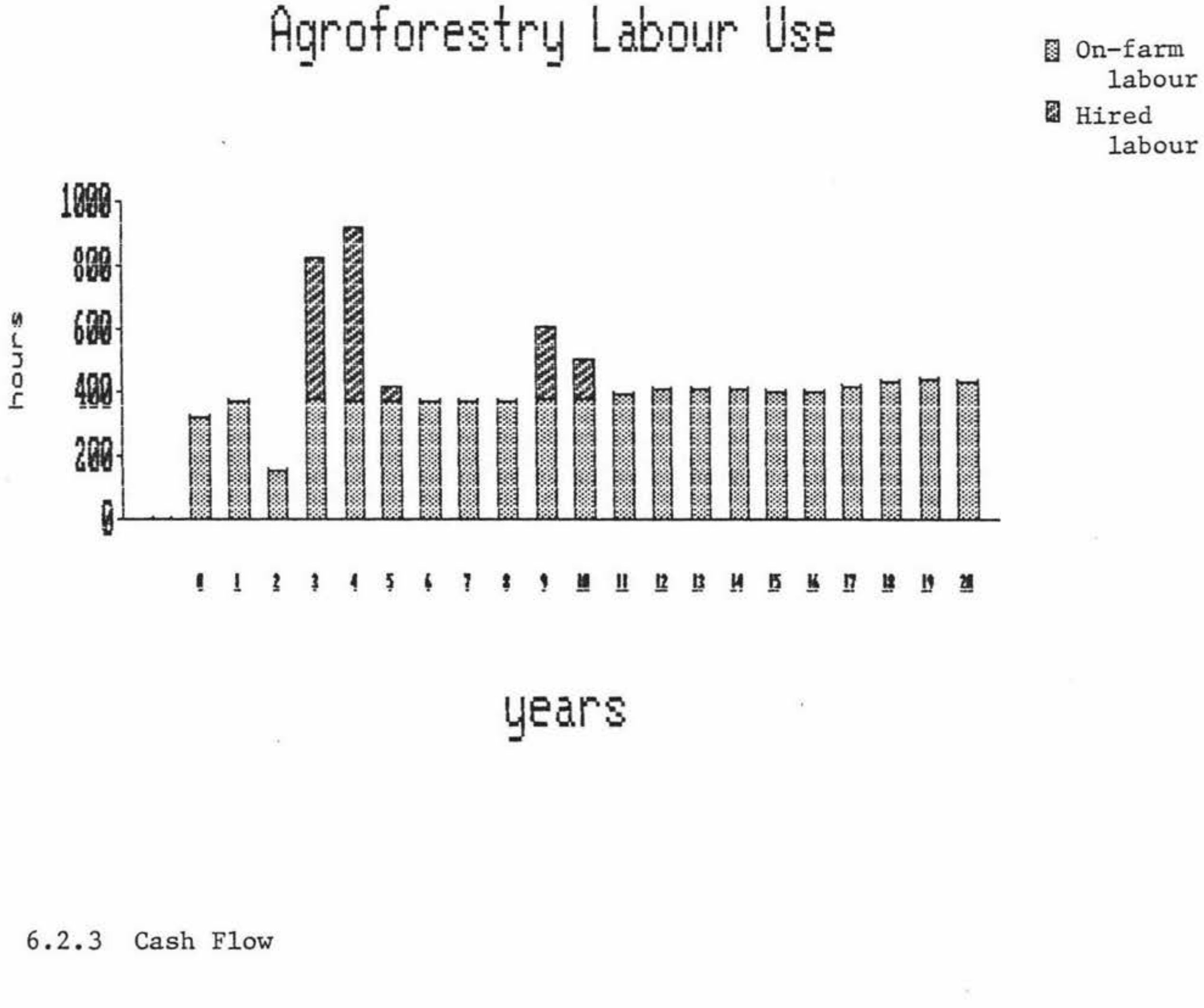
Table 6.3 Labour Profiles for the Benchmark and Agroforestry Plans

YEAR	SURPLUS LABOUR		LABOUR USED FOR AGROFORESTRY		
	BENCHMARK	AGROFORESTRY	FARM LABOUR	HIRED LABOUR	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

In the B model a substantial surplus of labour over the winter period was forecast at 354 hours, or 40% of those 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 6.4). In five of the years additional labour in hired, with a peak in year 4 of 556 hours. 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.

Figure 6.4 Agroforestry Labour Use



6.2.3 Cash Flow

Cashflows for both A.F. and B models are presented in Tables 6.4 and 6.5 respectively.

These tables reflect the pattern of cash flow described in Section 5.3.1. Thus for the B model (Table 6.5) 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.

Table 6.4 Agroforestry 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	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	38421	142964	72396	0	40269	227437	10425	217012	257281	6
257281	0	38421	142964	70822	0	43495	226832	10425	216407	259902	7
259902	0	40269	142964	71931	0	45007	226888	10281	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	6851	203316	243224	14
243224	0	45891	142964	66705	0	33555	209278	6750	202528	236083	15
236083	0	39908	142964	64600	0	28519	208495	7115	201380	229899	16
229899	0	33555	142964	66119	0	20816	203123	4220	198903	219719	17
219719	0	28519	142964	63598	0	13157	195333	2393	192940	206097	18
206097	0	20816	142964	63133	0	0	190335	1415	188920	188920	19
188920	20000	13157	142964	65956	0	0	189953	27	189926	189926	20

Table 6.5 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 6.5 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;

(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 6.5 Direct (variable) costs

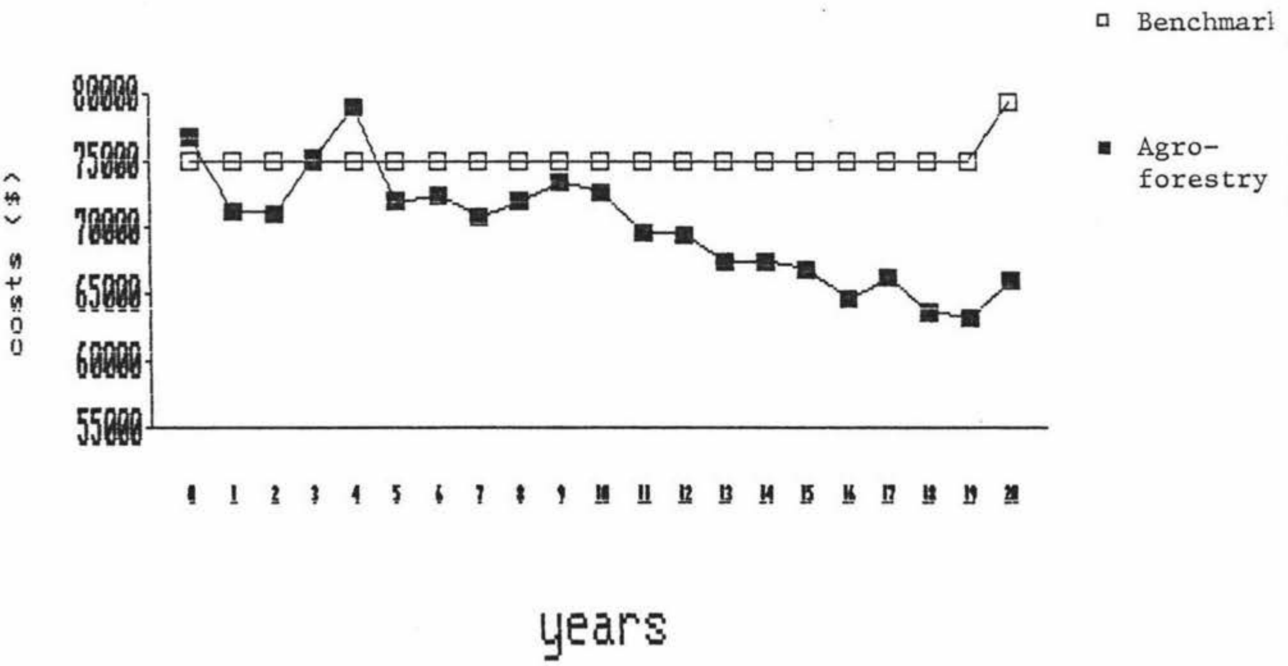


Figure 6.6 indicates the predicted differences in gross farm income between the A.F. and B models. The high initial income in year 0, particularly for the B model is due to the sale of the cattle. Under the stable sheep policy adopted for the B model income slowly increases as funds available for lending 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 6.2). 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 6.7) and the end of year bank balance (Figure 6.8). 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 6.6 Total Farm Revenue

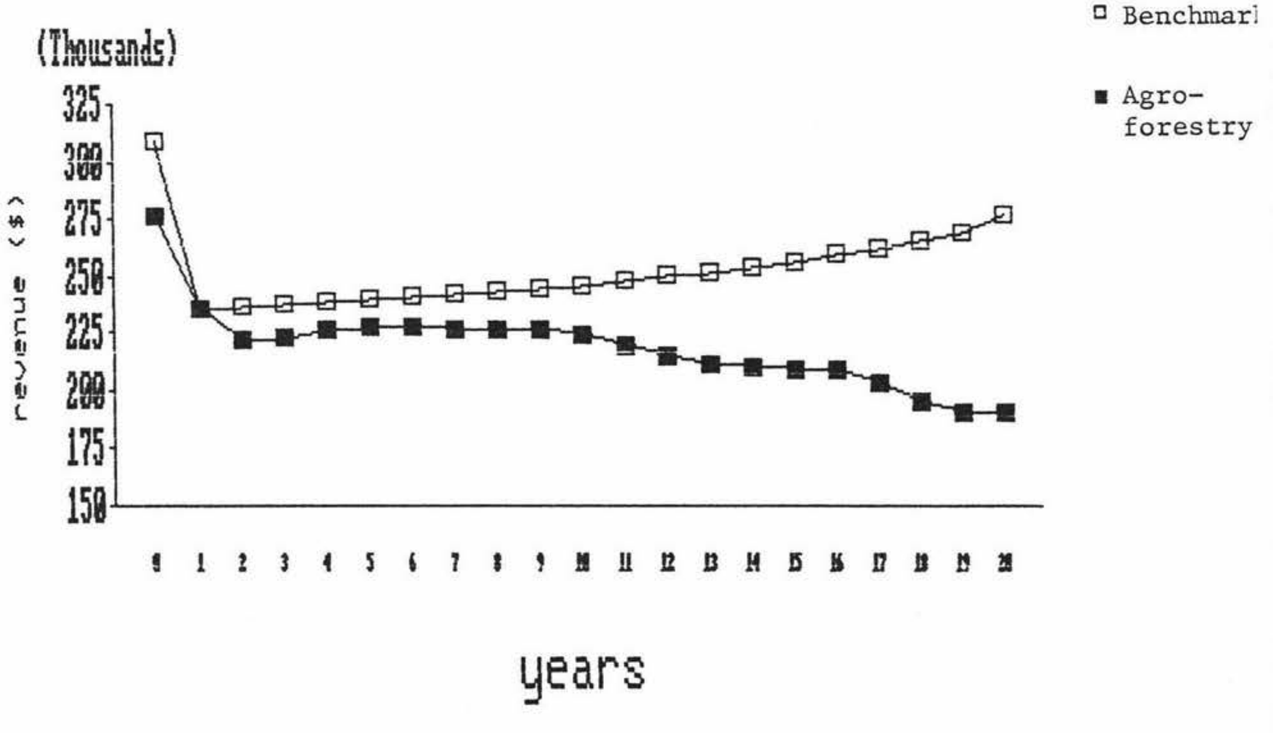


Figure 6.7 Net Farm Revenue

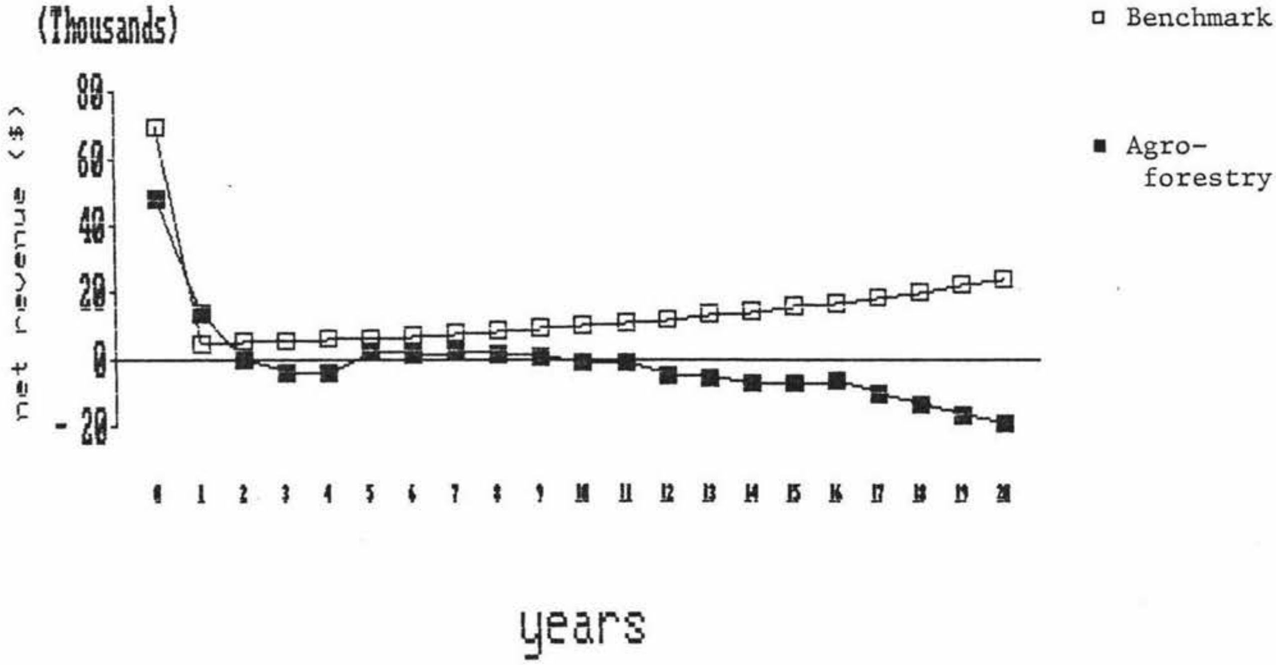
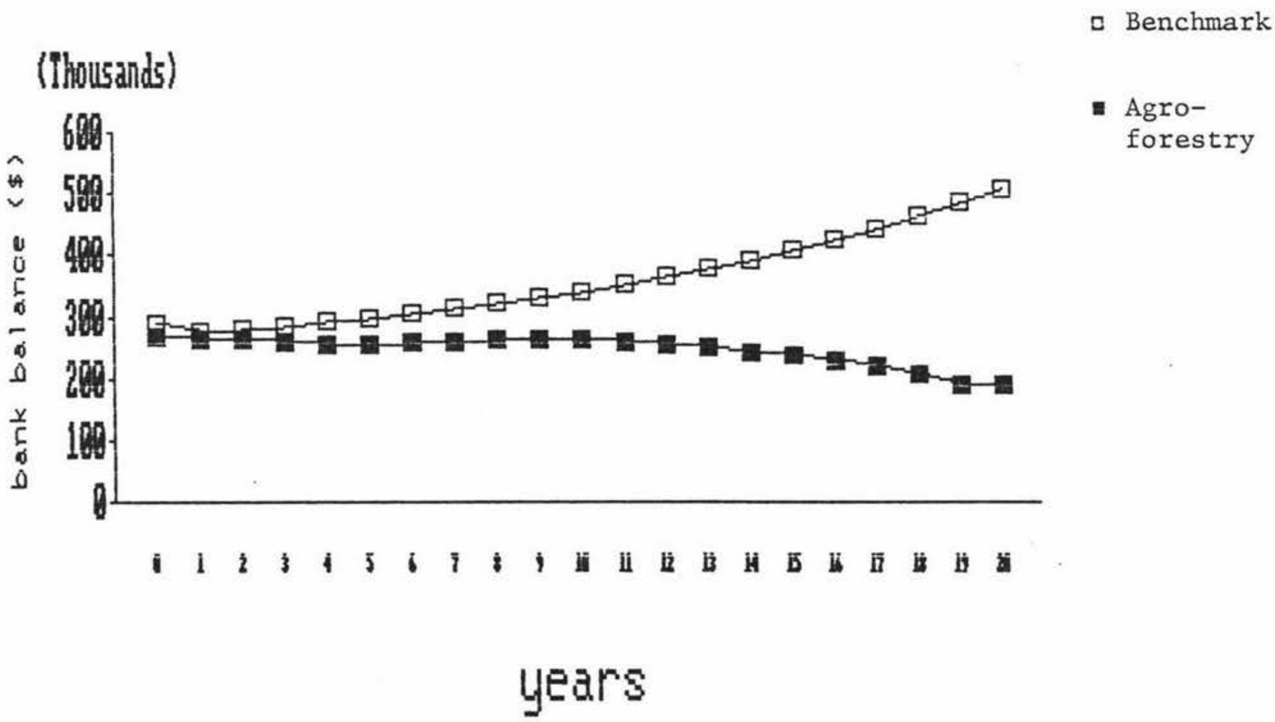


Figure 6.8 Cumulative Cash Balances



6.2.4 Objective Functions

Table 6.6 summarises the difference in objective function values between models B and A.F.

Table 6.6

	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, as viewed from the end of the planning horizon. 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.

6.4 SHADOW PRICE OF RESOURCES AND OPPORTUNITY COST OF ACTIVITIES

6.4.1 Resource Valuations

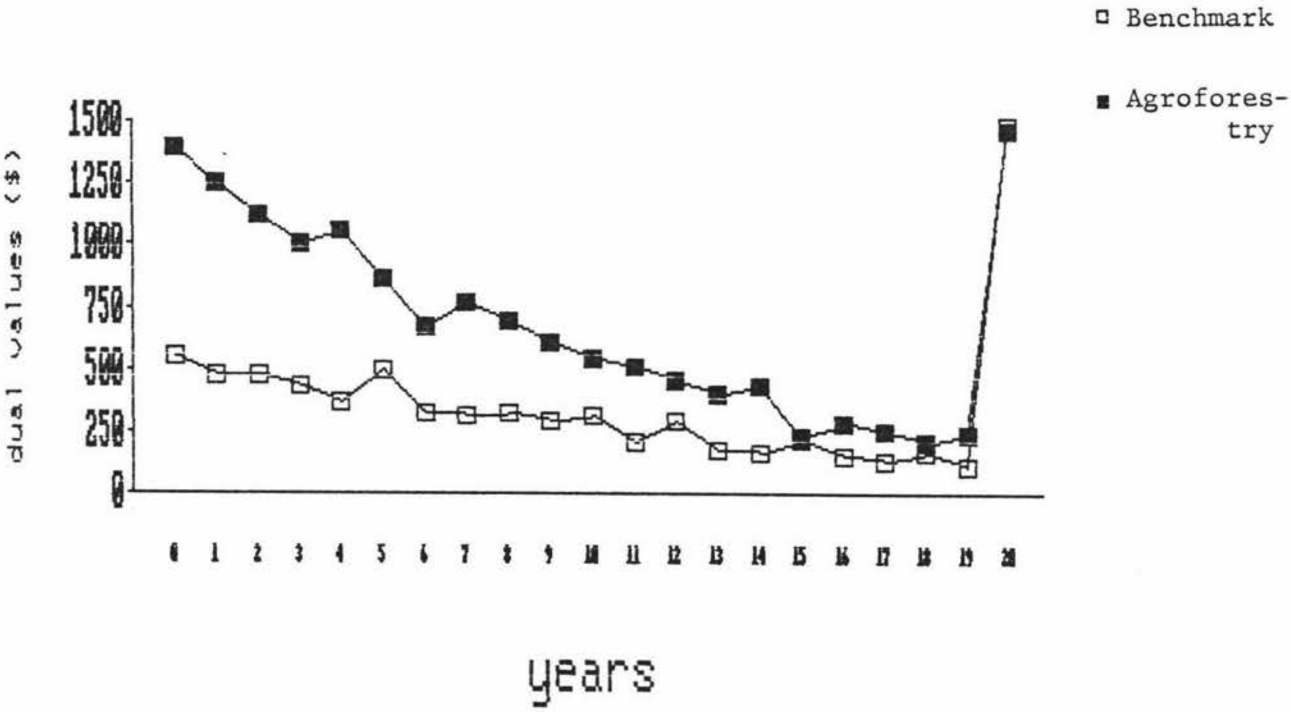
The marginal value product (shadow price) of resources used in the model provides further insight into the optimum solutions. In the case of a resource used at limit level the value of one extra unit of the resource is specified; for resources not fully used the penalty incurred by changing one unit of the resource is identified.

Land

Figure 6.9 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 6.10, 6.11). 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 6.11). 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 6.9 Shadow Prices (Land Class 2)



Labour

The marked differences in labour profile between the A.F. and B models have already been commented on. Figure 6.12 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 6.7 summarises the ranges over which the shadow prices apply.

Figure 6.10 Shadow Prices of Land Classes (yr 0)

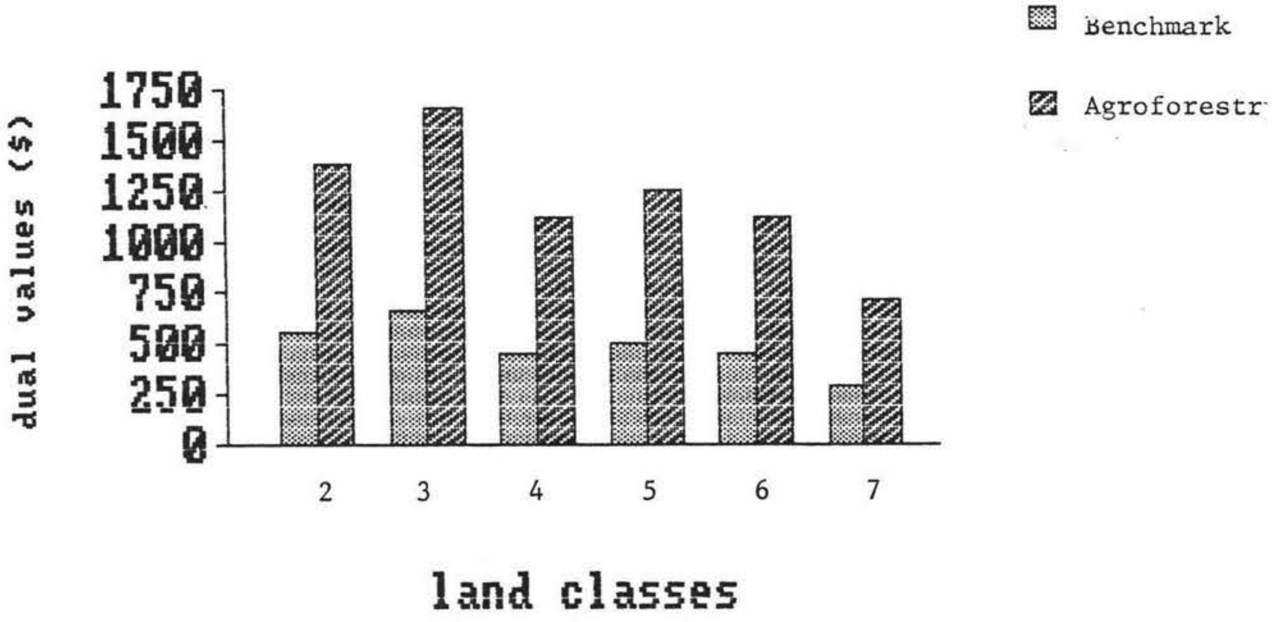


Figure 6.11 Shadow Prices of Land Classes (yr 20)

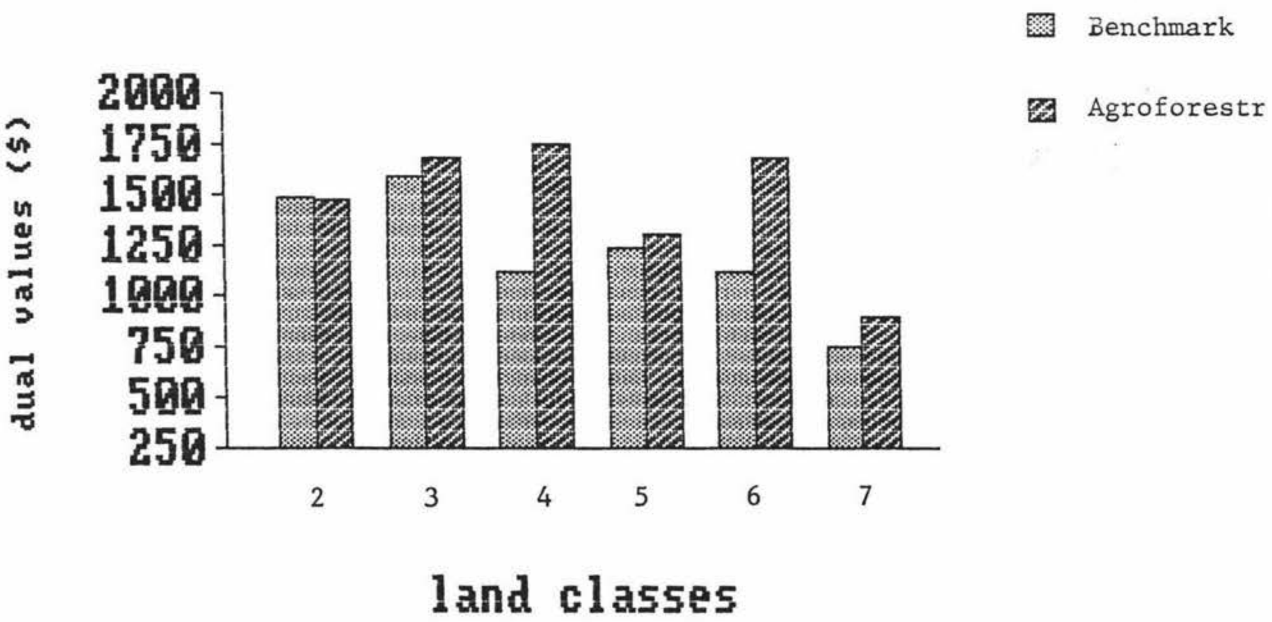


Figure 6.12 Shadow Prices of Labour

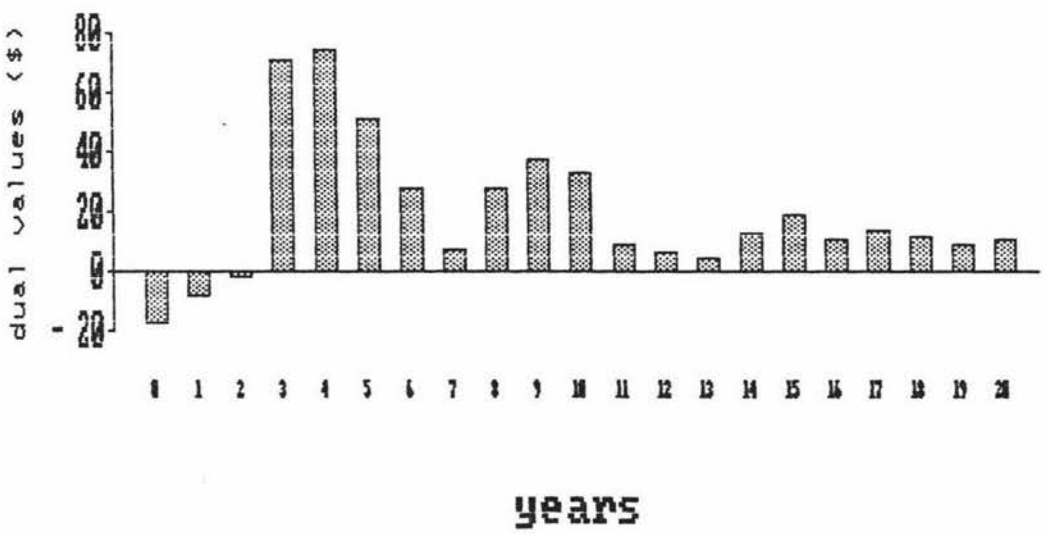


Table 6.7 Ranges Applicable to Shadow Prices for Labour

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

Tax-Free Cash

Table 6.8 indicates the shadow price of tax-free cash and the ranges over which these apply in year 0.

Table 6.8 Shadow Price of Tax-Free Cash

	Model B	Model A.F.
Value	5.98	12.29
Range	55,091 - 76,091	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.

6.4.2 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 6.13 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 changes with time for the other cattle activities. In comparison to the sheep policy the cattle policy has both higher capital values and labour requirements per stock unit (Table 6.9).

Table 6.9 Comparative Returns for Sheep and Cattle

	Sheep Policy	Cattle Policy
Capital ($/SU)	13.68	64.94
Net return (after 19% opportunity cost on capital) ($/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 6.14 and 6.15 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.

Figure 6.13 Shadow Cost of Cattle (Land Class 2)

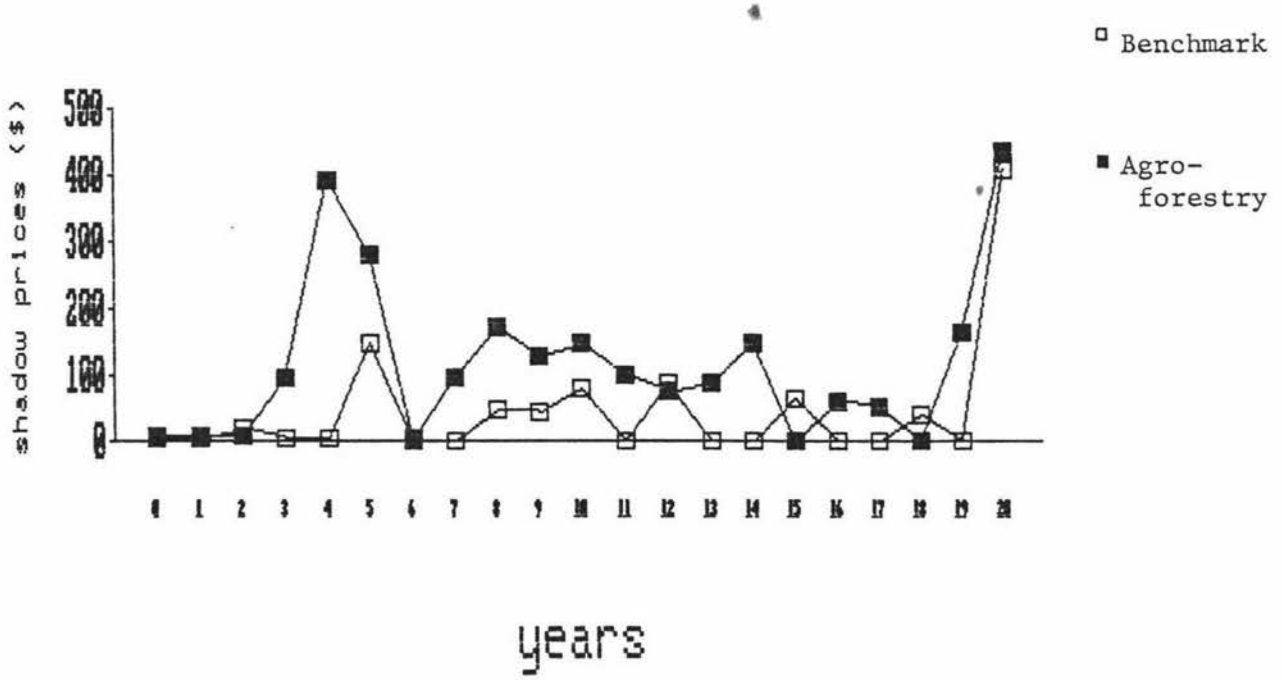


Figure 6.14 Savings from Reduction in Crop Area

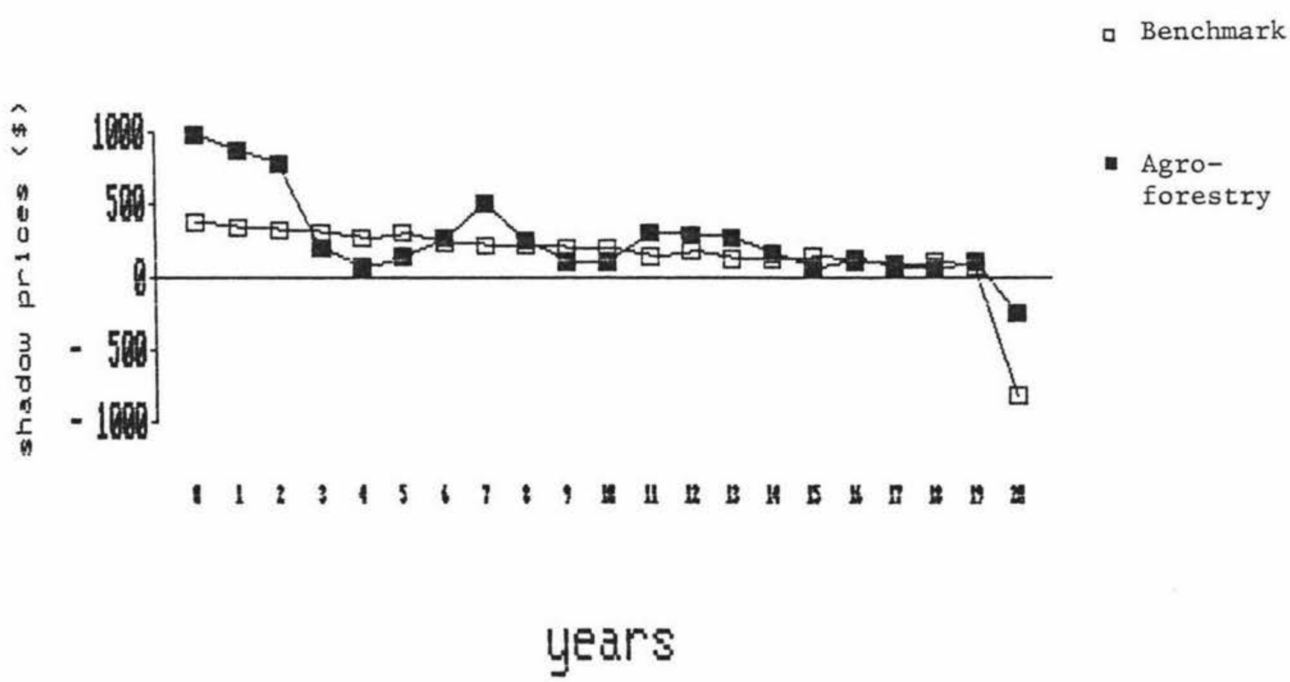


Figure 6.15 Costs of an Increase in Crop Area

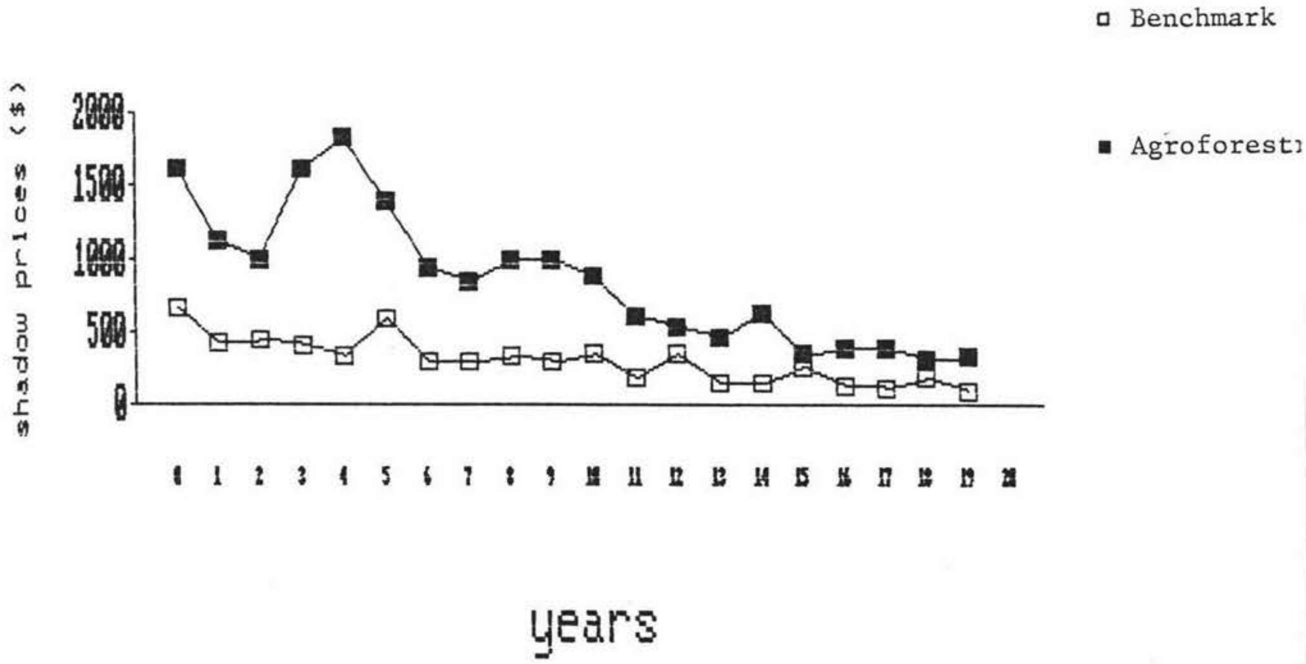
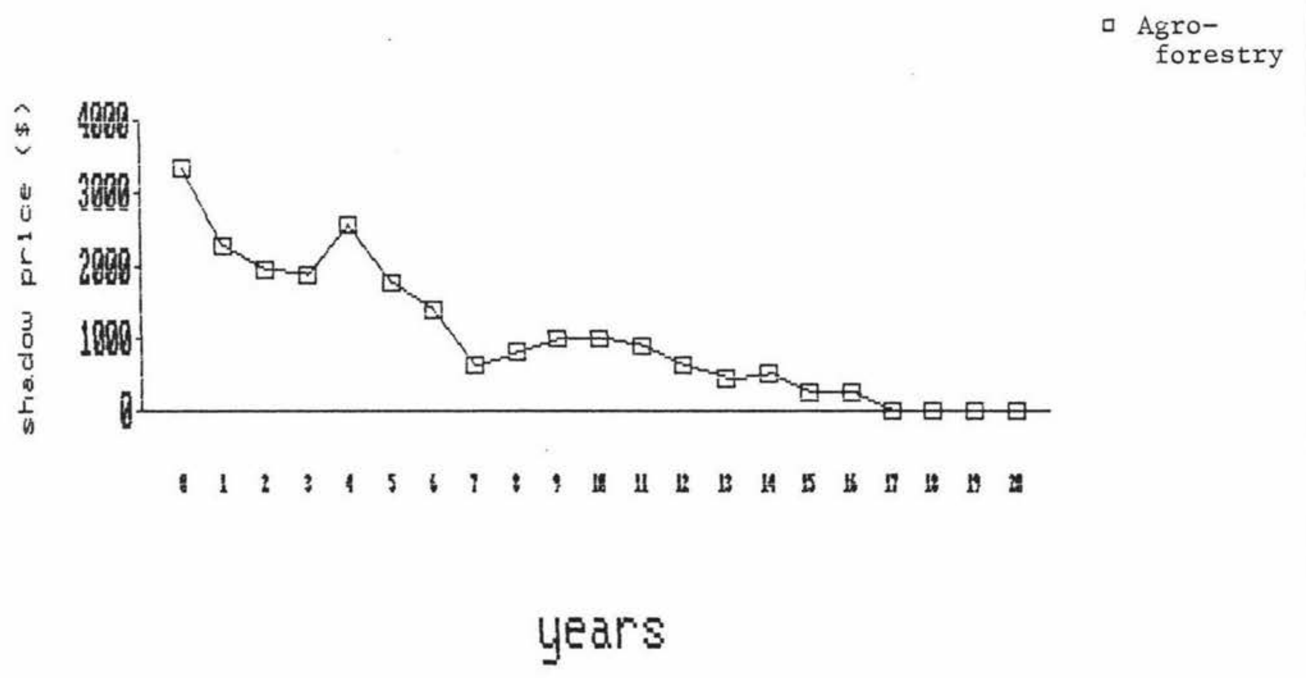


Figure 6.16 Shadow cost of Agroforestry on Land Class 7



Agroforestry on Class 7

Figure 6.16 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 (See Appendix 4).

Borrowing

A clear difference in the shadow price of borrowed funds was evident between the A.F. and B models (Figure 6.17). 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.

Forestry Tax Deduction

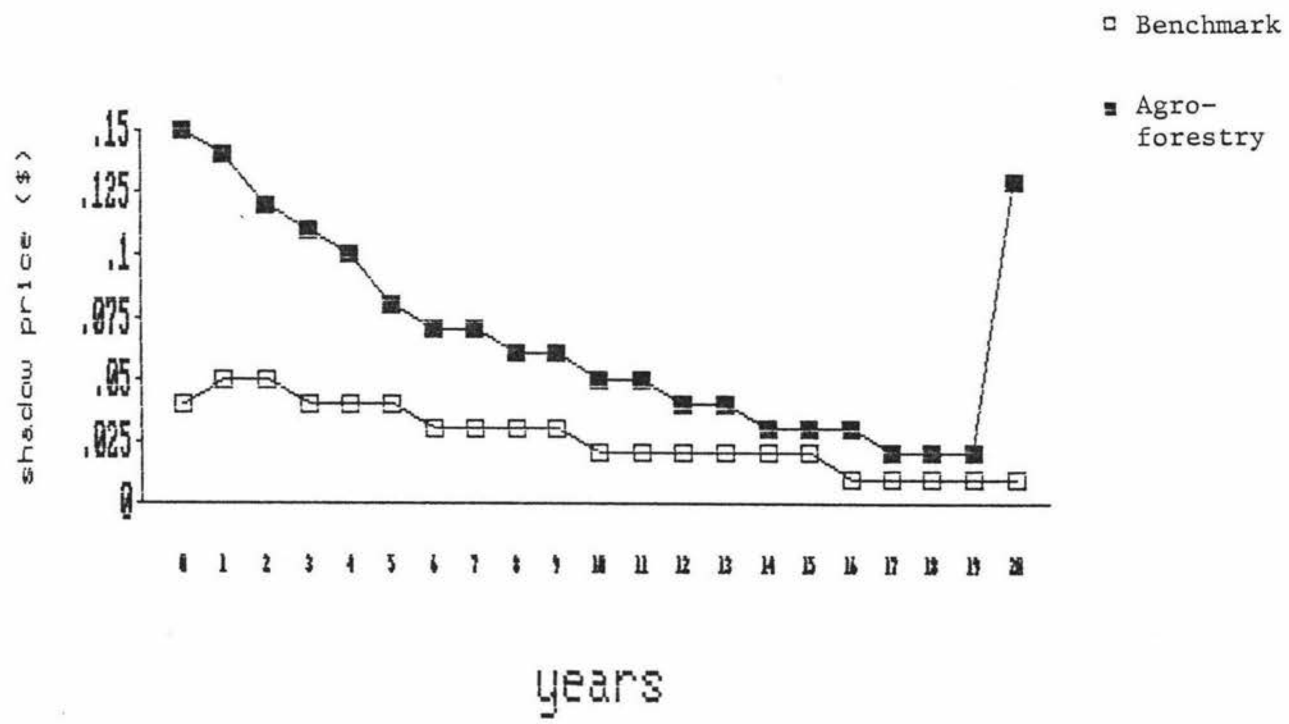
In periods 0 and 4 the permissable forestry tax deduction limit of $7,500/year was reached. Table 6.10 indicates that extending the limit would improve the profitability of the A.F. model.

Table 6.10 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.

Figure 6.17 Shadow Price of Borrowing



6.5 SUMMARY

The results indicate that agroforestry is both a profitable and economically viable development option for the case study farm. A continuous planting programme was specified, 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 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 (see Appendix 4).

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 VII

A SENSITIVITY ANALYSIS

7.1 INTRODUCTION

In the preceeding chapter several factors likely to affect an 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.

7.2 ON FARM FACTORS

7.2.1 Capital Restrictions

Debt Servicing

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).

The primary physical effect was to alter the rate of tree planting (Figure 7.1). 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.

Figure 7.1 Agroforestry Plantings - Effect of Debt Servicing

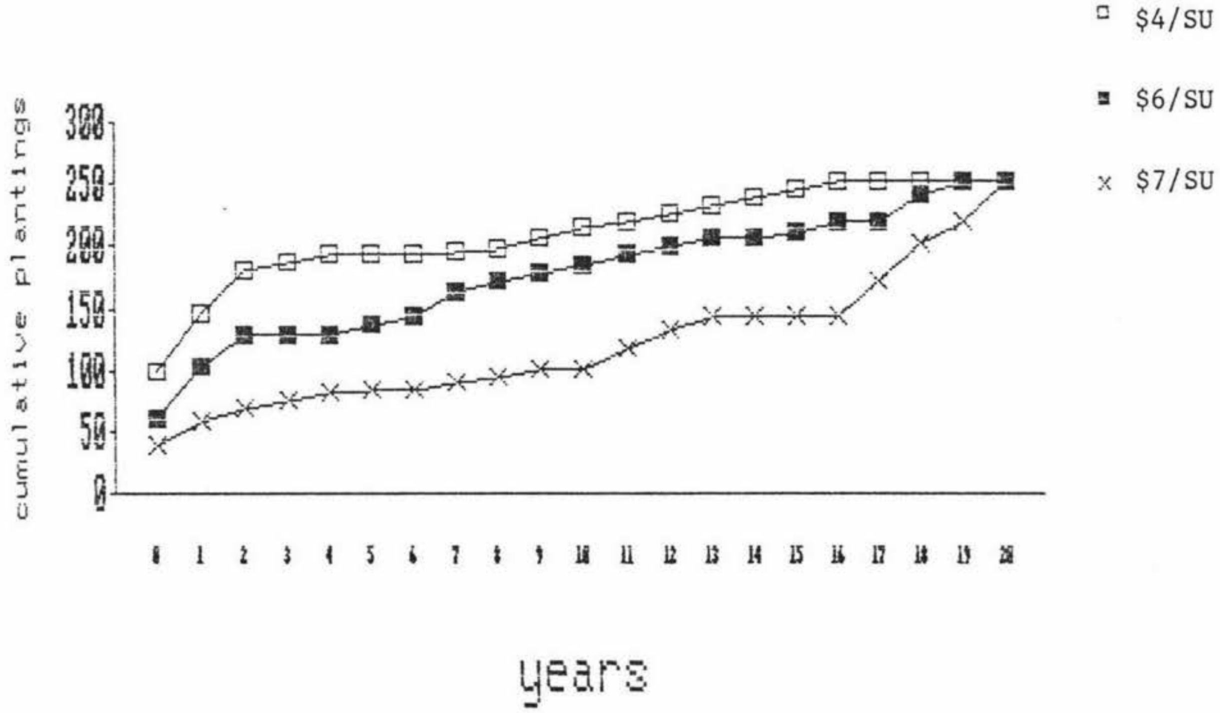


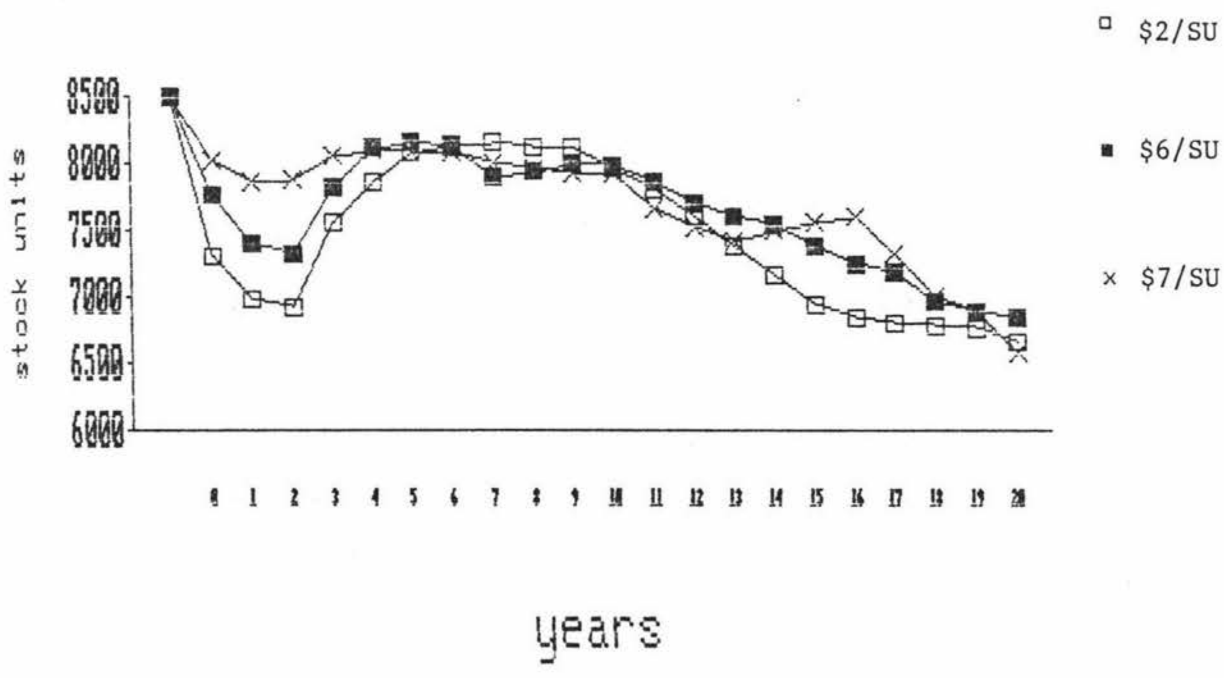
Table 7.1 indicates the pattern of planting under low and high levels of debt servicing. In all plans the rate of planting is initially highest for class 4 and lowest for class 7, reflecting the relative profitability of agroforestry in the different land classes. Even with no capital limitations, planting on class 7 land did not commence until year 7.

Corresponding changes in total stock units carried are indicated in Figure 7.2. 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:

Table 7.1 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

Figure 7.2 Total Stock Units - Effect of Debt Servicing



(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.

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 artefact 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 7.3) 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 7.4. The results indicate that a decline in cash balance only occurs with relatively high levels of debt servicing. At $6/SU debt servicing and below, an increase in cumulative cash balance occurs

Figure 7.3 Hire of Labour - Effect of Debt Servicing

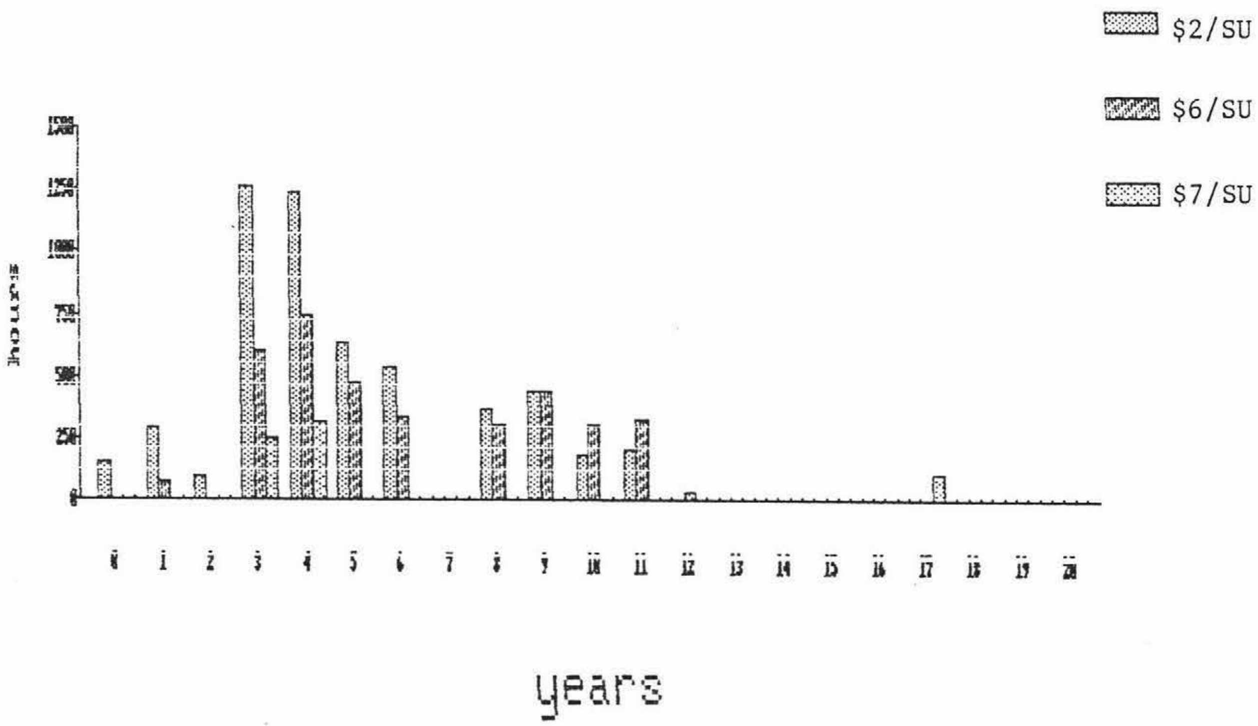
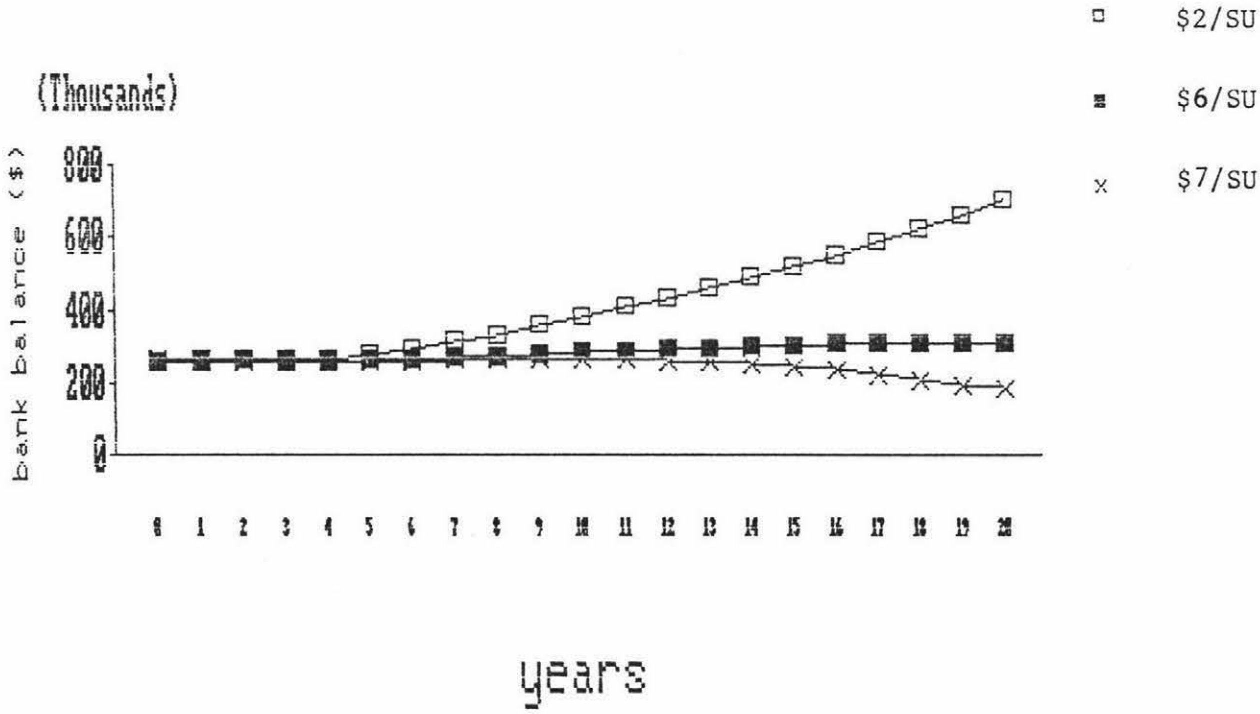


Figure 7.4 Cumulative Cash Balances - Effect of Debt Servicing



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.

Table 7.2 summarises the differences in objective function between plans.

Table 7.2 Effect of Debt Servicing on Objective Function

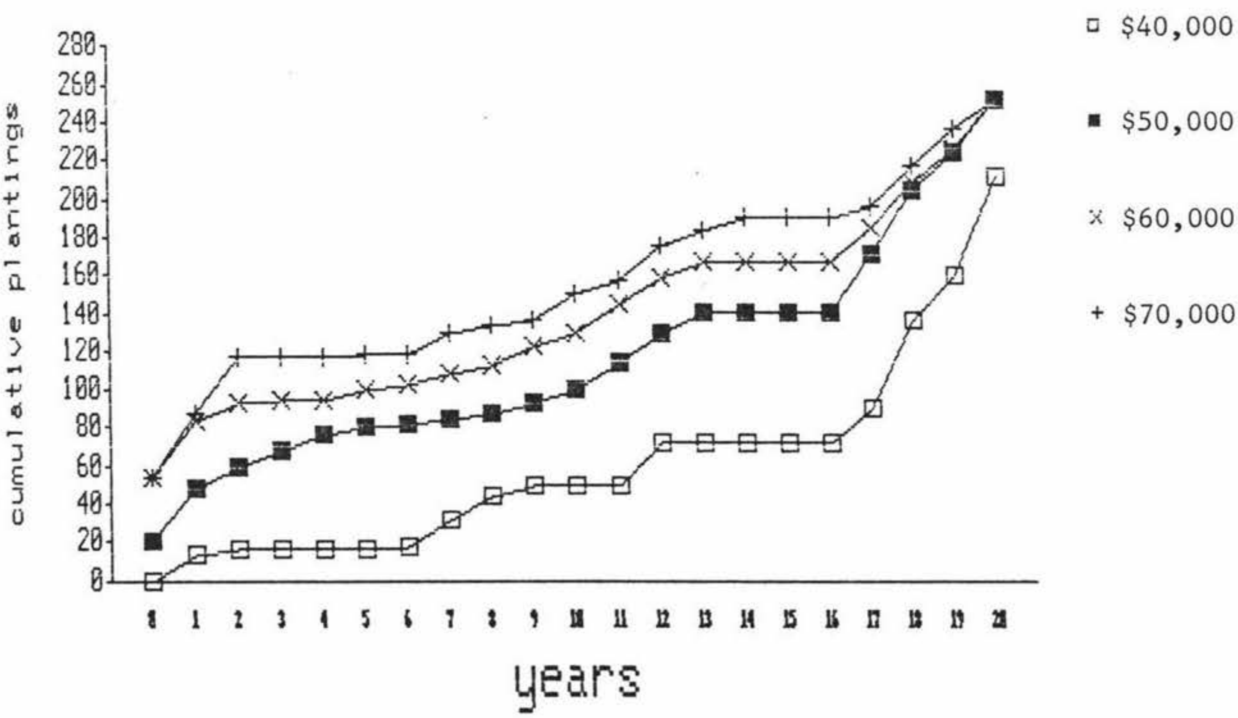
	Plans (Debt Servicing)			
	$2/SU	$4/SU	$6/SU	$7/SU
Values at the end of the planning horizon				
Final Cash Balance	1,173,654	600,992	190,785	34,592
Value of future income	2,300,120	2,260,634	1,992,034	1,613,982
Objective function	3,473,774	2,861,626	2,182,819	1,648,574
Present value (10% discount rate)				
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

<u>Opening Level of Cash</u>

Farms 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 before, the primary physical effect was to alter the rate of tree planting. Thus in the early years of the programme, especially years 0 - 2, increasing levels of opening cash led to a faster rate of planting (Figure 7.5). In contrast, from years 16 to 20 planting rates were faster for these plans with lower opening cash levels (Figure 7.5). As a result only the plan with a $40,000 opening cash figure did not fully plant all the area available for agroforestry. Again, extending the length of the planning horizon may have reduced later planting rates, as the peak overdraft limit of $20,000 was reached in year 20 for plans with $40,000 and $50,000 opening cash.

Figure 7.5 Agroforestry plantings - Effect of Opening Cash Level



Corresponding changes in total stock units paralleled those described in the previous section with, for example, similar final stock numbers for all plans. A point of difference was that at $40,000 and $50,000 levels of opening cash, not all land was utilised as stock were sold to finance the years operations (Table 7.3).

Table 7.3 Unutilized Land in Year 0

	$40,000	$50,000
Land Class	Areas Unutilized (ha.)	
4		0.8
6	96.7	
7	59.0	59.0

For these plans a change in cropping programme also occurred with some substitution of barley for wheat, an alternative with a lower variable cost requirement.

In other years similar patterns to those already described were apparent. For example, with increasing levels of opening cash and a faster rate of planting, the use of hired labour increased markedly (Table 7.4).

Cumulative cash balances are indicated in Figure 7.6. In contrast to the results for changes in debt servicing, end of year bank balances ultimately declined for all plans, with some borrowing specified in year 20.

Table 7.5 summarises the changes in objective function between plans.

Table 7.4 Effect of Opening Cash Level on Hired Labour Use

	HIRE OF LABOUR			
OPENING CASH	40000	50000	60000	70000
YEAR				
0	0	0	0	0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	536
4	0	275	449	584
5	0	66	556	368
6	0	0	49	170
7	0	0	0	0
8	0	0	0	0
9	0	0	0	226
10	0	0	228	187
11	0	0	127	99
12	0	0	0	19
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	160	0	0
18	0	17	0	0
19	96	103	0	0
20	0	0	0	0
	96	621	1409	2189

Table 7.5 Effect of Opening Cash Level on Objective Function

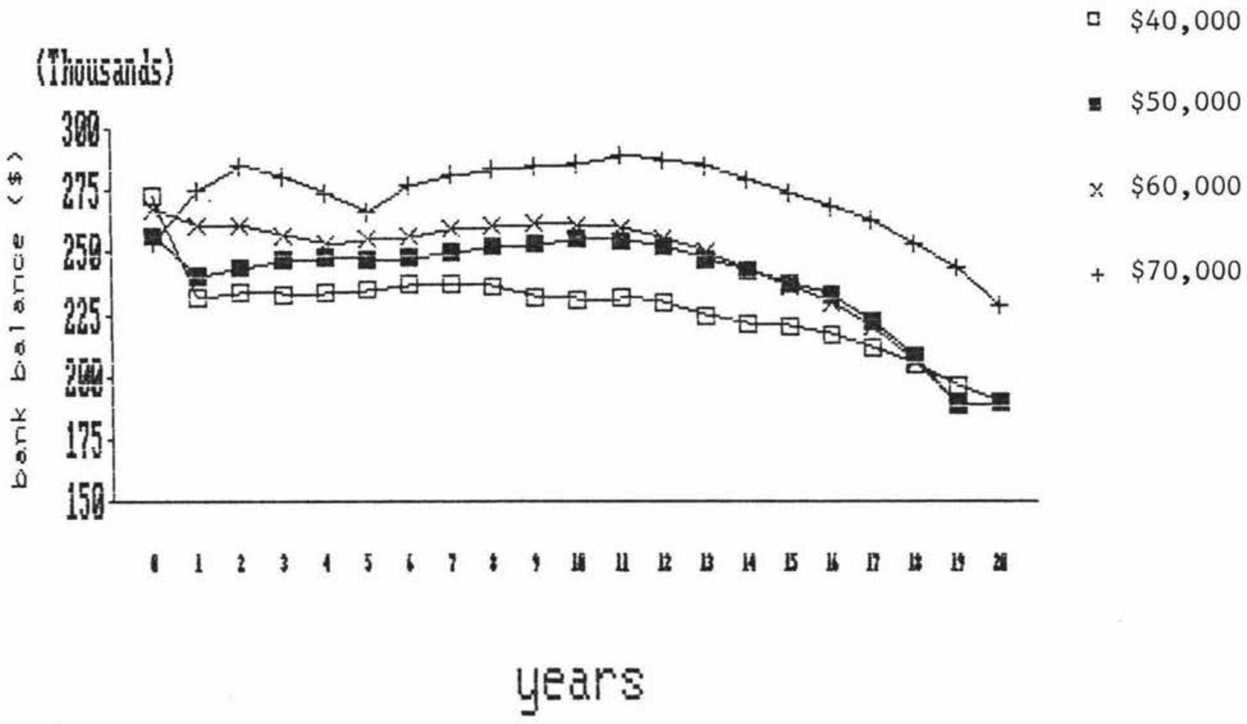
	Plans (Opening Cash) 40,000	50,000	60,000	70,000
Value at the end of the planning horizon				
Final Cash Balance	39,274	41,119	41,162	47,284
Value of Future Income	1,200,241	1,567,789	1,749,691	1,858.305
Objective Function	1,239,515	1,608,908	1,790,853	1,905,589
Present Values (10% Discount Rate)				
Final Cash Balance	5,306	5,555	5,561	6,388
Future Income	162,152	211,808	236,383	251,057
Objective Function	167,458	217,363	241,944	257,445
Proportional change relative to standard (60,000)	0.69	0.90	1	1.06

Another measure of profitability is indicated by the shadow price of opening cash which gives the marginal productivity of additional cash. Table 7.6 indicates these as well as the expected rates of return.

Table 7.6 Shadow Price of Opening Cash

Level of Opening Cash	Shadow Price	Rate of Return
40,000	54.74	21.0
50,000	27.36	17.1
60,000	12.29	12.7
70,000	10.69	11.9

Figure 7.6 Cumulative Cash Balances - Effect of Opening Cash Level



As could 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.

7.2.2 Labour Restrictions

In view of the significance of labour as highlighted in Chapter 6, it was decided to examine the effect of labour restrictions. Three situations were simulated:

A restriction of farm labour to 736 hours, instead of the standard of 876 hours, representing a four day working week for one of the farm staff.

A restriction on hired labour to maximums of 400 and 300 hours.

The primary physical effect was again to reduce the planting rate of agroforestry. The effect of the restrictions on permanent labour is indicated in Figure 7.7. In this case all the area suitable for agroforestry was eventually planted. To compensate for a reduction in permanent labour additional hired labour was used (Table 7.7).

Figure 7.7 Agroforestry Plantings - Effect of Labour Restrictions

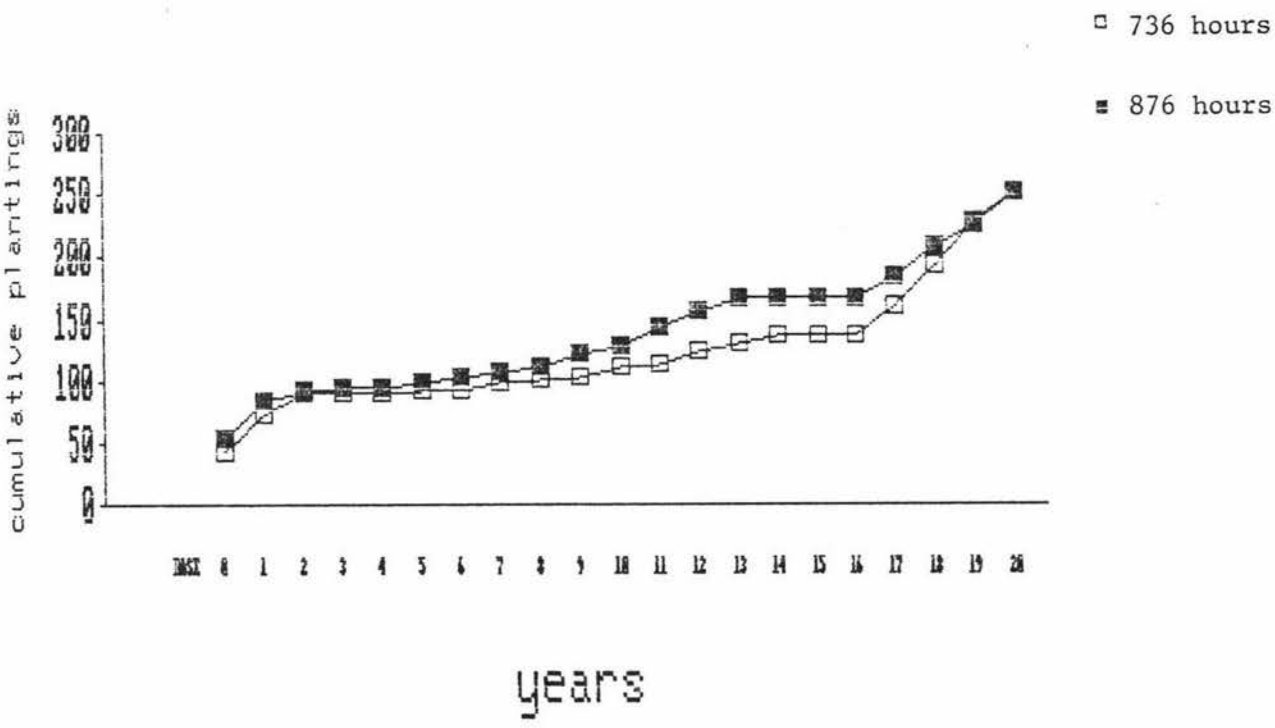


Table 7.7 Effect of Permanent Labour Restrictions on Labour Profile

STANDARD			RESTRICTED FARM LABOUR		
FARM FOR LABOUR	HIRE LAB	TOTAL FOR LABOUR	FARM FOR LABOUR	HIRE LABOUR	TOTAL FOR LABOUR
0	0	0	0	0	0
320.23	0	320.23	210.58	0	210.58
367.84	0	367.84	248.21	29.44	277.65
156.02	0	156.02	232.75	0	232.75
378.06	449.42	827.48	240.83	495.98	736.81
367.07	555.72	922.79	228.44	562.12	790.56
367.76	49.44	417.20	223.51	280.81	504.32
368.90	0	368.90	223.45	237.72	461.17
371.62	0	371.62	228.46	17.28	245.74
371.72	0	400.79	229.35	44.38	273.73
376.25	228.23	604.48	228.52	245.07	473.59
377.52	127.06	504.58	231.65	90.21	321.86
389.12	0	389.12	235.86	46.73	282.59
408.59	0	408.59	249.24	.38	249.62
406.62	0	406.62	253.65	0	253.65
404.70	0	399.50	267.79	0	267.79
400.79	0	415.28	258.69	0	258.69
399.50	0	432.47	257.39	0	257.39
415.28	0	432.47	272.48	296.20	568.68
432.47	0	434.50	295.67	75.09	370.76
441	0	434.50	313.68	405.08	718.76
434.50	0	434.50	298.75	0	298.75
7955.56	1409.87	9449.48	5228.95	2826.49	8055.44

The effect on objective function values is indicated in Table 7.8.

The results indicate that 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.

Table 7.8 Effect of Labour Restrictions on Objective Function

	Standard	Plans Less Permanent Labour	Hired Labour 400 hrs	Hired Labour 300 hrs
Value at the end of the planning horizon				
Final Cash Balance	41,162	48,364	41,373	50,222
Value of future income	1,749,691	1,665,676	1,746,195	1,732,080
Objective function	1,790,853	1,714,040	1,787,568	1,782,302
Present values (10% discount rate)				
Final Cash Balance	5,561	6,534	5,589	6,785
Future income	236,383	225,033	235,911	234,004
Objective function	241,944	231,567	241,500	240,789
Proportional change relative to standard	1.0	0.96	1.0	1.0

7.2.3 Land Classes

The case-study farm had a relatively small proportion of class 6 and 7 land (Appendix 1). In this respect it was atypical of many hill country farms in the Wairarapa (See 2.3.3). Accordingly a plan with 75% of area consisting of class 6 and 7 hill country was simulated. In order for the plan to be feasible it was necessary to reduce debt servicing to \$5/SU based on initial stock numbers.

Table 7.9 indicates the pattern of planting over the planning horizon. The results are similar to those already observed. Class 4 and 7 land was planted initially, with planting on class 7 only commencing in the latter years. The high rate of planting indicated in the final year is unlikely to have occurred if the planning horizon had been longer, as by this stage the \$20,000 borrowing limit had been reached. In subsequent years, borrowing requirements would probably have exceeded this limit.

Table 7.9 Planting Pattern - 75% of Farm Area Class 6 and 7

YEAR	AGROFORESTRY PLANTINGS					
	AF4	AF6	AF7H	TOTAL/Y	ACCUM TO	PROPORTION OF FARM
0	27.77	0	0	27.77	27.77	4.05
1	0	13.97	0	13.97	41.74	6.09
2	6.23	2.53	0	8.76	50.50	7.37
3	0	0	0	0	50.50	7.37
4	0	0	0	0	50.50	7.37
5	0	0	0	0	50.50	7.37
6	0	0	0	0	50.50	7.37
7	0	17.63	0	17.63	68.13	9.95
8	0	4.80	0	4.80	72.93	10.65
9	0	13.75	0	13.75	86.68	12.65
10	0	0	0	0	86.68	12.65
11	0	8.65	0	8.65	95.33	13.92
12	0	17.47	0	17.47	112.80	16.47
13	0	5.52	0	5.52	118.32	17.27
14	0	14.47	0	14.47	132.79	19.39
15	0	0	0	0	132.79	19.39
16	0	0	0	0	132.79	19.39
17	0	0	5.35	5.35	138.14	20.17
18	0	19.53	0	19.53	157.67	23.02
19	0	0	15.64	15.64	173.31	25.30
20	0	52.69	0	52.69	226	32.99
TOTALS	34	171.01	20.99			
PROPORTION	100	100	6			

7.2.4 Timber Value

The results discussed to date 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 7.8). The least profitable agroforestry regime, i.e. planting on land class 7, was reduced first followed by planting on class 6. Table 7.10 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 determinent.

The effect on objective function values is indicated in Table 7.11.

Figure 7.8 Agroforestry Plantings - Effect of Timber Values

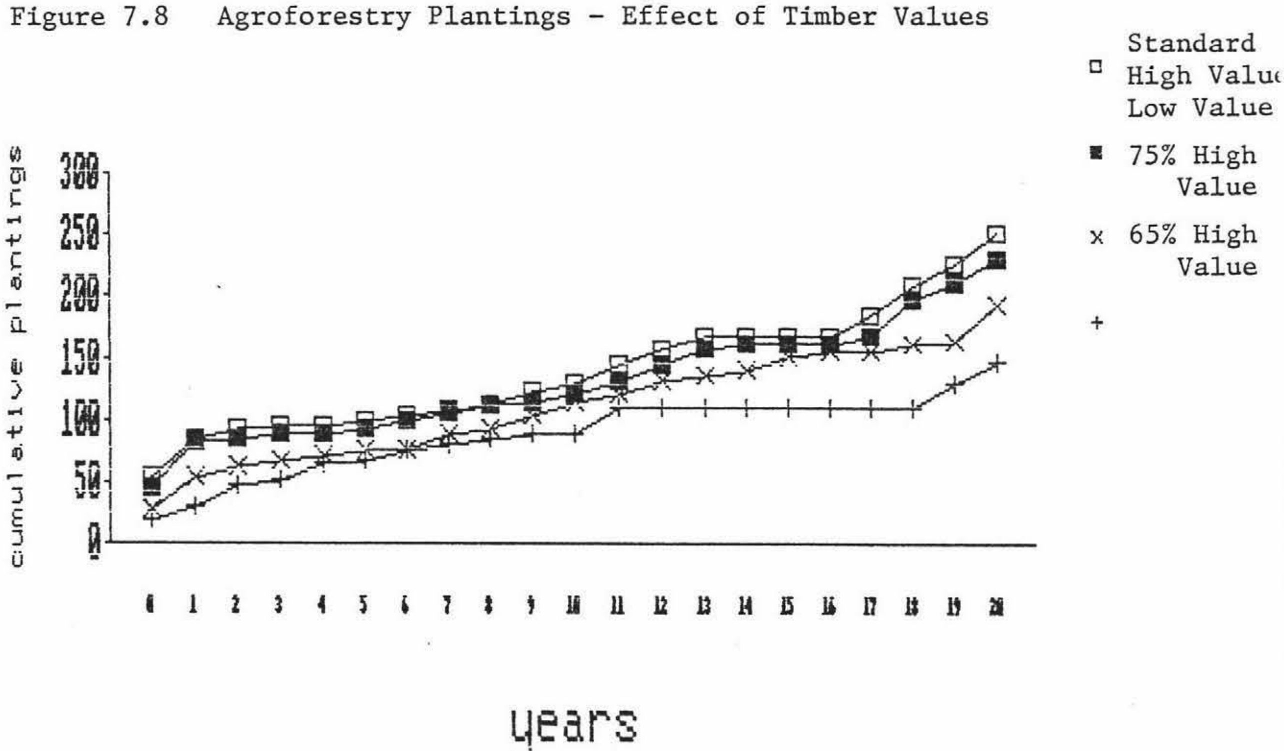


Table 7.10 Effect of Changing Timber Values on Planting Pattern

YEAR	HIGH VALUE AGROFORESTRY PLANTINGS AF4	AF6	AF7H	TOTAL/YR	ACCUM TOT	65% HIGH VALUE AGROFORESTRY PLANTINGS 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		

Table 7.11 Effect of Changing Timber Values on Objective Function

	Standard	Plans 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	165,658
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.

7.2.5 Objective Function

The standard plan was solved with weights on final cash and final asset values of 1 and 0.52 respectively. Individuals vary widely in the relative importance they place on these two measures of profitability. Thus a farmer near retirement may place little, if any, weight on final asset values. In contrast, a younger farmer may be more concerned with building up future assets rather than cash in the bank. To allow for these differences the model was solved 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.

Figure 7.9 Agroforestry Plantings - Effect of Different Objectives

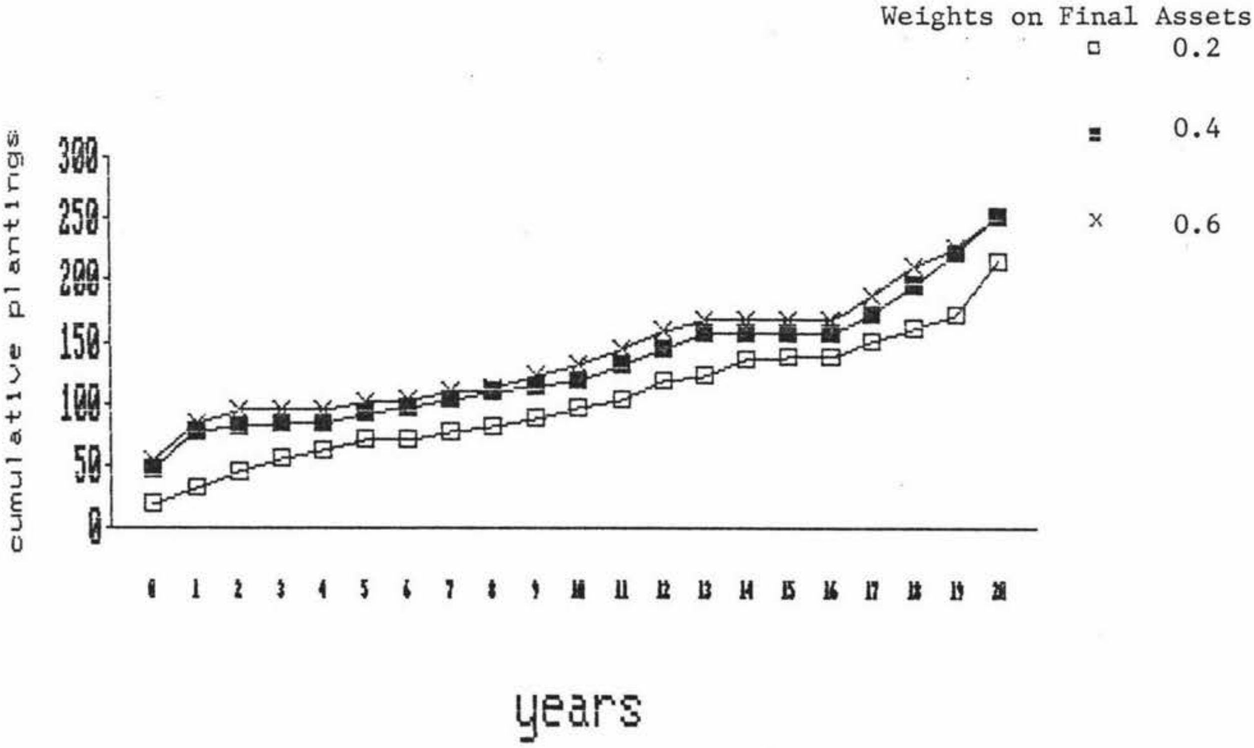
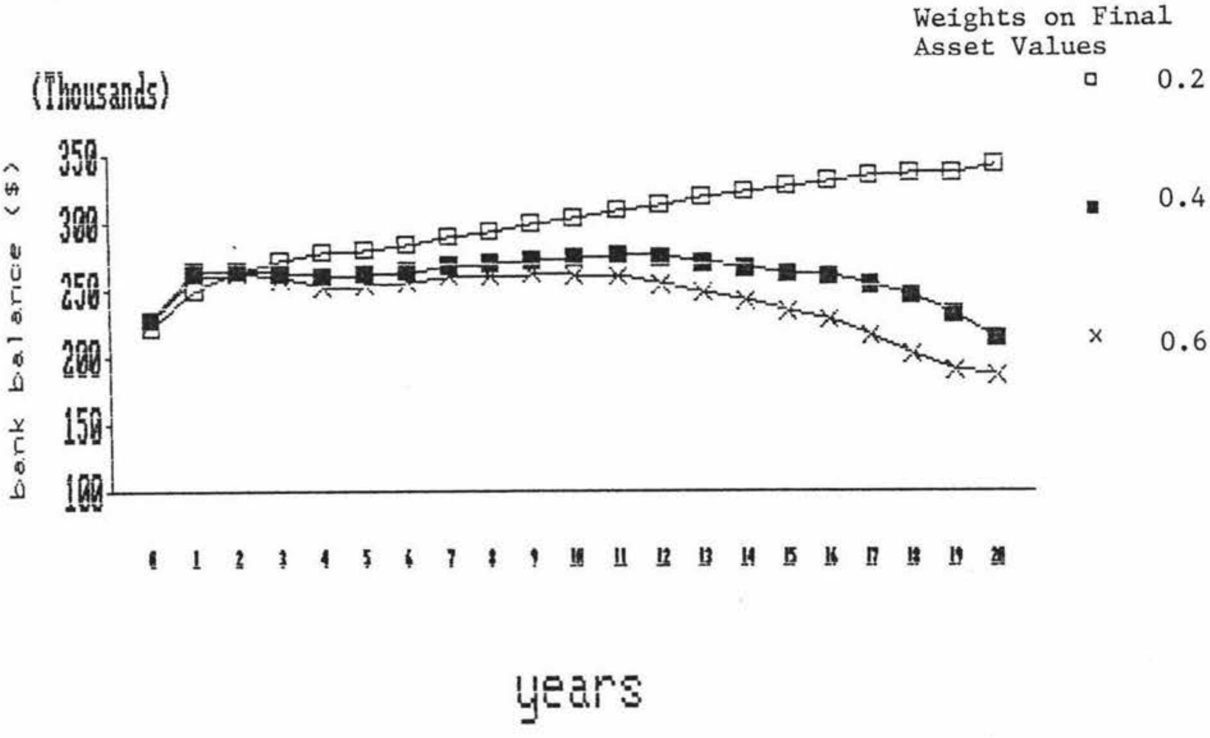


Figure 7.10 Cumulative Cash Balances - Effect of Different Objectives



As before, the primary physical effect was to alter the rate of planting (Figure 7.9). With a weight of 0 on final asset value an identical plan to the benchmark model resulted, as clearly there would be no economic advantage in agroforestry. However, 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 (Figure 7.10). Thus the plan with the weight of 0.2 on final asset values combined on extensive planting programme with an increase in cash balance. Plans with weights higher than this ultimately indicated a decline in cash.

7.3 OFF-FARM FACTORS

7.3.1 Interest Rate

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 7.11 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 7.12). Nevertheless, even at low interest rates, cattle numbers were gradually reduced and replaced by sheep and agroforestry.

At all interest rates the wheat rotation with its associated sheep activity entered the plan at the minimum level of 12 ha.

Figure 7.11 Agroforestry Plantings - Effect of Interest Rate

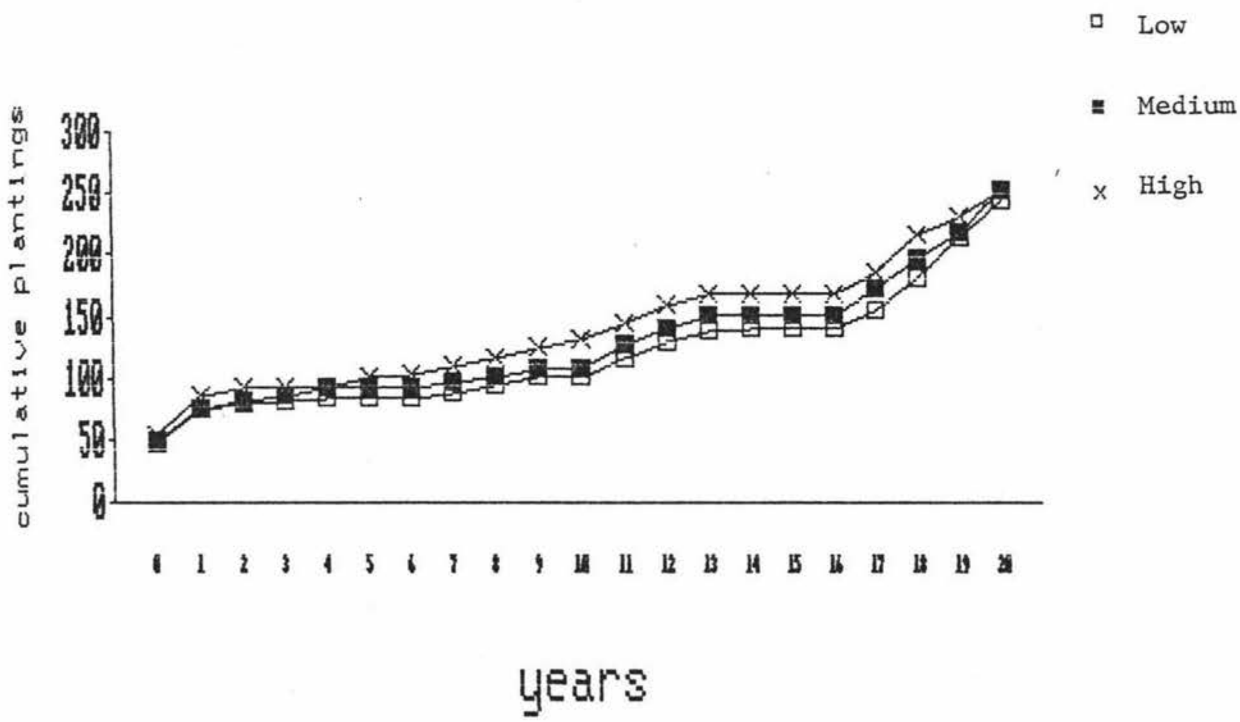


Table 7.12 Effect of Interest Rate on Livestock Policies

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

As would be expected, changes in interest rate had a marked effect on the pattern of borrowing and lending (Table 7.13). 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.

Table 7.13 Effect of Interest Rate on Borrowing

	BORROWING		
YEAR	LOW INTEREST	MEDIUM INTEREST	HIGH INTEREST
0	15688	16259	16751
1	12601	0	0
2	2556	0	0
3	10929	0	0
4	18249	0	0
5	13511	0	0
6	14359	0	0
7	11883	0	0
8	10817	0	0
9	5114	0	0
10	840	0	0
11	0	0	0
12	1218	0	0
13	0	0	0
14	0	0	0
15	5911	0	0
16	11876	0	0
17	20000	0	0
18	20000	0	0
19	20000	8839	0
20	20000	20000	10067

The combined effect of these changes was reflected in cumulative cash balances (Figure 7.12). At low interest rates the cash balance steadily declined, in contrast to plans with higher interest rates where the initial sale of cattle and lending activities combined to raise the cash balance.

The effect of changed interest rates on objective function values is indicated in Table 7.14. While profitability, as determined by objective function values, was lower at lower interest rates the effect was comparatively small.

Figure 7.12 Cumulative Cash Balances - Effect of Interest Rate

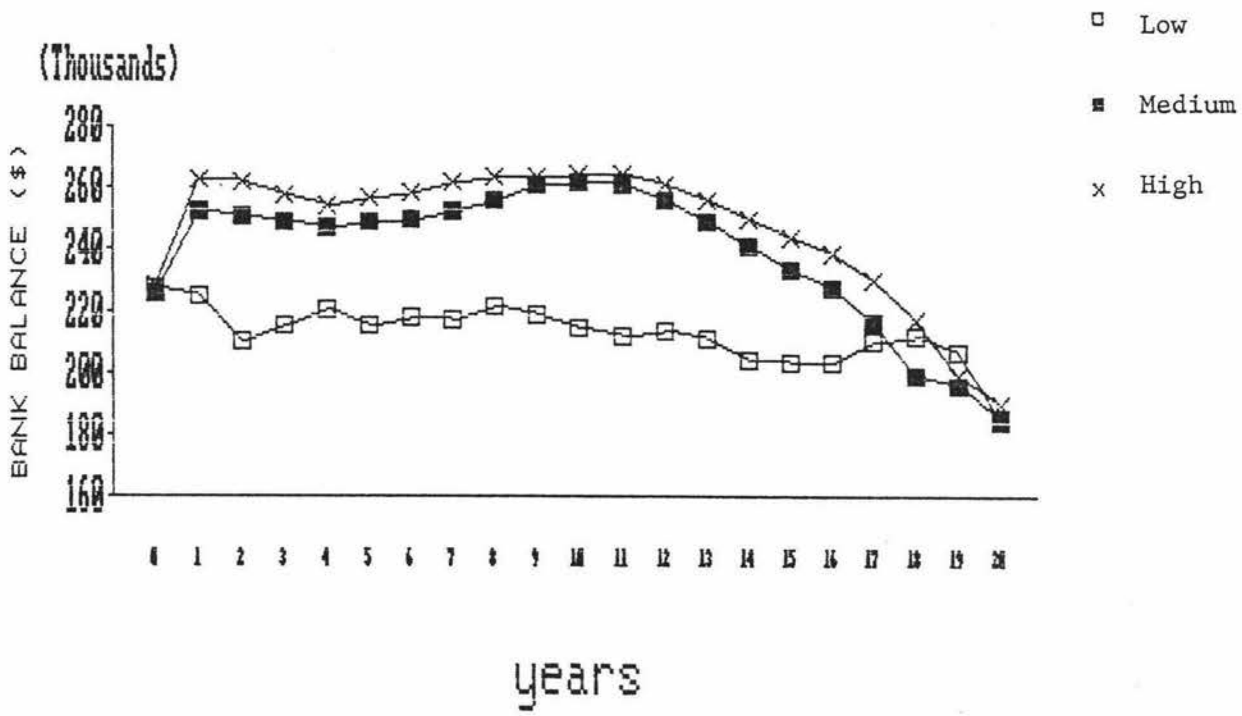


Table 7.14 Effect of Interest Rate on Objective Function Values

	Plans Low Interest	Medium Interest	Standard Interest	High Interest
Values at the end of the planning horizon				
Final Cash Balance	37,253	36,637	41,162	52,460
Value of future income	1,632,911	1,672,255	1,749,691	1,758,780
Objective function	1,670,164	1,708,892	1,790,853	1,811,240
Present Values (19% discount rate)				
Final Cash Balance	5,033	4,950	5,561	7,087
Future Income	220,606	225,920	236,383	237,611
Objective Function	225,639	230,871	241,944	244,698
Proportional change relative to standard	0.93	0.95	1.0	1.01

7.3.2 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 (Figure 7.13). However, it is noteworthy that even with no tax-deductible forestry expenditure, all land suitable for agroforestry was planted.

The resulting objective function values are shown in Table 7.15.

Figure 7.13 Agroforestry Plantings - Effect of Changing Forestry Tax Deduction Limits

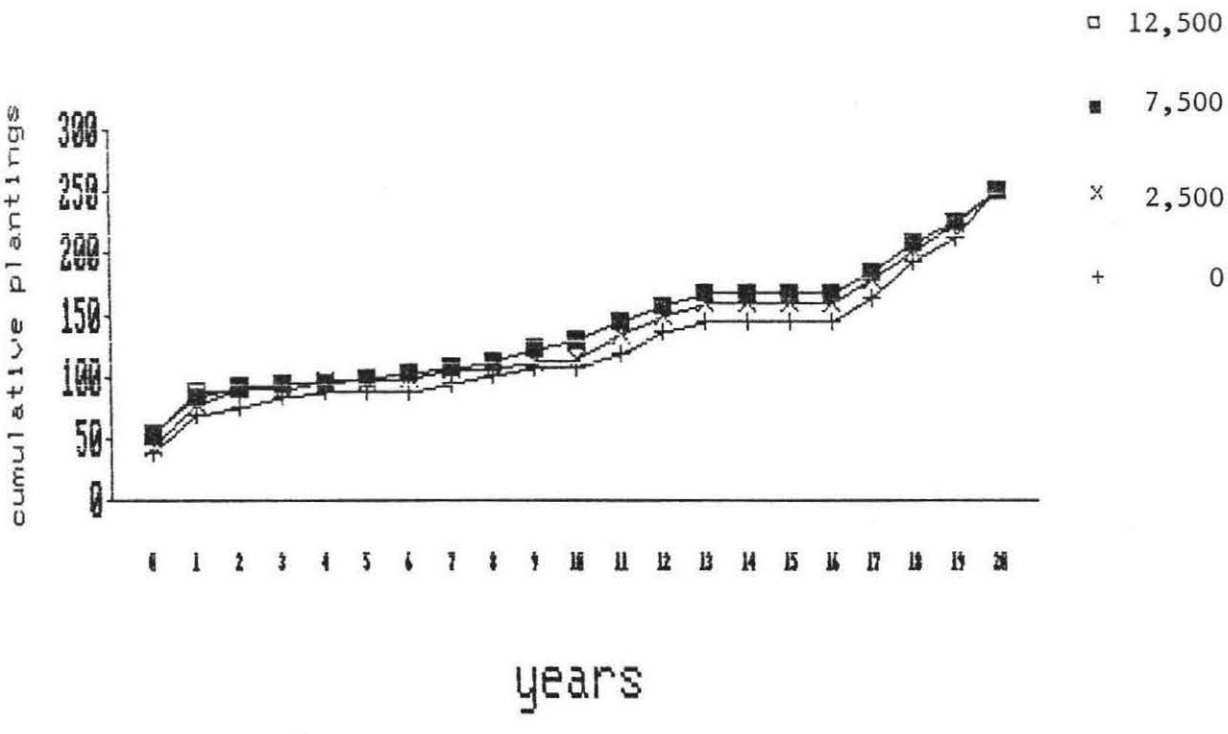


Table 7.15 Effect of Forestry Tax Deduction Limits on Objective Function

	Plans Tax Deductible Limits $0	$2,500	$7,500 (Standard)	$12,500
Values at the end of the planning horizon				
Final Cash Balance	37,415	40,674	41,162	41,116
Value of future income	1,644,522	1,709,028	1,749,691	1,750,602
Objective function	1,681,937	1,749,702	1,790,853	1,791,718
Present Values (10% Discount Rate)				
Final Cash Balance	5,055	5,495	5,561	5,555
Future Income	221,175	230,890	236,383	236,506
Objective Function	227,230	236,385	241,944	242,061
Proportion change relative to standard	0.94	0.98	1.0	1.0

Table 7.16 summarises the expected rates of return.

Table 7.16 Effect of Forestry Tax Deduction Limits on Rates of Return

Forestry tax Deduction Limit	Shadow Price of Opening Cash	Rate of Return
0	10.27	11.7
2,500	10.83	12.0
7,500	12.29	12.7
12,500	12.49	12.8

These results indicate that changes in the tax deductible limits had a relatively minor effect on profitability.

7.4 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, weight placed on final asset values, interest rates, and tax deductibility also affected the rate of development and profitability but to a lesser extent.

As the rate of agroforestry development was restricted, the least profitable agroforestry (land class 7) was always the first to be removed from the solution.

CHAPTER 8

CONCLUSIONS AND IMPLICATIONS FOR THE WAIRARAPA

8.1 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. Attention is drawn to the limitations of the study, both with respect to the model used, and factors not considered by it.

Finally, comment is made on possible further development and use of the whole-farm model.

8.2 IMPLICATIONS FOR WAIRARAPA HILL COUNTRY FARMERS

8.2.1 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 8.1 summarises the objective function values for various changes (in present value terms).

Table 8.1 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 hour	241,500	1.00
Hired Labour Limit 300 hour	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 over-riding 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.

In spite 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.

8.2.2 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 practiced 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 maintainance 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 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.

8.2.3 Model Limitations

No model can be expected to completely portray accurately, all facets of a particular economic situation. It is worthwhile to identify and suggest the implications of some of these limitations.

<u>Model Type</u>

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 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. The diminishing terms of trade faced by farmers in recent years was also left out of the model and, again, would suggest caution in the rate of planting in any one year.

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 5.4.2) but this did not seriously compromise the model.

Model Benefits

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.

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, while information available for the Wairarapa was 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 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.

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 activities. 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 criterion 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.

8.2.4 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.

In Chapter 4 the importance of timely and appropriate silviculture for the production of high quality timber was stressed. 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; 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.

8.3 IMPLICATIONS FOR THE WAIRARAPA DISTRICT

8.3.1 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 long-run 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 districts 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.

8.3.2 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. As was noted in Chapter 3, 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).

In the brief review of the history of hill country farming (Section 1.2.3) it was demonstrated that hill country farmers have adopted new production systems and technology in the past. Currently, however, many are under severe financial pressure and this is acting to restrict development options (Section 2.3.6). As with all populations, hill country farmers are differentially susceptible to innovations in technique, ranging from the innovators to the slow adopters. 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 thesis 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 (see Section 4.5). 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.

8.4 FURTHER MODEL DEVELOPMENT AND USE

The model developed in this thesis 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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APPENDIX 1

1.1 FARM AREA AND LAND USE CAPABILITY UNITS

1.1.1 Land Class Areas and Stocking Rates

Land Class	Area (ha)	Area Utilized (ha)	Proportion of Total Area Utilized	Carrying Capacity (SU/ha)
II wl	22.9	22.9	3.34	13.8
IIIsl	55.5	52.0	7.59	15.8
IV e4	74.7	74.7	10.90	11.8
V cl	368.4	357.4	52.16	12.8
VI e4	150.2	119.1	17.38	11.8
VII e2	61.1	59.1	8.63	8.8
Total	732.8	685.2	100.00	

1.1.2 Land Use Capability Units (from Noble, 1985)

II wl. Located on the river terrace area of the farm. The soil type, Ahikouka silt loam is a deep gley soil with a high natural fertility, but with slow natural drainage in the subsoils. On this property the unit is used for both grazing and cropping but is also considered suitable for a wide range of horticultural uses.

III sl. Located on the higher terraces. The soil type, tawaha silt loam is representative of a yellow grey earth with poor internal drainage and poor soil structure. However on the case study farm subsurface drainage (tile and mole) have reduced wetness limitations and increased its versatility for cropping. Most permanent horticultural and orchard crops are considered unsuitable for this unit.

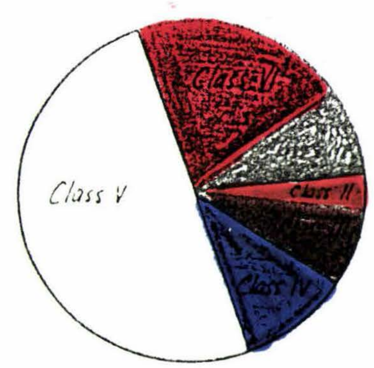
IV e4. Located on rolling to strongly rolling slopes (8-20 degrees) on limestone plateaux and downlands. The soil type, Kourarau silt loam, has a high natural fertility and well developed structure. Because of the slope angle there is a potential for severe sheet and sill erosion when cultivated. Together with sinkholes and rock outcrops this makes this unit unsuitable for cropping. The site index for P.Radiata is 26-28m.

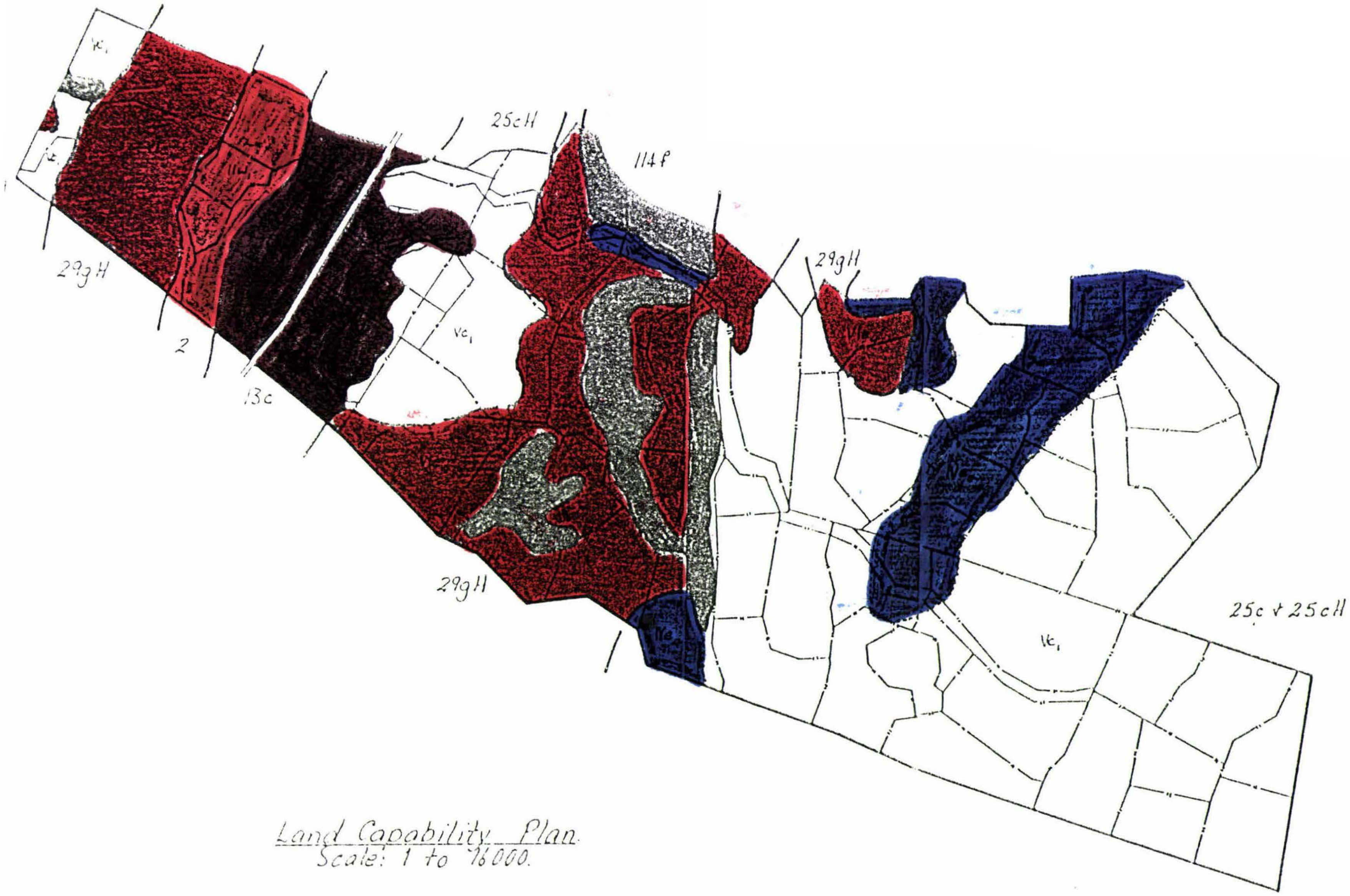
V cl. Located on short and stable slopes which range between 21 and 25 degrees. The soil type Kourarou hill soil is naturally fertile and only has a slight erosion hazard with a potential for slight sheet erosion on ridges during drought periods when the grass cover is sparse. In contrast to the previous unit agroforestry was not considered feasible by the district forestry officer. Trees grown on shallow alkaline soils such as this have restricted growth while the foliage can be quite chlorotic. It is thought that manganese uptake is restricted and that there is unlikely to be any economic way of correcting the condition (Will, 1985).

VI e4. Located on loess covered hill country with slopes between 16-25 degrees. In contrast to the preceeding units erosion is a continuing hazard of the Pirinoa hill soil. Aspect also has a marked effect on this unit and establishment of trees on north and west facing slopes can be difficult. Nevertheless the forestry site index is recorded as 26-28m for P.radiata.

VII e2. Located on steep mudstone and siltstone slopes and susceptible to various forms of erosion. The soil type Taueru silt loam is a typical shallow steepland soil. The site index for P.Radiata is 25-29m but the steep nature of the country makes it more suitable for higher density tree plantings.

Land Capability Percentage Area Graph.





Land Capability Plan.
Scale: 1 to 16000.

LEGEND.		SOIL TYPES.	CAPABILITY.	
Boundary Fence.	———	2 Ahikouka silt loam	Class II land.	(red)
Subdivision "	—·—·—	13c Tawaha silt loam.	" III "	(dark brown)
Electric. "	—+—	25c Kourarau silt loam.	" IV "	(blue)
Proposed "	—⊥—⊥—	25cH Kourarau hill soil.	" V "	(white)
Subsidised "	—+·s—	29gH Pirinoa hill soil.	" VI "	(dark red)
Buildings.	■	114P Taueru silt loam	" VII "	(grey)
Close Planting.	♣			
Open "	♣ ♣			
Completed Work.				

1.2 FIXED COSTS AND TAX-DEDUCTIBLE COSTS

1.2.1 Standard Agroforestry Model

Wages - Permanent	18,000
- Casual	3,000
Contracts	550
Electricity	3,100
Freight (General)	3,000
Weed & Pest	500
Repairs and Maintenance	10,000
Vehicle Expenses	9,000
Administration	5,000
Farm Insurance	4,000
Rates	5,200
Mortgage - Interest	44,725
Personal Insurances	3,034
Depreciation	6,500
	$115,609
Fixed Costs	
Tax Deductible Costs	$115,609
Less Depreciation	6,500
Plus Personal Expenses	18,000
Principal Repayments	12,855
Capital Items	3,000
	$142,964

1.2.2 Change in Debt Servicing

Base Level $6.78/SU with 8498 stock units

Debt Servicing Per SU	Total	Interest	Principal	Tax Deductible Costs	Fixed Costs
$2.00	16,996	13,202	3,794	84,086	102,380
$4.00	33,992	26,403	7,589	97,287	119,376
$6.00	50,988	39,605	11,383	110,489	136,372
$7.00	59,486	46,207	13,279	117,091	144,870

APPENDIX 2

LIVESTOCK AND CROPPING DATA

2.1 SHEEP

2.1.1 Nubmers and Capital Value of Sheep

Class	No.	SU	Value/HD	Total
Ewe Hoggets	1800	1260	12	21600
Ewes	5750	5750	12	69000
Wether Lambs	40	28	9	360
Rams	60	48	100	6000
	7650	7086		96960

2.1.2 Sheep Reconciliation

CLASS OF STOCK		OPENING	NO PURCHASED	NATURAL INCREASE	SALES	LOSSES	KILLERS	CLOSING	COMMENTS	
EWES	LAMBS									
	HGTS	1800		2961	1161					
	2TH				400	20		1800	SELLING MORE EWE	
	4TH								LAMBS AND CARRYING	
	6TH	5750			1030	350		5750	LESS HOGGETS THROUGH	
	5YR								THAN PREVIOUSLY	
	6YR									
	FATTENING									
WETHERS										
	LAMBS	40		2962	2922			40	CHECK	
	HGTS						40		7650	5513
	2TH								14	384
	4TH +								5923	40
RAMS										7650
	TERMINAL								13587	13587
	ROMNEY	60	14			14		60		
	TOTAL	7650	14	5923	5513	384	40	7650		

2.1.3 Sheep Partial Budget

EXPENDITURE		INCOME	
PURCHASES		WOOL	
14 RAMES @ $350	4900	37761 @ 3.19 NET	120139
ANIMAL HEALTH		EWES	
7086 @0.76/SU	5405	OLD EWES 1030 @ $3.00	3090
SHEARING/CRUTCHING		EWE HOGG 400 @ $15.00	5000
	17904	LAMBS	
FEED	0	EWE LAMBS 1161 @ $11.00	12771
		RAM LAMBS 2922 @ $13.00	37986
	28209		179986
	151777		

2.1.4 Effect of Variation in Sheep Performance and Returns

VARIATION IN COST
(OCOST) COSTS AFFECTED BY LX

LX	CLASS	NO	PRICE/UNIT	OCOST
	RAMS	14	350	4500
	ANIMAL HEALTH	7086	.76	5385.36
	SHEARING			
	MATURE STOCK	7593	1.20	9111.60
	CRUTCHING	5750	.35	2012.50
	WOOLPACKS	216	7.25	1566
	COMBS, CUTTERS, ETC			500
	FEED			0
	SUB TOTAL			23475.46

	LAMBING .90	.95	1	1.05	1.10	1.15	1.20
STATUS QUO	27085.83	27286.41	27486.98	27687.56	27888.14	28088.71	28289.29
+10	29794.41	30015.05	30235.68	30456.32	30676.95	30897.58	31118.22
+15	31148.71	31379.37	31610.03	31840.69	32071.36	32302.02	32532.68
+20	32503.00	32743.69	32984.38	33225.07	33465.76	33706.45	33947.15

GROSS REVENUE

		LAMBING .90	.95	1	1.05	1.10	1.15	1.20
	STATUS QU	171528.59	174978.59	178428.59	181878.59	185328.59	188778.59	192228.59
	+10%	188681.45	192476.45	196271.45	200066.45	203861.45	207656.45	211451.45
	+20%	205834.31	209974.31	214114.31	218254.31	222394.31	226534.31	230674.31
RETURNS	+30%	222987.17	227472.17	231957.17	236442.17	240927.17	245412.17	249897.17
	+40%	240140.03	244970.03	249800.03	254630.03	259460.03	264290.03	269120.03
	+50%	257292.89	262467.89	267642.89	272817.89	277992.89	283167.89	288342.89
	+100%	343057.18	349957.18	356857.18	363757.18	370657.18	377557.18	384457.18

2.1.5 Land Class Returns with Sheep

CLASS NO	MODEL IDENTITY	NAME OF SHEEP REGIME	PREDICTED CARRYING CAPACITY	ACTUAL CARRYING CAPACITY	FERTILIZER COST	SHEEP DIRECT COSTS	TOTAL COST (OCOST)	REVENUE (REV)	NET REVENUE
1	2	S2	12-20	13.80	54	54.37	108.37	360.87	252.50
1	3	S3	14-16	15.80	54	62.25	116.25	413.17	296.92
4	4	S4	10-13	11.80	54	46.49	100.49	308.57	208.08
1	5	S5	11-14	12.80	54	50.43	104.43	334.72	230.29
4	6	S6	10-12	11.80	54	46.49	100.49	308.57	208.08
2	7	S7	7-12	8.80	54	34.67	88.67	230.12	141.45

2.2 CATTLE

2.2.1 Numbers and Capital Value of Cattle

CLASS	NO	SU CONV	SU	VALUE/HD	TOTAL
R1YR HEIFERS	52	3.50	182	200	10400
R2YR HEIFERS	52	4	208	350	18200
COWS	125	6	750	320	40000
R1YR STEERS	51	3.50	178.50	250	12750
R2YR STEERS	15	4	60	450	6750
BULLS	6	5.50	33	600	3600
			1411.50		91700

2.2.2 Cattle Reconciliation

		OPENING	NO PURCHASED	CALVING	SALES	LOSSES	KILLERS	CLOSING	CHECK	
HFRS	CALVES			52						
	RISING 1YR	52						52		
	RISING 2&3YR (NOT RWB)	52			26			52		
COWS	BRDG. (INCLUDING HFRS. RWB)	125			21	5		125		
	DRY									
STEERS	CALVES			51						
	RISING 1YR	51						51	301	100.5
	RISING 2YR	15			36			15	.50	
	RISING 3YR+				15				105	30
BULLS		6	.50	2	2.50			6	406.50	406.5
		301	.50	105	100.50	5		301		

2.2.3 Cattle Partial Budget

EXPENDITURE		INCOME	
PURCHASES		STEERS	
0.5 OF A BULL @ 800	400	36 R2YR @450.0	16200
		15 R3YR @550.0	8250
ANIMAL HEALTH		HEIFERS	
1412 SU @0.6621	935	26 R3YR HEIFERS @ 400	10400
FEED		COWS	
500 BALES @ 2.50/BALE	1250	21 COWS @ 360	7560
COMMISSIONS		PPN BULL	
ON STEERS		2BULLS @ 600	1200
24450 @ 5.5%	1345		
CARTAGE			
ON STEERS			
36 R2YR 15 KM @ $4.71	170		
15 R3YR @ $4.71	71		
	4171		43610
	39439		

2.2.4 Effect of Variation in Cattle Performance and Returns

COST VARIATION

	CALVING .75	.80	.85	.90	.95
STATUS QUO	3977.79	4069.85	4161.91	4253.98	4346.04
+10%	4375.57	4476.84	4578.10	4679.37	4780.64
+20%	4773.35	4883.82	4994.30	5104.77	5215.25

REVENUE VARIATION

	CALVING .75	.80	.85	.90	.95
STATUS QUO	39703.75	42360	45016.25	47672.50	50328.75
+10%	43674.13	46596	49517.88	52439.75	55361.63
+20%	47644.50	50832	54019.50	57207	60394.50
+30%	51614.88	55068	58521.13	61974.25	65427.38
+40%	55585.25	59304	63022.75	66741.50	70460.25
+50%	59555.63	63540	67524.38	71508.75	75493.13
+100%	79407.50	84720	90032.50	95345	100657.50

2.2.5 Land Class Returns with Cattle

LAND CLASS NO	MODEL IDENTITY	NAME OF CATTLE REGIME	PREDICTED CARRYING CAPACITY	ACTUAL CARRYING CAPACITY	FERTILIZER COST	CATTLE DIRECT COSTS	TOTAL COST (OCOST)	REVENUE (REV)	NET REVENUE
2W1	2	C2	12-20	13.80	54	40.71	94.71	426.28	331.57
3S1	3	C3	14-16	15.80	54	46.61	100.61	488.06	387.45
4E4	4	C4	10-13	11.60	54	34.81	88.81	364.50	275.69
5C1	5	C5	11-14	12.80	54	37.76	91.76	395.39	303.63
6E4	6	C6	10-12	11.80	54	34.81	88.81	364.50	275.69
7E2	7	C7	7-12	8.80	54	25.96	79.96	271.83	191.87

2.3 CROPPING

2.3.1 Wheat Gross Margin

DIRECT COSTS		
PLOUGHING		37
OTHER CULTIVATION		65
SEED	170KG/HA@0.88	149.60
FERTILIZER	100KG/HA@0.54	54
DRILLING		28
WEED CONTROL	3L/HA MCPA@5.74+APPLN@15	32.22
RUST CONTROL		62.47
HEADING (CONTRACT)		138
RAKING AND PLOUGHING FIREBREAK		1
TOTAL AREA COSTS		567.29

YIELD COSTS	
CARTAGE 16KM	24.24
INS + LEVY	.53
	1.55
TOTAL YIELD COSTS	26.32

		YIELD(T/HA)			
	PRICE	4	4.50	5	5.50
DIRECT COST	$/T	672.57	685.73	698.89	712.05
	195	780	877.50	575	1072.50
	200	800	900	1000	1100
	205	820	922.50	1025	1127.50
GROSS REV	210	840	945	1050	1155
	220	880	990	1100	1210
	230	920	1035	1150	1265
	240	960	1080	1200	1320
	195	107.43	191.77	276.11	360.45
	200	127.43	214.27	301.11	387.95
	205	147.43	236.77	326.11	415.45
GM	210	167.43	259.27	351.11	442.95
	220	207.43	304.27	401.11	497.95
	230	247.43	349.27	451.11	552.95
	240	287.43	394.27	501.11	607.95

2.3.2 Barley Gross Margin

DIRECT COSTS		
PLOUGHING		37
OTHER CULTIVATION		65
SEED	130@0.72	93.60
FERTILIZER	100KG/HA@0.54	54
DRILLING		28
WEED CONTROL	3L/HA MCPA@5.74+APPLN@15	32.22
HEADING (CONTRACT)		138
RAKING AND PLOUGHING FIREBREAK		18
BALING 100@0.60		60
TOTAL AREA COSTS		525.82
YIELD COSTS		
CARTAGE 16KM		24.24
INS		.83
TOTAL YIELD COSTS		25.07

		YIELD(T/HA)			
	PRIC	4	4.50	5	5.50
DIRECT COSTS	$/T	626.10	638.64	651.17	663.71
	160	750	830	910	950
	165	770	852.50	935	1017.50
	170	790	875	960	1045
GROSS REV	180	830	920	1010	1100
	190	870	965	1060	1155
	200	910	1010	1110	1210
	160	123.90	191.37	258.83	326.30
GM	165	143.90	213.87	283.83	353.80
	170	163.90	236.37	308.83	381.30
	180	203.90	281.37	358.83	436.30
	190	243.90	326.37	408.83	491.30
	200	283.90	371.37	458.83	546.30

2.3.3 Red Clover Gross Margin

DIRECT COSTS		
PLOUGHING.		37
OTHER CULTIVATION		99
SEED	3KG@10.00/KG	30
DRILLING		28
FERTILIZER	150KG SUPER@$200/T	30
WEED CONTROL		135.94
DESSICATING		51.60
MOWING		37.50
HEADING		160
BOX HIRE		5.50
		614.54
YIELD COSTS		
DRESSING 285KG@0.25/KG		79.80
SACKS 7@2.95		20.65
RECEIVING,WEIGHING,STACKING 285KG@1.70/100KG		4.84
		105.29

GROSS REVENUE
285KG/HA FD,200KG/HA MD

		GROSS REVENUE	DIRECT COST	GM
	5	1000	719.83	280.17
PRICE	5.50	1100	690.33	409.67
($/KG)	6	1200	690.33	509.67
	6.50	1300	690.33	609.67
	7	1400	690.33	709.67

2.2.4 Costs of Feed

	WAIRANGI RAPE	PASTURE	GREENFEED
DIRECT COSTS			
PLOUGHING	37	37	
OTHER CULTIVATION	99	99	65
SEED	8.13	55	77
FERTILIZER	50	50	
DRILLING	28	28	28
	222.13	269	170
FEED SUPPLIED (SU)	7.10	33	7.10

2.2.5 Crop Rotation Incorporating Wheat

CROPS	REVENUE	DIRECT COSTS	GROSS MARGIN		FEED SUPPLY	
					CLASS2	CLASS3
WHEAT1	1150	698.89	451.11			
GF OATS		170			7.10	7.10
WHEAT2	1035	685.73	349.27			
RED CLOVER	1000	719.83	280.17		11.30	11.30
PASTURE1		269		}	33	38
PASTURE2		50				
RAPE		222.13			7.10	7.10
TOTAL	3185	2815.58	369.42			
FEED SUPPLIED					58.50	63.50
SHEEP					58.50	63.50
CATTLE					51.40	56.40

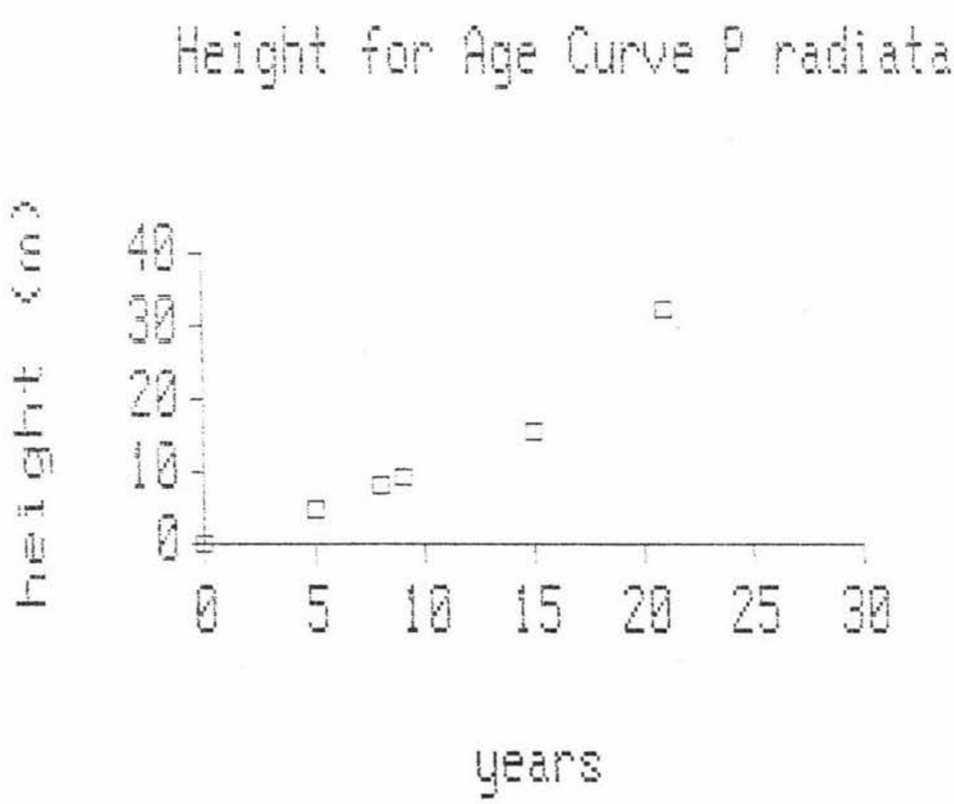
2.2.6 Crop Rotation Incorporating Barley

CROPS	GROSS REVENUE	DIRECT COSTS	GROSS MARGIN	FEED SUPPLIED CLASS 2	CLASS 3
BARLEY	960	651.17	308.63		
GF OATS		170		7.10	7.10
BARLEY	960	651.17	308.83		
RED CLOVER	1000	719.83	280.17	11.30	11.30
PASTURE 1		269		33	38
PASTURE 2		50			
RAPE		222.13		7.10	7.10
TOTAL	2920	2733.30	186.70		
FEED SUPPLY				58.50	63.50
SHEEP				58.50	63.50
CATTLE				51.40	56.40

APPENDIX 3

FORESTRY DATA

3.1 HEIGHT FOR AGE CURVE GLADSTONE AREA



3.2 FORESTRY DATA FOR FORESTRY REGIMES

3.2.1 Growth and Silvicultural Details

Land classes 4 and 6

Height/age curve 5	: Wellington
Basal area equation 1	: High Fertility
Volume equation 7	: Hawkes Bay
Pruning and thinning	: Scheduled on height
Site Index	: 28 m

Pruning and thinning

Lift number	Tree stocking	Mean Tree height	Mean Crop height	Pruned height	Diameter over stubs height	Branch %
	(stems/ha)	(m)	(m)	(m)	(m)	(stems/ha) (m)
1	300	3.7	3.7	1.8	0.8	16
2	200	4.9	5.0	2.5	1.8	22
3	100	6.5	6.5	3.5	2.5	30
4	100	8.0	8.0	4.5	3.5	36
5	100	9.5	9.5	6.0	4.5	42

Land Class 7

Height/age curve 5	: Wellington
Basal area equation 2	: Medium fertility
Volume equation 7	: Hawkes Bay
Pruning and thinning	: Scheduled on height
Site Index	: 26 m

Pruning and Thinning

Lift number	Tree Stocking	Mean Tree height	Mean Crop height	Pruned height	Diameter over stubs height	Branch %
	(stems/ha)	(m)	(m)	(m)	(m)	(mm)
1	500	5.5	5.0	2.2	0.8	31
2	250	7.8	7.6	4.0	2.2	42
3	200	10.9	10.7	6.0	4.0	48

3.2.3 Selected Harvesting and Transport Cost and Production Estimates

	Land Class 4	Land Class 6	Land Class 7
Ground Slope			
Class	0-10 degrees	10-20 degrees	10-20 degrees
Truck Cartage			
Lead	16 km	16 km	16 km
Current Consumer			
Price Index	1290	1290	1290
Logging System	Skidder	Tractor	Tractor
Cost of Spur			
Roads and	\$100/ha	\$100/ha	\$100/ha
Age of Clearfelling	28 years	28 years	28 years
Landings			
Mean Stem Diameter at			
Breast Height	76.4 cm	76.1 cm	59.3 cm
Stand Stocking	100 stems/ha	100 stems/ha	200 stems/ha
Total Stand Volume	492 m^3	489 m^3	645 m^3
Recovered Stand Volume	419 m^3	415 m^3	550 m^3
Breakage Volume	0 m^3	0 m^3	0 m^3
Net Recovered Volume			
Per Stem	4.2 m^3	4.2 m^3	2.8 m^3
Gross Recovered Volume			
Per Stem	4.4 m^3	4.4 m^3	2.9 m^3

	Land Class 4	Land Class 6	Land Class 7
Actual Costs Used			
Extraction and Loading Cost	12.00 $\$/m^3$	12.57 $\$/m^3$	14.81 $\$/m^3$
Transportation Cost	4.64 $\$/m^3$	4.77 $\$/m^3$	4.77 $\$/m^3$
Roading Upgrade/ Construction Cost	0.00 $\$/m^3$	0.00 $\$/m^3$	0.00 $\$/m^3$
Spur Road and Landing Cost	0.24 $\$/m^3$	0.24 $\$/m^3$	0.18 $\$/m^3$

3.2.4 Summary of Timber Yield, Harvesting Costs and Revenue (per ha)

	Land Class 4	Land Class 6	Land Class 7
Recoverable			
Volume - Sawlogs	413 m^3	410 m^3	540 m^3
- Pulplogs	5 m^3	5 m^3	10 m^3
Sawmill Conversion Factor	56.1	56.7	53.1
Harvesting Costs ($)			
- Extra Roading	100	100	100
- Logging and Roading	5,023	5,221	8,146
Sawing Cost ($)	15,856	15,774	25,055
Cartage Cost ($)	1,942	1,981	2,624
Revenues (Sawn Timber Only) ($)	55,401	54,702	61,607
Net Total Log Value/ha	32,470	31,615	31,378
Sawlog Stumpage $/ha	32,558	31,707	31,284
Sawlog Stumpage $/$m^3$	79	77	58

APPENDIX 4

AGROFORESTRY DATA

LANDCLASS 4

YEAR	CC%	ADJ.CC%	CC	ADJCC	CHGSU/HA	ADJSU/HA	FERTCOST	STOCKCOST	FORCOST	OCOST	BUY/SELL	AGRREV	FORREV	REVENUE	NET RET	DISCT10%	PVRETURN	TAXD	COBT	FORLAB	AGRLAB	TOTLAB	TERMV	YEAR
0	0	0	0	0	-11.80	-11.80	0	0	140	140	35.40	0	0	35.40	-104.60	.10	-104.60	-99.12	140	4.80	0	4.80	3576.63	0
1	20	16	2.36	1.89	2.36	1.89	0	7.44	0	7.44	-7.08	49.37	0	42.29	34.85		31.68	12.39	0	3.10	.14	3.24	32850.68	1
2	40	34	4.72	4.01	2.36	2.12	54	15.81	0	69.81	-7.08	104.91	0	97.83	28.03		23.16	-33.78	16.20	0	.28	.28	29926.20	2
3	87	84	10.27	9.91	5.55	5.90	0	39.05	0	39.05	-16.64	259.20	0	242.56	203.51		152.90	7.53	0	14.60	.61	15.21	27267.58	3
4	87	84	10.27	9.91	0	0	54	39.05	5	98.05	0	259.20	0	259.20	161.15		110.06	-76.85	21.20	8.20	.61	8.81	24850.65	4
5	87	84	10.27	9.91	0	0	0	39.05	0	39.05	0	259.20	0	259.20	220.15		136.69	-39.05	0	0	.61	.61	22653.77	5
6	87	84	10.27	9.91	0	0	54	39.05	0	93.05	0	259.20	0	259.20	166.15		93.78	-66.05	27	6.30	.61	6.91	20658.67	6
7	87	84	10.27	9.91	0	0	0	39.05	0	39.05	0	259.20	0	259.20	220.15		112.97	-39.05	0	0	.61	.61	18844.93	7
8	87	84	10.27	9.91	0	0	54	39.05	0	93.05	0	259.20	0	259.20	166.15		77.51	-66.05	27	4.50	.61	5.11	17196.09	8
9	91	89	10.74	10.50	.47	.59	0	41.38	0	41.38	-1.42	274.63	0	273.21	231.83		98.32	-37.41	0	4.50	.63	5.13	15697.46	9
10	80	76	9.44	8.97	-1.30	-1.53	54	35.33	0	89.33	3.89	234.51	0	238.41	149.07		57.47	-65.14	35.10	0	.56	.56	14337.45	10
11	71	66	8.38	7.79	-1.06	-1.18	0	30.68	0	30.68	3.19	203.66	0	206.84	176.16		61.74	-39.61	0	0	.49	.49	13101.07	11
12	62	56	7.32	6.61	-1.06	-1.18	54	26.04	0	80.04	3.19	172.80	0	175.99	95.95		30.57	-53.86	35.10	0	.43	.43	11979.48	12
13	53	47	6.25	5.55	-1.06	-1.06	0	21.85	0	21.85	3.19	145.03	0	148.21	126.36		36.60	-30.77	0	0	.37	.37	10962.24	13
14	45	39	5.31	4.60	-.94	-.94	54	18.13	0	72.13	2.83	120.34	0	123.17	51.04		13.44	-44.96	35.10	0	.31	.31	10042.10	14
15	37	31	4.37	3.66	-.94	-.94	0	14.41	0	14.41	2.83	95.66	0	98.49	84.08		20.13	-22.34	0	0	.26	.26	9175.59	15
16	36	30	4.25	3.54	-.12	-.12	0	13.95	0	13.95	.35	92.57	0	92.93	78.98		17.19	-14.94	0	0	.25	.25	8456.32	16
17	35	29	4.13	3.42	-.12	-.12	0	13.48	0	13.48	.35	89.49	0	89.84	76.36		15.11	-14.47	0	0	.24	.24	7774.79	17
18	34	28	4.01	3.30	-.12	-.12	0	13.02	0	13.02	.35	86.40	0	86.75	73.74		13.26	-14.01	0	0	.24	.24	7228.13	18
19	33	28	3.89	3.30	-.12	0	0	13.02	0	13.02	.35	86.40	0	86.75	73.74		12.06	-14.01	0	0	.23	.23	6706.55	19
20	32	27	3.78	3.19	-.12	-.12	0	12.55	0	12.55	.35	83.31	0	83.67	71.12		10.57	-13.54	0	0	.22	.22	6307.62	20
21	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		9.56	-12.55	0	0	.22	.22	5865.24	21
22	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		8.69	-12.55	0	0	.22	.22	5550.35	22
23	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		7.90	-12.55	0	0	.22	.22	5196.82	23
24	31	26	3.66	3.07	-.12	-.12	0	12.09	0	12.09	.35	80.23	0	80.58	68.49		6.95	-13.08	0	0	.22	.22	4924.51	24
25	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		6.29	-12.09	0	0	.22	.22	4623.32	25
26	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		5.72	-12.09	0	0	.22	.22	4388.03	26
27	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		5.20	-12.09	0	0	.22	.22	4014.60	27
28	31	26	3.66	3.07	-3.66	-3.07	0	12.09	22921	22933.09	10.97	80.23	55401	55492.20	32559.11		2257.76	-22963.82	0	0	.22	.22	3681.32	28
																	3328.70							

LANDCLASS 6

YEAR	CC%	ADJ.CC%	CC	ADJCC	CHGSU/HA	ADJSU/HA	FERTCOST	STOCKCOST	FORCOST	OCOST	BUY/SELL	AGRREV	FORREV	REVENUE	NET RET	DISCT10%	PVRETURN	TAXD	COBT	FORLAB	AGRLAB	TOTLAB	TERMV	YEAR
0	0	0	0	0	-11.80	-11.80	0	0	140	140	35.40	0	0	35.40	-104.60	.10	-104.60	-99.12	140	8.20	0	8.20	3513.00	0
1	20	16	2.36	1.89	2.36	1.89	0	7.44	0	7.44	-7.08	49.37	0	42.29	34.85		31.68	12.39	0	5.60	.14	5.74	32016.47	1
2	40	34	4.72	4.01	2.36	2.12	54	15.81	0	69.81	-7.08	104.91	0	97.83	28.03		23.16	-33.78	16.20	0	.28	.28	29167.83	2
3	87	84	10.27	9.91	5.55	5.90	0	39.05	0	39.05	-16.64	259.20	0	242.56	203.51		152.90	7.53	0	14.70	.61	15.31	26578.15	3
4	87	84	10.27	9.91	0	0	54	39.05	5	98.05	0	259.20	0	259.20	161.15		110.06	-76.85	21.20	10.50	.61	11.11	24223.90	4
5	87	84	10.27	9.91	0	0	0	39.05	0	39.05	0	259.20	0	259.20	220.15		136.69	-39.05	0	0	.61	.61	22084.00	5
6	87	84	10.27	9.91	0	0	54	39.05	0	93.05	0	259.20	0	259.20	166.15		93.78	-66.05	27	0	.61	.61	20140.69	6
7	87	84	10.27	9.91	0	0	0	39.05	0	39.05	0	259.20	0	259.20	220.15		112.97	-39.05	0	6.90	.61	7.51	18374.05	7
8	87	84	10.27	9.91	0	0	54	39.05	0	93.05	0	259.20	0	259.20	166.15		77.51	-66.05	27	0	.61	.61	16768.01	8
9	91	89	10.74	10.50	.47	.59	0	41.38	0	41.38	-1.42	274.63	0	273.21	231.83		98.32	-37.41	0	5.60	.63	6.23	15308.29	9
10	80	76	9.44	8.97	-1.30	-1.53	54	35.33	0	89.33	3.89	234.51	0	238.41	149.07		57.47	-73.24	27	5.60	.56	6.16	13983.66	10
11	71	66	8.38	7.79	-1.06	-1.18	0	30.68	0	30.68	3.19	203.66	0	206.84	176.16		61.74	-39.61	0	0	.49	.49	12779.45	11
12	62	56	7.32	6.61	-1.06	-1.18	54	26.04	0	80.04	3.19	172.80	0	175.99	95.95		30.57	-53.86	35.10	0	.43	.43	11687.10	12
13	53	47	6.25	5.55	-1.06	-1.06	0	21.85	0	21.85	3.19	145.03	0	148.21	126.36		36.60	-30.77	0	0	.37	.37	10696.43	13
14	45	39	5.31	4.60	-.94	-.94	54	18.13	0	72.13	2.83	120.34	0	123.17	51.04		13.44	-44.96	35.10	0	.31	.31	9800.46	14
15	37	31	4.37	3.66	-.94	-.94	0	14.41	0	14.41	2.83	95.66	0	98.49	84.08		20.13	-22.34	0	0	.26	.26	8955.91	15
16	36	30	4.25	3.54	-.12	-.12	0	13.95	0	13.95	.35	92.57	0	92.93	78.98		17.19	-14.94	0	0	.25	.25	8256.62	16
17	35	29	4.13	3.42	-.12	-.12	0	13.48	0	13.48	.35	89.49	0	89.84	76.36		15.11	-14.47	0	0	.24	.24	7593.24	17
18	34	28	4.01	3.30	-.12	-.12	0	13.02	0	13.02	.35	86.40	0	86.75	73.74		13.26	-14.01	0	0	.24	.24	7063.09	18
19	33	28	3.89	3.30	-.12	0	0	13.02	0	13.02	.35	86.40	0	86.75	73.74		12.06	-14.01	0	0	.23	.23	6556.51	19
20	32	27	3.78	3.19	-.12	-.12	0	12.55	0	12.55	.35	83.31	0	83.67	71.12		10.57	-13.54	0	0	.22	.22	6171.22	20
21	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		9.56	-12.55	0	0	.22	.22	5761.24	21
22	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		8.69	-12.55	0	0	.22	.22	5437.63	22
23	32	27	3.78	3.19	0	0	0	12.55	0	12.55	0	83.31	0	83.31	70.76		7.90	-12.55	0	0	.22	.22	5094.34	23
24	31	26	3.66	3.07	-.12	-.12	0	12.09	0	12.09	.35	80.23	0	80.58	68.49		6.95	-13.08	0	0	.22	.22	4831.35	24
25	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		6.29	-12.09	0	0	.22	.22	4538.63	25
26	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		5.72	-12.09	0	0	.22	.22	4311.04	26
27	31	26	3.66	3.07	0	0	0	12.09	0	12.09	0	80.23	0	80.23	68.14		5.20	-12.09	0	0	.22	.22	3944.60	27
28	31	26	3.66	3.07	-3.66	-3.07	0	12.09	23076	23088.09	10.98	80.23	54702	54793.21	31705.12		2198.54	-23131	0	0	.22	.22	3617.69	28
																	3269.48							

LANDCLASS 7 200

YEAR	CC%	ADJ.CC%	CC	ADJCC	CHGSU/HA	ADJSU/HA	FERTCOST	STOCKCOST	FORCOST	OCOST	BUY/SELL	AGRREV	FORREV	REVENUE	NET RET	DISCT10%	PVRETURN	TAXD	COBT	FORLAB	AGRLAB	TOTLAB	TERMV	YEAR
0	0	0	0	0	-8.80	-8.80	0	0	155	155	26.40	0	0	26.40	-128.60	.10	-128.60	-73.92	155	11.80	0	11.80	2306.74	0
1	20	16	1.76	1.41	1.76	1.41	0	5.55	0	5.55	-5.28	36.82	0	31.54	25.99		23.63	9.24	0	0	.10	.10	25455.54	1
2	40	34	3.52	2.99	1.76	1.58	54	11.79	0	65.79	-5.28	78.24	0	72.96	7.17		5.93	-34.80	16.20	0	.21	.21	23150.95	2
3	70	64.75	6.16	5.70	2.64	2.71	0	22.45	0	22.45	-7.92	149.00	0	141.08	118.63		89.13	-.27	0	0	.36	.36	21055.86	3
4	70	64.75	6.16	5.70	0	0	54	22.45	0	76.45	0	149.00	0	149.00	72.55		49.55	-60.25	16.20	30.90	.36	31.26	19151.24	4
5	71	65.85	6.25	5.80	.09	.10	0	22.83	5	27.83	-.26	151.54	0	151.28	123.44		76.65	-22.09	5	0	.37	.37	17419.76	5
6	71	65.85	6.25	5.80	0	0	54	22.83	0	76.83	0	151.54	0	151.54	74.71		42.17	-49.83	27	19.60	.37	19.97	15845.93	6
7	71	65.85	6.25	5.80	0	0	0	22.83	0	22.83	0	151.54	0	151.54	128.71		66.05	-22.83	0	0	.37	.37	14416.58	7
8	67	61.47	5.90	5.41	-.35	-.39	54	21.31	0	75.31	1.06	141.46	0	142.52	67.20		31.35	-51.27	27	17.40	.35	17.75	13118.57	8
9	54	47.79	4.75	4.21	-1.14	-1.20	0	16.57	0	16.57	3.43	109.97	0	113.41	96.84		41.07	-26.18	0	0	.28	.28	11939.99	9
10	46	39.79	4.05	3.50	-.70	-.70	54	13.80	0	67.80	2.11	91.56	0	93.68	25.88		9.98	-38.61	35.10	0	.24	.24	10869.73	10
11	40	34	3.52	2.99	-.53	-.51	0	11.79	0	11.79	1.58	78.24	0	79.82	68.04		23.85	-16.22	0	0	.21	.21	9897.49	11
12	32	26.56	2.82	2.34	-.70	-.65	54	9.21	0	63.21	2.11	61.12	0	63.23	.02		.01	-34.02	35.10	0	.17	.17	9017.24	12
13	24	19.44	2.11	1.71	-.70	-.63	0	6.74	0	6.74	2.11	44.74	0	46.85	40.11		11.62	-12.65	0	0	.12	.12	8217.02	13
14	14	10.99	1.23	.97	-.88	-.74	54	3.81	0	57.81	2.64	25.29	0	27.93	-29.88		-7.87	-30.10	35.10	0	.07	.07	7489.55	14
15	14	10.99	1.23	.97	0	0	0	3.81	0	3.81	0	25.29	0	25.29	21.48		5.14	-3.81	0	0	.07	.07	6781.51	15
16	14	10.99	1.23	.97	0	0	0	3.81	0	3.81	0	25.29	0	25.29	21.48		4.67	-3.81	0	0	.07	.07	6201.47	16
17	14	10.99	1.23	.97	0	0	0	3.81	0	3.81	0	25.29	0	25.29	21.48		4.25	-3.81	0	0	.07	.07	5637.72	17
18	11	8.55	.97	.75	-.26	-.21	0	2.97	0	2.97	.79	19.68	0	20.47	17.51		3.15	-5.18	0	0	.06	.06	5187.06	18
19	11	8.55	.97	.75	0	0	0	2.97	0	2.97	0	19.68	0	19.68	16.72		2.73	-2.97	0	0	.06	.06	4739.03	19
20	10	7.75	.88	.68	-.09	-.07	0	2.69	0	2.69	.26	17.83	0	18.10	15.41		2.29	-3.43	0	0	.05	.05	4396.25	20
21	9	6.95	.79	.61	-.09	-.07	0	2.41	0	2.41	.26	16.00	0	16.26	13.85		1.87	-3.15	0	0	.05	.05	4057.68	21
22	8	6.16	.70	.54	-.09	-.07	0	2.14	0	2.14	.26	14.18	0	14.44	12.30		1.51	-2.87	0	0	.04	.04	3805.81	22
23	7	5.37	.62	.47	-.09	-.07	0	1.86	0	1.86	.26	12.36	0	12.63	10.76		1.20	-2.60	0	0	.04	.04	3527.74	23
24	7	5.37	.62	.47	0	0	0	1.86	0	1.86	0	12.36	0	12.36	10.50		1.07	-1.86	0	0	.04	.04	3319.26	24
25	7	5.37	.62	.47	0	0	0	1.86	0	1.86	0	12.36	0	12.36	10.50		.97	-1.86	0	0	.04	.04	3083.46	25
26	7	5.37	.62	.47	0	0	0	1.86	0	1.86	0	12.36	0	12.36	10.50		.88	-1.86	0	0	.04	.04	2911.00	26
27	7	5.37	.62	.47	0	0	0	1.86	0	1.86	0	12.36	0	12.36	10.50		.80	-1.86	0	0	.04	.04	2652.88	27
28	7	5.37	.62	.47	-.62	-.47	0	1.86	35925	35926.86	1.86	12.36	61607	61621.22	25694.36		1781.73	-35932.07	0	0	.04	.04	2435.34	28
																	2146.78							

APPENDIX 5

CALCULATION OF DISCOUNT RATES

To determine the weighted average cost of capital (d) it is necessary to determine K(e), the after-tax rate of return on equity capital. This is given by:

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

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.

The following assumptions were made:

cash return on total capital = 3.4%

K(ne) = 4.6%

G = 0

t = 0.30

The resulting values are detailed (Table 5.1).

Table 5.1

Capital Structure

Equity	Debt	K(ce)	K(e)
100	0	3.4	6.98
90	10	3.78	7.25
80	20	4.25	7.58
70	30	4.86	8.00
60	40	5.67	8.57
50	50	6.80	9.36

The weighted average cost of capital is given by:

d = K(e) * we + K(d) (1-t) * wd.

where K(d) = the interest rate on debt

we = the long-run proportion of equity used to operate the firm

K(d) was assumed to be 17.5%, the current base Rural Banking and Finance Corporation Lending rate. The resulting values are indicated below.

Table 5.2

Capital Structure

Equity	Debt	Ke	Kd	d
100	0	6.98	17.5	6.98
90	10	7.25	17.5	7.74
80	20	7.58	17.5	8.51
70	30	8.00	17.5	9.28
60	40	8.57	17.5	10.04
50	50	9.36	17.5	10.81