Evaluation of agroforestry options for three tree species

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Abstract

Information on tree growth rates, economic returns and the effects of trees on pasture for radiata pine, Australian blackwood and *Eucalyptus fastigata* were analysed to assess the economic returns of using these tree species within a hill country farming operation. Under the assumptions made, all three species options were more profitable in the long run than sheep and beef farming. Radiata pine produced the greatest return, large increases in log prices or yields of other tree species being required to give equal profit. The results of the analysis and market information emphasise the importance of good site selection and silviculture in the production of high quality timber. For some species these requirements may not fit on-farm production systems or be economically attractive.

Keywords: *Acacia melanoxylon*, agroforestry, *Eucalyptus fastigata*, hill country farming, *Pinus radiata*

Introduction

There is increasing interest from both farmers and planners in developing sustainable land use practices on farms. On many farms an increase in tree cover by the inclusion of indigenous or plantation forest, riparian tree planting or spaced plantings would help to achieve more sustainable land management (e.g., Hawley & Dymond 1986; Quinn *et al.* 1997; Maclaren 1996). Many factors are involved in farmer decisions on the use of trees, including the economics of any option in terms of long-term profitability and cash flow. The choice of tree species and planting regime are two factors which will influence economic performance. Previously, sufficient data for full economic analysis was available for only radiata pine (*Pinus radiata*). In this paper we report a preliminary economic analysis comparing radiata pine with two other tree species which may be suitable for timber production within farm systems.

Method

Scenarios

This study compared four land use alternatives for a typical North Island hill country farm, based largely on the MAF farm monitoring report Bay of Plenty farm (MAF 1996):

1. Sheep and cattle grazing as at present carrying 3060 stock units (su) on 275 ha.
2. Development over 20 years of 91 ha of the most erosion prone and lowest producing land (8 su/ha) into a radiata pine agroforestry system with grazing continuing on the better 184 ha (13 su/ha) of the property.
3. Similar to 2 but utilising *Eucalyptus fastigata* instead of radiata pine.
4. A smaller area (11 ha) along streams and in sheltered gullies, planted with Australian blackwood (*Acacia melanoxylon*).

The scenarios were compared for the following:

1. Costs, including displacement of livestock and labour requirements.
2. Returns.
3. For options 3 (*E. fastigata*) and 4 (blackwood), we calculated the percentage change in the log prices needed to equal the rate of return achieved with radiata pine.

For the options involving radiata pine and *E. fastigata*, a planting and felling programme was adopted which would lead to normality (constant area in trees) after 35 years. Rotation lengths of 27 years were used for both these species. A 35-year rotation was assumed for blackwood.

The species evaluated are all considered to be suitable trees for sawlog production. Radiata pine is the industry standard timber in New Zealand, *E. fastigata* is currently the preferred eucalypt species owing to availability of good logs and low internal checking on drying, and Australian blackwood is seen as a high value joinery grade timber.

Cost and yield assumptions

Table 1 shows the various cost and yield assumptions made for the three scenarios. Timber yields for radiata pine were derived from the Pumice Plateau growth model (Garcia 1990) within STANDPAK (Whiteside 1990). Yield figures for *E. fastigata* are estimated from a limited MARVL assessment of untended stands, mostly in the North Island and can be considered indicative only. The yields for blackwood were derived from the upper quartile of data from 23 stands throughout the Waikato–Bay of Plenty–Auckland–Northland regions assessed by MARVL (G. Steward, pers comm). All species were evaluated assuming the stand was thinned to 300 stems per ha (sph) at the completion of pruning to 6.5 m.

Table 1 Costs and returns for the three agroforestry scenarios.

	Radiata pine	*E. fastigata*	Blackwood
Cost of plant material ($/ha)	$330	$430	$450
Herbicide ($/ha)	$ 50	$ 97	$ 95
Fertiliser ($/ha)	nil	$ 50	$ 50
Labour (hours/ha)	56	56	115
Marketable log yield (m^3/ha)	688	595	219
Weighted average log price($/$m^3$)	79	65	221
Rotation length (years)	27	27	35
Stock units displaced at normality	619	619	75
Livestock gross margin ($/su)	30.4	30.4	30.4

Pasture yields were obtained from tree canopy–pasture yield models within the STANDPAK Model for radiata pine. We have assumed that pasture yields would be the same under *E. fastigata* as under radiata pine. For blackwood we predicted tree canopy based on tree growth rates and used the radiata pine canopy–pasture relationship to predict pasture yield. Recent field trial data (Thorrold *et al.* 1997) suggest that this relationship will somewhat under-predict pasture yield, so loss of available pasture owing to slash was ignored in compensation.

Silvicultural costs are well documented for pine but not for *E. fastigata* or blackwood, as most of the current planting and tending of these species is by farm foresters. Cost estimates for *E. fastigata* and blackwood are based on information available from a variety of sources (e.g., MOF 1995). As the values were extremely variable, upper values have been included in this analysis.

Timber values for radiata were taken from recent prices. Well documented market information on eucalypt and blackwood log sales is more difficult to obtain, because of the dominance of one-off spot sales. This situation is likely to persist for another 10–20 years before well-tended stands are offered for sale on a regular basis. Thus prices quoted for eucalypt and blackwood can provide only a guide for the situation today.

These options for the model farm were evaluated using the Agroforestry Estate Model (Knowles & Middlemiss 1997). This model is designed to evaluate the profitability and feasibility of a selected agroforestry project on a farm scale.

Results

Costs

Compared with radiata pine, the other species have much higher plant materials cost, and blackwood in particular is extremely labour intensive. Each hectare of radiata pine cost $1805 including plant materials, herbicide, full contract labour and supervision. When the work was completed by on-farm labour 56 hours were required per hectare. This compares with $2032/ha and 56 hours for *E. fastigata*, and $3537/ha and 115 hours for blackwood.

Returns

Loss in annual grazing income for radiata pine and *E. fastigata* was $18 000 (Table 2). The effect of blackwood on pasture yield is lower, and coupled with the smaller planted area gave only small losses in grazing income. Because of its site specific nature blackwood was planted only in riparian areas and sheltered gullies. In practice these areas may be excluded from grazing so the value for income loss in Table 2 may be an underestimate. No additional fencing costs for the blackwood plantings are included in this analysis. Internal rate of return (IRR) of each option is calculated to discount the value of future income relative to income received today.

Table 2 Returns and sensitivity analysis for the current land use and the three agroforestry scenarios.

	Sheep & beef	Radiata pine (91 ha)	*E. fastigata* (91 ha)	Blackwood (11 ha)
Project IRR (%)	3.55	7.44	6.41	5.49
Annual farm surplus at normality ($)	$57 740	$208 720	$157 460	$69 300
Gross margin to equal IRR for each tree species ($/su)		53	46	39
% increase in log values to equal radiata pine			43	100
Annual loss in grazing income at normality ($)	0	18 000	18 000	2200

This is particularly appropriate to tree growing exercises where income is received well into the future.

The results show that all three agroforestry options produce higher long-term returns than the current sheep and beef farm. Of the three, radiata pine produces the greatest return, *E. fastigata* giving higher returns than blackwood, on a whole-farm basis, although the per ha returns were similar (about $1100/ha/year). *E. fastigata* had a higher IRR than blackwood because of the shorter rotation length. *E. fastigata* prices, currently estimated to be 10% below radiata pine on a weighted average, would need to increase by 43% to give the same return(Table 2). In contrast, blackwood prices, assumed currently to be three times higher than radiata pine, would need to double again to be competitive. Livestock gross margins would need to increase substantially (30–80%) to give equivalent IRR results to the forestry scenarios.

Discussion

The results from this analysis confirm earlier work (e.g., Brann *et al.* 1996) showing the long-term financial gains possible through the use of plantation forestry on farms. The high yield, short rotation and good prices of radiata pine combine to make it the most profitable forestry option. With the price estimates used for *E. fastigata* and blackwood, these species are not as profitable as radiata pine.

Of more importance than the simple figures in this analysis is the implications of market intelligence that has been obtained in gathering the data to write this paper. The management needed to grow high value radiata pine trees on farmland is well understood. Variable lift pruning regimes aim to ensure maximum clearwood production in the pruned log of radiata pine. Recent evidence shows the need for final stocking rates around 250–400 sph (depending on site) to limit branch size in unpruned logs and harvesting on tree age not tree size to produce adequate wood density. These requirements reduce the economic return from planting radiata pine into farmland in the wide-spaced parkland (50–100 sph) that was once thought desirable from an agricultural viewpoint. The economic *returns* from radiata pine production on farm land are maximised when quality timber production is given top priority. The economic *feasibility* of any option depends on planting rates and financing arrangements that maintain adequate cash flow until tree harvest begins.

It is generally accepted that the main role for timber trees other than radiata pine revolves around the distinctive wood properties of these species. For example, *E. nitens* is grown for short-fibre-length pulp, *E. fastigata* for the strength and appearance of the timber and blackwood is seen as a high value joinery timber. There is some suggestion that the silviculture required to produce high value timbers, while physically possible, may not be economically attractive. The eucalypt log market currently prefers logs from stands of 50 years of age or older, and requires that saw logs have a minimum small end diameter of 40–45 cm. Thus the analysis presented (27-year rotation) is viable only if we assume that future market changes or technology developments will allow utilisation of younger logs. If stands have to be taken through to 50 years the discounted cash flows mean that any economically realistic discount rate will produce very poor economic returns. Similarly, it appears that the high value blackwood market is currently demanding logs of 80 years of age to ensure adequate wood stability for joinery purposes. Again, the analysis above assumes that 35-year-old logs will be marketable at high prices. Further research is needed to identify the influence of age on key wood properties.

The analysis above shows that all species considered can improve farm profitability and probably the sustainability of the farm system. Attention to the production of high quality timber and maintaining adequate cash flow are the keys to success. For *E. fastigata* and blackwood this finding relies either on logs of 30–35 years being saleable at good prices, or huge price increase to justify the longer rotation length. Planting trees on the basis of 50-year plus rotations may be a lifestyle choice rather than an economic investment, although some consider the world shortage of high quality plantation timbers will generate the price structure to improve the economic performance of high quality hardwoods. Land owners may well feel that other benefits of tree planting outweigh the economic analysis, but promoters of tree species and agroforestry need to be realistic in the analyses that they present.

This analysis has highlighted the data required for good economic analysis of agroforestry systems. This includes data on tree growth rates and timber quality, silvicultural costs, market prices for timber, tree canopy–pasture relationships and slash production and decay rates. We have been forced to make some assumptions in this analysis, and these areas of canopy size–light transmission, slash production and decay and wood quality are where future work will concentrate.

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