CONTRACT REVIEW

INTEGRATION OF TREES WITH LIVESTOCK IN AGROFORESTRY SYSTEMS

P.. J. HAINES

Dept of Food and Agriculture, Rutherglen Research Institute, Rutherglen, Vic. 3685.

Trees have long been a part of Australia's farmland, although rarely integrated into grazing and cropping systems. Apart from providing shade for livestock and occasionally as a source of feed during drought, they were viewed more as competitors for scarce soil water and nutrients, than as contributors to farm production. Recognition in the 1970s of a serious decline in the health and numbers of farm trees, and of their role in ameliorating land degradation problems, was the impetus for commencing widespread replanting and various government assistance and incentive schemes. Our view of the role of trees in sustaining agricultural production has changed considerably since that time.

The management of trees and agriculture together is called agroforestry. It has the potential to increase the sustainability and profitability of farming by: (i) protecting the land resource (control of erosion, salinity and waterlogging), (ii) increasing agricultural productivity (shade, shelter, fodder), (iii) producing timber resources (on-farm and off-farm use), (iv) conserving plant and animal diversity.

However, integrating trees with livestock enterprises is difficult. Complex interactions of environmental, technical, social and economic factors need to be considered. In addition, very few farmers have the experience and skills required for successful management of trees for timber products, although this is gradually changing.

This contract looks at 4 key stages in the development and implementation of agroforestry systems: the economics of agroforestry including the role of farmer incentive schemes, research to understand the relationships between trees, pasture and livestock production, extension of new ideas through on-farm demonstration sites that provide a focus for developing new management skills, and some of the many practical and perhaps philosophical considerations for the farmer.

"IF THERE'S A BUCK IN IT I WILL" — ECONOMIC INCENTIVES FOR AGROFORESTRY

ROSLYN T. PRINSLEY

Rural Industries Research and Development Corporation, NFF House, Brisbane Ave., Barton, A.C.T. 2600.

A survey of farmer organisations (Prinsley 1991*a*) has estimated that approximately 25% of farmers in Australia (although this varies widely between regions) establish or protect trees. They do so mainly for windbreaks (17%), shelter (14%) and shade (14%), however, there is often no single reason for practising agroforestry and many farmers establish trees for several reasons simultaneously. The main reasons the other 75% are not practising agroforestry are economic (60%), in particular the high costs of establishment and the lack of a perceived benefit. If there were economic incentives to offset the costs of establishment then more farmers would be likely to adopt agroforestry.

ECONOMIC BENEFITS OF AGROFORESTRY

Benefits can be divided into 3 categories: (1) environmental, e.g. soil conservation; (2) increased agricultural productivity, e.g. using windbreaks and shelterbelts; (3) increases and diversification of farm income, e.g. through sale of timber and other products and use of fodder shrubs.

These general categories of benefits, even when accompanied by detailed technical information concerning suitable species and appropriate layouts, establishment and management techniques, do not always convince farmers that it is worth their while to plant trees. However if it were possible to inform a farmer with some certainty of the relative profits of farming operations with and without trees then the farmer could make a more informed choice.

ECONOMIC MODELS

Financial returns from agroforestry can be calculated using computer models, such as FARMTREE (Loane 1991) and MULBUD (Etherington 1991). Although such models are very useful, being the best way we have of rapidly assessing the benefits of agroforestry for a specific site, lack of knowledge concerning the benefits of agroforestry (which are described in the next section) lessens the value of such models. Economic models use technical information which must fulfil the following criteria

(Stocking *et al.* 1990). It must: (1) be identified, quantified and valued; (2) be timely data, in the right form; (3) discriminate between relevant and irrelevant; (4) have the ability to handle the future.

Two practical problems arise in satisfying these criteria. First, there is a dearth of relevant information. The complicated nature of agroforestry systems and lack of research into these means that all inputs and outputs have been quantified only in a very few cases. Instead, estimates, often no better than guesses, are made using results from the literature in agriculture and forestry. Second, it is very difficult to predict and quantify the future technical costs and benefits of agroforestry.

QUANTIFYING ON-FARM BENEFITS

Agroforestry has 2 main types of benefit: on-farm and off-farm. Off-farm benefits can stimulate government to provide incentives for tree establishment for such community and national benefits as improved water quality, decreased soil salinity in a catchment, maintenance of biodiversity and a possible contribution to a reduction of the Greenhouse Effect. On-farm benefits provide a direct incentive for a farmer to establish trees because they lead to:

(i) *Production of tree products.* It is generally possible to estimate present and future values for direct benefits such as timber, fodder, honey and pasture production. However there is lack of knowledge in many cases concerning the increase in future harvestable yield from most species. There are difficulties in predicting future timber royalties, particularly in currently non-traditional markets such as young eucalypt sawlogs. Little is known about the value of most fodder species, while the value of other products such as oils and flowers varies from state to state.

(ii) *Benefits for agricultural productivity.* It is difficult to account for interactions between trees, pastures and livestock. This applies particularly to both positive and negative microclimate effects. Other factors are difficult to quantify, such as trees as habitat for pests and predators, and the environmental benefits of trees which influence agricultural productivity.

(iii) *Environmental benefits.* On-farm environmental benefits include: reduction in soil salinity, improvement in soil fertility, control of erosion, control of waterlogging and possible checking of acidification (Prinsley 1991 *b).* These benefits accrue through the maintenance of resource productivity, and need to be analysed in terms of how soil properties are affected by agroforestry, and how much this difference in the soil affects production and income over time. While salinity research for agroforestry is one of the more advanced areas of agroforestry research in Australia, in which the potential of tree planting as a salinity control measure has been demonstrated (Schofield 1991), there has been much less research on the effects of agroforestry on soil fertility. Very few benefits can be quantified in a way which would allow widespread valuation in a cost-benefit analysis. An additional concern will be how to predict the performance and economically analyse an agroforestry system over many years as some benefits only accrue in the long term. Technical models can be used to resolve some of these problems and are also very useful for identifying gaps in knowledge.

TECHNICAL MODELS

Although there are a few tree growth models available which can predict productivity over time (e.g. Cromer and Kirschbaum 1991), these are still in the early stages of development and much more research is required in this area. Useful models have been developed for agroforestry aimed at preventing erosion in a range of environments (e.g. Schofield 1991), predicting soil erosion by water, and the changes in soil productivity following erosion (Stocking *et al.* 1990). There are as yet no technical models of the effects of windbreaks and shelterbelts on livestock and pasture productivity although this is an area where some research has been carried out. A model has been developed by Scanlan (1992) which determines the relationship between pasture production and tree density. This model allows valuation of pasture and livestock production but does not include timber yields.

Nevertheless, we must not stop planting trees and wait until we have all of the information required to develop accurate models. While research on the missing information proceeds, it is necessary to rely on assumptions and 'educated guesses'. Trees which are planted based upon such hypotheses should be scientifically monitored so that theories can be substantiated, and our economic analysis, decision support systems and future experiments improved.

FINANCIAL INCENTIVES AND DISINCENTIVES FOR AGROFORESTRY

There are presently about 74 assistance schemes for agroforestry for commercial and conservation purposes in Australia (Boutland *et al.* 1991), as well as various tax incentives for tree establishment on farrns (Roberts 1989). Together, these have been successful in attracting thousands of farmers to practise agroforestry (Prinsley 1991*a* and 1992).

Nevertheless, there are insufficient resources in existing schemes to service all the farmers in

Australia. Furthermore, apart from the fact that the economic benefits are not currently often understood or quantifiable, there are also very significant financial and structural impediments to practising agroforestry, particularly for commercial timber production. These impediments include taxation provisions, land use interventions, log marketing practices, policies of state forest agencies and market imperfections (Bhati *et al.* 1991). The removal of these impediments to commercial agroforestry, in association with technical and financial assistance schemes would stimulate investment in agroforestry.

PRODUCING WOOL AND TIMBER IN AN AGROFORESTRY SYSTEM

P. R. BIRD[A], *J. D. KELLAS*[B], *K. N. CUMMING*[C] *and G. A. KEARNEY*[A]

[A]Dept of Food and Agriculture, Pastoral and Veterinary Institute, Private Bag 105, Hamilton, Vic. 3300.
[B]Dept of Conservation and Environment, V.S.F. and L.M. Creswick, Vic. 3363.
[C]P.O. Box 722, Hamilton, Vic. 3300.

Whilst there is competition between trees and pasture for light, water and nutrients (depending on tree species, spacing, age and pruning factors), there are compensating effects of nutrient cycling and shelter from wind and sun. Grazing animals may also derive a benefit from a reduced maintenance energy requirement and by fewer losses at lambing or from bad weather following shearing.

Agroforestry research, using wide-spaced *Pinus radiata* and sheep, has been in progress in New Zealand and Western Australia (Anderson 1989) for at least 15 years. The Australian work has been with annual pastures. The project reported in this paper was one of several established in Victoria from 1983-1985 (Kellas *et al.* 1989).

MATERIALS AND METHODS

Design

The 30 hectare project was established on a portion of a 2-year old *P. radiata* plantation on farmland at Camgham in Western Victoria. The annual rainfall is 650 mm, mostly falling between March and November. The soils are basaltic. The pastures are sown perennial ryegrass and subterranean clover, together with volunteer annual species. The site was thinned from 1650 trees/ha to the desired final densities in August 1983. The treatments were allocated in 3 randomised blocks of 5 treatments: (i) grazing control (no trees), (ii) 100 trees/ha (12 by 8 m), (iii) 277 trees/ha (9 by 4 m), (iv) 277 trees/ha (5 rows of trees, with a 36 m pasture gap), (v) 1650 trees/ha (3 m between rows, 2 m between trees within row). Each plot consists of a central fenced core 48 by 104 m (0.5 ha) and a peripheral buffer of 31.5 m of trees thinned and managed to the same degree as the internal core. Grazing measurements with sheep, and tree data, are obtained from the internal plots.

Site management

Windthrow of trees occurred on all of the open-spaced plots. The average tree spacing on these plots has therefore been somewhat reduced from initial expectations. Pruning has followed the variable-lift pruning approach used in New Zealand of removing all branches below the point where stem diameter equals 10 cm, whilst retaining at least 3 m of green crown.

The pastures were slashed in November 1983 and in spring 1984. When grazing commenced in December 1984, with a set stocking of 14 sheep/ha, the pasture had deteriorated as a result of no grazing since June 198 1. In 1989 the pastures were resown with Kangaroo Valley perennial ryegrass (5 kg/ha), Ellett perennial ryegrass (5 kg/ha) and Karridale, Trikkala and Larissa sub. clover (each 10 kg/ha) mixed with 200 kg/ha of lime-super. The total fertiliser applied since 1986 is 1100 kg of super-phosphate, 150 kg KCl and 15 g Mo per hectare.

Between early 1986 and 1989 3 periods of set grazing (10 sheep/ha) have occurred. However, grazing could not be maintained in the 1650 trees/ha treatment after August 1986, as tree development effectively excluded pasture growth. After pasture resowing in 1989, 2 further periods of set grazing occurred. Each year a new flock of shorn 2-year old merino wethers are assigned to the plots at random from stratified liveweight classes.

RESULTS

Pasture production

Mean pasture growth for spring 1990 in the 100 and 277 trees/ha wide-spaced plots was not affected by tree position; in the 277 trees/ha 5-row plots growth within the rows and 1.5 m from the edge was

71% of growth in open plots but beyond 1.5 m was a little greater than in open plots, perhaps due to shelter. The poor response within the 5 rows of trees was partly due to pruning debris and not re-sowing those areas. In 1991 the situation was similar.

Tree performance

The effect of tree spacing on height and diameter growth is shown in Table 1.

Table 1. Growth of *Pinus radiata* at various spacings established in 1983 at Carngham

By 1989 the initial tree stocking of 100, 277, 277 and 1650 trees/ha was reduced to 60, 200, 200 and 1350 trees/ha, respectively, from windthrow and thinning

Treatment (trees/ha)	Top height (m) 1986	1987	1988	1989	1990	1991	Diameter (cm) 1986	1987	1988	1989	1990	1991
100 (open)	3.0	3.6	4.8	6.1	7.1	7.7	6.1	9.2	13.1	17.2	19.3	20.8
277 (open)	3.4	4.2	5.7	7.3	8.6	9.5	6.7	10.2	14.2	18.0	19.8	21.3
277 (5-rows)	3.3	4.3	5.8	7.7	8.8	9.9	6.4	9.8	13.5	16.7	18.4	19.7
1650 unpruned	3.6	5.2	6.8	8.6	10.8	11.3	6.6	10.7	13.1	15.2	16.6	17.6
1650 pruned[A]	—	—	6.9	8.8	10.7	11.4	—	—	13.0	15.4	16.8	17.8
l.s.d. ($P = 0.05$)	0.5	0.7	0.8	0.8	0.6	0.7	1.7	2.3	1.8	1.4	1.1	1.0

[A]In 1988 an additional 'treatment' was included: 7 contiguous rows were pruned in each plot of the original 15 rows of the 1650 trees/ha plots.

Tree diameters were similar in the 4 treatments until 1990, when the plantation trees were slimmer than the other trees. The 277 trees/ha 5-row trees are now also slimmer than the 277 trees/ha wide-spaced trees. After 1987 the differences in height were more pronounced, with the forest trees taller than all others and the 277/ha trees taller than trees at 100/ha. It is probable that greater exposure to wind reduces height growth, while differences in diameter growth reflect inter-tree competition.

Sheep performance

Liveweight gain and wool growth data for the various treatments are shown in Table 2.

Table 2. Sheep production in relation to tree density, Camgham 1986–91

Treatment (trees/ha)	Liveweight gain (kg/sheep) 1986	1987	1988	1990	1991[B]	Wool production (kg/sheep) 1986	1987	1988	1990	1991[B]
0 (pasture)	8.5	11.7	15.2	9.9	18.3	3.25	4.12	4.52	5.76	4.13
100 (open)	10.6	8.7	16.1	10.2	16.2	3.62	4.14	4.55	5.74	3.95
277 (open)	9.0	3.5	8.4	5.5	18.3	3.36	3.64	3.58	5.43	4.14
277 (5-rows)	9.3	7.7	12.3	7.1	20.0	3.68	4.17	3.79	5.78	4.23
1650 (woodlot)[A]	6.4	—	—	—	—	2.78	—	—	—	—
l.s.d. 5% level	2.1	3.5	2.9	4.2	5.6	0.23	0.52	0.16	0.44	0.50

*Sheep could not be sustained on these plots after August 1986.

[B]In 1991 the plots were stocked with 12 to 16 sheep/ha and the liveweight gains/ha were 293, 259, 220 and 280 kg (l.s.d. ($P = 0.05$)=74 kg) and wool produced/ha was 66, 63, 50 and 59 kg (l.s.d. ($P = 0.05$)=6.3 kg), for the respective treatments.

In 1986 there were no differences among treatments, but in 1987 liveweight gain was influenced by tree density and layout. Smaller gains were observed in the 277 trees/ha wide-spaced treatment than in the other treatments. In 1987 less wool was produced in the 277 tree/ha wide-spaced treatment than in the 277 trees/ha 5-row treatment and less than all treatments in 1988. In 1990 there were no differences in wool production among treatments, probably because the plots were all understocked. In 1991 less wool was produced on the 277 trees/ha wide-spaced plots than on any other plots.

DISCUSSION

The data indicate that, at year 10, there is some adverse impact of pines on animal production at tree spacing of 100/ha and a larger effect at higher tree density. This results from a decreased pasture production; the effect is more obvious when account is also taken of land occupied by trees and producing little pasture. However, despite apparently producing less pasture than other treed plots, animal production on the 277 trees/ha 5-row plots was greater in 1991. This may reflect a shelter advantage to sheep on those plots and/or a greater contribution than expected of pasture within the trees.

The timberbelt arrangement of trees appears to give better tree and animal production from the system. This approach allows the use of temporary electric fencing in the first 2–4 years to protect the trees from stock. It is too costly to protect individual trees, yet unless grazing is instituted as soon as possible (preferably within a year) the sown perennial pasture will rapidly degenerate and stock carrying capacity will decline.

Periodic heavy grazing is a better choice for an agroforest than the set-stocking regime that, for experimental reasons, was implemented here and which resulted in excessive tree damage. Boredom seems to account for much of the bark-stripping that occurs in mid-spring, but no bark damage was observed on unprotected trees from 1988-90, perhaps because as the trees age the bark hardens and is less susceptible to damage.

The use of timberbelts consisting of *P. radiata* alone or with native species that would provide shelter below the pruned height of the pine, or species such as macrocarpa cypress, *Acacia, Eucalyptus* and *Casuarina,* will be the preferred agroforestry choice of the future. This system will provide shelter and favourable conditions for tree growth and management. There are several examples of such belts in Victoria (Kellas *et al.* 1989).

AN APPROACH TO DEVELOPING AND DEMONSTRATING AGROFORESTRY SYSTEMS ON FARMS

N. D. O'BRIEN[A] and J. G. LAWRENCE[B]

[A]Dept of Food and Agriculture, Wodonga District Centre, P.O. Box 551, Wodonga, Vic. 3690.
[B]Dept of Food and Agriculture, Benalla District Centre, Bridge St., Benalla West, Vic. 3672.

While a recent survey indicates that an increasing number of farmers are establishing or protecting trees (Prinsley 1991*a*), the high costs of establishment and perceived lack of benefits are barriers to more widespread adoption. This is partly due to the inherent long term nature of agroforestry, especially the production of high value timber products. There may also be a reluctance amongst some farmers to harvest trees; they are still not widely viewed as a renewable crop in the same way that a crop of wheat is. Even though many benefits are claimed for integrating trees into farming systems, these benefits need to be better understood, described and demonstrated to farmers.

With more adequate technical information, less costly tree establishment methods and the development of sizeable agroforestry demonstrations where tree management skills can be taught, the adoption of agroforestry may be expected to increase.

AGROFORESTRY IN NORTH EAST VICTORIA

A major revegetation project on farms in N.E. Victoria, focussing mainly on developing agroforestry systems, commenced in 1990 with funding from the Murray Darling Basin Commission (Natural Resources Management Strategy). From the beginning, the project has sought to increase tree growing on farmland by integrating trees with agriculture, rather than seeing trees as merely an 'add-on', only for the unproductive areas of the farm. A program of research and demonstration was implemented, in order to gain a greater understanding of the interactions between trees, and agricultural crops, pastures and livestock, and to communicate this information to the farming community.

RESEARCH, VALIDATION AND EXTENSION

Traditionally, many research projects have been carried out on government research institutes where treatments are compared under tightly controlled conditions, with as few variables as possible. Results are then extended by trained personnel to the farming community, usually after a period of limited on-farm validation. Adoption of key findings may take up to 10 years or more. Under this system many farmers feel isolated from the research due to soil and climate variations (Stevenson 1990). Projects that involve all relevant groups (farmer groups and individuals, research and extension staff, planners and decision-makers) from the beginning are likely to meet with greater success since there is joint 'ownership' of the work.

An integrated approach involving research, demonstration/validation and extension programs has been adopted by the project team. Such an approach has been used successfully for farming systems research and development elsewhere in Australia. One of the likely strengths of the project is its combination of institutionalised research at Rutherglen Research Institute (RRI), with on-farm research and demonstrations across the region. Research at RRI is necessary to answer some of the more complex and perhaps fundamental questions, so sites are highly specialised, carefully managed and may require high labour inputs. Understanding the effects of shelterbelts on pasture growth, water usage, wind speed and livestock productivity is an example of such research. In addition to this are a large number of on-farm sites established by extension staff covering a variety of soil types and climates. Information on these sites is seen as been more relevant to local farmers since it is carried out in familiar conditions.

Direct seeding research sites have been established on 6 farms and are complemented by over 40 farm-scale sowings which can also be used as demonstrations of ideas tested in replicated experiments. Information and knowledge developed from direct seeding programs in other parts of S.E. Australia has been used in determining appropriate treatments. The aim is to develop low-cost establishment techniques that are reliable and practical, and suitable for N.E. Victorian conditions. Site selection and establishment of the research sites has been done in conjunction with local LandCare and Farm Tree Groups in order to maximise farmer involvement in the work.

The need for on-farm sites is also reinforced by the long time scale of agroforestry. Such sites can combine the need to develop farm systems for today's farmers with the requirements to obtain longer term research results. These on-farm sites provide an opportunity for practitioners to learn skills such as pruning both from department staff and from co-operating farmers.

Good examples of this process are 2 agroforestry demonstration sites that were established to compare single and double-row timberbelts at 2 different spacings for livestock grazing between the trees. There is a 3-way partnership between the landholder, Department of Food and Agriculture (DFA) and Department of Conservation and Environment (DCE) in the design and resourcing of these sites. Over time they will become extension sites for demonstration of agroforestry management techniques, will provide a return for the farmers involved, and can be used to gather information on the interaction of agriculture and forestry. Site selection was based not only on land characteristics, but also on the ability of the farmer to act in an extension role. Design of each site was a result of consultation between the landholder, departmental staff and agroforestry researchers. Establishment and management is the responsibility of the landholders, with technical guidance from department staff. Results from these agroforests are not yet apparent, although local landcare groups have shown keen interest in them.

A STATEWIDE APPROACH

This paper has focussed on one agroforestry program in N.E. Victoria. Other agroforestry programs are being successfully implemented elsewhere in the state. To ensure the best results from these programs, a joint management committee comprising representatives from DFA, DCE, industry and special interest groups oversees the work to ensure maximum cooperation and minimal duplication. The management committee recently published its 5-year plan for agroforestry in Victoria. Agroforestry is promoted through the production of pamphlets, videos, information sheets, and specialised field days and conferences. Networks of people, particularly farmer practitioners, are being established in different regions as a way of sharing information and experiences in this relatively new field.

AGROFORESTRY — A PRODUCER AND CONSERVATIONIST'S VIEWPOINT

J. FENTON

'Lanark', Branxholme, Vic. 3302.

Agroforestry is an 'in word', but what we are really talking about is a conscious effort to grow trees on the farm for extractive timber utilisation. This timber will not only give an alternative income to the farmer but will assist with amelioration of general agricultural degradation. The timber produced will initially augment, and may eventually take over from, old age natural forests as the main Australian timber supply. In addition, the incorporation of sound conservation principles involving trees is a crucial component of successful farming.

THE FARM OPERATION

The family operates a grazing property of 760 ha at Branxholme in south-west Victoria. Livestock enterprises include 7500 wool-producing sheep, beef cattle, a large Shetland pony stud and a Border Leicester stud.

On assuming management of the home property, it was bare and comparatively waterless. In 1957, a decision was made to partially recreate the timber and water on the farm. Over the years, 67 hectares of wetland environment have been recreated and more than 45,000 native trees have been planted. Some of these plantings, as well as a softwood component, have been in agroforestry arrangements or as woodlots. In all, around 5% of the farm is under agroforestry or in plantations, although the economic optimum for this farm is around 15%. However, the challenge of revegetation, which in the end will rest largely with farmers since they have the equipment and machinery to tackle large areas, is still far from complete. After 35 years, only 50% of the property has been attended to.

LAND USE MANAGEMENT

The agricultural systems that have been practised over the past 40 or more years have generally not worked. Farmers and agricultural scientists have been geared almost entirely towards production with little regard to planning and land management. The result of not matching land use to land capability has been a large increase in the extent and severity of degradation. It is estimated that just under one-half of the area affected by land degradation problems can be treated purely by adopting better management practices.

The improved land use management practices I refer to could start by regarding the farm as part of a whole ecological and catchment system which needs to be maintained and enhanced. We need to categorise the soils and water bodies on a given piece of land so that (i) some areas can be permanently retired from grazing — wildlife corridors, wetlands, native remnant grasslands and major habitat blocks, (ii) other sections can be partially grazed or cropped in combination with wetlands and trees (e.g agroforestry and/or 'water meadows'); (iii) for environmentally safe areas, agricultural production can be maximised if need be.

In order to win the battle of 'greening' Australia, we must at the same time as planting woodlots, retain our remnant native vegetation. One of the side benefits from the retention of remnants is that not only is biological and botanical diversity retained, but the perceived landscape integrity of the farm, region, and indeed the nation will be preserved.

OUR TREE PLANTING PROGRAM

The main benefits to come from our tree planting (and protecting key water bodies) are:

(i) habitat for birds and animals — the numbers of bird species has increased from 45 to 145 since 1950. Many of these are predatory and insectivorous.

(ii) amenity plantings — better home and working environment, and appearance.

(iii) microclimate — reduced windspeed, evaporation and exposure;
shade and protection from winter and summer extremes

(iv) pasture and livestock productivity — shelter reduces lamb mortality, and increases growth and productivity of pasture and livestock.

(v) capital value — saleability of well treed farms is generally better; the value of the property is greater.

(vi) timber products — a range of native hardwood species (e.g. *Casuarina, Eucalyptus, Acacia* spp.), radiata pine and macrocarpa cypress – provenances are grown for high value timber.

While many of the questions for successful farm forestry have been answered, information is still required in a number of areas, including hardwood provenance selection and their nutrient requirements. So how do some of the only 120,000 remaining farmers on broadacre commercial farms put this information into practice?

The farmers have the skills and the machinery but I think the money and the moral encouragement must come from outside. We don't have to re-invent the wheel for the solution - time and money is too short. For example, the New Zealand Government passed their Forestry Rights Legislation in 1983 and that document has far reaching benefits for the positive planting of farm woodlots. We should look more at sustainable environmental/farming systems and less at discounted timber values, computer models etc. and get on with the job of planting. If we keep a firm perspective on time and the fragility of the land we may yet retain that 'sense of place' that is Australia.

CONCLUSIONS

P. J. HAINES

Dept of Food and Agriculture, Rutherglen Research Institute, Vic. 3685.

Agroforestry provides many recognised environmental and economic benefits. However, because many benefits and costs are inadequately quantified, it may be difficult for a farner to determine whether the benefits outweigh the costs (Prinsley 1991b). Unlike established livestock enterprises where it is possible to estimate with some accuracy the likely economic returns over the short-term, the long-term nature of growing trees for timber, together with the difficulty of estimating 'environmental' benefits, make such an assessment difficult. A change in attitude towards viewing trees as a renewable resource that can be cropped like wheat (albeit on a very different time scale) is required for agroforestry to succeed. This necessitates careful planning, sound management and good technical skills. Areas of research requiring immediate or continued attention include:

* Relationships between pasture, livestock and tree productivity for a range of layouts and climates
* Improved planting material for agroforests to optimise growth rates and timber quality
* Less costly establishment techniques
* Better livestock management regimes to reduce the need for expensive tree protection
* On-farm processing and marketing
* Economics of various agroforestry designs

With continued development of improved systems, removal of various impediments to commercial agroforestry, technical support, continued enthusiasm and a degree of faith by the farmer, particularly in assessing economic returns for timber products in 30 or 40 years time, agroforestry will become more widespread and profitable. Such a development will benefit both the farmer and the wider community.

REFERENCES

ANDERSON, G. W. (1989). Proc. Third Agrofor. Conf., Morwell, Victoria, pp. 4-17.

BHATI, U. N., KLIGN, N., CURTOTTI, R., DEAN, M., and STEPHENS, M. (1991). ABARE Conference Paper 91.43.

BOUTLAND, A., BYRON, N., and PRINSLEY, R., (1991). 'Directory of Assistance Schemes for Trees on Farms and Rural Revegetation'. (Australian Globe Press: Melbourne.)

CROMER, R. N. and KIRSCHBAUM, M. (1991). 'Intensive Forestry: the Role of Eucalypts'. Proc. IUFRO Symposium, Durban, South Africa, Sept 1991.2: 622-34.

ETHERINGTON, D. (1991). Proc. 'The Role of Trees in Sustainable Agriculture', Workshop Paper, Albury, 1991. (Bureau of Rural Resources).

KELLAS, J. D., BIRD, P. R., BIENVENU, F., CUMMING, K. N., HALL, R., LYONS, A. and MORGAN, M. (1989). Agroforestry in Victoria – progress in research and extension. Technical Report of Dept. of Agriculture and Rural Affairs and the Dept. of Conservation, Forests and Lands, pp. 35.

LOANE, W. (1991). 'Agricultural Systems and Information Technology'. Vol. 3, No. 3, Dec. 1991.

PRINSLEY, R. T. (1991*a*). 'Australian Agroforestry'. (Rural Industries Research and Development Corporation: Canberra)

PRINSLEY, R. T. (1991*b*). Proc. 'The Role of Trees in Sustainable Agriculture', Overview Paper, Albury, 199 1. (Bureau of Rural Resources)

PRINSLEY, R. T. (1992). 'National Plantations Advisory Committee'. (in press)

ROBERTS, D. (1989). *Aust. J. Soil Water Cons. 2:* 11-3.

SCANLAN, J. C. (1992). *J. Range Man. 45* (in press)

SCHOFIELD, N. J. (1991) Proc. 'The Role of Trees in Sustainable Agriculture', Review Paper, Albury, 1991. (Bureau of Rural Resources)

STEVENSON, *G.* (1990). *Proc. Aust. Soc. Anim. Prod.* **18: 372-5.**

STOCKING, M., BOJO, J., ABEL, N. (1991). *In* 'Agroforestry for Sustainable Production'. p.13. (Commonwealth Secretariat Publications).