AN ECONOMIC STUDY OF AGROFORESTRY IN THE MANJIMUP REGION, WESTERN AUSTRALIA

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FORESTS DEPARTMENT OF WESTERN AUSTRALIA

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1984

PREFACE

In early 1984, Mr D.W.G. Treloar of the University of Western Australia completed a study dealing with the economics of forestry versus agriculture on farmland in the Manjimup region of Western Australia.

Subsequently, we were requested by the State Government to undertake a study of the economics of agroforestry, the combination of agriculture and forestry, on the same farmland. This report presents the results of our study.

Signed ..... Signed .....

Dr George Malajczuk Dr David Morrison

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SUMMARY

The findings of this study only concern farms within the Manjimup Shire which are presently used for sheep and cattle grazing. The results should be seen as indicative for the general area, rather than specific to any particular farm.

Comparison of Agroforestry Alternatives

Findings from this study indicate that there is not a great difference in profitability for the range of agroforestry alternatives considered. However, the alternatives involving a forestry emphasis and the farmer carrying out manageable forestry operations are slightly more profitable than those involving an agricultural emphasis and other levels of farmer labour input, respectively. Two forest rotations were considered (25 and 30 years), the more profitable depending on the discount rate used.

The alternatives are also similar in terms of the year to year variation in net income and labour requirements. Alternatives with an agricultural emphasis give rise to less fluctuation in net returns and employment than those with a forestry emphasis. Fluctuations in net income and labour requirement can be reduced in various ways; for example, by extending tree planting over a number of years.

Comparison of Agroforestry with Agriculture and Forestry

A comparison was made between the agroforestry results from this study and the results of Treloar's study (agriculture and forestry). The comparison was in terms of farm profitability, cash flow and labour requirements.

(1) Agroforestry Versus Agriculture

(a) Financial Returns

Results indicate that, in the long term, agroforestry is substantially more profitable than grazing livestock. Assuming a 5% real discount factor,

the most profitable agroforestry option would provide a net present value equivalent to $133/ha/year-versus $64/ha/year for cattle grazing. This suggests that there is a substantial profit incentive for farmers to convert from beef cattle grazing to agroforestry.

Against the higher long-term profitability are lower net income in the short term, and greater income fluctuation under agroforestry. A number of measures can be adopted to reduce these problems, most importantly - plantings extended over a number of years. Measures which increase short term profitability and reduce net income fluctuation also reduce the long term profitability of agroforestry. Even so, all systems of agroforestry studied are more profitable in the long-term than the agricultural enterprises considered.

The relatively high financial returns found for agroforestry are contingent upon the management programme being closely followed and enough trees being planted to achieve economies of scale.

(b) Labour Requirements

Labour requirements of agroforestry are considerably greater than for sheep or cattle grazing. There is also flexibility in the level of farmer input, depending on how many of the forestry tasks the farmer undertakes. The alternatives are contracting the Western Australian Forests Department (WAFD) or hiring casual labour. The agroforestry option found to be most profitable (for the farmer) requires the farmer to carry out the more manageable tasks, while the WAFD carries out the remainder. The farmer's labour input

under this option would be slightly greater than for agriculture. A problem with agroforestry labour requirements is the variation from year to year. Measures designed to reduce year to year net income fluctuations, such as extended planting schedules, would also smooth out agroforestry labour demands.

(c) Farmer Perceptions and Preferences

Other factors not accounted for in the analysis but which concern the agroforestry decision may include the farmer's preference for agriculture and an unfamiliarity with wood production, and the perception that agroforestry is riskier than agriculture because of the long production period for forest products. These problems may be offset by the risk-reducing effect of diversification, and by joint venture arrangements with the WAFD.

(d) Additional Benefits

Benefits from agroforestry which have not been explicitly accounted for in the analysis include the contribution of trees to livestock shelter, the reduction of water erosion and the enhancement of soil fertility.

(2) Agroforestry Versus Forestry

(a) Financial Returns

Results indicate that conversion to agroforestry is likely to be a more attractive option for farmers than conversion to pure forestry. Although the long term profitability of agroforestry was found to be of the same order as forestry, farmers are likely to prefer agroforestry because the problem of low net income prior to sawlog sale is reduced, and there are smaller fluctuations in net annual income (assuming no

Government schemes are introduced to reduce income fluctuations).

(b) Labour Requirements

Agroforestry is better suited to providing continued employment opportunity for farmers because the labour demands are higher and fluctuate less than for pure forestry.

(c) Farmer Perceptions and Preferences

Farmers are likely to prefer an enterprise involving some agriculture and some trees to one which is entirely forestry.

(d) Additional Benefits

Agroforestry logs are expected to be larger, on average, than forestry logs and, as a result, may attract relatively high stumpages.

The fire risk is likely to be less with agroforestry than forestry because of the wider tree spacing and livestock grazing.

The Community Perspective

Community benefits from farmer adoption of agroforestry would include the flow-on (income multiplier) effects of farmers spending additional income, and the stimulation of employment by direct increases in labour requirements and indirect flow-on (employment multiplier) effects.

The contribution of agroforestry towards meeting the Government's objective of net self sufficiency in timber, and improvements in soil conservation and fertility would also be advantageous.

Against these benefits could be the possible cost to Government of researching, demonstrating and extending agroforestry; and changes in patterns of land use and landscape which some people may consider undesirable.

Government Involvement and Farmer Attitudes

There are a number of reasons farmers may choose not to convert to agroforestry, in spite of its higher profitability. If the Government decides it is worthwhile encouraging farmer adoption of agroforestry then it should consider:

(1) the extension of information to farmers so that an informed decision can be made on whether or not to convert to agroforestry;

(2) the establishment of agroforestry demonstration areas;

(3) the provision of an advisory service to ensure that the best agroforestry practices are adopted when farmers convert to agroforestry, and

(4) the establishment of a financial scheme by which farmers are paid annually for the forestry part of their operations.

Co-operative Ventures

A co-operative venture between Government and farmers may encourage the adoption of agroforestry (or forestry) by farmers. The WAFD, acting on behalf of Government, could make annual payments to farmers and, in return, receive all income from forestry on the farmers' properties. It is assumed that the Government would not be financially involved in the agricultural part of the venture.

Some farmers may consider WAFD involvement in their farms to be an undesirable intrusion, so it is important that alternative agroforestry schemes (with minimum WAFD involvement) are also on offer.

Marketing and Research

It is suggested that the Government extends to farmers the results of this study, together with technical information and practical experience. Following this, it is suggested that a survey be conducted of farmer attitudes and any reservations they hold with respect to agroforestry. On the basis of this survey, Government could then decide whether to establish an agroforestry advisory service for farmers and/or implement any incentive programmes.

In order to ensure the cost effectiveness of Government expenditure on agroforestry, consideration should be given to:

(1) the level of expenditure (after taking into account the results of the farmer survey);

(2) a specified minimum number of trees and a maximum distance from log markets; and

(3) a review of experience with comparable programmes.

INTRODUCTION

Background

In mid 1983, the State Government commissioned Mr D.W.G. Treloar to undertake an economic study of pine planting on farmland in the Manjimup region of Western Australia. As indicated in the subsequent Treloar Report, the Government requested an examination of "the potential for co-operative ventures between the Forests Department and farmers in the South-West which would permit pine plantation establishment on privately owned land".

Significant points made in the Treloar report are:

(1) Forestry is more profitable than agriculture. This was at real discount rates between 3.5% and 6%, the range that Treloar considered to be the best representation of producers' and consumers' rates of time preference. In simple terms, a time preference rate is a factor expressing an individual's preference for present consumption or income relative to the same amount of consumption or real income in the future. It is applied to future values to convert them to present day equivalents (Bannock et al., 1972; Sugden and Williams, 1978).

(2) There are a number of reasons which may explain why farmers have not taken advantage of the higher profitability offered by forestry. They include the possibility that farmers derive some additional non-monetary benefit from farming, and the irregular pattern of cash flow generated by forestry.

(3) A financial scheme to improve the cash flow pattern could be set up to encourage farmers to practise forestry. Under such a scheme the Western Australian Forests Department (WAFD), acting on behalf of the Government, would pay farmers an annual sum for growing pines. The WAFD would have control over forestry practices and would receive all income from log sales.

(4) Forestry appears to offer reduced opportunity for on-site employment of farm labour, and this could also be an obstacle to farm forestry development.

Treloar only considered forestry and agriculture as mutually exclusive enterprises. The next logical step was our study of their combination, to see if it gave rise to a land use more profitable than agriculture, while generating a more attractive cash flow and labour demand than forestry. Agroforestry is defined as a combination of agricultural and forestry pursuits on the same land (McKinnell, 1982). For this study the forestry pursuits involve Pinus radiata, managed for sawlog production and grown sufficiently widely spaced to enable pasture growth to support beef cattle or sheep.

Study's Objectives

(1) To compare a number of agroforestry alternatives in terms of their profitability, cash flow and labour requirements.

(2) To compare agroforestry with agriculture and forestry, in terms of profitability, cash flow and labour requirements.

(3) To examine briefly agroforestry's benefits and costs to the community.

(4) To consider possible Government involvement in agroforestry, including Government/farmer joint ventures.

Setting and Scope

Our analysis of agroforestry applies only to farmland within the Manjimup Shire. At present there is no agroforestry production in the Shire.

It is envisaged that agroforestry would be established on sheep and cattle farms and would involve production of Pinus radiata sawlogs as well as hay and livestock. The reason for focusing on sheep and cattle farming was Treloar's finding that forestry appears more profitable than sheep and cattle production, but that it is significantly less profitable than the region's other agricultural enterprises (notably horticulture), and it was expected that agroforestry would not differ significantly from forestry in this respect.

The farmland would have to have the soil types and rainfall as specified for P. radiata in the Western Australian Foresters' Manual (WAFD, 1980).

As in Treloar's Study, the analysis is confined to monetary benefits and costs, cash flows and labour requirements. Although reference is made to other benefits and costs, this study does not include a complete social cost benefit analysis.

METHOD

Analytical Procedure

The data and procedure used to examine agroforestry were consistent with those used by Treloar to study farm forestry and agriculture. It was important to have this consistency so that the results for agroforestry could be compared with Treloar's findings.

A number of agroforestry alternatives were examined, using 1983 data. Data collected represented an average (hypothetical) farm in the Manjimup region. Consequently, results should be seen as indicative rather than specific to any particular farm.

(1) Profit

Profit was calculated in terms of net present value (NPV) per hectare, where

$$NPV = \sum_{t=1}^{n} \frac{b_t - c_t}{(1 + i)^t}$$

where b_t = returns per hectare accruing in year t
c_t = costs per hectare incurred in year t
i = discount rate
n = number of years

Net present values were calculated for a 30-year period and compared to those calculated by Treloar for farm forestry and agriculture.

Discount rates used were in the range 3% to 7%, consistent with those considered most appropriate by Treloar.

(2) Cash Flow and Labour Requirements

Cash flow and labour requirements were calculated for agroforestry on a whole farm basis. Cash flows were expressed in terms of annual net income. It was assumed that the farm size was 380 hectares and that 60% of the farm was planted to pines in the wide spacing for agroforestry, with 40% of the farm retained exclusively for agriculture. The pure agricultural area is required for hay making and to provide back-up pasture, especially as the trees mature on the agroforestry area. Its use tends to reduce the year to year variation in cash flow and employment.

Two alternative tree-planting schedules were considered. In the first, planting is completed within the first year of the agroforestry operation. In the second, planting is staggered over a number of years, at a rate of 6% of farm area every three years, until 60% of the farm is planted. (This is referred to hereafter as the extended planting schedule.) In practice, there is flexibility in the planting schedule and the proportion of farm to be planted. (Note: An extended planting schedule extends the time needed to grow and harvest the complete farm crop).

Calculations of cash flows and employment requirements for agroforestry were made for two periods: First, one forest rotation, which for this study is 25 or 30 years; and second, 60 years to allow for one complete clear felling under an extended planting schedule. (A forest rotation is the number of years between the establishment of the crop and its harvest).

It was necessary to adjust Treloar's employment and cash flow data to the same whole farm basis and the same duration considered in this study, so that cash flow and labour requirements for agroforestry could be compared with those for forestry and agriculture.

Estimates of labour input were based on Forests Department data for forestry operations and Treloar's case studies of agricultural operations.

Agroforestry Management Alternatives

The range of management alternatives considered (Figure 1) were:

(1) Production Emphasis

(a) Agroforestry with an agricultural emphasis, in which tree stocking is relatively low and agricultural production is relatively high; and

(b) Agroforestry with a forestry emphasis, in which tree stocking is relatively high and agricultural production relatively low.

(Note: These are, of course, just two of the many possible agroforestry combinations, which correspond to the prominence placed on the agricultural and forestry components.)

The two management programmes considered, agricultural emphasis and forestry emphasis (Table 1), were based on experience accumulated in agroforestry trials (Anderson and Batini, 1983; Anderson, 1984).

(2) Forest Rotation

Rotations of 25 and 30 years were considered. Net present values calculated for the 25 year rotation were adjusted so that they could be validly compared with those derived for the 30 year rotation. In practice there is flexibility in rotation length, so that farmers are not confined to harvesting after 25 or 30 years.

(3) Means of Operation

It was assumed that farmers would undertake all agricultural operations at their expense, but three basic alternatives for undertaking forestry operations were examined:

Figure 1: **Agroforestry options examined**

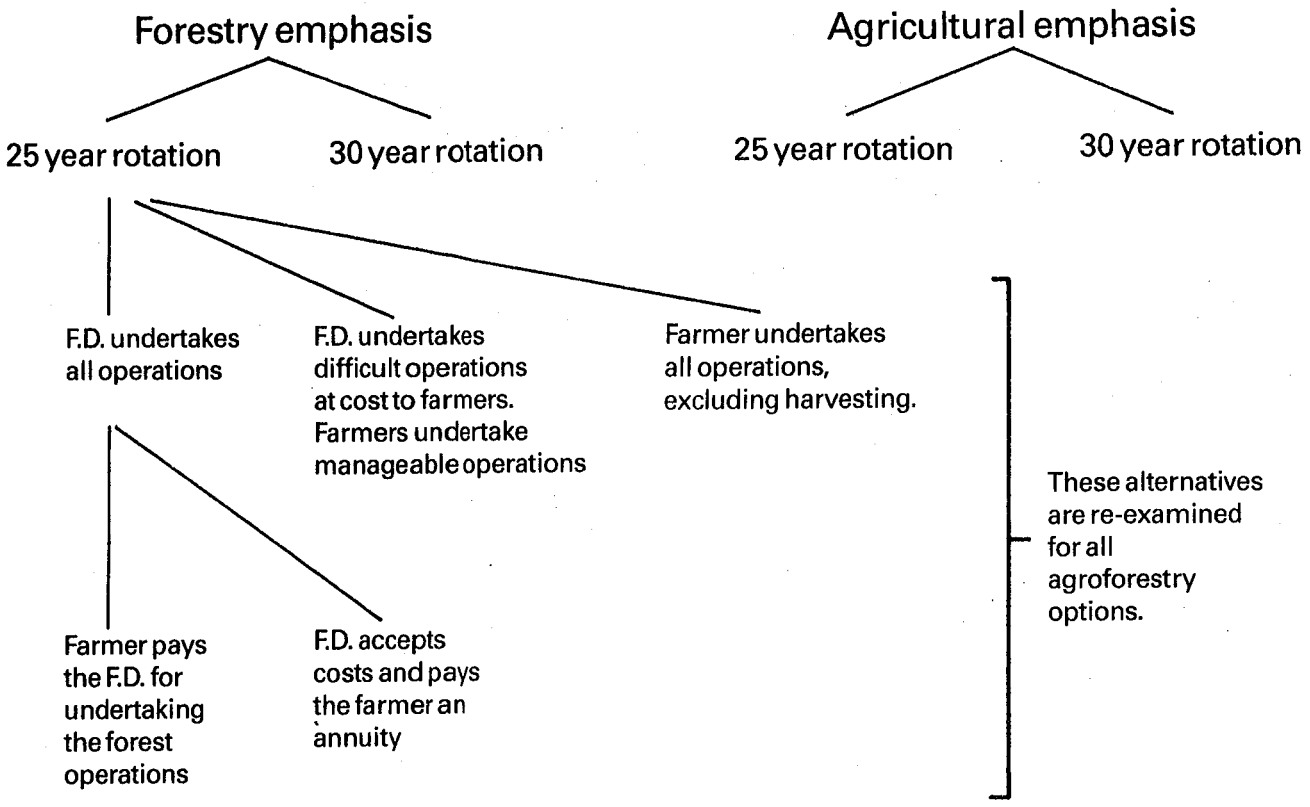

TABLE 1

MANAGEMENT PROGRAMMES CONSIDERED FOR AGROFORESTRY

Year	Management Operation	
	Agricultural Emphasis	Forestry Emphasis
0	Noxious weed control.	Noxious weed control.
1	Poison rabbits if they are prevalent. Spray herbicide along rows 14m apart (spray strips 1.5m wide). Plant trees 2m apart along sprayed row (350 s.p.h.). Fence off area if necessary. Apply 250 kg/ha Super and Potash. Cut hay. Construct roads and firebreaks.	Poison rabbits if they are prevalent. Spray herbicide along rows 10m apart (spray strips 1.5m wide). Plant trees 1.4m apart along sprayed row (700 s.p.h.). Fence off area if necessary. Apply 250 kg/ha Super and Potash. Cut hay. Construct roads and firebreaks.
2 & 3	Apply 250 kg/ha Super and Potash. Cut hay.	Apply 250 kg/ha Super and Potash. Cut hay.
4	Apply 150 kg/ha plain Super annually from year 3 to 30. Commence grazing with sheep. Noxious weed control.	Apply 150 kg/ha plain Super annually from year 3 to 15. Commence grazing with sheep. Noxious weed control.
5	Cull to 100 s.p.h. Commence low pruning.	Cull to 200 s.p.h. Commence low pruning.
7	Cull to 50 s.p.h.	Cull to 100 s.p.h.
8	Noxious weed control. Commence grazing with cattle and/or continue grazing with sheep (reduce animal stocking periodically). Commence high pruning (to 10m).	Noxious weed control. Commence grazing with cattle and/or continue grazing with sheep (reduce animal stocking periodically). Commence high pruning (to 10m).
18 or 20	Roading access for thinning.	Roading access for thinning.
19 or 21	Thin to 35 s.p.h. - sell sawlogs. Heap debris.	Thin to 50 s.p.h. - sell sawlogs. Heap debris. Recommence fertilizing and repeat annually until age 21 or 23.
26 or 31	Harvest 35 s.p.h. - sell sawlogs.	Harvest 50 s.p.h. - sell sawlogs.
0to26or31	Annual maintenance.	Annual maintenance.

(a) The WAFD undertakes all forestry operations at its expense and uses its own equipment in either of two scenarios;

(i) The farmer pays the WAFD to undertake the operations, and receives all income from log sales when the forest is harvested.

(ii) The WAFD accepts all costs and receives all income from log sales, but pays the farmer an annual sum for the use of the land. This arrangement could be a co-operative venture between the farmer and the WAFD, of the type considered by Treloar.

(Note: In either option the farmer could be employed as a member of the work crew.)

(b) Farmers undertake all operations using their own equipment; and

(c) The WAFD undertakes the more difficult operations (namely planting, roading and the establishment of firebreaks in the first year, and high pruning between years 8 and 11), leaving the farmer to undertake the more manageable operations using the farmer's own equipment.

(Note: All operations in alternatives (b) and (c) are undertaken at the farmer's expense, and the farmer receives all income from log sales when the forest is harvested.)

Agroforestry Data

(1) Yields

Yield data (Table 2) were derived from a series of agroforestry trials, some of which have been conducted for more than 10 years. The growth and sheep carrying capacities for open pastures with pines at various densities were based on trials

TABLE 2

SUMMARY OF AGROFORESTRY YIELD DATA

Scenario	Rotation Length (Years)	Sawlog Yield (m^3/ha)	Agricultural Production (% of Production in a Pure Agricultural Situation)
Agricultural Emphasis	25	202	65
	30	268	61
Forestry Emphasis	25	265	48
	30	353	42

conducted at Mundaring (Anderson and Batini, 1983; Anderson, 1984), with adjustments made for the higher productivity at Manjimup (the result of the higher rainfall and the longer growing season).

Only one roundwood product was considered - namely sawlogs, a high value product obtained mainly from the large pruned portions of tree trunks. Other products were not considered due to limited markets and/or the larger branch development expected on the smaller unpruned material. Tree branches in agroforestry are larger than those for forestry, due to wider spacing between trees.

(2) Prices and Costs

1983 cost and price data were used to keep results consistent with Treloar's. Farm gate prices for agricultural products and WAFD stumpages for sawlogs were used. (Stumpage is the value of timber as it stands uncut in a forest).

Agroforestry costs were based on estimates for forestry and agriculture. It was assumed that farmers would pay for the equipment needed for any operation they undertook. (Farmers can purchase equipment for each operation or join a group which collectively purchases equipment and shares it). For the

management situation where the WAFD undertakes all forestry operations, no fire insurance cost was applied but relatively high annual maintenance and overhead costs were used. These latter two costs, which were averages for all State afforested areas, reflect expenses within the WAFD for such items as intensive fire protection, road maintenance, research, information services to the public and maintenance of forest settlements.

In accord with Treloar, the value of the land was considered in calculating net present values. It was treated as a debit at the beginning of the agroforestry venture and as a credit at the end of the forest operation.

RESULTS

Comparison of Agroforestry Alternatives

(1) Long Term Profitability

The range of net present values (NPV) per hectare calculated for the different agroforestry alternatives is illustrated in Figure 2. Net present values for 3%, 5% and 7% discount rates are presented in Table 3. For these discount rates it can be seen that:

(a) For most rotation lengths and methods of operation, agroforestry with a forestry emphasis has a higher NPV than that with an agricultural emphasis. The exceptions all involve the 30 year rotation and the upper range of discount rates.

(b) For a given rotation age and production emphasis, the most profitable alternative with the highest NPV is that based on the farmer undertaking the more manageable operations, while the WAFD carries out the more difficult operations; and

(c) For a given production emphasis and method of operation, and for discount rates below 5%, the alternative based on a 30 year rotation has a higher NPV than that based on a 25 year rotation. For discount rates above 5% the opposite holds.

(2) Cash Flows

Figures 3 and 4 illustrate how annual net returns on a whole farm basis vary for two different agroforestry alternatives and different tree planting rates. It can be seen that:

(a) Within each planting schedule, the agroforestry alternatives show a similar pattern of net returns. However the net returns for agroforestry with an agricultural emphasis fluctuate less than for those with a forestry emphasis.

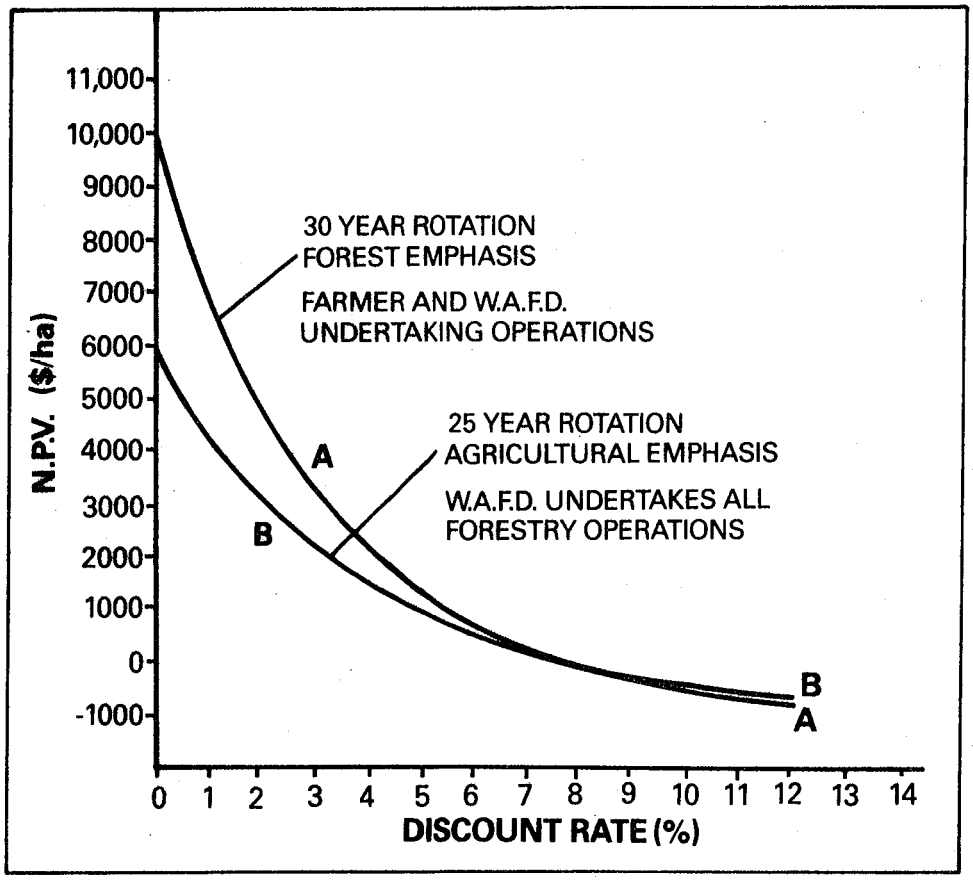

Figure 2: Range of net present values calculated for agroforestry.

TABLE 3

NET PRESENT VALUES FOR THE AGROFORESTRY ALTERNATIVES

		W.A. Forests Department undertakes all operations ($/ha)			W.A.F.D. undertakes more difficult operations and farmer undertakes more manageable operations ($/ha)			Farmer undertakes all operations ($/ha)		
		Interest Rate			Interest Rate			Interest Rate		
		3%	5%	7%	3%	5%	7%	3%	5%	7%
Forestry Emphasis	25 Year Rotation	2,474.20	1,056.19	191.10	2,805.40	1,347.26	449.55	2,780.02	1,324.64	429.19
	30 Year Rotation	3,001.48	1,033.95	-22.57	3,335.96	1,326.28	236.12	3,310.58	1,303.66	215.76
Agricultural Emphasis	25 Year Rotation	2,206.01	944.08	174.87	2,456.22	1,163.27	369.11	2,433.47	1,143.21	351.25
	30 Year Rotation	2,568.89	947.88	60.79	2,822.98	1,168.71	255.39	2,800.23	1,148.64	237.53

NOTES: Net present values are partly based on an 80% overhead on W.A.F.D.'s direct costs and the land value used by Treloar.

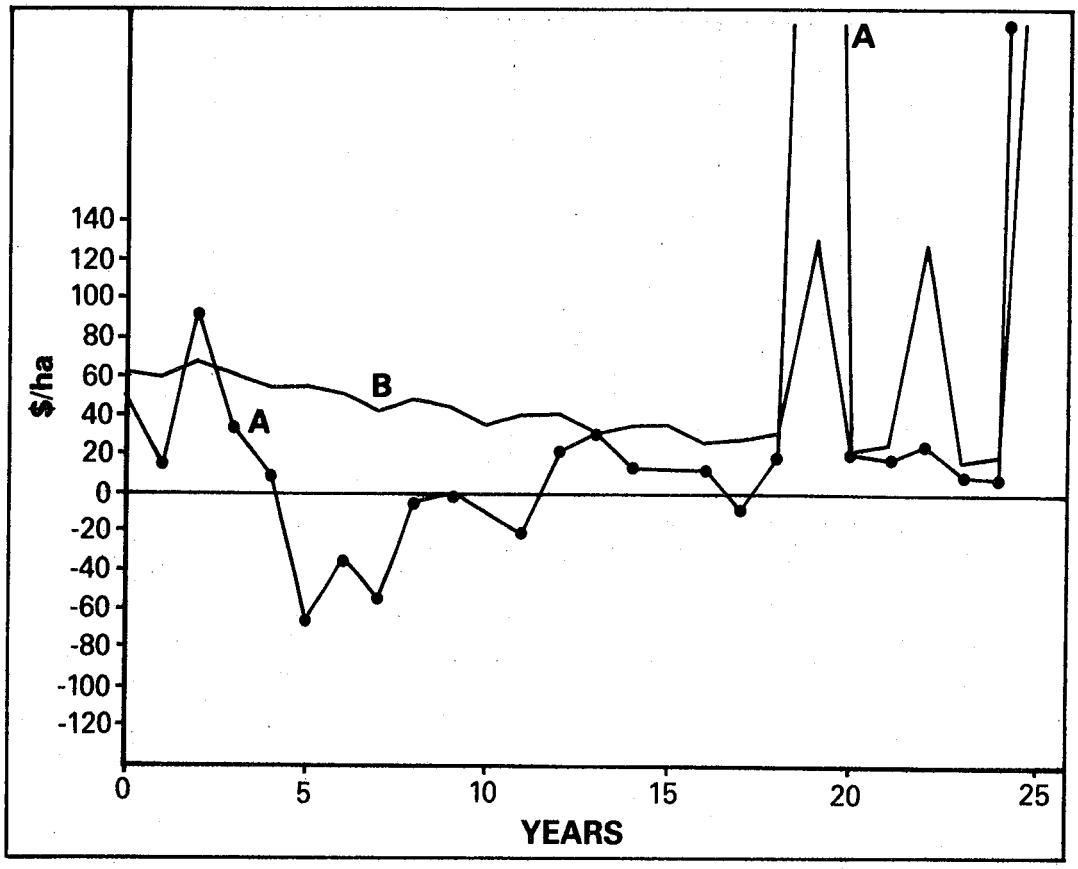

Figure 3: Annual net returns for agroforestry for two rates of tree planting - forestry emphasis (25 year rotation).

A - Total planting in one year

B - Conversion at 6% every 3 years

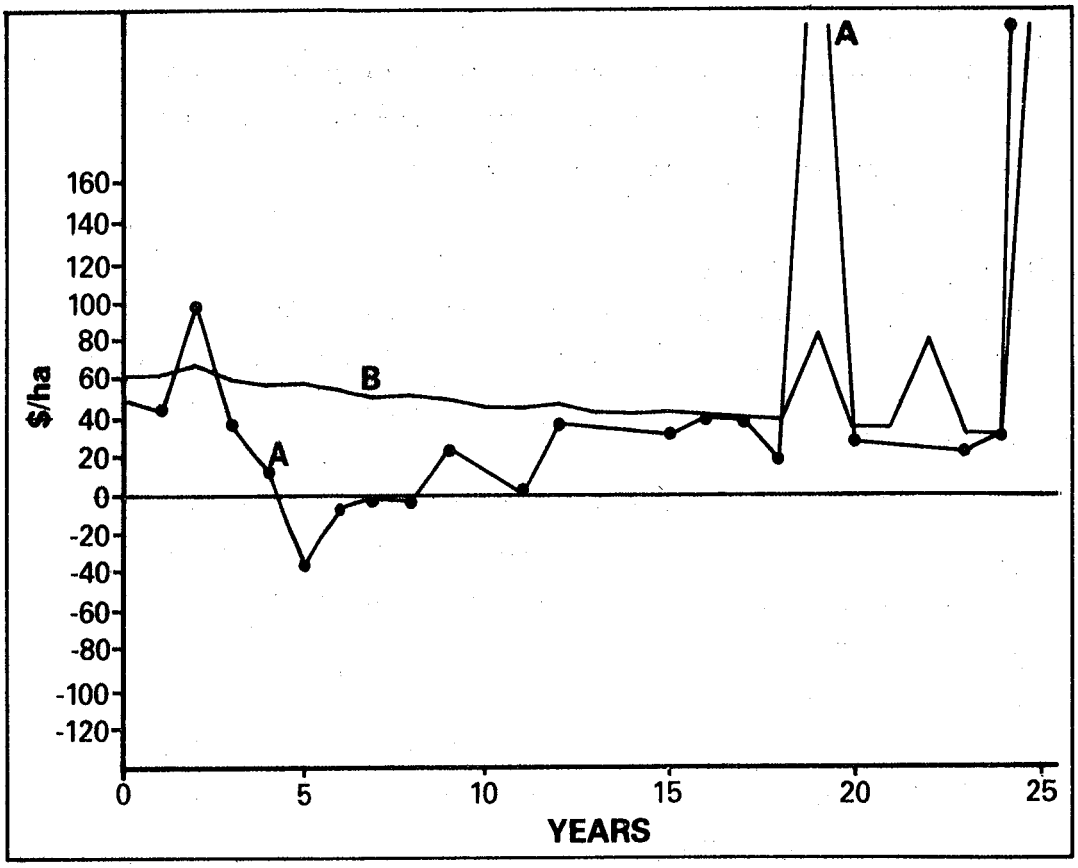

Figure 4: Annual net returns for agroforestry for two rates of tree planting - agricultural emphasis (25 year rotation)

A - Total planting in one year

B - Conversion at 6% every 3 years.

(b) Planting undertaken within one year results in negative net returns for up to 7 of the first 12 years and widely fluctuating annual net returns; and

(c) When planting occurs over a number of years, a positive net return is obtained each year and there is less variation in net returns from year to year.

(3) Labour Requirements

Figures 5 and 6 show the variation in whole farm labour requirements for different agroforestry emphases and different tree planting schedules. It can be seen that:

(a) Agricultural and forestry emphases show a similar pattern of variation in labour requirements, although variation is slightly less for the agricultural emphasis; and

(b) Variation in labour requirements is much less when planting is undertaken over a number of years, rather than all in the first year.

Table 4 indicates that average labour requirements are slightly higher for the agricultural emphasis than for the forestry emphasis, over nearly all planting rates and time spans. The exception is in the first rotation with an extended planting schedule.

Comparison of Agroforestry with Agriculture and Forestry

(1) Long Term Profitabilities

Net present values for agroforestry, forestry and agriculture are compared in Table 5 and Figure 7 for various discount rates. For discount rates between 3% and 7%, results show that:

(a) All agroforestry alternatives have substantially higher NPV's than agriculture; and

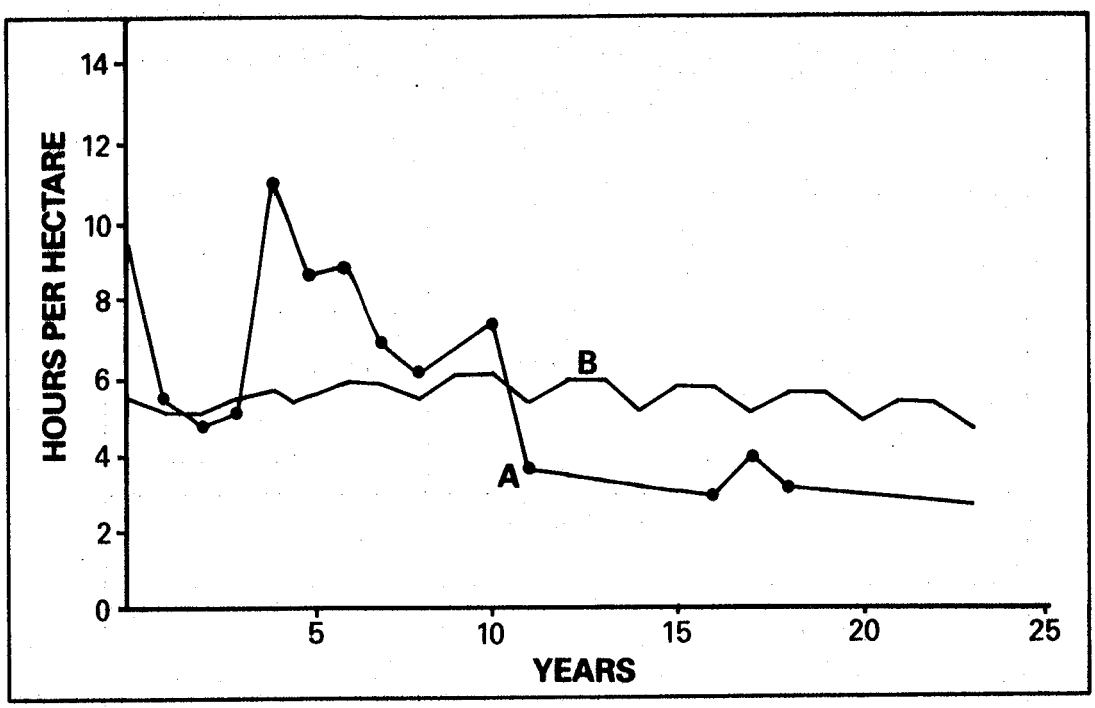

Figure 5: Labour requirements for agroforestry for two rates of tree planting - forestry emphasis (25 year rotation)

A - Total planting in one year

B - Conversion at 6% every 3 years.

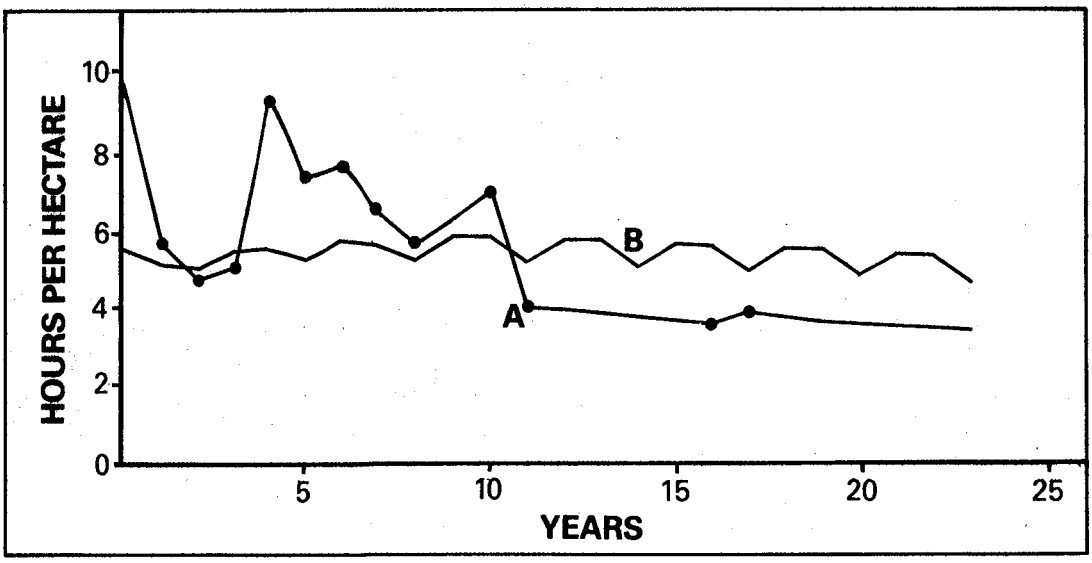

Figure 6: Labour requirements for agroforestry for two rates of tree planting - agricultural emphasis (25 year rotation)

A - Total planting in one year

B - Conversion at 6% every 3 years.

TABLE 4

AVERAGE LABOUR REQUIREMENTS FOR AGROFORESTRY, AGRICULTURE AND FORESTRY

	Total Planting in one year		Conversion at 6% every 3 years	
	One forest rotation 25 or 30 years (hrs/ha/yr)	Long Term (50 or 60 years) (hrs/ha/yr)	One Forest Rotation (hrs/ha/yr)	Long Term (hrs/ha/yr)
Agriculture	5.04	5.04	5.04	5.04
Forestry	4.19	4.19	5.07	4.04
Agroforestry (forestry emphasis)	5.09	5.09	5.45	5.18
Agroforestry (agricultural emphasis)	5.14	5.14	5.39	5.20

TABLE 5

NET PRESENT VALUES PER HECTARE FOR FORESTRY AND AGRICULTURE

Discount Rate (%)	Forestry		Agriculture	
	Optimistic* ($/ha)	Pessimistic** ($/ha)	Optimistic+ ($/ha)	Pessimistic++ ($/ha)
3	3,400	2,450	516	255
5	1,640	505	102	-104
7	552	-530	-158	-326

Source: Treloar (1984)

* Private Entrepreneur
** Donnybrook 80% Overheads + Pessimistic Outcome

\+ Budget 6A
++ Budget 6C

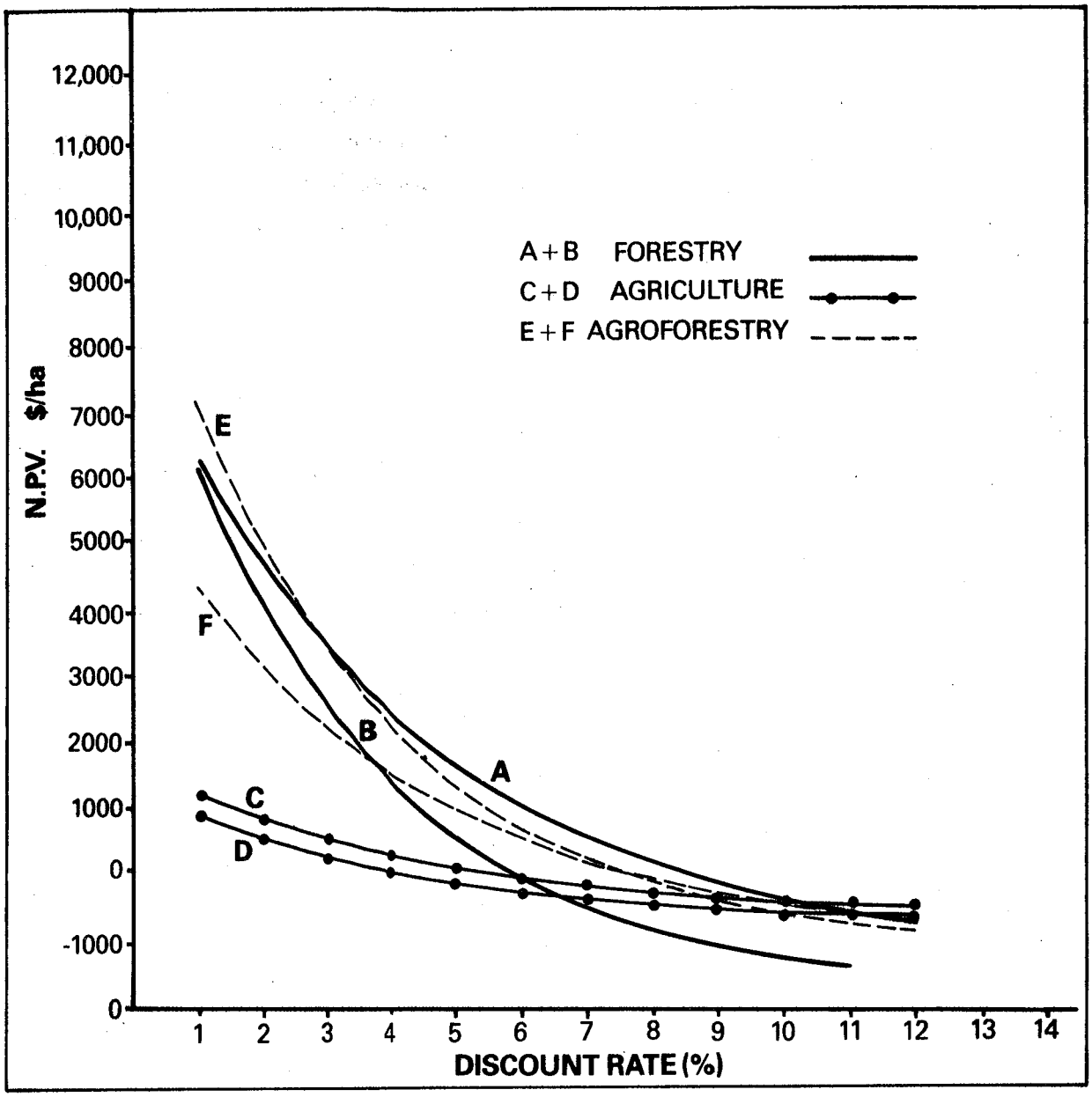

Figure 7: Range of net present values calculated for forestry, agriculture, agroforestry.

(b) Over most of the range of discount rates the NPV of agroforestry falls between Treloar's optimistic and pessimistic forestry scenarios.

The finding that NPV's for agroforestry are similar to those for forestry, rather than between those for agriculture and forestry, results from the complementarity of the agroforestry system. This complementarity is most clearly evident in the biological data. For example, it is possible to achieve 65% agricultural production in conjunction with 53% sawlog

production (agricultural emphasis), or 42% agricultural production in conjunction with 93% forestry production (forestry emphasis). (For further discussion of agroforestry complementarity see Anderson and Batini, 1983; Anderson, 1984; and Garland et al., 1984).

(2) Cash Flows

Figure 8 has been derived using data from Treloar's report and illustrates how annual net farm returns vary (for agriculture and forestry), and how this compares with agroforestry. Net returns from agroforestry vary less than forestry but more than agriculture. In reality, net returns to agriculture are not constant as depicted but change with seasonal and price variation.

Net returns are positive in all years for agroforestry under the extended planting schedule, but they are negative in some years if all planting is undertaken within a single year. Negative net returns occur in some years for forestry under both the extended and single year planting schedules. Net returns to agriculture are positive in all years.

(3) Labour Requirements

Figure 9 has been derived using data from Treloar's report and illustrates how whole farm labour requirements vary for agroforestry, forestry and agriculture.

Labour requirements for agroforestry fluctuate less than those for forestry but more than those for agriculture. In practice, seasonal variation will mean some year to year variation in agricultural labour requirements rather than the constant requirement depicted.

Overall, labour requirements are greatest for agroforestry, followed by agriculture and forestry.

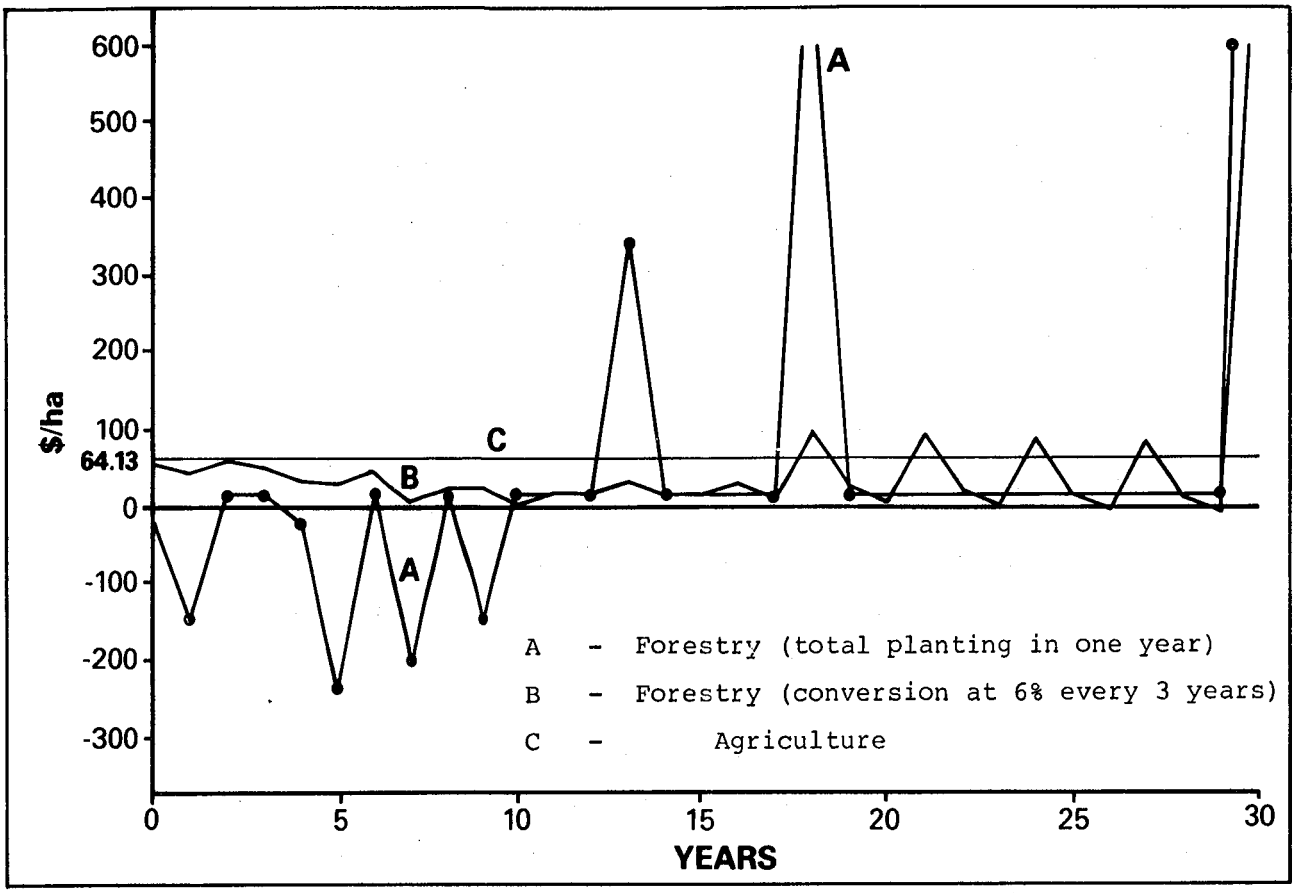

Figure 8: Annual net returns for forestry for two rates of tree planting and for agriculture.

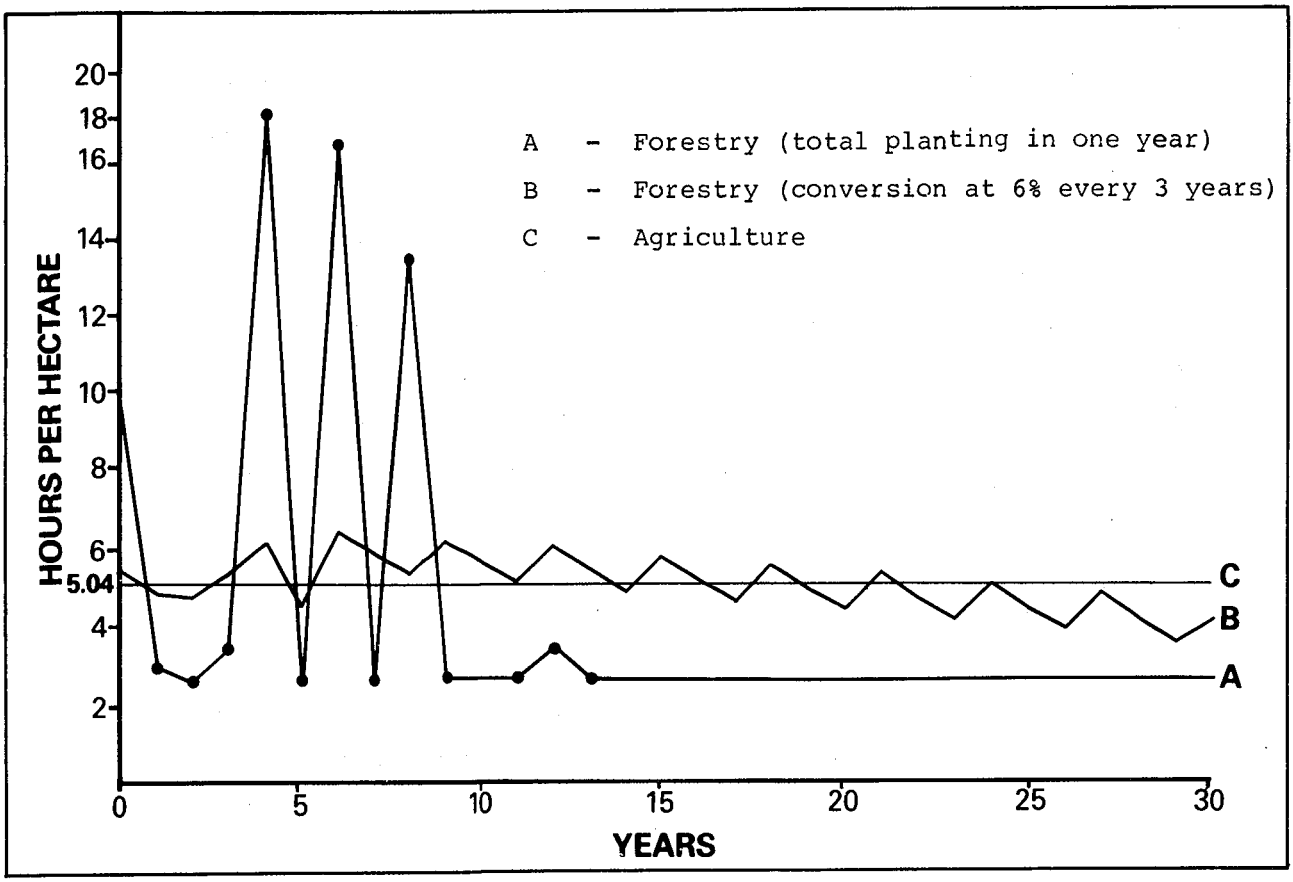

Figure 9: Labour requirements for forestry at two rates of tree planting and for agriculture.

DISCUSSION

Our discussion is largely based on the foregoing results without any reference to possible Government incentives. A number of considerations not accounted for in the analysis are included.

Agroforestry Versus Agriculture

(1) Financial Returns

Results indicate that in the long term agroforestry is more profitable than agriculture, suggesting that there is a substantial financial incentive for Manjimup farmers to convert grazing enterprises to agroforestry.

The financial incentive for agroforestry is particularly sensitive to future sawlog stumpages. Stumpages are expected to remain favourable to forest growers, particularly as State timber demands are increasing and a considerable area of pine planting is still required to attain the State's goal of timber net self sufficiency (WAFD 1982, 1984). A review of literature indicates that future stumpages in Australia and elsewhere are more likely to increase than decrease. (Forestry Commission of NSW, 1973; Wilson and Watt, 1976; Fairgrieve, 1979; and Haynes et al., 1980).

Moreover, stumpages for agroforestry logs could be higher than those for forestry (used in the analysis). Agroforestry logs are expected to be larger because of spacing and annual fertilization (Garland et al. 1984), and the timber industry prefers larger logs, partly for the efficiency of processing operations.

Against the long term profitability of agroforestry is its less favourable income distribution. Low or negative net returns prior to log sale could mean that agroforestry enterprises are not viable in the short term. The following strategies could help reduce the problem:

(a) Extended tree planting over many years rather than planting in a single year;

(b) Increasing the proportion of the farm to be used for pure agriculture relative to agroforestry;

(c) Adopting agroforestry with an agricultural rather than a forestry emphasis; and

(d) Manipulating the timing of silvicultural and agricultural operations. (Deviations from the prescribed timing of operations should not be great or the venture could fail).

The first three strategies (and perhaps the fourth) would slightly reduce the net present value (NPV) of agroforestry, so improvements in short term viability and less variation in net returns would have to be offset against long term profit. Irrespective of the extent of adoption of these measures, the NPV of agroforestry would still be above that for agriculture.

The relatively high financial returns for agroforestry are conditional upon a number of factors:

(a) Close adherance to the prescribed management programme;

(b) Proximity to log markets;

(c) Sufficient scale of operation to make all forest and agricultural practices economic;

(d) Sufficient scale of operation to make subsequent logging and delivery of logs to markets economic (the WAFD can advise farmers on minimum areas of pine required to ensure economic sales); and

(e) Soil type and rainfall requirements as specified in the W.A. Forester's Manual (WAFD, 1980).

(2) Labour Requirements

The most profitable agroforestry option involves farmers undertaking the more manageable tasks themselves, resulting in slightly higher labour requirements than for agriculture. The ability of farmers to handle additional labour requirements is likely to vary. In many cases existing on-farm labour could cope with the slight addition in labour requirements. In some cases the opportunity for increased employment of on-farm labour may be attractive. In other cases, the limited supply may require that labour is hired or that the WAFD undertakes all tasks.

Year to year variation in labour requirements of agroforestry is likely to be unattractive to farmers, although it is not an insurmountable problem. In addition to hiring casual labour or opting for WAFD involvement, the strategies used to minimize year to year variation in net income will also minimize year to year variation in labour requirements.

(3) Farmer perceptions and preferences:

It is important to recognize that farmer preference for agriculture and an unfamiliarity with wood production may delay or prevent conversion to agroforestry, in spite of apparent profit incentives for change. It is also important to recognize farmer perceptions of risk. Conversion from agriculture to agroforestry may reduce risk through crop diversification, but it is likely that agroforestry would be regarded less favourably because of the long production period for forest products.

(4) Additional benefits:

Agroforestry trees provide shelter for livestock, reducing stock losses and improving their general condition. Pine needles are grazed by livestock but this has been accounted for in the financial analysis by assumptions made about animal stocking rates.

Agroforestry assists nutrient re-cycling and the conservation of nutrients. Animals expedite nutrient re-cycling by converting pine needles and pasture to manure and by trampling litter.

Leaching can be reduced by the trees' interception and uptake of water. Agroforestry also has the potential to reduce wind erosion, water erosion and salinization, although these are not major problems in the Manjimup region.

(Further discussion of these conservational and environmental benefits of agroforestry is provided by Glencross, 1978; and by McKinnell and Batini, 1978).

Agroforestry Versus Forestry

(1) Financial returns

The profitability of agroforestry is similar to that of forestry (it could be higher than forestry in the future if larger sawlogs attract higher stumpages) so it provides about the same financial incentive for land use change. Results, however, suggest a number of reasons farmers may find agroforestry more attractive than forestry. They include the reduced problem of low or negative net returns for agroforestry in the years prior to harvest, and the smaller fluctuations in annual net returns.

(2) Labour Requirements

Agroforestry labour requirements are considerably more than those for forestry and similar to those for agriculture, so they are more likely to be in accord with present on-farm labour supply. Moreover, forestry operations for agroforestry are of a smaller scale than pure forestry, so it is likely that more of the work could be handled by on-farm labour.

(3) Farmer Perceptions and Preferences

Farmers may prefer agroforestry to forestry because they are more familiar with agriculture and may perceive forestry as a riskier venture.

(4) Additional Benefits

The fire risk associated with agroforestry is much less than with plantation forestry. This results from the relatively wide tree spacing, high pruning, and the grazing of litter.

The Community Perspective

(1) Benefits

Findings that agroforestry is likely to be more profitable and will employ slightly more labour than agriculture suggest benefits which would spread beyond those farmers adopting agroforestry. The community as a whole would benefit from higher farmer incomes through the redistributional effect of taxation and the flow-on effect of farmers spending the additional income. Employment in the region would be stimulated directly through the increased labour demand, either on-farm or through WAFD employment.

It appears that agroforestry creates more indirect employment than agriculture because there is a higher estimated employment multiplier for forestry than agriculture (Appendix I).

Farm conversion to agroforestry would also contribute to the State's goal of net self sufficiency in timber (WAFD 1982, 1984). Sawlogs produced would help compensate for the progressive reduction in native hardwood cutting (WAFD 1982, 1984). Furthermore, with farm agroforestry there would be less short term demand on the State's scarce resources of public finance and productive land, effectively freeing public resources for other purposes.

The community as a whole may also benefit from agroforestry's favourable effect on the environment, particularly the enhancement of soil fertility and reduced erosion.

(2) Costs

The State could incur costs of agroforestry research, demonstration and extension.

Agroforestry on pastured land would be accompanied by some reduction in livestock production and changed farm landscape which some people may consider undesirable.

(Note: On the basis of expected economic returns, agroforestry is not seen as an activity that would substitute or reduce horticultural production.)

GOVERNMENT INVOLVEMENT

Government Programmes and Farmer Attitudes

Reasons farmers may be reluctant to convert from agriculture to agroforestry (in spite of the lower profitability of agriculture) include:

(1) Relatively low net incomes in the early years of agroforestry may cause a cash flow problem;

(2) Farmers may simply dislike the idea of growing pines and prefer to continue with agriculture;

(3) The time span considered by farmers may be shorter than a forestry production cycle. This is most likely to be the case with older farmers, who may have little interest in enterprises which will not yield major returns for 25 to 30 years;

(4) Farmers who are not well informed about forestry and lack experience in tree crop management are likely to have a preference for agriculture because it is better understood; and

(5) Farmers may perceive agroforestry as a riskier enterprise than agriculture. There is a long delay between taking up the enterprise and selling timber, and the market could change in that time. There is also an increased fire hazard.

If the Government decides that agroforestry in the Manjimup region is worthwhile it should consider ways of encouraging farmer adoption of agroforestry. Bearing in mind possible objections we suggest the following:

(1) The allocation of resources for the extension of information to farmers to facilitate informed decisions on the conversion to agroforestry;

(2) The provision of an advisory service to ensure that the best forestry practices are adopted when farmers convert to agroforestry; and

(3) The establishment of a financial scheme under which farmers receive payment for forest products before they are sold. This would alleviate initial cash flow problems, reduce the uncertainty associated with long term production, and remove obstacles for farmers with short term planning horizons.

Government/Farmer Co-operative Ventures

One financial scheme for encouraging farmer conversion to agroforestry could be a co-operative venture between Government and farmers, similar to that proposed by Treloar (for forestry). In this venture the WAFD could represent Government interests. It is assumed that the Government would only be involved in the forestry part of the agroforestry operation. Although it is not appropriate for us to work out the final details, such a venture could involve annual payments from the Government to farmers, beginning when trees are planted and finishing when they are felled. The WAFD could be responsible for all direct forestry costs and, in return, would receive all income from sawlog sales.

While this type of scheme would remove the problems of cash flow, long term market risk and short term planning horizons, some farmers may wish to avoid such a high degree of Government involvement. Consequently, it is important that the promotion of agroforestry is not confined to Government/farmer ventures. Independent farmers and private companies should also be encouraged.

To ensure that any joint agroforestry venture meets the Government's economic objectives, the farmers would be required to plant sufficient trees to make forestry operations economic, and their farms would need to be within a specified distance of log markets and meet specified average annual rainfall and soil type criteria.

Payments could be constant (in real terms) or set to compensate for fluctuations in agricultural income over the period of the agroforestry venture. The level of annual payments could be

decided by negotiation between the Government and the farmer. (Operation of the suggested negotiation procedure is illustrated in Appendix II).

Marketing and Research

It was suggested earlier that the Government could have a role in extending agroforestry information to farmers. Specifically, it is suggested that the findings of this study, together with technical information from agroforestry trials and practical farmer experience with agroforestry elsewhere, be extended to farmers by means of publications, seminars and field days. Once farmers have been exposed to information on agroforestry, it is suggested that a survey of farmer attitudes be conducted and that reasons for any further farmer opposition to agroforestry be assessed. At that stage, Government could decide whether to establish an agroforestry advisory service for farmers and/or implement any incentive programmes.

In order to ensure that Government expenditure on agroforestry is cost effective, it would be worthwhile reviewing the experience of governments in comparable programmes elsewhere. There have been a number of public programmes aimed at encouraging management of private forests in the United States. Something may be learned from the successes and failures of these other projects (see, for example, Stoddard, 1961; Meunch, 1965). The decision on the level of Government expenditure for agroforestry should take into account results of the proposed farmer survey.

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Appendix I:

Sector employment multipliers

Sector		Western Australian Multipliers		South West Multipliers	
		Type 1	Type 2	Type 1	Type 2
Agriculture	Sheep	1.41	2.07	1.30[1]	1.83[1]
	Beef	1.19	1.52		
	Other	1.33	2.08		
Forestry and Logging		1.51	3.38	1.34	3.22

1 The average for all agricultural enterprises (Source : W.A. Department of Resources Development, 1980, 1982)

Appendix II:

Example of Negotiation of Annual Payments to a Farmer*

Suppose that a farmer, currently receiving an average net return of $64 per hectare per year from a beef enterprise, is considering entering into a co-operative venture with the WAFD. If the farmer were to receive an annual payment for the forestry component of the venture, what would be the minimum annual payment required? The return for the agricultural component of agroforestry with an agricultural emphasis was estimated to be $44/hectare, assuming a 5% real discount rate, so the minimum annual payment required to make agroforestry as profitable as agriculture is $20/ha/year. That is, an informed farmer in this case would accept nothing less than $20/ha/year for growing trees.

If the WAFD establishes, maintains, harvests and sells the timber, it is estimated that Forests Department's net income from agroforestry with an agricultural emphasis could be equivalent to an annual return of $70/ha (again assuming a 5% real discount rate). This would then be the maximum amount which the WAFD could pay the farmer without incurring a loss.

Thus, for this example, agreement between the WAFD and farmers would be reached somewhere in the range $20 to $70 per hectare per year.

The conditions of the scheme could be similar to those outlined by Treloar in his proposed financial scheme for farm forestry:

(1) That annual payments be indexed periodically to cover inflation;

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* This is an example only, and the discount rate and other parameters used are not necessarily those that would apply to any specific situation.

(2) That the WAFD control the silvicultural treatments and felling of trees. (The operations could be undertaken by the WAFD and/or farm labour paid by the WAFD);

(3) That the decision to insure trees rests with the WAFD. (The WAFD does not at present insure its forest stands, but applies intensive fire protection);

(4) That the agreement provides for renegotiation subject to initial agreement, or termination, in the event of destruction by fire;

(5) That the farmer be responsible for paying local government rates and other charges on the land; and

(6) That at the end of the first rotation, the WAFD be responsible for returning cleared land to the farmer in an acceptable state for farming. If restoration measures take time, the WAFD would have to make an annual payment equal to the net returns for agriculture. The agroforestry agreement could be renegotiated.