An Australian Government Initiative



Agroforestry and Farm Forestry

Support systems to assess the viability of whole-farm and regional agroforestry enterprises

RIRDC/L&WA/FWPRDC Joint Venture Agroforestry Program

edited by Steve Harrison and John Herbohn

This report discusses research conducted in the eastern Darling Downs of southern Queensland and the northern tablelands of New South Wales covering:

- landholder attitudes to farm forestry
- the development of a whole-farm financial model – the Australian Farm Forestry Financial Model – that evaluates the financial returns and feasibility of forestry within the farm business
- the construction and evaluation of regional farm forestry case studies
- the development of a multi-objective decision-support system (MODSS) for evaluation of forestry options from a regional and farm perspective.

The project addresses an identified need for additional financial information and decision-support systems for farm forestry at the individual property as well as catchment and regional level. The research provides farmers and policy makers with a multipurpose decision support system (DSS) that will allow comprehensive assessment of the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprise in a variety of farm systems.

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Foreword

This research set out to address the information needs of private landholders seeking to adopt forestry on their land, and governments and regional communities seeking a coordinated and better-informed approach to regional forest industry development. The work develops a whole-farm financial model – the Australian Farm Forestry Financial Model (AFFFM) – for evaluating the financial returns and feasibility of forestry within a farm business, and a multi-objective decision-support system (MODSS) for evaluation of forestry options from a regional and farm perspective. These models are informed by an exploration of landholder attitudes to farm forestry, and two case study areas, the Eastern Darling Downs of Southern Queensland and the Northern Tablelands of New South Wales, are examined in detail.

The AFFFM has been developed and tested through the conduct of this research to include biological growth and performance characteristics. It now provides a tool for evaluating forestry investment within the context of the overall farm business, including cropping and livestock enterprises. An economic analysis conducted for the Hodgson Creek catchment in the Eastern Darling Downs indicates that extensive farm forestry is not viable as an alternative to existing cropping and grazing enterprises on a financial basis alone. A review of a range of whole-farm scenarios using the AFFFM suggests that farm forestry based on existing native forests is the only seriously financially viable alternative to existing agricultural pursuits within the areas studied. Through this research, the MODSS methodology now effectively considers community criteria and integrates expert opinion.

This project was funded by the Joint Venture Agroforestry Program (JVAP), which is supported by three R&D Corporations - Rural Industries Research and Development Corporation (RIRDC), Land & Water Australia (L&WA), and Forest and Wood Products Research and Development Corporation (FWPRDC). The Murray-Darling Basin Commission (MDBC) also contributed to this project. The R&D Corporations are funded principally by the Australian Government. State and Australian Governments contribute funds to the MDBC.

This report is an addition to RIRDC's diverse range of over 1800 research publications. It forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems. The JVAP, under this program, is managed by RIRDC.

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Peter O'Brien
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A particular thanks is due to Kristen Williams for her sterling effort in coordinating the research proposal and integrating material provided from the four individual research groups that came together in this project. The project team would also like to thank Sandie Mertens, Lorraine Smith and Sam Farina for administrative assistance to the project. The efforts of Robert Harrison and Jungho Suh in checking and formatting the report are gratefully acknowledged.

Abbreviations

ACRES	Australian Centre for Remote Sensing
ACTFM	Australian Cabinet Timbers Financial Model
AEAM	Adaptive Environmental Assessment and Management
AEM	Agroforestry Estate Model
AFFA	Agriculture, Fisheries, Forestry Australia
AFFFM	Australian Farm Forestry Financial Model
AGLR	annual greatest limitation range
AHP	analytic hierarchy process
AKIS	agricultural knowledge and information system
AMU	agricultural management unit
ANOVA	analysis of variance
ANU	Australian National University
ANZSIC	Australian and New Zealand Standard Industrial Classification
BCP	business cash position
BOD	biological oxygen demand
BRS	Bureau of Rural Sciences
CARE	Centre for Agricultural and Regional Economics
CBA	cost-benefit analysis
CGE	closed general equilibrium
CMSS	Catchment Management Support System
CRC	Cooperative Research Centre
CRRP	Community Rainforest Reforestation Program
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEM	digital elevation model
DIY	do-it-yourself
DNR	(Queensland) Department of Natural Resources (now NRM)
DPI	(Queensland) Department of Primary Industries
dse	dry sheep equivalent
DSS	decision-support system
EAV	equivalent annual value
EIA	environmental impact assessment
FWPRDC	Forest and Woods Product Research and Development Corporation
GIS	geographic information system
GLR	greatest limitation range
GM	gross margin
ha	hectare
IRR	internal rate of return
IUFRO	International Union of Forest Research Organisations
JCU	James Cook University
JVAP	Joint Venture Agroforestry Program
LEV	land expectation value
LGA	local government authority (or, sometimes, local government area)
LR	limitation range
LSD	least significant difference
MAI	mean annual increment
MAUT	multi-attribute utility theory
MAV	multi-attribute value
MCA	multi-criteria analysis
MCDA	multi(ple) criteria decision aids
MCDM	multi(ple) criteria decision models
MCDSS	multi(ple) criteria decision-support systems
MODSS	multi(ple) objective decision-support systems
NAP	National Action Plan for Salinity and Water Quality
NDVI	Normalised Differenced Vegetation Index
NFFI	National Farm Forestry Inventory
NHT	National Heritage Trust
NPI	National Plantation Inventory
NPV	net present value
NRM	(Queensland Department) of Natural Resources and Mines
NSW	New South Wales
NQRM	North Queensland Rainforest Management
P-DSS	prototype decision-support system
PFNQ	Private Forests North Queensland
QFRI	Queensland Forest Research Institute
RAC	Resource Assessment Commission
RIRDC	Rural Industries Research and Development Corporation
ROC	rank order centroid
SA	South Australia
SEQ	south-east Queensland
SFNSW	State Forests of New South Wales
SLATS	(Queensland) Statewide Land Cover and Tree Study
SMART	simple multi-attribute rating technique
SMARTER	simple multi-attribute rating technique exploiting ranks
SMARTS	simple multi-attribute rating technique using swings
sph	stems per hectare
UQ	The University of Queensland
USQ	The University of Southern Queensland

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Executive Summary

What the report is about

This report documents a project involving four major components, namely an investigation of landholder attitudes to farm forestry, development of a whole-farm financial model – the Australian Farm Forestry Financial Model (AFFFM) – to evaluate the financial returns and feasibility of forestry within the farm business, construction and evaluation of regional farm forestry case studies, and development of a multi-objective decision-support system (MODSS) for evaluation of forestry options from a regional and farm perspective. The research was conducted in two regional study areas, the Eastern Darling Downs of Southern Queensland and the Northern Tablelands of New South Wales.

Who is the report targeted at?

The project addresses an identified need for additional financial information and decision-support systems for farm forestry at the individual property as well as catchment and regional level. The research provides farmers and policy makers with a multipurpose decision support system (DSS) that will allow comprehensive assessment of the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprise in a variety of farm systems.

Background

Farm forestry offers many benefits to both landholders and to the wider community. In the short term it can provide many private benefits, such as increasing the visual amenity of the farm, improved soil stability and in some cases improved productivity of other farm activities. Over the longer term, farm forestry can provide landholders with a source of income and a means of diversifying the farm business. Farm forestry also offers many potential benefits to the wider community. Trees on farms can improve catchment water quality, reduce streambank erosion, and increase biodiversity. Managed properly, farm forestry can also improve the economic and social sustainability of a region.

While farm forestry is a growing part of the forestry sector in Australia, in many regions the level of adoption by landholders has been low, and probably much less than is desirable given the positive externalities forestry can generate. A lack of knowledge about the expected benefits, especially financial, has been identified in a number of surveys of landholders as being an impediment to establishing farm plantations or woodlots. There is also need for a framework in which the multiple benefits of forestry can be evaluated. This project addresses these needs.

The project arose out of four initial funding submissions from four different research groups, namely the Rainforest Cooperative Research Centre (Rainforest CRC), the University of Southern Queensland (USQ), the Centre for Agricultural and Resource Economics (CARE) at Armidale, and the Queensland Department of Natural Resources and Mines (NRM). It commenced in January 1999 and was completed in February 2002.

Aims/Objectives

The objective of the integrated project was to produce a stakeholder-driven, multi-objective decision-support system for agroforestry that delivered:

- a link between financial and bioeconomic modelling
- biological models or expert systems that integrate current knowledge on tree growth and silviculture of agroforestry options (including native species in plantation, native forests and shelter-belts)
- an improved process to assess and plan agroforestry options which incorporates the needs of both individual landholders and regional stakeholders
- a user guide to assist farmers to assess the financial viability of their preferred agroforestry options
- an exchange of technology and skills between project team members
- a website to provide interactive information and extension of project results
- extension of outcomes to landholders through existing farmer, smallholder and forest grower networks
- an analysis of (and report on) the general economic viability of agroforestry for a range of farms on the Northern Tablelands of NSW, and medium to low rainfall areas of southern Queensland
- a complementary system to identify commercial and environmental values of various agroforestry landscapes in order to consider the socio-economic outcomes of alternative government decisions.

Methods used

The project broadly comprised the following four methodological components:

1. Development and refinement of a farm forestry financial model

- reprogramming the Australian Rainforest Cabinet Timbers Financial Model in Visual Basic for ease of access to a range of users, then redesigning and extending the Visual Basic model, now referred to as the Australian Farm Forestry Financial Model (AFFFM)
- inclusion of biological performance data for species selected by experts to be appropriate for planting in the study sites. This was based on the use of suitability indices based on the *Plantgro* approach
- inclusion of native forest as well as plantations management into the model
- inclusion of the ability to consider interactions with other elements of the farm enterprise (e.g. reduced cropland due to tree planting or increased carrying capacity due to shelter) in a whole farm model based on elements of the CARE Pty Ltd whole-farm model
- extensive testing and demonstrations (followed by further refinement to address issues arising from the tests)
- packaging for distribution including development of the facility to download across the web and production of a users manual.

2. Survey of farmer participation and attitudes to farm forestry

- development (through multiple iterations and in-house testing) and wide distribution of a questionnaire to farmers in the Eastern Darling Downs of Southern Queensland and the Northern Tablelands of New South Wales study areas
- analysis and interpretation of questionnaire responses to identify, for example, farmer options and criteria for farm forestry (to feed into the MODSS component of the project).

3. Construction and evaluation of regional farm forestry case studies

- collection of Geographic Information Systems (GIS) and other data (e.g. input/output multipliers) for a selected case study catchment
- generation of maps (and associated economic data) for various regional farm forestry scenarios for the selected case study catchment

- workshops to review and comment by community and expert stakeholders on the various scenarios.

4. Trial implementation and evaluation of a multi-objective decision-support system
- refining the pre-existing MODSS tool to incorporate multi-stakeholder inputs at varying levels
- conduct of workshops to collect community and expert preferences for selected study areas
- analysis of farm forestry options for case study areas using information collected from stakeholder workshops.

Results/Key findings

Landholder attitudes

A survey of landholder attitudes to farm forestry in the Eastern Darling Downs of Southern Queensland and the Northern Tablelands of New South Wales indicated that:
- There is unlikely to be any large-scale increase in the rate of plantation establishment by existing landholders in broadacre agricultural landscapes. Nor is there likely to be a major increase in the area of native forests that is managed for timber production.
- Any expansion in the number of plantation growers will primarily be based on smallholder activity, especially those with higher incomes, professional backgrounds and off-farm income and with some pre-existing interest in, or experience with, trees. These same types of landholders are more likely to be interested in the commercial management of native forests, but whether or not they will provide a reliable source of native timbers is as yet unclear and warrants further investigation.
- Plantations are seen by landholders as having the potential to provide soil protection benefits, although this purpose is most strongly supported by the low-production landholders. The more commercially oriented landholders are not so likely to see native forests as having a land protection role, nor having a significant role in providing habitat.
- Both plantation and native timber production are seen by landholders, especially those with a commercial focus, as something that is best placed on poor soils. This thinking is likely to contribute to poor production experiences because landholders assess forest potential on the basis of plots that are established in inappropriate areas.
- It appears that landholder attitudes vary with experience with trees, irrespective of whether that experience was gained through having native forest areas on their farms or through undertaking conservation plantings. Those who have experience with harvesting native timber believe there are economic reasons for managing native forests for timber production, although they tend to be more interested in producing timber for on-farm use. This suggests that over time attitudes may change if an increasing number of landholders gain some experience with trees, though the cause and effect relationship needs further investigation.
- Those who have a native timber resource, or at least believe their native forest has production potential, do see some reasons, including both conservation and economic reasons, for commercialising the resource. They are also more likely to believe it can be done (less constrained by a management barrier). However, they still seem to be concerned about the economic barriers.
- Landholders, particularly those with relatively low levels of education and a high dependency on agriculture for their income, are concerned about the perceived threat of government regulations restricting future harvesting opportunities. Those who have the native timber resource on their properties are more concerned about regulation than those who do not. It is notable that those who believe they have the tenure that allows them to harvest native timber are more likely to consider native timber production.

Across the landscape, plantations will most likely be established near the Great Dividing Range, where smallholders are most numerous, with little farm forestry activity in the cropping or pastoral zones. Plantations will be small, most likely scattered, and in some cases productivity may be quite low. This is because landholders, including the low-production groups, see plantations as primarily serving functions that tend to be associated with 'mosaic' plantings. Assuming that landholders see most land degradation as being at particular and limited sites within a property and given that minimising land degradation is viewed as being one of the most important reasons for establishing plantations, then those who act to minimise such degradation will at least initially plant small and perhaps irregularly shaped plots. Shelter-belts will only be strips on the landscape, and in some cases farmers have only patches of low-fertility land which they will be inclined to plant. Therefore, if landholders act according to the apparent priorities revealed by this analysis, then the result will be a mosaic of forestry pieces, rather than any orderly aggregation. These results suggest that landholders are likely to favour plantation options that fit around cropping and grazing activities, even where those activities are conducted at a sub-commercial level. In particular, most landholder types tend to see plantations as having a conservation function. Some commercial landholders may consider native timber production if it can be shown that combined grazing and timber production result in a net increase in income, although some landholders may still be reluctant to consider managing trees because of a lack of interest in the activity, and in some cases, a hostility to trees in production landscapes.

Farm forestry options

On the basis of the landholder survey and discussion with forestry experts, eight farm forestry options were identified as having potential for implementation for a case study on the Eastern Darling Downs (the Hodgson Creek catchment).

These options may be briefly described as follows:

1. *An approximation of current land-use*: This scenario is based on assumptions about 'typical' land-uses, and provides a baseline against which the others are measured. For an alternative land-use to be financially viable, it must perform better or at least as well financially as the current land-use.
2. *High-priority salinity prevention*: This option involves identifying saline and at-risk areas in the catchment. Forestry activity is designed for the groundwater recharge zones in the upper catchment.
3. *Medium-priority salinity plantings*: As in (2), but with a greater proportion of the recharge area planted.
4. *Additional under-used areas*: As in (3), but with additional areas recognised as having little crop or pasture production being planted, especially if adjacent to the priority salinity areas.
5. *Commercial plantations (with corporate land ownership):* This option is based on a medium-scale corporate investment in purchase of land and establishment of forestry in the higher rainfall areas of the region.
6. *Commercial plantations (with leased land):* As in (5), except that the corporation leases land from landholders.
7. *Private medium-sized plantations:* This option is based on a medium-scale forestry planting undertaken by landholders.
8. *Agroforestry (plantations and grazing):* This would involve establishing wide-spaced plantations, in conjunction with improved or native pasture or even fodder crop strips in more fertile areas.

These eight forestry options are not necessarily an exhaustive list, but they would appear to be the most promising options on the basis of practical and scientific input.

Spatial analysis

A spatial analysis of future forestry options on the Eastern Darling Downs was carried out using a GIS. Current land-use was modelled, based on existing spatial data sets and some interpretation of satellite imagery, and then adding possible farm forestry scenarios to create new land-use combinations for the catchment. The spatial analysis provides useful indications of the changes in output that could result from various changes in land-use as well as providing an idea of the spatial distribution of a new form of land-use, based on particular criteria. The results of the economic analysis for this case study suggest that it would be difficult to argue that plantations result in a clear economic advantage, especially in the short to medium term. This is largely because of the opportunity cost of displacing existing production. However, the spatial analysis reveals that there is a considerable area of land within the catchment that is not being used for agricultural or pastoral purposes for which there is little opportunity cost associated with converting to farm woodlots. Hence, a possible strategy to increase the area of plantations is through the development of a mosaic of plantations across the landscape on under-utilised sites. This will mean a low opportunity cost in terms of production, but it may also mean there is a limited contribution to conservation and land protection benefits.

Australian Farm Forestry Financial Model (AFFFM)

A financial model for a forestry enterprise (the Australian Rainforest Cabinet Timbers Financial Model) was modified in this project, to produce the Australian Farm Forestry Financial Model (AFFFM).

Major developments include:

1. *Reprogramming in Visual Basic*: The model is now independent of proprietary software such as Microsoft Excel. This overcomes previous problems with software compatibility and improves ease of access for a range of users.
2. *Inclusion of biological performance data for species selected by experts as appropriate for planting in the study sites*: This was achieved mainly through the use of suitability indices compiled using the PlantGro software package. This greatly improves the usefulness of the model to users who do not have specialist knowledge of tree performance.
3. *Inclusion of native forest as well as plantations management into the model:* Native forests form an important part of many farms in the south-east Queensland and the inclusion of the native forests greatly increases the usefulness of the model to landholders and extension staff in this area.
4. *Inclusion of the ability to consider interactions with other elements of the farm enterprise:* Many farmers wish to consider forestry in context of the ‘whole-farm’ activities. Elements of the CARE Pty Ltd whole-farm model have been adapted to allow users to model the impact that farm forestry will have on other farm activities and overall profitability and cashflows. This provides a powerful tool for exploring a variety of combinations of traditional farm activities and forestry (e.g. reduced grazing land due to tree planting or increased carrying capacity due to shelter).
5. *Extensive testing and demonstrations:* Further refinements were made to address issues arising from the tests.
6. *Packaging for distribution:* This included the development of the facility to download across the World Wide Web and production of a user manual.

The usability of the AFFFM has been enhanced by generation of data files through use of PlantGro and the collection of harvest age and mean annual increment (MAI) data through Delphi surveys. Default data are available for initial runs of the model where the user does not have access to data for specific forestry sites.

Testing of the financial model proved to be a major challenge, particularly in terms of ensuring that the package operated well for users not involved in its development and not fully conversant with its

purposes, features and limitations. A wide variety of people experimented superficially with the model, but in general did not provide extensive feedback. The most effective testing was when students of the School of Natural and Rural Systems Management at the Gatton Campus of The University of Queensland undertook an assessable project using the model. The exercise identified a range of problems when people unfamiliar with the model attempted to use it in a practical setting, and resulted in extensive refinement of the model in terms of operational (as distinct from analysis) features to improve user-friendliness.

A number of uses of AFFFM have emerged as this project has proceeded. The major user of the model is envisaged as individual landholders and their advisors to investigate the potential for farm forestry development on private landholdings. Within the project, the model was applied in two case studies. Bringing native forest under management in the Northern Tablelands region was found to be compatible in cashflow terms with the farm business, and lead to an increase in net present value (NPV) per hectare for the farm. Milling on-farm greatly increased the financial payoff. On the other hand, inclusion of a 50 ha plantation forest on an Eastern Darling Downs farm was found to be financially non-viable, reducing farm NPV per hectare.

A number of additional uses of the AFFFM have also been identified. *Business* applications include:

- Evaluation of the economic payoff from forestry investment for individual landholders. The model allows this type of analysis to be carried out within the context of the overall farm business and cashflow situation.
- Providing evidence of forestry business status for taxation purposes. Recent changes have been made to Australian taxation legislation in respect to the deductibility of expenses incurred in undertaking farm forestry operations. An important component of being eligible to claim these deductions is for the farm forester to be able to demonstrate that they are carrying on a business with the reasonable expectation of profit.
- Estimating the land value impacts of forestry. The AFFFM can provide estimates of changes in land value due to forestry for land valuers and real estate agents, with improved credibility relative to estimates based on broad rules of thumb.

Potential *research* applications of the AFFFM include:

- Identifying key variables and issues which affect the profitability of individual forestry investments. This could be undertaken as case studies across various regions and farming systems. In this way, the AFFFM can be used to define the limits of financial viability of various forestry species and planting configurations[1]
- Predicting the financial performance of timber production using non-traditional species, mixtures, and production and harvest regimes.
- Investigating the potential economic payoff from forestry in areas where this has not been a traditional land-use.
- As a support tool for the development of regional forestry industry through case studies for business groups or policy makers.
- With further development of the model, for demonstrating the differences between do-it-yourself and joint venture options.
- Providing economic data as input to the spatial modelling approaches described in this study or for the MODSS approach.

For instance, the AFFFM can be used in landholder workshops to demonstrate the financial impact of alternative forestry options, which in turn may encourage landholders to plant trees.

Estimates of the profitability of farm forestry have already been developed for landholders in north Queensland, in association with Plantation Forests North Queensland (the regional plantation

[1] RIRDC funding has been approved for using the AFFFM to carry out a series of case studies of the financial performance of farm forestry.

committee), and Greening Australia has indicated an interest in using the model. The model could be used in landholder workshops in other regions to demonstrate the financial impact of alternative forestry options, which in turn may encourage landholders to plant trees.

A further potential application relates to education about farm forestry. Much of the education relating to farm forestry concentrates on the technical side of the investment decision. There are few tools that allow potential investors to explore the financial implications for their own businesses. The AFFFM provides this capacity and is amenable to use in workshop situations.

Multi-Objective Decision-Support System (MODSS)

MODSS were developed in relation to farm forestry, for both Southeastern Queensland and for the Hodgson Creek catchment on the eastern Darling Downs. Forestry options investigated were those developed from the landholder survey. Input for the MODSS *effects tables* were provided by both a technical advisory group and a meeting of landholders. A large number of economic, environmental and social *decision criteria* for farm forestry were identified. Some deletions and amalgamations of criteria were made, on the basis of practical logic and correlation analysis of scores provided by the informants. Two time periods were considered in the analysis, viz. plantation establishment and steady-state forestry.

Two solution methods of the MODSS were employed, viz. the weighted summation and the Electre II methods. The former is a compensatory aggregation method (meaning that poor performance on one criteria can be compensated by high performance on another) while the latter is a non-compensatory aggregation method (and hence can identify options which are 'fatally flawed' with regard to essential performance criteria). Aggregate performance measures have been derived for forestry options overall and for economic, environmental and social perspectives. Aggregate scores, using weighted summation, fall in the range zero (extremely poor) to one (outstandingly good). The Electre II method produces an ordinal ranking of the options.

In the Hodgson Creek analysis, for the transition period and under the weighted summation method, all the options fall into a tight range (0.51 to 0.63), i.e. there is little difference between the options. Within this range, 'current forestry practice' performs best, 'high-priority salinity plantings' and 'medium-priority salinity plantings' perform next best, followed by 'commercial plantations (leased land)' and then the other options. There is a general trend that performance drops as the area planted by trees increases. Considering the Electre II analysis, the results are quite different. The 'commercial plantations (leased land)' option is ranked first, followed by all the other forestry options and with 'current practice' ranked last. 'Commercial plantations (leased land)' perform well overall, with scores for the individual criteria generally high and with few exceptionally poor performing criteria. This option scores poorly in the economic criterion of *liquidity of assets* (as do all the forest options) but not on any other criteria. The drop in performance of 'current practice' is due to critically poor performance in a number of environmental and social criteria.

In the steady-state period and using the weighted summation analysis, there is more definition between the options (a range of 0.54 to 0.73). All the forestry options perform similarly within the range of 0.68 to 0.73, and all outperform current practice. Using the Electre II method, 'medium-priority salinity plantings' performs best, 'high-priority salinity prevention' second then 'agroforestry', followed by all the other forestry options and with current practice having the worst performance. The poorer performance of the large-area forestry options is largely due to poor performance in the social group of criteria.

Implications for relevant stakeholders

The project has developed and demonstrated tools that will assist decision-makers to choose between farm forestry options. At the individual property level, the AFFFM will assist farmers to integrate the complex financial considerations of their whole enterprise (including off-farm income) to compare forestry and non-forestry options. At the regional and catchment level, the utility of the MODSS approach and Facilitator tool in planning farm forestry, supported by Geographic Information Systems and regional economic analysis and stakeholder workshops, has been demonstrated in the Hodgson Creek case study. Applying these tools in a trial catchment has shown that smaller-scale fragmented farm forestry options are more favoured and provide more communal social and economic benefits than large-scale industrial block plantings.

At the policy level, the farm survey provides a further understanding of how the rural community is segmented in their involvement and interest in farm forestry and the particular barriers and incentives perceived by farmers to have most impact on their forestry decisions. The survey confirms the finding of other surveys that managers of the most commercially viable large-scale pastoral properties are least inclined to engage in farm forestry, while those engaged in small-scale farming, with relatively high levels of education and with substantial off-farm income, are most inclined to engage in farm forestry. It also revealed that those engaged in the management of native forest on their property are also inclined to engage in managing farm forest plantations.

Recommendations

The research identified a number of areas for further research. A recommended procedure for MODSS development has been devised. The desirability of further applications of decision-support systems in areas where there is a limited history of farm forestry is noted. A parallel MODSS application is now being undertaken in north Queensland by members of the research team. Areas in which the AFFFM could be extended have been identified, including addition of modules for determining income tax implications of farm forestry, evaluation of joint venture forestry investments and assessment of the potential revenue from carbon and salinity credits.

1. Project Overview

P. Norman, G. Cockfield, S. Harrison, J. Herbohn, P. Lawrence and D. Thompson

This project, funded by the Joint Venture Agroforestry Program (JVAP), commenced in January 1999 and was completed in February 2002. The project was created out of four initial funding submissions from four different research groups, namely the Rainforest Cooperative Research Centre (Rainforest CRC), the University of Southern Queensland (USQ), the Centre for Agricultural and Resource Economics (CARE) at Armidale, and the Queensland Department of Natural Resources and Mines (NRM). The research was conducted in two regional study areas, the Eastern Darling Downs of Southern Queensland and the Northern Tablelands of New South Wales. The project addressed the RIRDC identified research need for additional financial information and decision support systems for farm forestry.

The project followed four key threads:

- development and refinement of a whole-farm agroforestry financial model
- survey of farmer participation and attitudes to farm forestry
- construction and evaluation of regional farm forestry case studies
- trial and further development of a multi-objective decisions support system.

The project was successful in achieving its objective of providing farmers and policy makers with a multipurpose decision support system (DSS) that will allow comprehensive assessment of the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprise in a variety of farm systems.

1.1 The Research Problem

Whilst the project was funded from the JVAP and as such is strictly directed toward agroforestry applications, in reality it is not possible (nor particularly useful given the nature of the enterprises) to try to distinguish agroforestry in the pure sense (e.g. silvo-pastoral systems) from farm woodlots and other small-scale farm forestry within Australia. In this report, the terms *agroforestry* and *farm forestry* will be used interchangeably.

Farm forestry is an important and rapidly increasing use of agricultural land in rural and regional Australia. The National Farm Forest Inventory reported that the area of farm forest existing in 1999, almost 67,000 ha, had more than doubled in the previous five years (Wood *et al*. 2001).

Increasing the planting of trees on farms has been identified by a range of programs as desirable for biological, economic and social reasons. The newly launched *National Action Plan for Salinity and Water Quality in Australia* for example lists as a priority action the development of integrated catchment and region management plans which (amongst other things) include specific actions to establish multiple purpose perennial vegetation (focussed on agriculture, forests, biodiversity and carbon credits) in targeted areas (AFFA 2002).

A lack of knowledge about the expected benefits (in particular financial) from forestry has been identified in a number of surveys of landholders as being an impediment to them becoming involved in farm forestry. This has also been stated as a reason for land valuers not making allowance for timber in property valuations (Harrison *et al*. 2001). Developing decision support tools to assist landowners assess the financial and economic viability of agroforestry options has been recognised as a priority research need in the RIRDC R&D Plan for the JVAP (RIRDC 1999).

A number of stakeholders have roles to play and interests in farm forestry and agroforestry. Governments (Local, State, and Federal) have a variety of statutory responsibilities related to ensuring sustainable natural resource use, supporting communities and industry, and providing employment and social infrastructure. Various groups (farmers, catchment and regional groups) likewise are becoming an increasingly prominent vehicle for delivery of some of these government programs and for tailoring them to particular local needs through for example the planting of trees for a range of economic, environmental and social benefits. Surveys indicate that individual farmers are likewise motivated to plant trees in pursuit of a mix of benefits, including many non-financial ones (e.g. aesthetics, soil and water conservation). The need for *decision-support tools applicable to emerging industries and multiple benefits* is also recognised by RIRDC as a priority gap in agroforestry research.

1.2 Project Background

Clearly, there is a need for precise biological information when evaluating the economic impacts at the farm level of choices related to species or site selection, and forest management regimes (both native forest and plantation systems). In addition, there is a need to consider a range of socio-economic and environmental implications when making decisions or developing policy that will affect the value of, or provide incentives for, agroforestry options in farm management. Such information is required by private landholders seeking to adopt forestry on their land, and Governments and regional communities seeking a co-ordinated and better-informed approach to regional forest industry development.

The governments of Victoria and Western Australia have programs and research activities to boost farm forestry. However, the Victoria FFORNE project (Howell 1997) and the WA work (WA Farm Forestry Task Force 1995) are concentrated in the higher rainfall, non-cropping zones. The Victorian FARMTREE computer program (Loane 1994) is a financial package that can be used in those regions. Other work of a similar nature, such as that in the Mt Lofty region of SA (Bulman 1995) is based on New Zealand experiences. The 1996 review of the Farm Forestry Program identified that a major contributor to the failure of regional forest industries was the fact that research projects to that time had not advanced landholder skills and knowledge. The project reported here was designed to address this deficiency, and in a more comprehensive way, construct a framework to integrate subsequent research outcomes.

1.3 Project Development

This project was developed through the integration of four project bids initially submitted separately to RIRDC for funding under the JVAP in 1998, namely:

- a decision support system for managing private native forests submitted by CARE Pty Ltd
- information systems for predicting likely financial returns from farm forestry submitted by the Rainforest CRC
- a multi-objective decision support system for agroforestry submitted by the then Department of Natural Resources (now NRM)
- economic tools for agroforestry decision-support submitted by USQ.

The applicants based all but one of these projects explicitly on the extension of previous work and the focus of each submission reflected the particular needs identified through that previous work.

The CARE Pty Ltd project builds on previous case study work undertaken by CARE and funded by RIRDC which examined the financial feasibility of managing existing native timber on Northern Tablelands farms. The new proposal was directed at establishing links between the biology and ecology of native forest growth, the production of commercial timber and the impact on farm business performance of alternative management options.

The Rainforest CRC project aimed to extend the Australian Cabinet Timber Financial Model, a farm plantation financial evaluation tool developed by the applicants as part of a previous CRC funded project, to become a site-specific information system for the assessment of the financial performance of farm forestry situations elsewhere in Australia.

The NRM project aimed to apply, evaluate and further develop a multi-objective decision-support system (MODSS), developed previously by NRM in collaboration with the USDA-Agricultural Research Service in Tucson, Arizona, into a spatially explicit decision-support system for developing property and catchment farm forestry and tree management plans that best meet the individual combination of multiple objectives and aspirations of farmers, farmer groups and governments.

The USQ project was developed from the ground up to provide a decision-support system for comparing crop, livestock and agroforestry options including a guide or manual for farmers to demonstrate means of assessing economic viability of agroforestry options and a means for policy-makers to report on general economic viability of agroforestry on a range of farms in medium to low rainfall zones of southern Queensland.

Given the similarity in the projects (on the surface at least they were each directed at the development of decision-support tools) and the geographic proximity of the applicants, the funder (RIRDC) suggested that the four applicants collaborate in developing a joint proposal. An integrated proposal was developed in early 1999 and, following a highly favourable external review, was funded by RIRDC for $305,699, (considerably less than the combined request for the four initial submissions), for a project duration of three years.

The objective of the integrated project was to produce a stakeholder-driven, multi-objective decision-support system for agroforestry that delivered:

- a link between financial and bioeconomic modelling
- biological models or expert systems that integrate current knowledge on tree growth and silviculture of agroforestry options (including native species in plantation, native forests and shelter-belts)
- an improved process to assess and plan agroforestry options which incorporates the needs of both individual landholders and regional stakeholders
- a user guide to assist farmers to assess the financial viability of their preferred agroforestry options
- an exchange of technology and skills between project team members
- a web site to provide interactive information and extension of project results
- extension of outcomes to landholders through existing farmer, smallholder and forest grower networks
- an analysis of (and report on) the general economic viability of agroforestry on a range of farms on the Northern Tablelands of NSW, and medium to low rainfall areas of southern Queensland
- a complementary system to identify commercial and environmental values of various agroforestry landscapes in order to consider the socio-economic outcomes of alternative Government decisions.

1.4 Research Methodology

The need for co-ordination of the activities of four distinct and geographically separate organisations was an important influence on the research method. The budget and timeframes for the project were relatively modest and a high degree of co-ordination was required in order to achieve the objectives. Despite their superficial similarities, each of the four initial submissions had distinctly different elements reflecting the different strengths of the four partners and their varying understanding of research needs. Whilst it was reasonable for RIRDC to assume that the overall end product would benefit (in terms of efficiency and comprehensiveness) from close collaboration, achieving this promised to be no easy task (there are many examples of where attempts at such forced collaboration

have failed). The success of the collaboration in the current project is a testament to the tolerance, goodwill and openness of the partners.

Regular workshops (about two per year) of the project team were the primary vehicle by which co-ordination and collaboration was achieved. These workshops were held at a central location in Brisbane, attended by all partners and typically included: a brief update on the activities of each of the partners; a review of progress against project milestones; planning future activities; and some forthright discussion on methodological issues. These meetings were in general successful at resolving any major concerns about progress and methodology. Issues that remained unresolved following a meeting were dealt with out-of-session through email and telephone discussions.

The project methodology was built around a number of relatively distinct but interrelated bodies of work. Initially it was envisaged that these would comprise two stages: stage 1 to focus on the integration and testing of the Australian Cabinet Timbers Financial Model and CARE Pty Ltd financial and economic models, including the implementation of a biological module, in NSW Northern Tablelands; and stage 2 to be dominated by the collection of information for the agroforestry MODSS, primarily in southern Queensland districts, and evaluation of agroforestry options. The project did broadly follow this pattern although as it actually transpired the work more effectively fell into four components, as follows:

Development and refinement of a farm forestry financial model

Activities in this component included:

- reprogramming the Australian Rainforest Cabinet Timbers Financial Model in Visual Basic for ease of access to a range of users, then redesigning and extending the Visual Basic model, now referred to as the Australian Farm Forestry Financial Model
- inclusion of biological performance data for species selected by experts to be appropriate for planting in the study sites. This was based on the use of suitability indices based on the *Plantgro* approach
- inclusion of native forest as well as plantations management into the model
- inclusion of the ability to consider interactions with other elements of the farm enterprise (e.g. reduced cropland due to tree planting or increased carrying capacity due to shelter) in a whole farm model based on elements of the CARE Pty Ltd whole-farm model
- extensive testing and demonstrations (followed by further refinement to address issues arising from the tests)
- packaging for distribution including development of the facility to download across the web and production of a users manual.

Survey of farmer participation and attitudes to farm forestry

Activities in this component included:

- development (through multiple iterations and in-house testing) and wide distribution of a questionnaire to farmers in Eastern Darling Downs and northern New England Tablelands study areas
- analysis and interpretation of questionnaire responses to identify for example farmer options and criteria for farm forestry (to feed into the MODSS component of the project).

Construction and evaluation of regional farm forestry case studies

Activities in this component included:

- collection of GIS and other data (e.g. input/output multipliers) for a selected case study catchment
- generation of maps (and associated economic data) for various regional farm forestry scenarios for the selected case study catchment

- workshops to review and comment by community and expert stakeholders on the various scenarios.

Trial implementation and evaluation of a multi-objective decision-support system

Activities in this component included:
- refining the pre-existing MODSS tool to incorporate multi-stakeholder inputs at varying levels
- conduct of workshops to collect community and expert preferences for selected study areas
- analysis of farm forestry options for case study areas using information collected from stakeholder workshops.

These activities and their outcomes are described in detail and critically reviewed in chapters that follow.

1.5 Major Achievements

At the outset there was an expectation that the elements of the project could be 'hard–wired' into a single fully integrated multi-purpose system. In reality this was never going to be possible, given the diversity of interests and capacities involved in farm forestry decisions (i.e. from individual farmers with relatively modest levels of education through to scientists with interest in more complex applications). Also, it became clear quite rapidly that the design elements of a tool for farm-based decisions are of necessity quite different to those for regional or catchment decisions (e.g. in their treatment of taxation, on and off farm income). Consequently, the project outputs are presented as a package of tools and case study demonstrations that will support and guide farm forestry decision-makers at both the private (i.e. farm) and social (i.e. catchment, regional and Government policy) levels.

Notwithstanding this, the initial project objectives have been met as follows:

1 A link between financial and bioeconomic modelling.
The AFFFM now includes biological growth and performance characteristics as derived from Plantgro.

2 Biological models or expert systems that integrate current knowledge on tree growth and silviculture of agroforestry options (including native species in plantation, native forests and shelter-belts).
The AFFFM now includes information on product yields, rotations and silviculture derived from expert knowledge for Northern NSW and South-east Queensland. Previously this information was only available for north Queensland. The ability to amend these or substitute new figures based on the users' knowledge has also been extended.

3 An improved process to assess and plan agroforestry options which incorporates the needs of both individual landholders and regional stakeholders.
The catchment case study has demonstrated the utility of GIS and economic models in developing and evaluating regional farm forestry options.

4 A user guide to assist farmers to assess the financial viability of their preferred agroforestry options.
The AFFFM provides a tool for evaluating forestry investment within the context of the overall farm business including cropping and livestock enterprises.

5 An exchange of technology and skills between project team members.
Many fruitful exchanges between project team members occurred throughout the project. The project partners collaborated on external publications and on submissions for further joint projects.

6 A web site to provide interactive information and extension of project results.
Project information has been accessible on the NRM website and AFFFM has been programmed for downloading over the web.

7 Extension of outcomes to landholders through existing farmer, smallholder and forest grower networks.
One-on-one discussions and demonstrations have been held with a number of farmers, workshops have been held with farmer groups and with technical experts and a final workshop was held with a number of extension staff and technical experts to share project outcomes.

8 A report on general economic viability of agroforestry on a range of farms on the Northern Tablelands

of NSW, and medium to low rainfall areas of southern Queensland.
An economic analysis has been conducted for the Hodgsons Creek catchment in the Darling Downs. This analysis reveals that extensive farm forestry is not viable on a financial basis alone as an alternative to existing cropping and grazing enterprises. Use AFFFM to review a range of whole farm scenarios suggests that farm forestry based on existing native forests is the only seriously financially viable alternative to existing agricultural pursuits within the areas studied.

9 A complementary system to identify commercial and environmental values of various agroforestry landscapes in order to consider the socio-economic outcomes of alternative Government decisions.
The MODSS methodology has been tested and revised through the project to demonstrate a process for effective consideration of community criteria and integration of expert opinion.

1.6 Concluding Remarks

The project has developed and demonstrated tools that will assist decision-makers to choose between farm forestry options. At the individual property level, the AFFFM will assist farmers to integrate the complex financial considerations of their whole enterprise (including off-farm income) to compare forestry and non-forestry options. Applying the model to data collected from case study farms within the Darling Downs and Northern New England Tablelands has demonstrated how the model can assist landholders in evaluating farm forestry options.

At the regional and catchment level, the MODSS work and the Hodgson's Creek case study have demonstrated the utility of the MODSS Facilitator tool and GIS combined with regional economic analysis and stakeholder workshops in planning farm forestry. Applying these tools in a trial catchment has demonstrated that smaller-scale fragmented farm forestry options are more favoured and provide more communal social and economic benefits than large-scale industrial block plantings.

At the policy level, the farmer survey provides a further understanding of how the rural community are segmented in their involvement and interest in farm forestry and the particular barriers and incentives perceived by farmers to have most impact on their forestry decisions. The survey further confirmed the finding of other surveys that managers of the most commercially viable large-scale pastoral properties are least inclined to engage in farm forestry whilst those engaged in small-scale farming, with relatively high levels of education and with significant off-farm income are most inclined to engage in farm forestry. Further, it found that those engaged in the management of native forest on their property are also inclined to engage in farm forest plantations.

These results lend considerable weight to the argument for a set of policy actions and extension programs that encourage and enhance the involvement of farmers in sustainable utilisation of existing native forests.

1.7 References

AACM International Pty Ltd (1996), *Farm Forestry in the Murray Darling Basin: Farm Forestry Assessment Report Upper Condamine Catchment*, AACM International, Adelaide.

AFFA (Agriculture, Forestry and Fisheries Australia) (2002), *Our Vital Resources – A National Action Plan for Salinity and Water Quality in Australia*, http://www.affa.gov.au, accessed March 2002.

Battaglia, M. and Sands, P. (1997), Modelling the productivity of Eucalyptus globulus in response to climatic and site factors. *Australian Journal of Plant Physiology*, 24(6): 831–850.

Bulman, P. (1995), *Farmtrees for the Mount Lofty Ranges: a regional agroforestry handbook, South Australia*, Department of Primary Industries, Adelaide.

Capill, L. (1996), 'Adoption of a New Zealand agroforestry evaluation model to a site in south east Queensland', *Managing and Growing Trees on Farms*, in A. Grodecki ed., Greening Australia Queensland, Brisbane, Volume 2, pp. 399–407.

Davis, J.R., Nanninga, P.M., Biggins, J. and Laut, P. (1991), Prototype decision support system for analyzing impact of catchment policies. *Journal of Water Resources Planning and Management*, 117(4): 399–414.

DPI Forestry (1998), *An Overview of the Queensland Forest Industry*, Queensland Department of Primary Industries, Brisbane.

Fraser Island Inquiry (Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region) (1991), Appendices, Volume 1, GoPrint, Brisbane.

Grayson, R.B., Doolan, J.M. and Blake, T. (1994), 'Application of AEAM (Adaptive Environmental Assessment and Management) to water quality in the Latrobe River Catchment', *Environmental Management*, 41(3): 245–258.

Greening Australia (1996), *Farm Forestry in Australia: Integrating Commercial and Conservation Benefits*, Greening Australia, Canberra.

Hamilton, N.A., ed. (1992), *Attitudes and behaviours of farmers and other stakeholders involved in southern Queensland farming systems*, QDPI, Dalby.

Harrison, S.R., Stehn, N.H., Boydell, S. and Herbohn, J.L. (2001), 'The Valuation Impact of Reforestation on Degraded Farm Land', in S.R. Harrison and J.L. Herbohn, eds., *Sustainable Farm Forestry in the Tropics*, Edward Elgar, Cheltenham, pp. 133–146.

Herbohn, J. L., Harrison, S. R., Smorfitt, D. B., and Emtage, N. (1998), *Attitudes of Landholders to Farm Forestry in North Queensland*, International Symposium on Integrating Environmental Values into Small Scale Forestry, August, Vancouver, IUFRO 3.08 Small Scale Forestry.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1997), *Financial Models for Small Scale Farm Forestry: An Australian Case Study Involving Mixed Species Plantations, in Sustainable Management of Small Scale Forestry*, Proceedings of IUFRO Symposium in Kyoto, Graduate School of Forestry, Kyoto University, pp. 48–54.

Howell, A. (1997), The FFORNE Project: Farm Forestry North East/North Central Project, *Trees and Natural Resources*, 39(2): 19–22.

Keenan, R. (1998), Forest Research Institute, Atherton, personal communication.

Landsberg, J. J. and Waring, R. H. (1997), A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning. *Forest Ecology and Management*, 95(3): 209–228.

Lane, L.J., Ascough, J.C. and Hakonson, T.E. (1991), *Multi-objective decision theory decision support systems with embedded simulation models*, Irrigation and Drainage Proceedings, IR Div., American Society of Civil Engineering, Honolulu, July 22–26, pp. 445–451.

Lawrence, P.A., Stone, J.J., Heilman, P. and Lane, L.J. (1997), 'Using measured data and expert opinion in a multiple objective decision support system for semiarid rangelands', *American Society of Civil Engineering*, 40(6): 1589–1597.

Loane, B., (1994), *The FARMTREE model: computing financial returns from agroforestry*, Faces of farm forestry: Australian Forest Growers Conference, Launceston.

Lourain-Smith, R. (1993), Modelling mixtures of species, Ch. 7 in *Computers in Forestry: Use of Spreadsheets*, Wiley, New York.

Roberts, B. and Kajewski, L. (1997), *Developing Strategies for the Sustainable Use of Native Timber*: The Queensland Cyprus Pine Case, Landcare Conference, Roma,

RIRDC (1999), *R&D plan for the Joint Venture Agroforestry Program* 1999–2004, http://www.rirdc.gov.au/pub/aft5yr.htm, accessed March 2002.

Russell, J.S., Cameron, D.M., Whan, I.F., Beech, D.F., Prestwidge, D.B., and Rance, S.J. (1993), Rainforest Trees as a New Crop for Australia, *Forest Ecology and Management*, 60(1–2): 41–58.

Todd, C.R., Loane, I.T. and Ferguson, I.S. (1997), *Potential impact of a farm forestry industry on the Goldburn regional economy*, Bulletin No.10, School of Forestry and Resource Conservation, University of Melbourne.

Vanclay, F. (1986), *Socio-Economic Correlates of Adoption of Soil Conservation Technology*, Unpublished M.Soc.Sci. thesis, University of Queensland, Brisbane.

Vanclay, F. (1992), The Social Context of farmers' adoption of environmentally-sound farming practices', in G. Lawrence and B. Furze, eds., *Agriculture, Environment and Society*, Melbourne, Macmillan, pp. 94–121.

Vanclay, J.K. (1991), *Modelling the Growth and Yield of Tropical Forests*, D.Sc.For. thesis, The University of Queensland, Brisbane.
Vanclay, J.K. (1994), *Modelling Forest Growth and Yield: Applications to Mixed Tropical Forests*, CAB International, Wallingford, UK.
Western Australia Farm Forestry Task Force (1995), *Farm Forestry in Western Australia*: Report of the Farm Forestry Task Force, Farm Forestry Task Force, Perth.
Wood, M.S., Stephens, N.C., Allison, B.K., and Howell, C.I. (2001*), Plantations of Australia – a report from the National Plantations Inventory and the National Farm Forest Inventory* (abridged version) National Forest Inventory, Bureau of Resource Sciences, Canberra.
Yakowitz, D.S., Lane, L.J. and Szidarovszky, F. (1993), 'Multi-attribute decision making: dominance with respect to an importance order of the attributes', *Applied Mathematics and Computing*, 54(2–3): 167–181.

2. The Current Status of Farm Forestry in Australia

J. Herbohn, S. Harrison, N. Emtage and P. Norman

The purpose of this chapter is to place the current project to develop a farm forestry financial model and a multi-objective decision support system in context of the farm forestry scene in Australia and to highlight relevant aspects of past research. As part of this, a brief overview of the history of forest use in Australia and the developing plantation estate is provided. The nature and extent of farm forestry in Australia is discussed, including an assessment of recent developments in the two key regions in the current study. The key elements of past research, which are relevant to the current project, are then identified.

2.1 The Australian Forestry Sector

Historically, forestry activities in Australia have been based on the exploitation of the extensive eucalypt forests that existed at the time of European settlement or has regenerated following the exclusion of regular fire events. The forest resource has been depleted since European settlement, and large tracts of forest land have been withdrawn from timber production following a bitter public policy debate between the forestry industry and conservation groups. At present about 17.5 M ha are currently in conservation reserves (Table 2.1). It is likely that over the next 10 years further large areas of native forest will be placed within conservation reserves.

Table 2.1 Area of native forest and plantation estate in Australia

Forest type	Area (1000 ha)
Native forest[1]	
Conservation reserves	17,580
Multiple-use forests	13,351
Leasehold land	66,103
Other crown land	15,597
Private forests	42,018
Total native forest area	155,835
Plantations[2]	
Softwood	972
Hardwood	503
Other (mixed species and unknown)	10
Total plantation area	1,485

1 As at December 1997.
2 As at September 2000.
Source: National Forest Inventory (1998), Wood et al. (2001).

Control over the exploitation of the native timber resource has traditionally rested with the various State governments. However, the Commonwealth government has exerted increasing influence through a combination of economic incentives and the application of external powers provided by the Constitution. In addition to timber production, Crown-controlled native forests have been used as a means of achieving a number of social objectives such as regional development and the provision of

low-cost housing materials. The pricing and allocation of logs has been a controversial issue (O'Regan and Bhati 1991). The ready supply of logs at artificially low prices from public native forests has contributed to a lack of interest in private plantation forestry and a corresponding high level of public ownership of the plantation resource.

2.2 The Australian Plantation Estate

Domestic timber requirements are increasingly being drawn from the plantations. Softwood plantations currently comprise over 972,000 ha, or over 65% of the current plantation estate of 1,485,000 ha (see Table 2.1). A high proportion of the softwood estate is controlled by public organisations, while most hardwood estate is under private control. A breakdown in the ownership and types of plantations is provided in Figure 2.1.

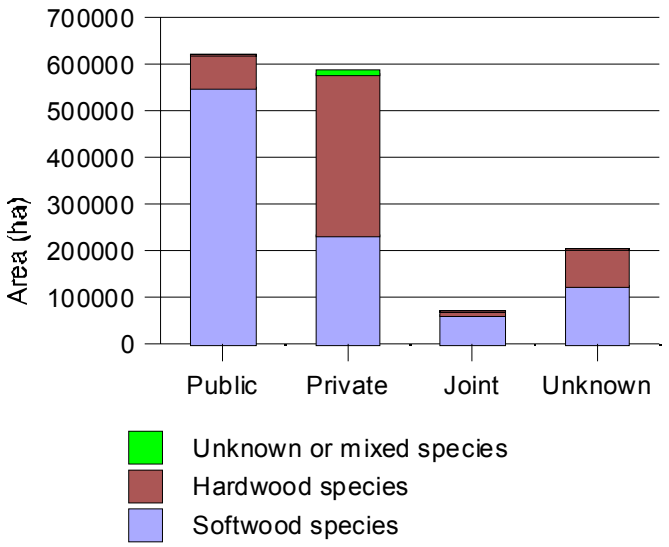


Figure 2.1 Total area under hardwood (HW) and softwood (SW) as at September 2000 by tree ownership

Note: 'Joint' refers to plantations with both public and private sector equity.
Source: Wood *et al*. (2001).

There have been concerted efforts in recent years to expand the plantation estate. Under the 2020 Vision (a joint policy statement agreement between the federal and state governments) it is planned to triple the existing plantation estate to 3.3 M ha (Plantations 2020 1997). As part of the National Forest Policy Statement (Commonwealth of Australia 1992, p. 29) there is an agreement that 'all States share the policy, consistent with ecologically sustainable development, of not clearing public land for plantation establishment…'. This thus dictates that most of the expansion in the plantation estate will have to be on freehold cleared land. The 2020 Vision and the National Forest Policy Statement have important implications for an increased role for the private sector, including farm foresters. This represents a major shift away from the current State domination of the forestry sector.

The efforts to expand the plantation estate are reflected in the recent rate of plantation establishment. In 2000, it was estimated that almost 125,000 ha of new plantations would be established, of which about 116,000 ha were to be hardwoods (NPI 2000 and Figure 2.2), most of which have been established for hardwood pulp. This represents an increase in the plantation estate of around 10% in one year. The vast majority of new plantations were established on private land (Figure 2.3), which is

a major shift away from the previous focus of establishing softwoods on public land by State forestry organisations.

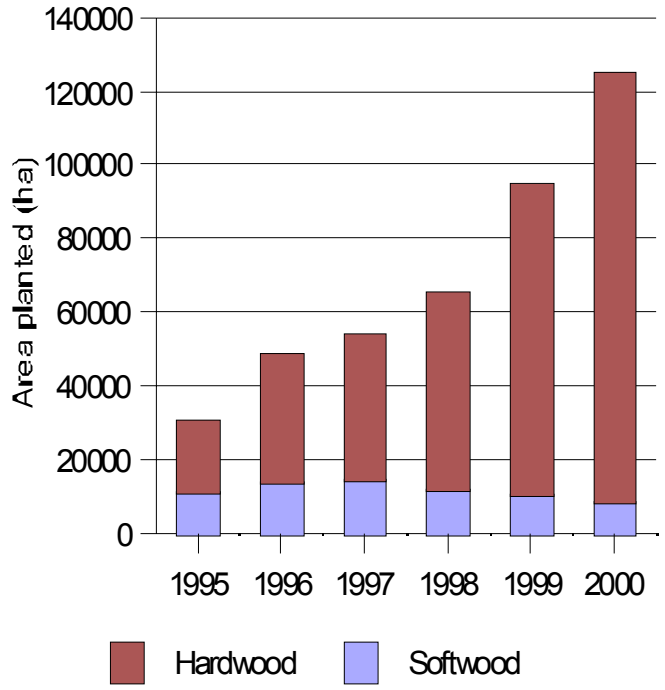


Figure 2.2 Annual areas of new plantations established in Australia since 1995

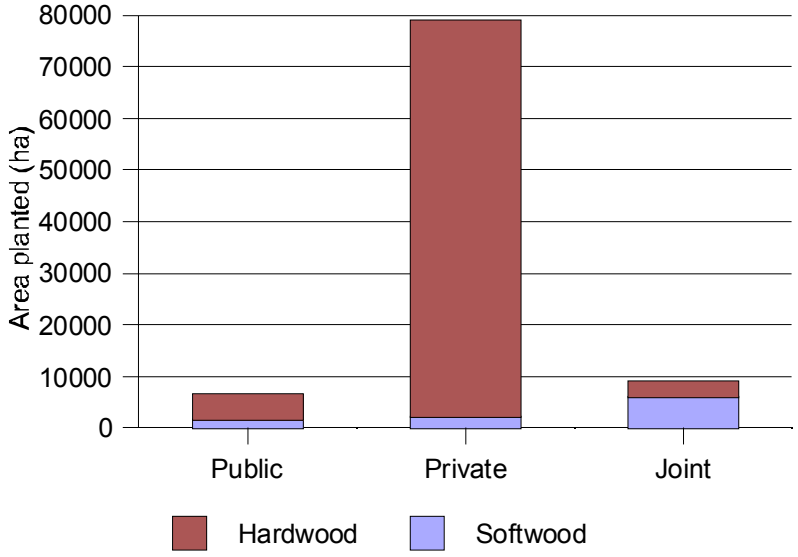


Figure 2.3 New areas planted to hardwood and softwood in 1999 (up to September) by tree ownership

Source: NPI (2000).

2.3 Types of Private Forestry in Australia

Three common types of private forestry can be identified in Australia based on the motivations for participation, which range from predominantly environmental plantings to a strong production focus.

Large-scale industrial plantings established primarily for timber production constitute by far the largest areas of plantation establishment. Private large-scale plantations are typically owned by large forestry companies, or alternatively established under joint venture arrangements, either with forestry companies or government. There is also an increasing number of forestry investment companies establishing large-scale plantations. Based on data in Wood *et al.* (2001), about 95% of the area of plantations in Australia could be classified as 'large-scale industrial'.

Conservation plantings or initiatives are at the other end of the production–environment spectrum. These plantings tend to take place in environmentally sensitive areas such as along watercourses. They are commonly established to ameliorate environmental damage such as streambank erosion and rising watertables leading to salinity caused by past poor land management practices. A sizeable proportion of the conservation plantings in the past 10 years in Australia has occurred under the umbrella of 'Landcare'. Landcare is an Australian community-wide program with strong government support at all levels and currently involves over 4000 autonomous groups (Marriott *et al*. 2000). Most groups comprise farmers and other landowners restoring land and increasing sustainability, and to a lesser extent groups based in towns and cities. Marriott *et al*. (2000) observed that increasingly landcare members are focussing on whole catchments and regional themes, rather than confining attention to their own properties, and many groups have amalgamated into loosely bound but highly task-orientated and opportunistic regional networks. There are also a large number of other groups active at a regional level that promote or assist in tree planting for environmental purposes which are not directly associated with Landcare. Due mainly to the high establishment cost, limited financial support and a lack of direct economic returns (at least in the short term), conservation plantings tend to be small in area. While timber production is not excluded as a potential forest use, the environmental sensitivity of many of the areas established and high non-wood benefits generated from these areas suggest that it is unlikely they will produce substantial volumes of timber.

Small-scale forestry involving the establishment of woodlots as an integrated part of farm activities is growing in popularity, although accurate figures on the extent of planting are difficult to obtain. There are also about 42 M ha of native forest under private ownership in Australia (Table 2.1). Most is on leasehold land, with the forests under the control of the Crown. However, some of the more productive native forest is on private land. Logging of these areas is often ad hoc and uncontrolled. The importance of these areas for conservation and as a source of sustainable timber production has recently been recognised by governments, and programs have been developed to improve the management of these forests.

2.4 The Nature and Extent of Small-scale (Farm) Forestry in Australia

The nature of small-scale forestry differs from country to country (see for example Harrison *et al*. 2000) and it is difficult to define what is meant by small-scale forestry. Harrison and Herbohn (2000) have suggested that large-scale forestry is typically owned or managed by government or large companies, and has a focus on large, even-aged, single species blocks, with compartments of varying ages. A primary aim of large-scale forestry is to provide regular volumes of timber over time in a cost-effective manner with minimal labour input, to supply established long-term market contracts. In contrast, small-scale forestry typically consists of a single blocks (or a small number of stands), non-professional management and often a lack of silvicultural skills, with little planning for future marketing.

The term 'farm forestry' is commonly used in Australia, although it's meaning is poorly defined. The common interpretation is simply 'forestry undertaken on farms', which involves small-scale farm woodlots, but may also include windbreaks and shelter belts, agroforestry (in the narrow sense of combining forestry with crops) and break-of-slope plantings. These activities are consistent with the interpretation of small-scale forestry outlined by Harrison and Herbohn (2000). Farm-based forestry may also involve large-scale planting of monocultures under joint venture arrangements, and the leasing of farmland to industrial forestry companies for industrial plantations. These latter activities are more consistent with the definition of large-scale forestry suggested by Harrison and Herbohn (2000).

Preliminary data from the National Farm Forestry Inventory (NFFI) (see Table 2.2) indicates that there are 66,983 ha of small-scale plantations in Australia, most of which are found in the states of Victoria, New South Wales, Western Australia and Tasmania. Queensland, despite highly favourable growing conditions and an abundance of suitable land, has a relatively small area of small-scale plantations. The data reported in Table 2.2 relate to farm forestry plantations established by farmers alone. Specifically excluded from these data are the large number of individual landholders who have entered into farm forestry via joint venture agreements or leasing arrangements with commercial tree grower companies. It is probable that of the order of 20% of Australia's total plantation resource has been established via joint venture arrangements (Stephens 2001). Early analysis of data collected through the NFFI suggests that the size and nature of plantations can vary greatly between regions (Stephens 2001).

It appears that there are two quite distinct farm forestry sectors developing in Australia. The first is based around the growing of *E. globulus* for pulp. Planting of *E. globulus* on farms mirrors recent trends in the large-scale industrial private sector, and the area is greatest in those States where this species is grown in industrial estates, i.e. Victoria, Tasmania and Western Australia. Rotation periods are typically around seven to eight years. Farmers involved in growing *E. globulus* seem typically to be primarily motivated by financial returns. The second distinct type of farm forestry involves the growing of native hardwoods, often in mixed-species configurations, for saw and veneer logs. This type of farm forestry dominates in NSW and is developing in Queensland. Rotation periods are typically 30 to 50 years. A range of motivations has been found for farmers entering into farm forestry (e.g. see Emtage *et al*. 2000). In addition to financial returns, considerations such as conservation, personal satisfaction and farm aesthetics are viewed as being important.

Table 2.2 Small grower plantations in Australia. Source: National Farm Forestry Inventory (2001), Bureau of Rural Sciences

State/ region	Total Area (ha)	Main species planted
VIC	21,086	*Eucalyptus globulus, E. nitens, E. cladocalyx, Pinus radiata*
NSW	7,862	*E. nitens, E. grandis, Corymbia maculata, P. radiata* & cabinet timbers
QLD	3,292	Numerous eucalypt species and cabinet timbers, *P. caribbea*
WA	12,496	*E. globulus, P. radiata, P. pinaster*, mallee species
SA	6,106	*E. globulus* and *P. radiata*
Tasmania	16,100	*E. globulus, E. nitens* & *P. radiata*
NT	44	*E. pellita*, Sandalwood & Acacia sp.
Total*	66,983	

* some rounding errors in totals

2.5 The Forestry Sector in Northern NSW and South-east Queensland

The two areas of interest in the current project closely approximate the Northern Tablelands region and to a lesser extent the South-east Queensland region, as defined in the National Plantation Inventory (NPI).

Forestry in the Northern Tablelands

Wood *et al*. (2001) described the Northern Tablelands as having a total plantation resource of about 16,543 ha, comprising 16,142 ha of softwood species (mostly *Pinus radiata*) and 392 ha of hardwood species. There is limited farm forestry planting in the region, with 15,722 ha (95%) of the plantation estate being industrial plantations and only 821 ha (5%) being farm forestry plantings. In the Northern Region of NSW, which incorporates the Northern Tablelands, forestry contributed 1.5% ($81.4M) of regional output and 2.0% (1,278) of the number of paid jobs in 1993-94. The equivalent shares for agriculture in the region were 19% and 18%, respectively. The economic impact of forestry is far greater on a local scale in some towns (e.g. Walcha, which has the largest hardwood mill in NSW). There are few hardwood plantations, and all hardwood timber is sourced from State Forest and private native forests. A conservative estimate of the sustainable harvest of hardwood on private land in the Region has been set at 250,000 m^3/year. CARE studies suggest that less than 10,000 m^3 of this resource is used for timber production. Consequently, the scope for the sustainable management and harvesting of native hardwood and cypress forests on the Tablelands is large.

The Northern Tablelands/New England Regional Plantation Committee has actively promoted farm forestry; however, there is a lack of markets and processing capacity for farm-produced timber. Landholders in the region do not currently have access to annuity schemes or joint venture arrangements with State Forests of NSW to grow hardwoods on their land, as are available to landholders in some other regions (Wood *et al*. 2001). A recent study by Greening Australia identified the following species as having sound potential: *Corymbia maculata* (Spotted Gum), *Eucalyptus albens* (White Box), *E. melliodora* (Yellow Box), *Casuarina cunninghamiana* (River Oak), *E. sideroxylon* (Mugga Ironwood) and *E. camaldulensis* (River Red Gum).

Forestry in south-east Queensland

State Forests have been a major source of native hardwood timbers in south-east Queensland. However, as noted by Capill (2002, p. 3), ‘half the State native forest used for hardwood timber production is being transferred into the conservation reserve system, as part of the SEQ Forest Agreement, with the remainder to be transferred progressively during the next 25 years’. Hence, in the future there will be increased reliance on plantation forestry, supplemented by a small proportion of the timber native forests on private land.

There are substantial plantation resources in the South-east Queensland NPI region, with a total of 165,451 ha comprised 155,523 ha of softwood species and 9,046 ha of hardwood species (Wood *et al*. 2001). Most of these plantations are located in the coastal strip north of Brisbane. There are currently few plantations on the Darling Downs. In the South-east Queensland NPI region here are 989 ha of farm forestry plantations, comprising less than 1% of the total plantation estate. About 890 ha of farm plantations are hardwoods and over 80% of these are recorded as being mixed species plantings.

In the greater Darling Downs area, there is an estimated 120,000 ha of privately owned native forests, most of which has no previous history of harvesting. With an approximate production of millable timber of 0.3 m^3/ha/yr, an estimated on-farm price of $30/$m^3$, and a regional forest multiplier of 1.75, immediate sustained harvesting could boost the local economy by $1.98 M/yr. In addition, 20,000-30,000 ha has been set aside from agricultural use each year for the last few years, for

conservation and other purposes but only 50-100 ha is used for commercial tree crops in block plantings. There is also growing interest in establishing commercial trees in strip plantings around farm and paddock perimeters. If 5% (a recommended optimal increase by AACM International, 1996) of the 7.9 M ha was set aside for plantation, with a millable return of $5m^3$/yr and at $\$35/m^3$, this would contribute $122.5 M/yr to the regional economy. Perimeter plantings also offer potentially large benefits in northern NSW cropping zone and the central Highlands. Forest process models, such as 3PG (Landsberg and Waring 1997) and ProMod (Battaglia and Sands 1997) provide the means to quantify the commercial viability of yields from such plantings. These models are being refined for application in sub-tropical environments (including SE Queensland) in a related JVAP project, the outcomes of which have contributed to the incorporation of biological growth information within this project.

Wood *et al*. (2001) reported that farm forestry pursuits in the region are promoted via a large network of forest grower groups and that strategic guidance is provided by the South Queensland Forestry Development Association which is developing an action plan to promote plantation development and native forest management. Twenty five private forestry support groups currently exist in Queensland, about 10 of which are in the south-east (Anon 2002).

2.6 Farm Forestry Research

The importance of research in the development of a vibrant farm forestry sector in Australia cannot be overstated. Up until 10 years ago, a relatively scant amount of research had been undertaken. Most research relating to forestry had been focussed on improving the silviculture and performance of industrial conifer plantations, with some research on native forest management. With the decreasing importance of native forest logging, and the substantial increase in the rate of establishment of native hardwood plantations, there has been a corresponding shift in forestry research emphasis towards the genetics and silviculture of native hardwoods. There has also been an increase in farm forestry research, both from a silviculture and socio-economic perspective. This research, while still at a relatively early stage has provided important information that has greatly assisted the development of farm forestry plantings.

There are a number of Commonwealth funded agencies that either undertake farm forestry research or act as funding providers for other organisations to do so. Two notable examples are the Joint Venture Agroforestry Program (JVAP) that draws funds from three separate Commonwealth funding agencies and the Forestry division of AFFA. At least two Cooperative Research Centres (the Rainforest CRC and the CRC for Sustainable Production Forestry) are also undertaking research relevant to farm forestry. Various State agencies have undertaken important farm forestry research. For example, In Queensland, the Queensland Forest Research Institute (QFRI) and the Queensland Department of Natural Resources and Mines (NRM) have undertaken a number of farm forestry studies in such diverse areas as plant breeding, silvicultural systems, management of private native forests and some socio-economic research.

The breadth and extent of recent farm forestry research is indicated by publications which span such diverse studies areas as:

- the identification of suitable areas for farm forestry (e.g. Stephens *et al*. 1998)
- planting systems and trials (e.g. Abel *et al*. 1997, Lamb and Borschmann 1998, Lamb and Keenan 2001)
- integrating biodiversity and farm forestry (e.g. Dames and Moore NRM/FORTECH 1999, Herbohn *et al*. 2000)
- financial models and information systems (e.g. Herbohn *et al*. 1998b,c, Norman *et al*. 2001, Emtage *et al*. 2001b)
- landholder attitudes and extension (e.g. Harrison *et al*. 1994, Herbohn *et al*. 1998a, Black *et al.* 2000, Emtage *et al*. 2000, Emtage *et al*. 2001a)
- markets for farm forestry products (e.g. Smorfitt *et al*. 2002)

- processing timber on farms (e.g. Hanson and Stewart 1997, Smorfitt *et al*. 1999, McCormack *et al*. 2000)
- taxation (e.g. Smorfitt and Berry 1997, Smorfitt *et al*. 2001b)
- various other social aspects of forestry (e.g. Race 2000).

Apart from these completed projects there are a large number of projects currently in process which will provide information to further assist the development of a vibrant farm forestry industry (e.g. RIRDC 2002). There have been a number of recent efforts to ensure dissemination of information relevant to farm foresters (e.g. the market report compiled by U.N. Bhati at ANU) and to more widely disseminate research results (e.g. publishing of conference proceedings by Race 2000, Herbohn *et al*. 2001), and the web-based forestry publications of RIRDC).

It is beyond the scope of this chapter to review all the recent literature on farm forestry. The following sections briefly outline some of the more important farm forestry research that is directly related to the current project.

2.7 Landholders' Attitudes to Farm Forestry

Surveys of landholders have produced useful insights into what are important elements to consider when developing financial models and decision-support systems. Recent surveys of landholders are summarised in Table 2.3.

The key findings of these studies are:
- financial returns from forestry are important but there is little information available, particularly for native hardwoods (excluding *E. globulus*)
- the main reasons for planting trees are 'environmental', although the number of trees planted for this purpose tends to be small and concentrated in non-productive areas of the farm
- the main impediments to greater planting are associated with economic factors
- farmers are interested in the wider benefits of trees, possibly because of poor information on financial returns and the economic impediments.

More detailed discussions of the implications of past studies of landholder attitudes for farm forestry development are presented in subsequent chapters of this report.

Table 2.3 Results of past surveys examining reasons for tree planting, incentives to planting and constraints to tree planting and management

Survey	Reasons for planting	Constraints to planting	Incentives to plant
Schaefer and Sinden (1969)	Only looked at one planting scheme (poplar plantations)	Rotation time 59% Economic doubts 23% Trad. farmland 10% Technical doubts 4% Too much work 4%	-Support for: Annual payment a)equal to present income 63% b)annuity of expected return 44% -Full tech. assist. 8% -Subsidy of % costs 4%
Reid (1987)	Reasons for practicing agroforestry; -liked trees and the idea -diversification of income -sound economic investment -economically efficient way to provide shelter to stock -to produce timber	Disadvantages of agroforestry ; -loss of grazing returns in early years -demand on labour -lack of good information -tree protection from stock and vermin -management skills required	Not examined
Prinsley (1991)	-windbreaks 16.6% -shelter 14.1% -shade 13.8% -soil conservation -salinity control and reclamation -biodiversity -commercial timber Overall 26% had planted, over 50% in Vic. and W.A., less than 10% in N.S.W. and Qld	-economic and financial doubts 60% -technical doubts 14% -competition with agriculture 14% -negative attitude 6% -low priority 5%	Prove the economic advantages and compatibility of integrating forestry with agriculture
Harrison, Sharma and Lamb (1994) Harrison *et al.* (1994)	Most planting for ecological and aesthetic rather than commercial reasons; to protect/restore land, for wildlife, personal interest in trees, farm beautification, watershed protection. Overall, 36% had planted trees	-long wait for returns -high capital needs -high labour demands -concern about harvest regulations -concern about profitability -lack of machinery for tree growing -risk of pests and diseases	Not examined
Stewart and Reid (1994)	Remnant forests good for: -shelter 46% -wildlife 21% -on-farm timber 20% Plantings for:	Problems with commercial wood production; - establishment 15% - management 12% - marketing 12% - cost in time 12%	Not examined

Survey	Reasons for planting	Constraints to planting	Incentives to plant
	-shelter 70% -land protection 55% -timber 35% -wildlife 17% -aesthetics 13%	- harvesting 11% - cost in money 10% - information 9% Note: variation across region	
Lyons and Lambrino (1994)	-diversify farm income -increase capital assets, long term speculation, control of land deg. -shelter for stock/pastures -wildlife habitat and landscape improvement	-lack of compatibility of joint venture schemes with agricultural pursuits, -perception of problems marketing/sales	Better understanding between farmers and industry, in terms of contracts offered and compatibility with agricultural activities.
Mues, Roper and Okerby (1994) Mues *et al*. (1994)	Examined conservation farming practices, -reported 44% of farmers planting in total, mostly for wind breaks/stock shelter, -reported 11% planting for soil conservation, -many plantings said to be multi-purpose	Not surveyed, discusses impacts of economics and financial pressures, behavioural influences/ personal attitudes, impacts of government policies, the role of information etc	Not examined specifically in relation to tree establishment and management
Emtage (1995)	Conservation highest rated reason for planting or managing trees, followed by shelter and timber. Greatest actual number of trees planted for timber, shelter then conservation	Lack of water rated as greatest impediment followed by uncertainty about harvest rights the financial effects of planting and then the size of the landholding and pest risks (time of extreme drought)	Commercial incentives including harvest guarantee rated significantly more useful than joint venture type incentives.
Specht and Emtage (1998)	As above. Landholders grouped according to their ratings of reasons for planting.	Economic constraints (including lack of time and time until harvest) rated highest, followed by production problems such as damage from cattle and lack of equipment	Harvest guarantee rated highest followed by tax incentives, information provision and annuity schemes.
Herbohn *et al*. (1998a)	'Conservation/environmental' protection highest rated reason for planting, then 'personal' reasons and then 'timber'. Landholders grouped according to their ratings of reasons for/restrictions to planting.	In order of descending importance: Economic/structural impediments; Satisfaction with current activities; Information limitations; Resource limitations; Physical risks; Site limitations	In order of descending importance: Economic incentives; Information incentives; Joint venture schemes

2.8 Studies of Financial and Economic Impacts of Farm Forestry

Financial models, typically in the form of a computer spreadsheet, are used to determine the profitability of farm forestry, say in terms of net present value per hectare (e.g. Lourain-Smith 1993, Herbohn *et al*. 1998b). Also, financial models may examine the profitability of forestry within the context of other farm enterprises (Capill 1996). There a number of financial models available to calculate costs and returns associated with farm forestry in Australia, and these are reviewed in Chapter 3. For example, the Australian Cabinet Timbers Financial Model (Herbohn *et al*. 1998b,c) is a spreadsheet-based model developed primarily to predict returns from mixed-species plantations of high-value rainforest cabinet timber (Harrison *et al*. 2001). This Australian Cabinet Timbers Financial Model (ACTFM) uses a series of Visual Basic macros and buttons bars to enhance usability of the model. The model is readily adaptable to areas outside of north Queensland and has been used recently in the Philippines (Venn *et al*. 2001).

Input-output and closed general equilibrium (CGE) models are used by economists to examine the impacts of forestry investment at the regional level. Impact is typically expressed as output, employment and income multipliers. A recent example of such an analysis is the assessment of the potential impacts of a farm forestry industry on the Goulburn regional economy undertaken by Todd *et al*. (1997). As well, employment and output multipliers for the five forestry regions in Queensland are reported by DPI Forestry (1998). Earlier estimates were obtained by the Fraser Island Commission of Inquiry (1991). Typically, each $1M increase in forestry expenditure results in about $1.8M output and income in the region, and about 40 additional jobs. It is well documented that the regional economic flow-ons from forestry are substantial, provided processing and contractor operations are carried out within the region. In cost-benefit terms, the potential net benefits from the management of existing native forest with commercial volumes of extractable timber are positive because there are no establishment costs – only silvicultural costs – and harvesting can begin immediately rather than in 20-30 years time. Past 'high grading' (selective harvesting through removal of only the best and biggest trees) has left many of these native forests in a degraded condition and requiring some investment in improved silviculture and some time before substantial timber production can take place.

The advantage in straight economic terms is that native forest management is not an alternative enterprise competing with other farm activities. For farms with sufficiently large areas of native forest resource, the issue is about converting largely unproductive resource into a productive one. Moreover, in terms of regional employment effects, work by CARE has shown that on a per hectare basis, a well-integrated forestry industry can employ up to 12 times as many people as the beef cattle industry, for the same area of land. On the Northern Tablelands, the basis of such an industry is more likely to be native forest where costs are relatively low compared with plantations of fast growing softwoods.

In addition to market benefits, there will be non-market benefits from the retention of native forest (and from the establishment of plantations) on private land in terms of shelter for stock, biodiversity and habitat value, erosion control and water and nutrient cycling. The current incentive for many landholders is to gradually clear native forest for more traditional agricultural activities. If the native forest resource can be shown to have a commercial value and sound guidelines for its management are applied, this trend may be reversed.

2.9 Estimates of Stand Growth Rates

Only limited information is available about yields of most native timber species, especially for rainforest cabinet timbers (e.g. as established by Russell *et al*. 1993, Herbohn *et al*. 1999). Some progress has been made in biological modelling of timber yields of mixed species plantings in the tropics (Vanclay 1991, 1994). Further work is in progress at the Forest Research Institute at Atherton, using the North Queensland Rainforest Management (NQRM) model (Keenan 1998).

2.10 Efforts to Develop Farm Forestry Decision-Support Systems

Natural resource management decisions, such as those involving farm forestry, are distinguished from single objective problems by the need to consider several, and possible conflicting, criteria in the decision-support process. When trade-offs are required between economic, environmental, social and legislative aspects, it is more appropriate to use a Multi-Objective Decision-Support System (MODSS). Recently, several MODSSs have been developed or adapted within Australia for applications in natural resource management, for example, AEAM (Adaptive Environmental Assessment and Management, Grayson *et al*. 1994) and CMSS (Catchment Management Support System, Davis *et al*. 1991). These systems integrate modelling approaches with stakeholder information to examine the impact of policy and land-use at the catchment scale. From the literature, it appears that both the AEAM and the CMSS systems provide only a limited capacity to include social aspects of resource management. Research work in progress, which will advance decision-making, includes 'Decision support for sustainable management of grazing lands' (J. Bellamy, CSIRO–LWRRDC funding), 'Community participation in improving land use and management' (A. Campbell, University of Melbourne–LWRRDC funding) and 'Decision support systems for sustainable agricultural management and sustainability' (R. Itami, Victorian Department of Natural Resources and Environment). While considerable work has been undertaken to develop and verify indicators of sustainability, there are limited accounts of specific applications of MODSS to identify preferred options in the farm forestry industry. A means of integrating farm forestry economics with biophysical modelling and expert opinions is needed.

Decision-support systems that are generic, capable of considering soil, water, plants, air, animals and human requirements and supported by scientific rigour are needed to successfully support property and regional scale decision-making. The USDA-ARS and the NRM in Queensland jointly developed a MODSS which can integrate a diverse range of decision criteria and utilise measured data, simulation models and expert opinions in the decision-support process (Lane *et al*. 1991, Yakowitz *et al*. 1993, Lawrence *et al*. 1997). In addition, the decision model requires participants to nominate an importance order for the criteria which overcomes the difficult, and largely contentious, issue of assigning numerical weights to decision criteria. The process involves stakeholders at the outset, and becomes highly interactive when exploring 'what-if' scenarios. In 1993, a RIRDC Postgraduate Scholarship provided the opportunity for Paul Lawrence, a member of this project, to work with the USDA-ARS in Arizona. Since that time, NRM has undertaken several studies to assist landholders improve their decision-making using this tool.

2.11 Concluding Comments

The growing of trees is clearly an activity that farmers consider to be part of wider farm activities. The modelling work developed as part of the current project recognised this – directed at both the individual farm level (i.e. the Australian Farm Forestry Financial Model) and at the regional scale (i.e. the farm forestry MODSS). This provides support for the 'whole farm' financial modelling approach adopted in the development of the AFFFM which will allow farmers to investigate the impact of forestry on the overall farm financial operations. It is also clear that an integrated framework to assist planning of farm forestry development on a regional scale would be useful. Such a framework is provided by MODSS that has been developed in the current project.

2.12 References

Abel, N, Baxter, J., Cambell, A., Cleugh, H., Fargher, J., Lambeck, R., Prinsley, R., Prosser, M., Reid, R., Revell, G., Schmidt, C., Stirzacker, R. and Thorburn, P. (1997), *Design principles for farm forestry: a guide to assist farmers to decide where to place trees and farm plantations on farms*. RIRDC, Canberra.

Anon (2002), 'Private Forestry Support Groups in Qld', *Queensland Forest Network News*, Issue 7, May, p. 48.

Alexandra, J. and Hall, M. (1998), *Creating a viable farm forestry industry in Australia: What will it take?* RIRDC Publication No. 98/74, Canberra.

Battaglia, M. & Sands, P. (1997), Modelling the productivity of *Eucalyptus globulus* in response to climatic and site factors, *Australian Journal of Plant Physiology*, 24: 831–850.

Black, A.W., Forge, K. and Frost, F. (2000), *Extension and advisory Strategies for Agroforestry*. A report for the RIRDC/LWRRDC/FWPRDC Joint Venture Agroforestry Program, RIRDC Publication No. 00/184, Canberra.

Capill, L. (1996), 'Adoption of a New Zealand agroforestry evaluation model to a site in south east Queensland', in A. Grodecki, ed., *Managing and Growing Trees on Farms*, Greening Australia Queensland, Brisbane, Volume 2, pp. 399–407.

Capill, L. (2002), 'Trends in Private Forestry in Queensland', *Queensland Forest Network News*, Issue 7, May, p. 3, 6, 28.

Commonwealth of Australia (1992), *National Forest Policy Statement: a New Focus for Australia's Forests*, Canberra.

Dames and Moore NRM/FORTECH (1999), Integrating Farm Forestry and Biodiversity. RIRDC Publication No. 99/166, Canberra.

Davis, J.R., Nanninga, P.M., Biggins, J. and Laut, P. (1991), Prototype decision support system for analyzing impact of catchment policies, *J.Water Resources Planning and Management*, 117: 399-414.

DPI Forestry (1998), *An Overview of the Queensland Forest Industry*, Queensland Department of Primary Industries, Brisbane.

Emtage, N. (1995) *Landholders' Perceptions of Planting and Managing Trees*, B.App.Sci. Hons. Thesis, Southern Cross University, Lismore.

Emtage, N.F. and Specht, A. (1998), 'Landholders' perceptions of farm forestry in the northern rivers region of New South Wales', in R. Dyason, L. Dyason and R. Garsden eds., *Plantations and Regrowth Forestry: a Diversity of Opportunities*, Proceedings of the biennial conference of the Australian Forest Growers, Southern Cross University, Lismore, pp. 345–369.

Emtage, N.F., Harrison, S.R. and Herbohn, J.L. (2001a), 'Landholder attitudes to and participation in farm forestry activities in sub-tropical and tropical eastern Australia', in S.R. Harrison and J.L. Herbohn, eds., *Tropical Small-scale Forestry*, Edward Elgar, Cheltenham, pp. 195–210.

Emtage, N.R., Herbohn, J.L., Harrison, S.R. and Thompson, D. (2001b), *The Australian Farm Forestry Financial Model (Visual Basic Version)*, School of Natural and Rural Systems Management, The University of Queensland, Brisbane.

Emtage, N.F., J.L. Herbohn and S.R. Harrison (2000), '*Using Segmentation Analysis to Understand Landholders Attitudes to Farm Forestry in Australia'*, proceedings of the *10th World Congress of Rural Sociology*, held in Rio de Janerio July-August 2000, International Rural Sociology Association.

Fraser Island Inquiry (Commission of Inquiry into the Conservation, Management and Use of Fraser Island and the Great Sandy Region) (1991), Appendices, Volume 1, Goprint, Brisbane.

Grayson, R.B., Doolan, J.M. and Blake, T. (1994), *Application of AEAM (Adaptive Environmental Assessment and Management) to water quality in the Latrobe River Catchment*, Environmental Management 41(3): 245–258.

Hansen, I. and Stewart, M. (1997), *Processing trees on farms: A literature review for the Rural Industries Research and Development Corporation*, RIRDC Report 97/20, Canberra.

Harrison, S.R., Sharma, P.C. and Lamb, D. (1994), *Progress in farm forestry in the Obi Obi Valley*. Paper presented to the Farm and Community Forestry Seminar, Dorroughby Field Studies Centre, NSW.

Harrison, S.R., Herbohn, J.L. and Herbohn, K.F. (2000), *Sustainable Small-scale Forestry: Social and Economic Analysis and Policy*, Edward Elgar, Cheltenham, p. 247.

Harrison, S.R. and Herbohn, J.L. (2000), 'The role of small-scale forestry throughout the world', in S.R. Harrison, J.L. Herbohn and K.F. Herbohn, eds., *Sustainable Small-scale Forestry: Social and Economic Analysis and Policy*, Edward Elgar, Cheltenham, pp. 3–13.

Harrison, S.R., Herbohn, J.L. and Emtage, N.F. (2001), 'Estimating investment risk in small-scale plantations of rainforest cabinet timbers and eucalypts', in S.R. Harrison and J.L. Herbohn, eds., *Sustainable Farm Forestry in the Tropics: Social and Economic Analysis and Policy*, Edward Elgar, Cheltenham, pp. 47–60.

Herbohn, J.L., Harrison, S.R., Emtage, N. and Smorfitt, D.B. (1998a), Attitudes of landholders to farm forestry in North Queensland and the implications for policy development, *Integrating Environmental Values into Small Scale Forestry*, IUFRO Symposium, Vancouver, Canada, 16-20 August 1998.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1998b), *Australian Cabinet Timber Financial Model, Computer software based on Microsoft Excel*, James Cook University, Townsville.

Herbohn, J.L., Harrison, S.R., Emtage, N. and Smorfitt, D.B. (1998c), The Australian Cabinet Timber Financial Model: A model for mixed species cabinet timber plantations in North Queensland, *Proceedings from the Managing and Growing Trees Training Conference, October* 1998, Vol. 2 pp. 397–406.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1999), 'Potential performance of rainforest and eucalypt cabinet timber species in plantations in North Queensland', *Australian Forestry*, 62(1): 79–87.

Herbohn, J.L., Harrison, S.R., Lamb, D. and Keenan, R. (2000), Small-scale Forestry Systems for Timber and Non-timber Benefits including Biodiversity, in S.R. Harrison, J.L. Herbohn and K.F. Herbohn, eds., *Sustainable Small-scale Forestry*, Edward Elgar, Cheltenham, pp. 14–25.

Keenan, R. (1998), Forest Research Institute, Atherton, personal communication.

Lamb, D. and Borschmann, G. (1998), *Agroforestry with high value trees*, RIRDC Publication 98/142, Canberra.

Lamb, D. and Keenan, R.J. (2001), Silvicultural research and development of new plantation systems using rainforest tree species in north Queensland. in S.R. Harrison and J.L. Herbohn, *Tropical Small-scale Forestry*, Edward Elgar, Cheltenham, pp. 21–38.

Lane, L.J., Ascough, J.C. and Hakonson, T.E. (1991), *Multiobjective decision theory – decision support systems with embedded simulation models*, Irrig. and Drainage Proc., IR Div., American Society for Civil Engineering, Honolulu, July 22–26, pp. 445–451.

Landsberg, J. J. and Waring, R. H. (1997), 'A generalised model of forest productivity using simplified concepts of radiation-use efficiency, carbon balance and partitioning', *Forest Ecology and Management*, 95: 209–228.

Lawrence, P.A., Stone, J.J., Heilman, P. and Lane, L.J. (1997), 'Using measured data and expert opinion in a multiple objective decision support system for semiarid rangelands', *American Society for Agricultural Enginering*, 40(6): 1589–1597

Lourain-Smith, R. (1993), 'Modelling mixtures of species', in *Computers in Forestry: Use of Spreadsheets*, Wiley, New York, Ch. 7

Lyons, A. and Lambrino, M. (1994), *Survey on commercial tree growing information*, Department of Conservation and Natural Resources, Melbourne.

McCormack, B., Kerruish, B., Reid, J., Antilla, E. and Stewart, M. (2000), *Harvesting trees on farms*, RIRDC Report No. 00/46, Canberra.

Marriott, S., Nabben, T., Polkinghorne, L. and Youl, R. (2000), Landcare in Australia: Founded on local action, *International Landcare Conference*, Melbourne, Australia, February.

Mues, C., Roper, H., and Okerby, J. (1994) *Survey of Landcare and land management practices: 1992–93*, ABARE Research Report 94.6, Canberra.

National Forest Inventory (1998), *Australia's State of Forests Report 1998*, Bureau of Rural Sciences, Canberra.

National Farm Forest Inventory (2001), Bureau of Rural Sciences, Canberra.

NPI (2000), National Plantation Inventory, *National Plantation Inventory Tabular Report* – March 2000. Bureau of Rural Sciences, Canberra.

Norman, P., Cockfield, G., Emtage, N., Harrison, S.R., Herbohn, J.L., Lawrence, P., Thompson, D. and Williams, K. (2001), Trees and cows, cash and conservation: A whole farm and regional agroforestry decision making system, in *Developing Policies to Encourage Small-scale Forestry*, J.L. Hebohn, S.R. Harrison, K.F. Herbohn and D.B. Smorfitt, eds., Proceedings of the IUFRO Research Group 3.08 Symposium, Cairns, Australia. 9–13 January, 2000, pp. 201–211.

O'Regan, M. and Bhati, U.N. (1991), *Pricing and allocation of logs in Australia*, Discussion Paper 91.7, Australian Bureau of Agricultural and Resource Economics, Canberra.

Plantations 2020 Vision Implementation Committee (1997), *Plantations for Australia: The 2020 Vision*, Ministerial Council on Forestry, Fisheries and Agriculture, Standing Committee on Forestry, Plantations Australia, Australian Forest Growers and National Association of Forest Industries, Canberra.

Prinsley, R.T. (1991), *Australian Agroforestry – setting the scene for further research*, Rural Industries Research and Development Council, Canberra.

Race, D. ed. (2000), *Socio-economic research to support successful farm forestry: Selected papers from the ANU Forestry Colloquium*, RIRDC Report No. 01/13, Canberra.

Reid, R. (1987), '*Agroforestry: a study of agroforestry extension and a model of light interception in agroforestry*', Masters thesis, Melbourne University School of Forestry, Melbourne.

RIRDC (2001), http://www.rirdc.gov.au/programs/aft.html#newprojs, accessed 8 July, 2002.

Russell, J.S., Cameron, D.M., Whan, I.F., Beech, D.F., Prestwidge, D.B., and Rance, S.J. (1993), 'Rainforest Trees as a New Crop for Australia', *Forest Ecology and Management*, 60: 41–58.

Sinden, J.A. and Schaefer, N.T. (1969), *Farmer attitudes to farm forestry on the north coast of New South Wales*, Department of University Extension, University of New England, Armidale.

Smorfitt, D. B. and Berry, M. L. (1997), 'A review of the capital gains tax treatment of the disposal of existing trees by landholders', *Australian Forestry*, 60 (4): 213–217.

Smorfitt, D.B., Herbohn, J.L. and Harrison, S.R. (1999), 'Factors in the acquisition and utilisation of portable sawmills in Queensland', *Australian Forestry*, 62(1): 45–50.

Smorfitt, D.B., Herbohn, J.L. and Harrison, S.R. (2001a), 'Australian Rainforest Timbers as a Valuable Resource: Community Perceptions and Purchase Habits of Rainforest Timber Products', *Economic Analysis and Policy*, 31(2): 161–173.

Smorfitt, D.B., Berry, M.L., Cummine, A.J. and Townsend, P.V. (2001b), 'Taxation in the forestry setting', in S.R. Harrison and J.L. Herbohn, eds., *Tropical Small-scale Forestry*, Edward Elgar, Cheltenham, pp. 179–194.

Smorfitt, D.B., Herbohn, J.L. and Harrison, S.R. (2002), 'Cabinet-Makers' Awareness and Usage of Rainforest Cabinet Timbers in Queensland', *Small-scale Forest Economics, Management and Policy* 1(1): 103–117.

Specht, A. and Emtage, N.F. (1998), *Landholders' perceptions of farm forestry in the Northern Rivers region of New South Wales*, Report to the Northern Rivers Regional Plantation Committee, Ballina, NSW.

Stephens, N., Sun, D. and Tickle, P. (1998), *Plantation Potential Studies in Australia: an Assessment of Current Status*, Bureau of Rural Sciences, Canberra.

Stephens, N. (2001), Project Manager, National Farm Forestry Inventory, personal communication.

Stewart, A. and Reid, R. (1994), The design and development of agroforestry and farm forestry options to match farmer needs in the Otway ranges, proceedings *Australian Forest Growers conference (1994) Faces of Farm Forestry*, Launceston, Tasmania.

Todd, C.R., Loane, I.T. and Ferguson, I.S. (1997), *Potential impact of a farm forestry industry on the Goldburn regional economy*, School of Forestry and Resource Conservation, Bulletin No.10 University of Melbourne.

Vanclay, J.K. (1991), *Modelling the Growth and Yield of Tropical Forests*, D.Sc.For. thesis, The University of Queensland, Brisbane.

Vanclay, J.K. (1994), *Modelling Forest Growth and Yield: Applications to Mixed Tropical Forests*, CAB International, Wallingford, UK.

Venn, T.J., Harrison, S.R. and Herbohn, J.L. (2001), 'Relative financial performance of Australian and traditional timber species in the Philippines', in S.R. Harrison and J.L Herbohn, eds., *Socio-economic Evaluation of the Potential for Australian Tree Species in the Philippines*, ACIAR Monograph 75, pp. 93–110.

Vise, S.M. and Creighton, C. (2001), 'Institutional impediments to farm forestry', in S.R. Harrison and J.L. Herbohn, eds., *Tropical Small-scale Forestry*, Edward Elgar, Cheltenham, pp. 241–256.
Wood, M.S., Stephens, N.C., Allison, B.K. and Howell, C.I. (2001), *Plantations of Australia – A report from the National Plantation Inventory and the National Farm Forestry Inventory*, National Forestry Inventory, Bureau of Rural Sciences, Canberra.
Yakowitz, D.S., Lane, L.J. and Szidarovszky, F. (1993), 'Multi-attribute decision making: dominance with respect to an importance order of the attributes', *Applied Math. and Comput*., 54: 167–181.

3. Development of Farm Forestry Financial Models in Australia

J. Herbohn, D. Thompson and S. Harrison

An integral component of planning investment in forestry is the need for financial information about the likely cash flows associated with the establishment, management and final harvest of a plantation. Financial models provide a useful framework for the assessment of financial performance of forestry. A number of generic forestry financial models have been developed in recent years in Australia and New Zealand. A financial model is a tool that aids in the assessment of forestry projects, providing the means through which financial performance measures such as net present value (NPV), land expectation value (LEV) and internal rate of return (IRR) are calculated. Outputs of financial models should however be interpreted with caution. The usefulness and accuracy of these output parameters are much dependent on the accuracy of information provided by model users. The chapter provides some background to the development of financial models for farm forestry and reviews a range of models that are currently available in Australia.

3.1 Introduction

An assessment of the potential financial performance of farm forestry is important for decision-support. Financial models provide a mechanism through which this type of assessment can be made. Financial models may be useful to landholders who often require this information when they are considering incorporating farm forestry into their farm activities. Financial models can also be useful for government forestry extension staff and private consultants wishing to promote farm forestry as a land-use option. Such models are also useful for local governments to demonstrate the potential economic significance of small-scale forestry, especially when the returns are aggregated on a regional basis. This is particularly important in lobbying various levels of government to provide financial and policy support for reforestation. Financial models are also important tools that may assist in valuation of land and in the resolution of property disputes. Financial models also may provide important input in the design, implementation and monitoring of joint venture arrangements between farmers and either government or private sector investors.

The following sections review appropriate approaches to financial analysis of farm forestry. Estimation of timber yields is then examined. Growth data collected using a Delphi survey approach for rainforest and eucalyptus species planted under the Community Rainforest Reforestation Program (CRRP) scheme are then reported and discussed. The need to consider other factors such as markets and non-wood benefits of plantations when undertaking a financial analysis is also examined

3.2 Key Parameters for Forestry Models

The cash outflows associated with forestry operations typically include: establishment costs (e.g. land and site preparation such as clearing, fencing and ripping, purchase of planting stock, planting, mulching and watering), weed control, fertilization, pruning and thinning to waste, and commercial harvesting. The major cash inflows come from sale of commercial thinnings and final harvest, and perhaps tree residues such as firewood. In some situations revenues are also derived from non-wood forest products such as wild berries, mushrooms, honey and hunting, all of which are made possible by the environment created by the forest.

Cash flow estimates of growing native timbers as a business enterprise will vary depending on a variety of factors, some of the more important of which are listed in Table 3.1. In principle, a spreadsheet could be devised which incorporates each of these factors. One factor that can have a major impact on eventual cash flows is timber yield from plantations. Yield is commonly expressed

as ‘mean annual increment’ (MAI) which is the aggregate volume of harvestable timber produced per year from the growth of trees in a plantation. It is usually expressed as cubic metres of timber produced per hectare per year. Factors such as site productivity, species mixture, silvicultural system and harvest ages will determine the MAI. Another parameter which has a critical impact on financial performance is timber price (usually expressed as $\$/m^3$). Factors in the regulatory environment such as forestry codes of practice and taxation regime also affect cash flows.

Table 3.1 Key factors in financial performance

Site characteristics (e.g. climate, soil, aspect)
Species mixture
Silvicultural system (e.g. planting density, weed control and pruning)
Harvest age and harvest scheduling
Interactions between species in mixed-species plantations
Final yield or MAI of individual species
Stumpage price (affected by a number of supply and demand factors)
Costs (land preparation, planting and establishment, maintenance, harvesting)
Amount of government assistance
Harvest rights (buffer zones, harvest on steep land, roading permission)
Taxation regime (deductions allowable, treatment of harvest revenue)
Allowance for non-wood benefits
Discount rate

3.3 Key Measures of Financial Performance

There are a number of financial or economic criteria by which the financial performance of a project may be measured. The most common and conceptually sound measure is that of net present value (NPV). However in cases where projects of different lifespans are being compared, such as plantations with difference rotation length, land expectation value (LEV) is more appropriate. Although conceptually inferior, the internal rate of rate of return (IRR) is also often used, providing a relative measure of rate of return on investment.

The net present value of a project is calculated by subtracting the present value of the capital outlays and operating costs from the present value of the cash inflows. If the capital outlay occurs only at the beginning of the first period (year) of the analysis, then it is already a present value and does not require discounting.

When mutually exclusive projects have different lives, NPV cannot be used directly to compare the projects. In such cases it is appropriate to calculate the LEV, which is simply the NPV of an infinite series of identical projects or forestry rotations. LEV is particularly useful to compare forestry projects of differing rotation lengths (the period from planting to harvest), which in effect is the net present value of an infinite sequence of identical timber rotations (with the assumption of replanting immediately after harvest). The LEV will be considerably higher than the NPV for short rotations, but for long rotations will differ little from the NPV.

The internal rate of return is the discount rate, *r*, at which the NPV will be equal to zero. In project evaluation, analysts often erroneously base the decision to accept or reject a project by specifying a required IRR (often taken as the cost of capital) for the project to be acceptable. It is beyond the scope of the current chapter to provide a detailed outline and critique of the calculation and application of the key measures of financial performance. Such coverage can be found in any good business finance text, such as Brealey *et al*. (2000) and Dayananda *et al*. (2002).

3.4 Discount Rates and Inflation

There is often confusion over how to deal with a number of key aspects in the financial assessment of farm forestry. The two most common areas are the choice of the discount rate and how to deal with inflation. The confusion is not limited to those in the forestry sector but rather is shared in the appraisal of all long-term capital projects. It is beyond the scope of the current chapter to deal with the theory and practicalities of project appraisal and capital budgeting. Those wishing more detailed coverage are referred to the two books mentioned above. The following discussion is based on the capital budgeting text by Dayananda *et al*. (2002), of which two of the authors (Harrison and Herbohn) are also coauthors of the current chapter.

Choosing the appropriate discount rate

The discount rate used in financial analysis is often the factor that most influences the estimated NPV or LEV, especially projects such as forestry with a long planning horizon. It is also the element of financial appraisal of forestry investments that is the least understood and the greatest source of error and inappropriate application. The risk-adjusted discount rate (k) consists of three additive components:

$$k \qquad r + u + a$$

where r is the risk free rate, u is the average risk premium for the firm and a is an additional risk factor to account for the difference in the risk between that faced by the firm and that of the proposed project.

The risk-adjusted discount rate k is commonly estimated based on the cost of capital. In simple terms this involves estimating the weighted average cost of financing the project. For example, if a plantation is to be financed entirely by a bank loan, then the cost of capital would be the effective after-tax interest rate charged by the bank. If the plantation is to be financed from a combination of sources (e.g. a combination of debt and cash or equity contributions by the farmer), then the cost of capital is the after-tax weighted average of these. Another way to estimate the risk-adjusted discount rate is to use the Capital Asset Pricing Model (not elaborated upon here).

How to deal with inflation in evaluation of forestry projects

Inflation will have an effect on the expected cash flows of the project. Both cash inflows and outflows could be affected by inflation. Market rates, such as interest rates and equity returns, in general will also rise when the expected inflation rate is high. As the market rate rises, the required rate of return by investors will also rise. To deal with inflation appropriately, the project analysis must recognize expected inflation in the forecast of future cash flows and use a discount rate that reflects investors' expectations of future inflation.

If all cash flows as well as the discount rate are equally affected by expected inflation, the NPV is the same whether the inflation is included or excluded. However, most projects will consist of a multitude of cash flows over a number of years and it would be erroneous to assume that prices associated with all of these cash flows would increase at exactly the same rate each year. Some cash flows are unaffected by inflation while other cash flows are affected by varying degrees by inflation.

An outstanding example of the differential impact of inflation on a project's cash flow is the depreciation tax shield. Tax-allowable depreciation is totally unaffected by inflation. Depreciation tax shields are calculated on the basis of historical costs of the assets at the time of their acquisitions. Similarly, a long-term supply contract at a fixed price may lock in the present prices.

Given the differential impact of inflation on different cash flow components, cash flow forecasts in *nominal* terms – incorporating the inflationary effect – have an advantage over cash flow forecasts in *real* terms – excluding the inflationary effects. That is, nominal cash flow forecasts can incorporate potentially different inflationary trends in selling price, labour, material costs and so on, into cash flow estimates by applying different inflation rates for different components of the cash flow.

The required rate of return used for discounting cash flows is normally derived from observed market rates such as interest rates and return on equity. These observed market rates usually have the expected annual inflation rates built in and are usually quoted in *nominal* terms (as opposed to *real* terms).

Observed market rates expressed in nominal terms can, if necessary, be converted into their real terms using the algebraic relationship expressed in the Fisher equation, which states:

$$(1+ n) \qquad (1 + r)\,(1+ p)$$

where n the annual nominal interest rate (expressed as a decimal value)
r the annual real interest rate (expressed as a decimal value)
p the expected annual inflation rate

From the above equation the real interest rate can be easily derived, as

$$r = \frac{(1 + n)}{(1 + p)} - 1$$

Consistency in the discounted cash flow analysis requires that if the project cash flows are specified in nominal terms then they should be discounted by nominal discount rates, and if the project cash flows are in real terms they must be discounted by real discount rates. Real and nominal quantities cannot be mixed and matched.

The interest rate used for discounting cash flows is normally derived from observed market rates. In an efficient financial market, investors' required rate of return will include a component $(1+p)$ to compensate for expected inflation. The use of observed market-required rates then implies that for consistency inflation should be incorporated into cash flows.

If real cash flows are appropriate in the analysis then the real interest rate (i.e. rate net of the effects of inflation) must be used. In such situations, the real discount rate can be calculated from market (nominal) rates using the Fisher equation presented above.

3.5 Sources of Variability in Forestry Investment Performance

Plantation forestry is not a risk-free investment. A variety of factors can contribute to the uncertainly in revenue generated. Most revenue from plantations occur with the final harvest of trees when they reach maturity, although some cash inflows may be generated from the sale of trees that are thinned as part of the normal management practices. Typically it takes 30 or more years until plantations are ready for final harvest as sawlogs, hence long-term predictions of physical and financial performance have to be made. The main sources of variability in financial performance of forestry are summarised in Table 3.2.

Table 3.2 Sources of risk in farm forestry

Risk category	Major sources
Risk of poor establishment	Dry weather, poor weed control
Production (timber yield) risk	Storm or cyclone Fire Pest (insect, disease) Unsuitable species or mixture for the site Collateral damage at harvest
Timber quality and product type risk	Inappropriate pruning and thinning regime Insect damage Product type and fashion changes in demand
Sovereign risk	Regulatory changes re machinery use and roading Changes in taxation arrangements Uncertain harvest rights and compensation
Market risk	Uncertain future timber prices

A variety of sources of risk arise with respect to timber quantity, quality and price. Landholders often have little information about likely plantation performance and payoff. This is particularly the case when growing species which have not been widely used in industrial forestry, and for which little 'growth curve' data are available. In Australia, most industrial forestry relies on exotic conifers, and there is little information available about growth rates of native tree species, yet these species are increasingly being favoured by growers and markets. One native conifer species, which is widely grown in plantations in Queensland, is Hoop Pine (*Araucaria cunninghamii*) but this species is limited to favourable sites in terms of soil fertility and climate.

Some opportunity exists to minimize these risks. While plantation insurance is not normally taken out, the relatively non-perishable nature of the product allows harvesting to be timed when timber prices are relatively high. Also, forestry may be conducted as a risk-reducing business diversification, with harvesting when other income is low. In fact, forestry is sometimes viewed as a form of superannuation or savings, with harvest when there is a particular need for cash, say to assist in intergenerational property transfer or to buy out the equity shares of siblings.

3.6 Methods of Allowing for Risk in Evaluation of Forestry Investments

It is typical of projects spanning a number of years into the future that costs and benefits (and in particular the latter) are estimated subject to a high degree of uncertainty. That is, the cash flow estimates are simply best-guess point values arising from (unknown) probability distributions of random cost and benefit variables. This is certainly the case with forestry investments. Some of the methods used to deal with investment risk in forestry are now outlined.

Taking conservative benefit estimates. This is probably the simplest and most widely adopted method of allowing for risk in forestry projects. However, benefits tend to be adjusted in a rather arbitrary manner, and the approach provides little information to the decision-maker about the extent of risk faced. The emphasis is on protection against 'downside risk', and no recognition is given of the possibility of payoffs above the single-point estimates. As a result, projects which are financially sound could easily be rejected.

Requiring a short payback period. Sometimes projects are favoured because they lead to recovery of expenditure in relatively short period. The payback period in forestry is usually the number of years from plantation development to clearfell (i.e. when all remaining mature trees are harvested at the same time), since thinnings (even the later commercial thinnings) cannot be expected to recover plantation establishment costs. Favouring a short payback period usually means adopting short-

rotation species or systems such as production of pulpwood from eucalypts with harvest after about seven to 10 years. A shortened payback period means that there is less uncertainty about whether a market will exist for the timber harvested and associated with this the stumpage price which is more predictable.

Including a risk margin in the discount rate. Earlier, the risk-adjusted discount rate *k* was expressed in terms of three components – i.e. *k* $r + u + a$ – where *r* is the risk free rate, *u* is the average risk premium for the firm and *a* is an additional risk factor to account for the difference in the risk between that faced by the firm and that of the proposed project. Adjusting '*a*' to reflect the additional riskiness of forestry would result in an appropriate risk-adjusted discount rate commensurate with the risk of this investment is employed.

Sensitivity analysis. The approach can be employed to identify the most critical sources of investment risk for forestry projects. A project performance criterion such as NPV is derived for several levels of each of the uncertain parameters. Timber yield (MAI multiplied by rotation length) at a nominated harvest age, and timber price, are frequently subjected to sensitivity analysis. Several levels may be specified for parameters defined for a number of product lines from the same plantation, e.g. thinnings and final harvest, or poles, peelers (high quality logs used to produce veneer) and sawlogs. It is also usual to test sensitivity with respect to the discount rate, or alternatively to plot the NPV profile with respect to discount rate.

Risk or venture analysis. This is sometimes carried out to provide an overall estimate of project risk, compared with sensitivity analysis which is usually designed to estimates risk with respect to one variable at a time (e.g. see Harrison *et al*. 2001). This technique provides an estimate of the probability that a plantation will be profitable (positive NPV or required rate of return achieved), which can be particularly useful information for decision-makers. Commonly, Monte Carlo simulations are used here.

3.7 Decisions Faced in Developing Financial Models

There are numerous problems that may be encountered in developing financial models for assessing forestry investments. These problems usually arise out of the nature of the forestry – a long investment period over which world wood prices are likely to fluctuate, combined with the multiple-use nature of forests and how forestry interacts with other ventures in a diversified firm.

Forestry is a long-term activity. Typically it takes 20 to 30 years for pine plantations to mature in temperate countries such as Australia and New Zealand. In Europe, rotations are typically 50 to 80 years for pines and up to 200 years for broadleaf species such as English Oak. At the opposite end of the scale are some fast growing hardwoods that can be harvested after only eight to 10 years in some tropical countries. The long investment period typical of forestry projects provides a number of challenges when developing financial models. In particular, wood prices are likely to fluctuate over the rotation period and the price that will be obtained for timber when it is harvested is highly uncertain. The problems with forecasting wood prices thus pose a challenge in when estimating cash flows as part of the financial modelling process. Timber prices may increase over time in real terms, i.e. the price increase may be greater than the rate of inflation. For example, an annual increase in the real price of timber of 1.3% was assumed by Russell *et al*. (1993). Furthermore, there is risk that technological change or fashion change could result in weak demand for some timber types (e.g. satellite communications reducing demand for poles for phonelines, consumer preferences' for wood colour changing over time). Regulatory change in response to changing community attitudes could increase costs and restrict areas which can be harvested.

The long time required for trees to grow also means that there is sometimes a lack of biological growth data that can be used to predict growth rates (and hence timber yield). Timber yield and harvest timing are critical variables in forestry financial models. The lack of such data is most critical when new (non-traditional) species are being used in plantations for which there are no past history

of cultivation. The Delphi and other group forecasting methods can be used to develop estimates of growth and harvest ages which can be used in financial models.

The multiple-use nature of forests has also been recognized in the management of large industrial and government plantation estates. These management practices can have direct impact on the financial performance of the investment and thus should be considered in the appraisal process. For example, in Finland, when a plantation estate is harvested, a number of habitat trees must be retained. Similarly, when harvesting native forest in Queensland, there is a requirement to retain approximately six habitat trees per hectare. The failure to harvest these trees directly reduces cash inflows to the investor. Similarly in the United Kingdom, there is recognition that native Scots Pine and native broadleaf species provide greater non-timber benefits than the exotic Sitka Spruce. The result has been the harvesting of Sitka Spruce plantations earlier than their optimal rotation age and their subsequent replacement with plantations of Scots Pine and broadleaf species. In many countries there are also large incentives provided to establish plantations, ranging from tax incentives to direct cash payments. Where incentives exist, these also need to be incorporated in any appraisal from a landholder's perspective (though not from a social perspective).

As with any appraisal of a capital project, it is necessary to gain an understanding of the social environment in which the project is being undertaken. In the case of a forestry investment, the way in which a forest is managed, and the ultimate quantity of timber which can be harvested, can be greatly affected by the increasing need for forests to be managed for multiple uses.

3.8 Forestry Financial Models and Decision-Support Systems in Australia

While one-off models can be developed to evaluate individual forestry projects, the nature of the cash outflows and inflows has much in common between forestry projects, giving rise to the opportunity to develop a *generic model* which can be used to evaluate a variety of separate investment projects by a variety of users. Generic models are often large and complex, and involve considerable development effort. A generic model has some important advantages over a one-off model for investment areas where projects with a number of similar features repeatedly arise. Development costs can be spread over many applications or users. Greater expertise can be brought be bear in the design, development and testing of the models, and it is often possible to include a greater range of features or capabilities in the model. These generic models are often decision-support systems (DSS).

When designing and developing a generic model that acts as a decision-support system, a number of important questions need to be addressed: What is the model to be used for? Who is going to use the model? How is it to be used? What are the most appropriate design features? How will the model be tested for validity and user friendliness? Who will be responsible for making changes in the future to the model to accommodate unanticipated or novel applications? Who will be responsible for handling user inquiries and training?

The following sections provide a discussion on decision-support systems (DSS) in general and a brief overview of some forestry financial models currently available in Australia and New Zealand, and outlines the rationale and process leading to the final structure of the particular financial model developed in this study, viz. the Australian Farm Forestry Financial Model (AFFFM).

In general terms, it is fair to say that models and decision-support systems for both agriculture and forestry in Australia have had a chequered history. Numerous models have been developed but few are widely adopted by decision-makers. Their use has been confined to research purposes, though some are used by advisory staff or consultants to assist in decision-support. There are several reasons for poor adoption as well as a number of issues which need to be considered in developing farm forestry financial models. These will dictate the final form of the model.

Identify the target audience. Identifying key users is often overlooked in the development of models and decision-support systems. Often, the model builder knows what their skills are, has some preconceived ideas about what the model should look like, but has no input from end users. Sometimes, it is not even clear who the end users are. The result can be a model that lacks the key information and functionality users seek and is too complex for them to use. There is a tendency amongst model builders to attempt to design a product that is 'all things to all people'. The model may end up being 'nothing to anybody', being so complex that only the model builder can use it.

Model scope. The boundaries of the model are often poorly defined, leading to models which do not fit user needs. To some extent, these boundaries will be defined by feedback from the target audience regarding which elements of the farm forestry system about which they require information.

Economic modelling in farm forestry can range from:

- a cost-effectiveness approach (e.g. the least cost way to alleviate an environmental problem on-farm through tree planting)
- private cost-benefit analysis (on-farm financial analysis)
- social cost-benefit analysis (includes both private and public on and off-farm costs and benefits associated with farm forestry).

Within these approaches, the model may also be deterministic or stochastic in nature, may be an optimising model, a whole-farm model or just focussed on the forestry enterprise, and may cater for a range of farm forestry layouts (e.g. plantations, native forests, shelter-belts, conservation plantings).

A major problem in defining model scope is that users may not know what information they need. In other words, they do not know what financial analysis is possible, so are unable to make informed decisions about what should be included in the scope of the model. Again, this highlights the importance of making potential users aware of the scope of alternative models which might be developed. Model scope ultimately impacts on the user interface design and, as discussed below, the user interface can be critical to adoption.

Farmer incentives. A key objective in model building is to assist farmers with the farm forestry investment decision. In many areas of Australia, the private commercial returns (incentives) alone from forestry are insufficient to stimulate investment. For this reason, consideration might be given to the inclusion of an environmental module. This could include both internal (i.e. on-farm) and external (i.e. off-farm) benefits. Issues such as environmental credits could be catered for in this module. It is important to remember that many private investors are only interested in the total return from their forestry investment – it does not matter if the return comes from timber, environmental credits or a mixture of both.

Alternative investment vehicles. Farmers can become involved in farm forestry via a number of options including DIY (do-it-yourself), leasing land to someone else, joint venture arrangements with annuities or cost and revenue sharing. These options may need to be included in the model.

Modular construction. One way of tackling the model scope issue and to appeal to a wider target audience may be to develop a series of linked modules which handle different elements of the decision-support process (e.g. farm forestry enterprise alone, whole-farm module, environmental credits module, on-farm sawn timber module, tree growth and timber products module, taxation module, financing module, and results/graphics module). These modules could be run stand-alone, but would also have the ability to pass information to each other for collation and presentation in a results module. This gives the user the option of increasing levels of complexity – they can halt their analysis at the stage which most suits their purpose or skill level. Modular construction will have implications for the user interface. Users will need a straightforward method of moving between and linking the modules to generate the desired model output.

Updating data. The data required to run these models (e.g. costs, prices, input-output relationships) changes regularly. A system is required whereby these data can easily be updated without the need to completely re-engineer the basic generic framework.

The user interface and software maintenance. User interfaces are notorious for poor design. One of the reasons for this is that those people with 'modelling expertise' do not have software development expertise. Many models do not conform to software engineering standards in terms of the user interface and the investment in user interfaces is too low relative to investment in the 'number crunching' capacity of the model. So what one ends up with is a clever and detailed model that is too difficult to use. Lack of interaction with the target audience also plays a role here because if affects the level of user interface complexity which is feasible.

A further issue with farm forestry is that the operating environment is changing rapidly. New investment options and markets emerge regularly and most models would need major re-engineering to cater for this. Because the majority of generic forestry models available have been developed using government funding with a set timeframe, these models quickly become obsolete unless they are well maintained.

Delivery mechanisms and support. Most of the farm forestry models developed in Australia and New Zealand are not commercial software and are freely available (Agroforestry Estate Model or AEM being the exception). The option to download models from the Internet (e.g. available for Agroforestry Calculator) has dramatically improved their accessibility although one would suspect their use is still not widespread. This may be a result of their perceived complexity. When compared to simple financial tools, such as mortgage calculators provided by the major banks on the Internet, farm forestry models may appear too complicated for all but the most experienced model user.

The downside of the 'free software' path is that software development and support arrangements for these models fall well short of what is expected when a user pays for commercial software. This has been a major problem with most decision-support systems developed using government funding in Australia and a key contributor to their limited use by actual decision-makers.

3.9 Some General Comments on Decision-Support Systems

The objective of any DSS is to provide a vehicle for structuring complex decision problems to enhance the *likelihood* of producing good outcomes (Gough and Ward 1996). The emphasis on the word 'likelihood' is an important point to make when discussing DSS. Due to the uncertain nature of most natural systems, no DSS can guarantee a good outcome is achieved by following a particular management regime. However, the probability of a favourable outcome can be greatly enhanced through a structured analysis of the problem.

Due to the expanding availability of computer software with the capacity to perform large and complex calculations quickly, contemporary DSS usually take the form of computerised models. The large amounts of time and cost expended on the development of large and intricate computerised DSS has not yet lead to widespread practical application. As already discussed above, an important reason for this may be a lack of interaction between the model developer and the client. Ideally, this interaction should be by way of direct client involvement in model development as opposed to arms-length communication.

Many of these DSS have been developed in a research environment which draws upon the technical expertise of peers, but seeks minimal input from the intended beneficiary of the research. In some cases, this has lead to DSS tools being regarded as 'black boxes' by farmers with a resulting degree of scepticism about their practical application. Certainly, the ability or willingness of many farmers to use these tools for their own management purposes has been limited. Some argue that the results only describe what they already intuitively know, though in terms of model validation, this may in fact be a positive outcome.

The development of DSS in many cases can produce a more practical outcome if viewed as a two-step process:

- step 1 – the development of research models which are more complex and are geared toward research outcomes
- step 2 – practical DSS applications, arising from Stage 1 models, but which are simpler and purpose built with the client in mind.

To achieve greater acceptance amongst decision-makers, the DSS should add to their existing knowledge, or provide a structured framework within which complex decisions can be simplified or viewed with greater clarity. They may also require extension to other situations in time, location, seasonal conditions, prices and costs. Recent experience with whole-farm financial models (e.g. Thompson *et al.* 1996) has demonstrated the benefits of having likely users involved in defining the purpose of the model, model development and the validation process.

Having said that, it is not necessary to have the intended beneficiary understand all the details of the model, so long as they have an appreciation of the nature of the DSS and the factors included and excluded from the framework, and model output can be communicated in a practical, understandable manner. In short, the client should have 'confidence' in the model. Inevitably, building a DSS of this nature requires that the tool be developed in close communication with the decision-makers, rather than in isolation. However, there is often still a need for some interpretative expertise in most cases to assist in the extension of the findings. The reasons why particular management actions lead to the predicted outcomes might not always be clear to the client, and complex model interactions may require interpretation by someone with detailed knowledge of the DSS. This is also a useful means of validating the model, through the investigation of outcomes which the client finds counter-intuitive. In the case of farm forestry, clients may interface with the DSS by having forestry options analysed, and then comparing outcomes in a group situation along with those who have developed the DSS. Alternatively, DSS output might be extended as 'rules of thumb' to be considered when assessing options.

In addition to providing guidance on strategies or tactics, a DSS can act as a useful learning tool as opposed to a tool whose sole function is to provide definitive answers. The systems dynamics modelling approach is often lauded as providing a framework whereby the impact of important system variables on outcomes can be observed. This provides the decision-maker with a better understanding of how the system operates and responds to alternative management options. It may also provide insights into the interaction between management options and system components such as climate which cannot be manipulated by the decision-maker and cannot be 'observed' without many decades of experience.

Recent development in systems dynamics software have made DSS tools of this nature more accessible and user-friendly, allowing simple system manipulation to be performed to assess the importance of key variables. Simple graphical model output displays can also be added. These provide the basis for an excellent learning framework.

It is important to recognise that DSS tools need not be computerised models. Published information, decision tree diagrams and flowcharts, stakeholder workshops and site visits are all valid mechanisms for developing an understanding of the system and thereby aiding the process of decision-making.

In the design of any DSS, obtaining a clear understanding of the intended use of the tool – including consideration of the target audience – is critical in deciding its design and level of complexity. There are trade-offs between DSS development cost and complexity. There are trade-offs between complexity and the ability of decision-makers to use the tool themselves and trade-offs between DSS complexity and the accuracy of the output provided. A solution to the complex-model-simple-outputs issue might be to develop a more complex version of the DSS with the objective of researching the system relationships and responses, then producing a simpler version for applied use by the decision-maker. Cacho (1997, p. 2) describes the DSS model building dilemma well, as 'an all-encompassing

model runs the risk of becoming as complex as the real system, defeating the purpose of the model as a simplified representation of reality'.

All DSS will involve some degree of simplification of real-world events. The extent of this simplification will be determined by a range of factors including the reasons for developing the system, budget and time constraints, data availability and the knowledge of what system components are important and should therefore be included. Experience has shown (e.g. Pannell 1996) that the answers provided by some sophisticated DSS represent only marginal improvements on current practice – again the criticism that the system only reinforces what the decision-maker already knows. It may also be the case that the DSS has been constrained to contemporary and limited thinking and that a complete change of focus is needed to achieve large improvements in the decision-support process and practical outcomes (e.g. see Thompson and Powell 1996).

Lowes and Bellamy (1994) provided a useful summary of features which might be desirable in any DSS. These include:

- assisting managers in their decision-making where the objectives of the decision-maker and the problem cannot be fully defined
- supporting and enhancing managerial judgement rather than replacing it
- improving the effectiveness of decision-making rather than its efficiency
- enabling the user to combine models, analytical techniques and data
- providing flexibility of use and the capacity to evolve to meet new needs
- providing additional insights into the problem by exploring alternative options (i.e. a learning function)
- formalising the intuitive approach to allow structured analysis of problems
- allowing the introduction of subjective judgments.

Lowes and Bellamy also suggested that for natural resource applications, a DSS framework is required which allows the integration of a number of DSS technologies to cope with the heterogeneous nature of the data and knowledge as well as spatial and temporal issues. They made particular note of the complexities involved in land resource management.

3.10 Current Farm Forestry Models in Use in Australia

There are a range of farm forestry models currently in use in Australia which aim to provide estimates of the economic impact of trees on farms. A comparison of several of the more widely used farm forestry models is provided in Table 3.3. These models differ considerably in complexity and scope. Some such as FARMTREE (Loane 1994) contain considerable detail on tree growth rates, product recoveries and stock shelter effects. The outputs from FARMTREE are calculated on a per hectare basis.

Table 3.3 Comparison of financial models available in Australia and New Zealand

Model	Farmula	Farmtree	Agroforestry Estate Model (AEM)	AGROFARM
Key purpose	Compare alternative farm plans (might include farm forestry)	Assess investments in farm forestry	Assess investments in farm forestry	Assess investments in farm forestry
Intended use	Farm management tool	Farm forestry assessment tool	Farm forestry assessment tool	Farm forestry assessment tool
Likely users	Farmers, farm advisers, researchers	Farmers, farm advisers, researchers	Farmers, farm advisers	Researchers, farm advisers
Whole-farm	yes	no	yes	yes
Menu-driven structure	yes	yes	yes	no
Accounts for:				
Stock shelter	no	yes	no	yes
Erosion/land degradation	yes	no	no	no
Season type	yes	no	no	no
Taxation	no	no	no	yes
Risk	no	no	no	Risky variables can be added
Tree understorey production	no	no	yes - detailed	no
Stochastic	no	no	no	yes, if risky variables added
Alternative investment options	no	no	yes	yes (some versions)
Iterative simulation capacity	no	no	no	yes, if risky variables added
Geographic focus	Western Australia	Victoria	New Zealand	New South Wales
Farm plan graphics	yes	no	no	no
Optimising capacity	no	no	no	Can be modified to optimise
Time frame	20 years	Unlimited	Unlimited	60 years
Inputs	Electronic map of property	Default data for agricultural and forestry enterprises supplied but can be modified	Physical and financial data for agric. and forestry entered by user. Allows detailed crop understorey option choices.	Default physical and financial data for agricultural and forestry enterprises supplied but can be modified
	Defined mgt. units (e.g. based on soil type)		Labour requirements	Farm taxation arrangements
	Crop plans		Cutting right options	Probability distributions if using in stochastic mode
	Stock plans		Joint venture options	Existing timber area and mgt. options
	Financial plans			
Outputs	Cashflow	Cashflow	Cashflow	Cashflow
	Net Present Values	Net Present Values	Net Present Values	Net Present Values
	Equivalent Annuity Values	Internal Rates of Return	Area planted	Internal Rates of Return
	Breakeven analysis	Sensitivity analysis	Enterprises displaced by trees	Annuity values
		Annuity values	Woodflows	Taxable income
			Labour requirements	Farm Equity
			Sensitivity analysis	Profit and loss statement

Table 3.3 (cont.) Comparison of financial models available in Australia and New Zealand

Model	**Agroforestry Calculator**	**ACTFM**	**IMAGINE (under development)**	**APSIM (under development)**	**AFFFM**
Key purpose	Assess investments in farm forestry	Assess investments in farm forestry	Assess best-guess species		Assess investments in farm forestry
Intended use	Farm forestry assessment tool	Farm forestry assement tool	Identify best guess tree options for further RandD	Shelter belt and alley farming assessment too	Farm forestry assessment tool
Likely users	Researchers, farm advisers	Landholders, farm advisors and landholders	Researchers	Researchers in conjunction with landholders	Researchers, farm advisers and some landholders
Whole-farm	no	no	yes	no	yes
Menu-driven	no	yes	no	no	yes
Accounts for:					
Stock shelter	no	no			yes
Erosion/land degradation	yes	no			no
Season type	no	no			no
Taxation	no	no			no
Risk	no	yes - in versions modified for research	no	?	no, risk version being developed
Understorey production	yes - basic	no	no	?	yes - basic
Stochastic	no	no	no	yes	no
Alt. investment options	yes	no	?	?	no
Iterative simulation capacity	no	yes - in versions modified for research	no	?	no
Geographic focus	Western Australia	North Queensland	Western Australia	South East Queensland	Northern NSW, South East Qld
Farm plan graphics	no	no	basic - blocks	?	no
Optimising capacity	no	yes - in versions for research	no	?	no
Time frame	50 years	unlimited	?	?	Unlimited
Inputs	Default physical and financial data for agricultural and forestry enterprises supplied but can be modified	Default physical and financial data for agricultural and forestry enterprises supplied but can be modified	All data provided by users	Simulated data from APSIM for a few species	Default physical and financial data for agricultural and forestry enterprises (including native forestry) supplied but can be modified Has capability to estimate species suitability rating based on location and soil type and to import yield tables associated with ratings
Outputs	Net Present Values Annuity values Benefit-cost ratio Cashflow Sensitivity analysis	Net Present Values Internal rate of returns Land expectation Value Cashlow Sensitivy analysis	Net Present Values	Net Present Values	Can graph numerous key model variables Net Present Values Internal Rates of Return Land expectation values Business cash position Can output key model variables to text file for manipulation in excel Sensitivity analysis

Others such as the Agroforestry Estate Model (Middlemiss and Knowles 1996) operate at the whole-farm level, and estimates of timber yields are provided by the user (or calculated via other software) rather than being calculated internally by the model. AEM, which was developed originally for use in NZ, has the capacity to model numerous and varied combinations of tree understorey enterprises and track farm labour requirements. It should also be acknowledged that AEM is commercial software, used under license and is regularly maintained and has user-support mechanisms in place. When combined with the fact that it is actively marketed by the developers, it has a higher adoption rate than the other models mentioned here.

Models such as Farmula (Kubicki *et al.* 1991) provide a graphical interface for farm planning purposes and were originally designed as a tool for examining land management practices such as erosion amelioration effects as opposed to being a specific farm forestry model.

The AGROFARM models are a suite of spreadsheet models developed for research and extension purposes by the Centre for Agricultural and Regional Economics (CARE) Pty Ltd and have a focus on northern NSW. These are whole-farm models. They include taxation, and several versions are in existence to cater for plantations, native forestry and joint venture arrangements. Risk can be added to the model structure using the @RISK™ add-in for Excel™.

The Australian Cabinet Timbers Financial Model or ACTFM (Herbohn *et al.* 1998) is spreadsheet model developed under a project funded by the Rainforest CRC. It estimates NPV and LEV for forestry investments in northern Australia involving non-traditional eucalypt and rainforest timber species. The model contains a large amount of default data including harvest age and growth estimates obtained from a survey of experts (Herbohn *et al.* 1999), and estimates of costs and revenues obtained from a number of sources. The model includes a series of button bars, pull-down menus and Visual Basic macros. Users have the option of selecting default data contained in the model or inputting their own data.

The AFFFM model developed in this study involves a combination of the features of the CARE AGROFARM models and the ACTFM developed by the Rainforest CRC. It also makes use of tree suitability ratings and yield tables derived from the PlantGro Software developed by Clive Hackett from CSIRO (Hackett 1988, 1991a and b). The objective with AFFFM has been to develop a stand-alone whole-farm model for use by researchers and forestry advisers, with a geographic focus on northern NSW and south-east Qld, and which included tree growth and timber yield data specifically for those regions.

3.11 Summary

This chapter has discussed the development of financial models in Australia, and set the background for the development of the Australian Farm Forestry Financial Model. Specifically, this chapter had outlined the key factors affecting financial performance of farm forestry and identified NPV and LEV as being the most appropriate measures of financial performance. Care needs to be taken when choosing the appropriate discount rate and this choice dictates how inflation is dealt with in the appraisal process. Forestry involves risk, and there are various ways to deal with this risk in financial analysis. These ways include taking conservative estimates, requiring a short payback period, including a risk margin in the discount rate and undertaking sensitivity and risk analyses as part of the appraisal process. There are a number of important issues that need to be considered when developing financial models and decision-support systems, including the need to identify the target audience and to define the model scope. A number of generic financial models of farm forestry are available in Australia, with differing levels of complexity and user-friendliness.

3.12 References

Brealey, R., Myers, S., Partington, G. and Robinson, D. (2000), *Principles of Corporate Finance*, McGraw Hill Australia, Roseville.

Cacho, O.J. (1997), 'Systems modelling and bioeconomic modelling in aquaculture', *Aquaculture Economics and Management*, 1(1): 45–64.

Dayanandra, D., Irons, R., Harrison, S., Herbohn, J. and Rowland, P. (2002), *Capital Budgeting: Financial Appraisal of Investment Projects*, Cambridge University Press.

Gough, J.D. and Ward, J.C. (1996), 'Environmental Decision–Making and Lake Management', *Journal of Environmental Management*, 48: 1–15.

Hackett, C. (1988), 'Matching plants and land: development of a general broadscale system from a crop project for Papua New Guinea', *Natural Resources Series No. 11*, CSIRO Division of Water and Land Resources, CSIRO, Melbourne.

Hackett, C. (1991a), *Plantgro: A Software Package for Coarse Prediction of Plant Growth*, CSIRO, Melbourne.

Hackett, C. (1991b), 'Mobilising environmental information about lesser known plants: the value of two neglected levels of description', *Agroforestry Systems*, 14: 131–143.

Harrison, S.R., Herbohn, J.L. and Emtage, N.F. (2001), 'Estimating Investment Risk in Small–Scale Plantations of Rainforest Cabinet Timbers and Eucalypts', in S.R. Harrison and J.L Herbohn, eds., *Sustainable Farm Forestry in the Tropics*, Edward Elgar, Cheltenham, pp. 47–60.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1998), *Australian Cabinet Timber Financial Model*, Computer software based on Microsoft Excel, including Draft Manual, James Cook University, Townsville.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1999), 'Potential performance of rainforest and eucalypt cabinet timber species in plantations in North Queensland' *Australian Forestry*, 62(1): 79–87.

Kubicki, A., Denby, C., Haagensen, A. and Stevens, M. (1991), *Farmula User Manual*, W.A Department of Agriculture, South Perth.

Loane, B. (1994), *The FARMTREE Model: Computing Financial Returns from Agroforestry, Faces of Farm Forestry*, Australian Forest Growers Conference, Launceston.

Lowes. D. and Bellamy, J.A. (1994), 'Object orientation in a spatial decision-support system for grazing land management', *AI Applications*, 8 (3): 55–66.

Middlemiss, P. and Knowles, L. (1996), *AEM Agroforestry Estate Model, User Guide for v. 4.0*., New Zealand Forest Research Institute, Rotorua.

Pannell, D.J. (1996), 'Lessons from a decade of whole-farm modelling in Western Australia', *Review of Agricultural Economics*, 18: 373–383.

Russell, J.S., Cameron, D.M., Whan, I.F., Beech, D.F., Prestwidge, D.B. and Rance, S.J. (1993), 'Rainforest trees as a new crop for Australia', *Forest Ecology and Management*, 60(1): 41–58.

Thompson, D., Jackson, D., Powell, R., *et al.* (1996), *Analysing Drought Strategies to Enhance Farm Financial Viability: Final Report*, prepared for the Land and Water Resources Research and Development Corporation and the Rural Industries Research and Development Corporation, by NSW and WA Departments of Agriculture and the Centre for Agricultural and Resource Economics, University of New England, Armidale.

Thompson, D. and Powell, R. (1996), 'Risk management in livestock systems – financial and taxation issues', in *Animal Production in Australia – Proceedings of the Australian Society of Animal Production*, Vol. 21, pp. 44–47, Brisbane.

4. MODSS Literature and Software Relevant to Farm Forestry Decision-Support

I. Jeffreys

This chapter reviews recent literature on Multi-Objective Decision-Support Systems (MODSS) and Multi-Criteria Analysis (MCA). This chapter investigates the relevance of MODSS and MCA approaches for evaluating natural resource and land-use management practices. It provides the background for the MODSS work in evaluating farm forestry and other land-use practices in this study. The chapter draws on the theoretic and practical experience of the use such techniques in Australia and the rest of the world. This review of literature on MODSS and MCA is split into five sections. The first is a description of MODSS, what they are, and how they are defined. The second section examines the justification for the use of MODSS in natural resource and land-use management. The third section presents MCA methods and their principles, and the fourth some of the processes used in applications of these methods. In the fifth section, some of the more recent software applications and their usefulness for natural resource and land-use management are discussed.

4.1 What are MODSS?

There are many definitions of Multi-Objective Decision-Support Systems, and many terms to describe them (RAC 1992). Some definitions vary only slightly as do the names; others refer to quite different processes and objectives. It is important to define these different systems and their uses. Commonly used terms include: Multi(ple) Objective Decision-Support Systems MODSS, Multi(ple) Criteria Decision-Support Systems MCDSS, Multi(ple) Criteria Decision Models MCDM, Multi(ple) Criteria Decision Analysis or Multi(ple) Criteria Decision Aids MCDA and Multi(ple) Criteria Analysis or Assessment MCA.

The terms *objectives* or *goals* and *criteria* are often mistakenly considered to be referring to the same thing. Objectives or goals are an abstraction of the values of the community in which the decision is to be made. An objective or goal may be as specific as achieving a particular water quality standard at a point in a watercourse or as general as improving the quality of the natural environment. On the other hand, criteria are the measures used to evaluate a given practice or policy in meeting these objectives.

Multiple objectives, as opposed to a single objective, recognise that within the community there are many values and objectives related to a particular decision and also that an individual decision-maker can hold multiple objectives. Single objective decision-making focuses on optimising a single criterion, for example net present value in cost-benefit analysis or environmental quality in environmental impact assessment (Archibugi 1989). When allowing for multiple objectives, an optimal solution with regards to all the objectives is rare. Therefore, a 'satisficing'[2] compromise solution should be sought (Froger and Munda 1998).

[2] 'Satisficing is an alternative to optimization for cases where there are *multiple* and *competitive* objectives in which one gives up the idea of obtaining a "best" solution. In this approach one sets lower bounds for the various objectives that, if attained, will be "good enough" and then seeks a solution that will exceed these bounds. The satisficer's philosophy is that in real-world problems there are too many uncertainties and conflicts in values for there to be any hope of obtaining a true optimization and that it is far more sensible to set out to do "well enough" (but better than has been done previously)' (IIASA) (Principia Cybernetica Web 2001).

Decision-support is not decision-making. A decision-support system is not designed to, and often does not have the capacity to, find an optimal solution. It is not a substitute to the considered opinion of the decision-maker; these systems do not make decisions. Rather, they provide decision-makers with a process to gather and display the required data in a clear and transparent framework. This process includes weighting and evaluating criteria and objectives, and providing methods to aggregate data when required (Froger and Munda 1998).

This study will focus on (1) MODSS, Multi-Objective Decision-Support Systems, as the process of identifying objectives, goals, criteria and options or alternatives, and (2) MCA, Multi-Criteria Analysis, as a method for weighting and aggregating data, and prioritising options and alternatives.

According to the RAC (1992), MCA is defined as a system that has the following attributes:

- a finite number of alternative plans or options
- a set of criteria by which the alternatives are to be judged
- a method for ranking the alternatives based on how well they satisfy the criteria.

MODSS are used when there are many and often conflicting objectives which need to be addressed, as is often the case in natural resource management. Robinson *et al*. (1999) stated that the MODSS approach offers a number of dimensions to decision-support, including:

- a comprehensive and systematic framework for ensuring that a wide range of alternative plans are formulated and appropriately researched to meet the needs of natural resource management
- a clear statement of the dominant choices to decision-makers and the economic, environmental and social trade-offs involved in the selection of a preferred management strategy
- a framework within which public participation could contribute effectively to the planning process.

MCA is the tool for processing, weighting and aggregating the data that describe an issue, whereas MODSS is the process by which the data are selected and framed, reflecting the multiple needs and objectives of society.

4.2 A Justification of MODSS and MCA

MCA and MODSS provide a structured approach that summarises and integrates varied data types and sources. This approach is especially useful in natural resource and land-use management in that it provides a process for integrating economic, environmental and social impacts. The MCA and MODSS processes can incorporate objectives of the various stakeholder groups, which are not easily included in traditional analysis methods.

MCA and MODSS provide an integrated and comprehensive socio-economic planning process (Archibugi 1989) specifically concerned with the relationship between economic and environmental wellbeing. Archibugi (1989) asserted that environmental, social and economic impacts are equally important and should be represented in a comprehensive integrated assessment. Archibugi compared MCA to more traditional methods of assessment such as Environmental Impact Assessment (EIA) and Cost-Benefit Analysis (CBA), viewing EIA and CBA as supporting ‘single-faceted approaches’ that are ‘less rational (often sub-optimal)’.

Froger and Munda (1998) stated that MCA techniques are based on the assumption of a complex world and incorporate a large number of different inputs and decision criteria. MCA can be used to frame and analyse a problem and to identify and analyse conflicting goals and objectives. Once these conflicts have been identified, trade-offs and compromise solutions can be identified. In that MCA provides a logical framework to represent and identify these issues, it can increase transparency in decision-making.

For example,

> the major strength of multicriteria methods is their ability to address problems marked by various conflicting interests. …[MCA] cannot solve these conflicts, but it can help to provide more insight into the nature of these conflicts and into ways to arrive at political compromises in case of divergent preferences in a multigroup or committee system, so increasing the transparency of the choice process (Froger and Munda 1998, p. 177).

4.3 MODSS and MCA Methodologies

This section will discuss the mechanics of MCA, including the processes of assessing and evaluating options and the theoretical bases for the differing techniques.

There are many techniques that can be described as MCA and MODSS. Figure 4.1 lists attributes of the various techniques. The techniques studied in this report all fall in the highlighted area. These techniques share the same basic building blocks, these being options, criteria and ranking methods (RAC 1992).

In natural resource and land-use management, the options (also be called alternatives or scenarios) are the proposed land-use or land management practices. In previous studies these have included options to preserve groundwater quality and depth in Far North Queensland, including tree planting, restricting water allocations and greater use of efficient irrigation practices (Robinson *et al*. 1999). In the Burnett MODSS study in Southern Queensland (Eisner *et al*. 2000), the options related to water infrastructure in the Burnett catchment. These options included varying sizes of dams and weirs at various sites in the catchment and other non-infrastructure options such as water harvesting of overland flows (Eisner *et al*. 2000).

Decision criteria, also known as effects or attributes, are measures against which the land-use options are evaluated. These are often placed in hierarchy trees to aid their development and to define the structure of the issue (Saaty 1980, p. 11). These clusters or groups of criteria or composite criteria (DNR *et al*. 1999) are not evaluated separately; they take the aggregate value of the criteria they contain.

Most MCA techniques use the options and criteria to construct an *effects table* or matrix. The techniques differ in the ways in which data are combined and how the data are presented. The evaluations are values derived from models, measured data or expert opinion (Eisner *et al*. 2000). The Analytical Hierarchy Process evaluates the options against the criteria using pairwise comparisons (Saaty 1980), and therefore is always based on the opinion of the decision-maker or experts.

Figure 4.1 (adapted from RAC 1992) provides a breakdown of the various types of MODSS and MCA tools. The dashed area includes the tools considered in this study (and in RAC 1992). CBA and other single-faceted economic models do not form part of the MODSS analysis but are used in other sections of this study. The separation of qualitative and quantitative techniques in Figure 4.1 is not strictly correct, because many of these techniques use both qualitive and quatitive data (see Janssen 1991 and Yakowitz *et al*. 1992) and EVAMIX was specifically designed to integrate both (see Voogd 1983 and Nijkamp *et al*. 1990, p. 94). Examples of these techniques are used in the software applications, Facilitator (DNR *et al*. 1999), Java AHP (Zhu and Dale 2001) and Definite (Janssen 1991, Janssen *et al*. 2001).

Some tools and techniques use score standardisation methods. These are used to convert the raw data from the effects table into consistent and comparable measures, or *single dimensionless utilities* (Keeney and Raffia 1976, Edwards and Barron 1994) using a linear function or a non-linear function (described by Janssen 1991).

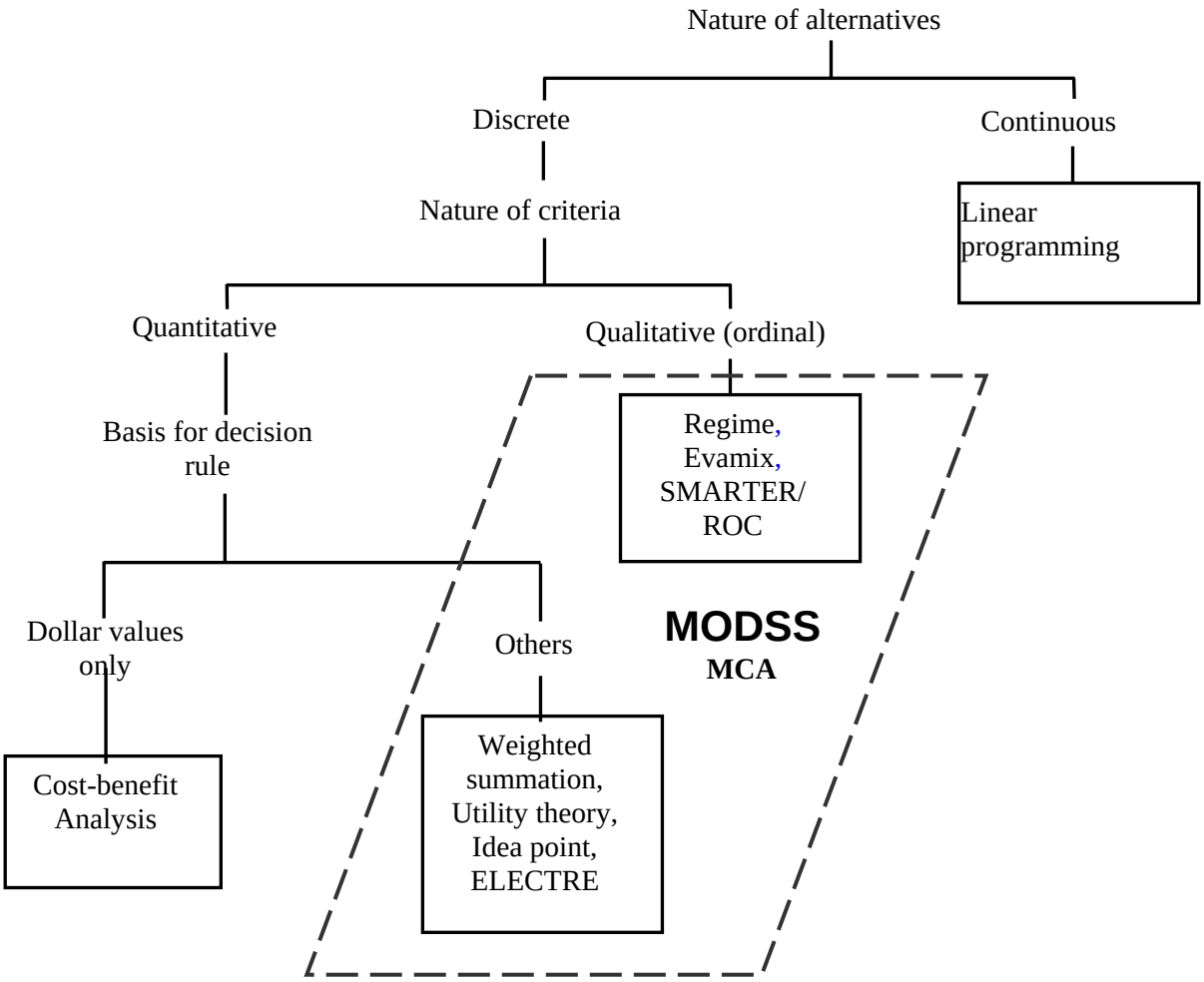


Figure 4.1 A classification of multi-criteria analysis methods

Appropriate selection of standardisation, weighting and aggregation techniques is vital for robust and consistent results. For example, in the software application Definite (Janssen *et al*. 2001), the criterion for the worst performing option can receive a zero value, even if the performance is not really poor, and the best will receive one, even if the performance is not excellent. These standardisations have the added problem that removal of options can affect the relative performance and ranking of the remaining options (Lootsma 1999).

The multiple criteria are aggregated using the MCA and MODSS to produce a single measure of the relative performance of an option. The theoretical legitimacy of aggregating multiple criteria is provided by Keeney and Raffia (1976) in their Multi-Attribute Utility Theory.

Multi-attribute utility theory (MAUT)

Multi-Attribute Utility Theory provides the theoretical basis for multiple criteria methods. It states that the overall utility of an option (an option's attractiveness to the decision-maker) can be derived from the sum of the measured value of its attributes. The attributes are transformed into single dimensionless utilities using utility probability functions. These probability functions are assessed for each attribute and are often complex. They are the basis for standardising functions used in many evaluation methods.

MAUT procedures use a performance matrix or effects table. This is a fundamental component of many MCA techniques, including the commonly used software applications. There is considerable debate on the requirement that criteria are independent. Keeney and Raffia propose lengthy techniques to ensure independence of criteria (Keeney and Raffia 1976, pp. 299-301); these involve interviewing the decision-maker and asking a series of 'what if' questions with regards to the relative values of the criteria.

Once this legitimacy is established, there are many methods that can be used to evaluate options by defining and evaluating an *effects table*. These methods are presented in Appendix 4.1.

4.4 Processes for Using MCA and MODSS in Natural Resource and Land Use Management

Saaty (1980, pp. 33-34) proposed the following set of steps to carry out the Analytic Hierarchy Process:

1. State the problem.
2. Put the problem in broad context – embed it if necessary in a larger system including other actors, their objectives, and outcomes.
3. Identify the criteria that influence the behaviour of the problem.
4. Structure a hierarchy of the criteria, sub-criteria, properties of alternatives, and the alternatives.
5. In a many-party problem the levels may relate to the environment, actors, actor objectives, actor policies, and outcomes, from which one derives the composite outcome (state of the world).
6. To remove ambiguity, carefully define every element in the hierarchy.
7. Prioritise the primary criteria with respect to their impact on the overall objective called the focus (described as 'the issue' in this report).
8. State the question for pairwise comparison clearly above each matrix. Pay attention to the orientation of each question, e.g. costs go down, benefits go up.
9. Prioritize the subcriteria with respect to their criteria.
10. Enter the pairwise comparison judgements.
11. Calculate priorities.

Whilst Saaty's process uses pairwise comparison to evaluate and weigh options and criteria, it is equally valid to apply to other MCA techniques. The process of pairwise comparison is replaced by the process of evaluating option against criteria and weighting of options using various techniques.

Janssen (1991) separated the decision process into three stages, *Identification, Development and Selection.* In the identification stage it is recognised that a problem or issue exists and the decision-makers seek to comprehend the nature of the issue. Development involves searching for and designing possible solutions. Selection involves an evaluation, a choice between the options.

Janssen (1991, pp. 8-12) asserts that a MODSS analysis must fulfil five functions, as outlined below. To create a robust process, these functions should be considered when defining a MODSS process.

1. Support of the selection phase

This phase is feedback cycle of *analysis – evaluation – redefinition – analysis.* This process does not change the options and criteria, only the scores and weightings. This may lead to changes in assumptions and priorities. This process in the selection phase is to increase understanding the influence of the assumptions and priorities and will aid result reliability. This function is a feedback mechanism for a well-structured problem.

2. Support of the development phase

This phase of the feedback cycle is used if the results from the previous phase are still unsatisfactory. The feedback is extending backwards through the process to include the definition of options and criteria, and aims to produce a more complete set of options and criteria. This function aids the structuring of poorly structured problems.

3. Support learning by doing

Janssen described this function as ‘playing with the problem’. The DSS provides a direct link between the data and the outcomes. The decision-makers (the stakeholders) gain experience of how changing the data or priorities affects the outcomes, thus increasing their understanding of the problem and related issues.

4. Support integrated use of judgement, methods and data

MODSS provides a framework for integrating information, models and judgement. Judgement relates both to technical evaluation and stakeholder priorities. An effective MODSS analysis integrates these data, but also clearly separates the data sources.

5. Support information processing

The MODSS analysis should provide a single framework and system for data management, simulation models, evaluation methods and sensitivity analysis. This point relates to the software package used in the evaluation as much as the process.

So far these processes have only dealt with the decision-maker and the analyst. The former is the person responsible the final decision and the latter is the person driving the system and providing analyses. In natural resource and land-use management and planning the identity of decision-maker is unclear. This was recognised by Eisner *et al*. (2000, pp. 6-7) and the roles of stakeholders as decision-makers were more clearly defined. Eisner *et al*. (2000, pp. 6-7) proposed the following course of action for developing a MODSS with stakeholder and expert input.

- an issue requiring action is identified
- stakeholder reference groups and technical reference groups convened
- alternative courses of action are defined by the stakeholder group, with input from the technical reference group
- criteria by which those alternatives or options will be assessed are described by the stakeholder group, with input from the technical reference group
- the technical group evaluates the alternatives against each criterion
- the stakeholder group ranks the criteria into an order of importance, according to their values; this may result in several weight sets
- the results are analysed to prioritise the alternatives
- results are reported back to stakeholder and technical reference group for re-evaluation.

4.5 MODSS Software Applications

In this section a number of recently developed MODSS designed specifically for natural resource and land-use management will be discussed with regards to their possible application to farm forestry decision-making. These are Facilitator (DNR *et al*. 1999), DEFINITE (Janssen *et al*. 2001) and JavaAHP (Zhu and Dale 2001).

Facilitator

The MODSS software application Facilitator (DNR *et al*. 1999) was developed jointly by the Queensland Department of Natural Resource and Mines, the Agricultural Research Service of the United States Department of Agriculture and Netstorm Pty Ltd, Toowong, Brisbane. This tool was developed to fulfil a need to provide a transparent decision framework to integrate multiple objectives, multiple stakeholders and varied data sources and bodies of knowledge (Lawrence *et al*. 2000).

Facilitator MODSS is a generic MCA tool. It was developed using algorithms and aggregation techniques from a prototype decision-support system (P-DSS) which had been developed by the USDA Agricultural Research Service in Tucson, Arizona (Lane *et al*. 1991, Yakowitz *et al*. 1992). The weighting algorithm is the same as the extreme value method and the aggregation is a weighted summation.

Facilitator is limited by the weighting techniques it provides. The Range of Values or the extreme value method provides a range of results. These ranges are often wide and can be difficult to interpret (see Eisner *et al*. 2000). It is argued that this variation in results reflects the uncertainty of the outcomes (Eisner *et al*. 2000). This problem is likely to be somewhat alleviated in the release of Facilitator Version 1.3 in 2002, which is expected to include the Rank Order Centroid method.

Facilitator can be downloaded from the web free of charge, from the site http://facilitator.netstorm.net.au/. Facilitator is specifically aimed at groups or individuals engaged in natural resource planning with limited funding. Facilitator has a simple user interface for ease of take-up (see Eisner and Jeffreys 2001). Facilitator is written in platform-independent Java and can be run on any operating system that supports Java. Facilitator reports in Hyper text Mark-up Language (html), therefore the reports can be viewed using any Internet browser software.

Definite

Definite (Janssen 1991, Janssen *et al*. 2001) is a high-end multi-objective decision-support tool. It is a modular program with much functionality. The problem definition module includes the ability to construct hierarchies and to evaluate the options by direct assessment or by pairwise comparison, as well as checks for dominance (when one option is outperformed against every criterion by other options), and also correlation analysis on the criteria. The multi-criteria analysis module includes many aggregation and weighting techniques (most of those detailed early in this chapter). Definite includes a cost-benefit analysis module as well as a sensitivity analysis module. Definite is designed to run on the Microsoft Windows operating system and uses other Microsoft products extensively for importing and exporting analyses and reporting analyses. The high level of functionality has both costs and benefits. The user interface is cluttered and complicated to follow and use. This is a tool for researchers and policy workers, not community groups.

Definite is a commercial product and the current cost is A$2500 to A$5000 depending on the license type. This precludes it from most catchment management and other community-based groups engaged in natural resource planning and landholders.

JavaAHP

JavaAHP (Zhu and Dale 2001) again is a relatively simple tool. The problem definition part of the tool builds hierarchy trees as described by Saaty (1980). This offers a different approach to the matrix or effects table to that applied by Definite and Facilitator. There are benefits to both approaches and it appears largely down to the personal choice of the decision-maker. The weighting techniques available in JavaAHP are the AHP (Saaty 1980) and SMARTER (Edwards and Barron 1994), and the aggregation technique is the weighted summation method. The user interface is relatively simple and easy to use.

JavaAHP is run solely over the Internet and is not available for download. It can only be run when the user is connected to the JavaAHP web site. All analyses are also saved on to the web site's host server. The analyses are password protected and therefore can be made available to chosen stakeholders or other decision-makers, thus allowing easy access to current analyses. Mounting and running JavaAHP on the Internet has it's pros and cons: no specialised software is required on the user's computer; JavaAHP runs using Internet browsing software and it is currently freely available. JavaAHP can only be used if the user has an Internet connection. Whilst care has obviously been taken to maximize processing speed and data transfer speed, many people – especially those concerned with natural resource and land-use management – often reside in rural and regional areas and have poor or no access to the Internet. JavaAHP can be found at http://www.chris.tag.csiro.au/JavaAHP/.

4.6 Summary

MODSS provides a framework to aid decision-making, where multiple and often conflicting objectives exist. The MODSS process supports decision-making by performing two key roles. Firstly by providing a framework in each decision-makers and stakeholders can 'play' and experiment with the issues concerning a problem, and secondly by providing an integrated analysis of alternative plans or options as decision-support.

MODSS can evaluate a finite number of alternative plans or options in respect to a number of criteria. These criteria reflect the objectives, goals and values of those involved in the decision-making process. The MODSS framework can be used to integrate economic, environmental and social consideration in natural resource and land-use management and planning. Provided within MODSS are a number of analysis techniques, which perform functions of weighting criteria and aggregating criteria. Each technique has relative strengths and weaknesses and each is more or less suited to specific applications.

There are a number of software applications for MODSS. Each application has its strengths and weaknesses and is applicable to different problems. Of the three applications have been considered in this chapter, for simple studies Facilitator or JavaAHP are more appropriate. Facilitator is the most appropriate for use in group work. For an in-depth and robust analysis, Definite is more appropriate.

4.7 References

Archibugi F. (1989), 'Comprehensive social assessment: an essential instrument for environmental policy-making', in *Economy and Ecology: Towards Sustainable Development*, Archibugi, F. and Nijkamp, P. eds., Kluwer Academic Publishers, Dordrecht.

Barron, F. and Barrett B. (1996), 'Decision quality using ranked attribute weights', *Management Science*, 42(11): 1515–1523.

Chowlka A. and Raith R. (2000), 'Supporting group decisions with the AHP: harmonization vs. aggregation of preferences', in Wanka G., *Decision Theory and Optimization Theory and Practice*, Saker Verlag, Aachen.

Cook W., Golan I., Kazakov A. and Kress M. (1988), 'A case study of a non-compensatory approach to ranking transport projects', *The Journal of the Operational Research Society*, 39(10): 901–910.

DNR (Department of Natural Resources), Agricultural Research Service, USDA, and Netstorm Pty Ltd, 1999, *Facilitator 1.2.17 Beta, A Multi-Objective Decision Support System*, presented at the 2nd International Conference for Multiple Objective Decision Support Systems for Land, Water and Environmental Management (MODSS'99), Brisbane.

Dodgson J., Spackman M., Pearman A. and Phillips L. (2001), *Multi Criteria Analysis: A Manual*, Department for Transport, Local Government and the Regions (UK), Rotherham.

Edwards W. and Barron F.H. (1994), 'SMARTS and SMARTER: improved simple methods for multiattribute utility measurement', *Organizational Behavior and Human Decision Processes*, 60(3): 306–325.

Eisner R., Lawrence P. and. Jeffreys I. (2000), *Use of MODSS (Multi-Objective Decision Support System) in the Burnett River Catchment Study*, Project report, Department of Natural Resources, Brisbane.

Eisner R. and Jeffreys I. (2001), *Facilitator: Multi-criteria Decision Support Tool – User's Manual*, distributed with the Facilitator software, Department of Natural Resources and Mines, Brisbane.

Froger G. and Munda G. (1998), 'Methodology for environmental decision support', in *Valuation for Sustainable Development*, in Faucheux and M. O'Connor, eds., Edward Elgar, Cheltenham.

Hayashi K. (2000), 'Multicriteria analysis for agricultural resource management: A critical survey and future perspectives', *European Journal of Operational research*, 122(2): 486–500.

Hinloopen E. and Nijkamp P. (1990), 'Qualitative multiple criteria choice analysis: The Dominant Regime Method', *Quality and Quantity*, 24(1): 37–56.

Janssen R. (1991), *Multiobjective Decision Support for Environmental Management*, Kluwer Academic Publishers, Dordrecht.

Janssen R., van Herwijnen M. and Beinat E. (2001), 'DEFINITE (version 2) Decision support system for a FINITE set of alternatives', *Institute for Environmental Studies*, Vrije Universiteit, Amsterdam.

Janssen R, and van den Bergh J. (1996), 'Multicriteria evaluation for sustainable use of Australian forests', in *Ecological Economics and Sustainable Development: Theory, Methods and Applications*, Edward Elgar, Cheltenham, pp. 231–242.

Keeney R. and Raffia H. (1976), *Decisions with Multiple Objectives*, Cambridge University Press, Cambridge.

Lane L.J., Ascough J.C. and Hakonson T.E. (1991), 'Multiobjective decision theory – decision support systems with embedded simulation models', in *Proc. Irrigation and Drainage IR Division*, ASCE, Honolulu, pp. 445–451.

Lawrence P., Shaw R., Lane L. and Eisner R. (2000), *Participatory Multiple Objective Decision Making Processes: Emerging approaches with new challenges*, paper presented at the American Society for Civil Engineering (ASCE) Watershed Management Symposium 20–24 June, 2000, Ft Collins, Colorado.

Lawrence P. and Shaw R. (in process), A framework for evaluating options for water resource infrastructure development, *Proceedings from the 2nd International Conference on Multi Objective Decision Support*, Brisbane.

Lootsma F. (1999), 'Distributed multi-criteria decision making and the role of the participants in the process', presented at the IIASA/DAS workshop on *Decision Support in the Public Sector*, Delft. www.iiasa.ac.at/Research/DAS/roundtables/delft99/papers/ lootsma.pdf, accessed 14 Dec. 01.

Nijkamp P. (1989), 'Multicriteria analysis: a decision support system for sustainable environmental development', in F. Archibugi and P. Nijkamp, eds., *Economy and Ecology: Towards Sustainable Development*, Kluwer Academic Publishers, Dordrecht.

Nijkamp P., Reitveld P. and Voogd H. (1990), *Multicriteria Evaluation in Physical Planning*, North Holland Publishing, Amsterdam.

Principia Cybernetica Web (2001), *Web Dictionary of Cybernetics and Systems*, http://pespmc1.vub.ac.be/ASC/INDEXASC.html#S, accessed 14 Dec. 01.

RAC (Resource Assessment Commission) (1992), *A Multi-criteria Analysis as a Resource Assessment Tool*, Research Paper No. 6, Canberra.

Robins E. (1999), *The Analytic Hierarchy Process – Issues, Problems, and Recommendations, Technical Report Number 9811pub-esr*, Technology Evaluation Center, Worcester. http://www.technologyevaluation.com/arlingsoft/Analysis_ofAHP.pdf, accessed 14 Dec. 2001.

Robinson J.J., Lawrence P., Shaw R., Cogle L., Rose K. and Lait R. (1999), *Development and Outcomes from a Multiple Objective Decision Support System for the Cattle Creek Catchment*, unpublished project report, Department of Natural Resources, Mareeba.

Roy B. (1991), 'The outranking approach and the foundations of ELECTRE methods', *Theory and Decision*, 31(1): 49–73.
Saaty T. (1980), *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, McGraw-Hill, New York.
Simpson, L. (1996), 'Do decision makers know what they prefer?: MAVT and ELECTRE II', *The Journal of the Operational Research Society*, 47(7): 919–929.
Voogd H. (1983), *Multicriteria Evaluation for Urban and Regional Planning*, Pion Ltd, London.
Winterfeldt D. and Edwards W. (1986), *Decision Analysis and Behaviour Research*, Cambridge University Press, Cambridge.
Yakowitz D., Lane L., Stone J., Heilman P. and Reddy R. (1992), 'A decision support system for water quality modelling', *Proc. Water Resources Sessions/Water Forum '92*, ASCE Water Resources Planning and Management, Baltimore.
Yakowitz D., Wedwick S. and Weltz M. (1997), 'Computing multiple attribute value function ranges under a hierarchy of attributes with application to environmental decision making', *Proc. IEEE International Conference on Systems, Management and Cybernetics*, Orlando, pp. 323–328.
Yakowitz D. and Weltz M. (1998), 'An algorithm for computing multiple attribute additive value measurement ranges under a hierarchy of the criteria: application to farm or rangeland management decisions', in E. Beinat and P. Nijkamp, eds., *Multicriteria Analysis for Land Use Management*, Kluwer, Dordrecht.
Zhu X. and Dale A. (2001), 'JavaAHP: a web-based decision analysis tool for natural resource and environmental management', *Environmental Modelling and Software*, 16(3): 251–262.

Appendix 4.1: Detailed descriptions of multi-criteria analysis techniques

The following sections deal with methods of weighting and aggregating the performance of options. There are a number of 'complete' processes such as Saaty's Analytic Hierarchy Process (AHP) (Saaty 1980), and SMART, SMARTS and SMARTER (Edwards and Barron 1994), and a number of individual components that can be combined for given situations. The following sections examine these separately. Prior to this, criteria structures then criteria weighting methods and finally aggregation methods will be discussed.

Criteria structures – hierarchy trees

Hierarchy trees are used in many DSS to define the structure of the decision problem. They allow the decision-maker to structure the system into manageable sub-systems, whilst maintaining the mutual relationships between the components (Saaty 1980). This hierarchy structure is evident in many MODSS. This objective hierarchy or value tree can be used to subdivide and group the criteria into similar areas of concern (Keeney and Raiffa 1976). For example, Eisner *et al*. (2000) started by defining the criteria as economic issues, environmental issues and social issues. Each for these is then further sub-divided. The economic issues are further sub-divided into economic and financial viability, risk and regional impacts, thus creating the hierarchy tree. Archibugi (1989) suggested this be continued until the criteria have a homogeneous measure.

Criteria weighting methods

This section will discuss several methods for eliciting weights to be applied to the criteria. Weights are an abstraction of the importance of criteria to the overall issue. A number of methods have been proposed to translate this stakeholder preference into a numerical weight or range of weights. Methods including pairwise comparison and importance rankings will be discussed.

Pairwise comparison and the analytic hierarchy process (AHP)

The Analytic Hierarchy Process (AHP) (Saaty 1980) provides a hierarchic framework for evaluating multi-criteria problems. AHP uses the definitions of relative importance to evaluate the weights received by individual decision criterion and the score received by each option for a given criterion. This process takes the form of a number of pairwise comparisons. The decision-maker evaluates each criterion against all the others. The relative importance is assigned on a nine-point scale, with 1 being equal importance and 9 being very strongly more important. The value of this relative importance is assigned to more important criteria and the reciprocal to the lesser important criteria. After assigning all the relative comparisons, the principal eigenvector of the effects table is calculated for each criterion. These are normalised across all the criteria to unity.

A clear advantage of this method is the ease with which the decision-maker can answer the pairwise question, but this assumes that the decision-maker has complete knowledge about the issue (Janssen 1991, p. 72).

Inconsistency is a major issue with AHP. It quite possible to make circular statements, e.g. Criterion 1 is preferable to Criterion 2, Criterion 2 is preferable to Criterion 3 and Criterion 3 is preferable to Criterion 1. To counter this, an inconsistency rating is calculated (see Saaty 1980, p. 61), where a value of greater than 0.1 is considered undesirable. With a small number of criteria it is possible to achieve consistency according to this measure; as the number of criteria increases this becomes increasingly difficult (Robins 1999). Saaty (1980) suggested a maximum of between five and nine criteria for a given branch in the hierarchy tree. The chance of a consistency of less than 0.1 with three criteria, applying the weights randomly, is found to be 1 in 4, while with seven criteria it is 1 in 8000 (Robins 1999).

When differing opinions emerge whilst making pairwise comparisons in groups, it is suggested that the mean (geometric or arithmetic) of the two positions be used (Saaty 1980). This can hide valuable trade-offs when there are differing opinions (Chwolka and Raith 2000). These authors concluded that each group member should quantify their individual preferences, rather than attempting to aggregate the preferences for an average group member. In this way, divergent opinions are acknowledged rather than hidden. This issue is common to all MCA techniques but is often more pronounced in the AHP, because there are many more decisions (pairwise comparisons) to be made.

Rank order methods

Rank order based methods are straightforward and efficacious and provide appropriate tools for decision analysis (Barron and Barrett 1996). Several weighting techniques assign weights to the individual criteria according to a statement of importance or rank. These are usually in the form ‘Criterion 1 is more important than Criterion 2, which is more important than Criterion 3, which is more important Criterion 4’, and so on, written $Cr1 \geq Cr2 \geq Cr3 \geq Cr4$. It is assumed in all of these techniques the total sum of the weighs will equal 1.0. Given these statements, a set of feasible weights can be defined, as well as the probability density function for all the feasible weights. For a simple case $Cr1 \geq Cr2 \geq Cr3$ this will be a triangular distribution with the extreme points at (0,0,1), (0,1,1) and (1,1,1). Changing the number of criteria will change the shape of the probability density function for the feasible weight set. These sets and distributions are the basis for the Rank Order Centroid (Nijkamp *et al*. 1990), the SMARTER technique (Edwards and Barron 1994), and the Range of Values or RoV method (Yakowitz and Weltz 1998).

Rank Order Centroid (ROC) – as used in the SMARTER technique (Edwards and Barron 1994) – uses the centroid value as the weight for the criteria. The Expected Value Method (Nijkamp *et al*. 1990) – as used in Definite (Janssen 1991 and Janssen *et al*. 2001) – also uses the centroid value. The centroid value is also the most probable or expected value.

The method used in Facilitator (DNR *et al*. 1999) and the P-DSS (Yakowitz *et al*. 1992) reports two values from this distribution, these being the extreme values, the maximum additive value and the minimum additive value. This method is known as the Range of Values method and also the Extreme Value method.

SMART, SMARTS and SMARTER

SMART, SMARTS and SMARTER (Edwards and Barron 1994) refer to Simple Multi-attribute Rating Technique, Simple Multi-attribute Rating Technique using Swings and Simple Multi-attribute Rating Technique Exploiting Ranks. Edward and Barron asserted that SMART contained an error in logic, which was subsequently fixed in SMARTS, and they strongly recommended that SMART should not be used because it has been superseded by SMARTS. Therefore only SMARTS and SMARTER are discussed here. Both use linear approximation to standardise the scores to single dimensionless cardinal utility functions and a weighted additive aggregation function. These assumptions though acknowledged as sub-optimal, are justified as good enough. Sensitivity analysis is used to check the robustness of the assumptions. The weights for SMARTS are determined using 'swings'. This method involves defining a hypothetical worst option, i.e. one that has the worst possible score for each criterion. The decision-maker is asked to identify the criterion for which good performance would most greatly increase the performance of the whole option, and then the second and third to the nth criterion. These are then given a weight according to their importance. In an example with n criteria, a weight of n is assigned to the most important criterion, n-1 to the second and so on. In an example with 9 criteria, a weight of 9 is assigned to the most important criterion, 8 to the second, 7 to the third and so on. These weights are standardised to sum to 1.0. In SMARTER, the decision-maker places the criteria into an importance order for example 'Criterion 1 is more important than Criterion 2, which is more important than Criterion 3, which is more important Criterion 4' and so on, $Cr1 \geq Cr2 \geq Cr3 \geq Cr4$. . . . SMARTER then assigns weights according to the Rank Order Centroid method described earlier.

Aggregation techniques

Aggregation techniques can be broadly classified as compensatory techniques and non-compensatory techniques. Compensatory techniques aggregate the criteria to an overall utility function; these include all methods using the weighted summation aggregation technique, MAUT and the Analytic Hierarchy Process (AHP). In these techniques, poor performance in a possibly critical criterion is compensated for by good performance in other criteria. Non-compensatory techniques include a measure of discordance; options that include poor performance against an individual criterion will be attributed poor overall performance (Hayashi 2000).

Weighed summation

This is the simplest and most commonly used aggregation technique (Janssen 1991, Yakowitz *et al*. 1997); it is also described as the multi-attribute value (MAV) model (Barron and Barrett 1996). The value accorded to an option is the sum of the value the option receives for each criterion multiplied by the weight given to that criterion. The weighting of the criteria is derived from the weighting technique chosen by the decision-maker or embedded in the tool being used. The weighted summation is one of many Multi-Attribute Utility Models (see Keeney and Raffia 1976), and whilst other models have a stronger theoretical basis they are rarely used because they are complicated and time consuming (Winterfeldt and Edwards 1986).

Electre method

The Electre method (*El*imination *e*t *c*hoix *t*raduisant la *ré*alité or Elimination and choice corresponding to reality) (Roy 1991, also see Janseen 1991 p. 61 and Cook *et al*. 1988) uses pairwise comparison of options with regards to the measured value of each criterion. A concordance set is derived from the differences between each criterion for the two options. The discordance index

reflects the maximum difference between any individual criterion in the two options. Threshold values are set for concordance and discordance. For example, when comparing option 1 with option 2 for a given criterion, option 1 is said outperform option 2, if the following statement is true:

The difference between the value of option 1 compared to option 2 is greater than the concordance threshold and lower than the discordance threshold.

The concordance index measures the relative overall performance of the options, the discordance index measures poor performance in individual criteria. The rationale of the discordance index is that overall good performance in most criteria cannot compensate for poor performance in an individual criterion. Five versions of the Electre method have been proposed by Roy (Roy 1991, Simpson 1996), these being Electre I, II, III, IV and TRI. Electre I can be used for selection problems, Electre TRI for assignment problems, and Electre II, III and IV for ranking problems

Regime method

The Regime method (Hinloopen and Nijkamp 1990) uses pairwise comparison of options to determine dominance. Each criterion for a given option is compared against the same criterion in a second option. If the given option outperforms the second option in every criterion, the given option is said to strictly dominate the second option. However, usually there are a varying number of dominating criteria. In these cases the probability that an option is dominant is calculated (as the number of dominant criteria over the total number of criteria). The sum of these pairwise probabilities of dominance is the overall probability of dominance. The overall probability of dominance becomes the measure by which the options are rated.

Evamix

Evamix (Voogd 1983) also determines dominance of an option on a criterion-by-criterion basis; it is especially designed for mixed (quantitative and qualitative) data. The quantitative and qualitative scores are normalised separately to a 0 to 1 range. The degree of pairwise dominance for each pair of criteria is calculated. The value assigned to each option is the weighted sum of the dominance scores. The weights can be derived by any of the weighting techniques.

5. Landholder Attitudes to Farm Plantations

G. Cockfield

This chapter contains an analysis of landholders' attitudes to the potential for establishing plantations on farms in a medium rainfall area (650-780 mm per year) where the current dominant forms of land-use are grain and fibre crop production and the grazing of cattle. The data collection method was a survey of landholders. Results were derived by statistical analysis of landholder responses to various questions and statements relating to themselves, the property they own or manage and their attitudes to farm forestry. The aim of the research was to identify what type of landholders, if any, might consider establishing plantations, where, on their properties they are most likely to establish them and what factors deter them from establishing plantations. This information can be used by researchers, policy-makers and land-use administrators to develop regional or catchment-scale land management plans that take account of the views of landholders. The specific project goal was to provide data that could be used as part of a Multi-objective Decision Support System (MODSS) but it was anticipated that the data could also be used in other forms of community engagement, such as consultation processes. A secondary goal was to add to the stock of information on landholders' attitudes to farm forestry and, in particular, to consider the attitudes of landholders in the medium rainfall areas.

5.1 The Adoption of Farm Forestry in Broadacre Farming and Pastoral Areas

The area devoted to farm forestry in Australia has increased substantially since the early 1990s, but the majority of plantations, and most of the total area of plantations, are in the higher rainfall areas of Western Australia, Victoria, NSW, Tasmania and Queensland (Tonts *et al*. 2001). The exception is in the inland areas of Western Australia where salinity outbreaks are a problem. There is comparatively little planting occurring in the inland broadacre and pastoral zones, especially in the northern 'wheat/sheep zone', consisting of the Darling Downs, Western Downs, Maranoa and Central Highlands regions of southern Queensland and the plains of northern NSW. For example, in the Darling Downs region, there are few plantations and most of those are less than 10 ha in area (BRS 2000). The number of plantations has increased significantly in the 1990s, but most of these have been small. While there has been some corporate investment in the New England area of NSW and in the South Burnett region of Queensland, these plantations are on or near the Great Dividing Range, in the 750-800 mm rainfall zone. Few commercial landholders, those who depend on agricultural activity for much or most of their income, have established plantations and very few have established plantations of more than a few hectares. Most inquiries to forestry extension personnel, relating to the prospects for plantations, come from people with property sizes of less than 100 ha who do not derive their primary income from agriculture (Bailey 2001).

Landholders, especially commercial farmers and graziers, seem to prefer growing crops and running livestock to establishing and managing plantations. This may be because of economic factors, such as the length of time until there is a return from plantations, but some researchers have suggested that there might be social and cultural factors that contribute to a resistance to having substantial areas of commercially grown trees on farms. Some historical accounts suggest that there is a long tradition of hostility by farmers to trees in the landscape (Bolton 1981, Lines 1991). Added to this, governments also actively encouraged and subsidised the removal of trees from land that was to be converted to crop production (Cockfield 1994). It should be noted that not all authors agree with this assumption of farmers' implacable hostility towards trees (Barr and Cary 1992, Bonyhady 2000). Other studies have examined how attitudes amongst people from farming and rural backgrounds are shaped by a

form of rural ideology that encourages political conservatism and a hostility to the imposition of what are perceived to be externally generated policy ideas (Aitken 1988, Wear 1991). In particular, there is a general hostility to environmental ideas and proposals (Hamilton 1991). While landholders do hold some concern for environmental problems, such as soil erosion, they do not always recognise such problems on their own properties (Chamala *et al*. 1982, Chamala *et al*. 1983). Finally, some studies reveal that many landholders have a strong preference for conventional farm production as a work activity, as opposed to just a business activity (Hamilton 1991). From this, it might be anticipated that landholders with a reliance on, or personal attachment to, conventional agricultural production, would not be particularly supportive of a non-traditional activity such as forestry, especially if that activity was seen as serving environmental rather than commercial purposes.

There has been considerable growth in landcare group membership in the last 20 years (Lockie and Vanclay 2000), which could be interpreted as a sign of changing values amongst landholders. A number of surveys of attitudes to tree planting and farm forestry plantations, conducted in north Queensland, the northern rivers area of NSW and south-east Queensland, suggest that there are landholders who are planting trees for land and water protection, aesthetic appearance and habitat development (Harrison *et al*. 1994, Herbohn *et al*. 1998). These and other surveys also show that landholders' attitudes vary with gender, age, education level, income, degree of dependency on agricultural income and the type of agricultural activities they carry out. Emtage *et al*. (2001) in a review of previous studies of attitudes to farm forestry has noted the similarity in responses amongst the work so far undertaken.

The aim in this study is to identify variables that are associated with differing attitudes to farm forestry development. Particular attention is given to those variables associated with income and agricultural activities. In addition some landholder types are defined and an assessment is made of how attitudes to farm forestry vary across landholder types, especially the differences between commercial landholders and others. The regions covered include a range of land use activities. The New England region is predominantly a grazing area, with a relatively high proportion of sheep producers. In the Darling Downs shires, there major form of extensive grazing is beef production while crops include summer and winter cereals, grain legumes and cotton. The survey also covered some intensive livestock and crop producers. The respondents represent at most, a range of landholder types found in the northern wheat/sheep zone, although attitudes may vary according to local sub-cultures.

5.2 Research Methodology

The survey instrument was developed from questionnaires used in north Queensland (Herbohn *et al.* 1998). It was modified to reflect prevailing land-use activities and environmental issues in the study regions, which comprise six shires on the Darling Downs and one on the New England Tableland. Data from all shires are included in the analysis. The re-phrasing of questions was informed by discussions with local forestry extension personnel, interviews with two plantation owners on the Darling Downs and the conduct of a pilot survey at the 2000 Agshow in Toowoomba. While the results from the pilot survey were not analysed statistically, the feedback from respondents was taken into account in refining the final questionnaire. This questionnaire was tested on three types of landholders – namely a part-time farmer, a farmer with a plantation and a commercial crop producer – prior to being sent out to landholders.

Questionnaire design and administration

The four-page questionnaire used in the survey consists of four sections. Section 1 includes questions relating to experience with plantation and native timber. Questions in Section 2 relate to the extent and type of agricultural activities the respondents undertake on properties they own or manage. Sections 3 and 4 contain sets of statements, relating to reasons for, and barriers to, farm forestry. In each of the sections, there are two columns; one is a set of statements relating to plantations and one

is a set of statements relating to the management of native trees for timber production. A five-point Likert scale is placed adjacent to each statement. The Likert scale for the questions relating to reasons for planting and managing is labelled as *very important, quite important, moderately important, somewhat important* and *not important*. The Likert scale for the questions relating to barriers to tree establishment and management is labelled *strongly agree, agree, neither agree nor disagree, disagree* and *strongly disagree*. Each section commences with a statement of the reasons for the questions. This is based on the principle that such explanations encourage trust and cooperation. The most personal questions have been placed in Section 5.

There was some concern about how respondents perceived their role in answering the forestry questions, given that during the pilot survey landholders frequently refused to participate on the grounds that they did not have any experience with forestry. Therefore, recipients were asked to score the reasons as to why 'landholders' in general might or might not consider farm forestry. To counteract the problem of answering on the basis of perception of others, at the end of each set of statements, there was a question *does your personal position differ to your answer above?* This was followed by a 'yes/no' check box. Only a few respondents ticked 'yes', although many left this blank so there is some doubt in a number of cases about which perspective is taken. Section 5 contains questions relating to personal characteristics, including gender, age, level of education, profession, trade or skill, time spent in off-farm employment and income. There were also questions relating to the respondent's business connection with the property or properties described in Sections 1 and 2 to find out whether the respondent owned, managed or rented the property, and whether they were in a partnership or a company.

The sample database of landholders' names and addresses was compiled from electronic databases held by five shire councils in the greater Darling Downs region and the Dumeresq Shire in the New England area. The sample was not stratified and the shires were selected on the basis of a willingness and capacity to provide the names and addresses of ratepayers. Some shire councils have a non-disclosure policy with regard to their ratepayer databases and unfortunately one of those shires covers much of the study area used for the spatial analysis in Chapter 8. The database was searched manually to eliminate duplication in cases where one owner or set of owners was registered against several blocks of land. However, the total area for each ratepayer was retained, and those with areas of less than 10 ha were excluded. Despite this there are five respondents who have less than 10 ha.

The remaining addresses were formatted as labels and printed. Each questionnaire was accompanied by a covering letter, explaining the purpose of the survey and offering merchandise vouchers as prizes, in an effort to increase the response rate and to identify, where possible, the shire of origin for each completed questionnaire. The questionnaires could either be posted back anonymously, or if respondents wished to enter a draw for some merchandise vouchers, they returned an additional sheet providing their names and addresses. This sheet was colour coded to indicate the shire in which the respondent resided. The choice of geographical anonymity was required under the ethical guidelines of the University of Southern Queensland. The response rates are reported in Table 5.1.

Table 5.1 Questionnaire responses by shire

Shire	Total sent	Total returned	Identified response rate	Proportion of total sent	Proportion of total responses
Chinchilla	345	73	21.2	10.0	9.8
Dumeresq	675	110	16.3	19.6	14.7
Jondaryan	230	31	13.5	6.7	4.1
Millmerran	490	77	15.7	14.2	10.3
Rosalie	430	77	17.9	12.5	10.3
Warwick	1272	232	18.2	37.0	31.1
Unknown origin		147		0.0	19.7
Total	3442	747	21.7	100.0	100.0

Both Warwick and Dumeresq shires were formed from recent amalgamations of several shires and so are much larger in terms of landholder numbers than the other shires included in the survey. Larger properties are more likely to be found in Chinchilla and Millmerran Shires and in the west of Jondaryan Shire, where more extensive farming activities are practiced. Given the relatively high anonymous return rate, it is not possible to determine whether there is any geographical bias in the responses.

Data were entered into the SPSS statistical analysis program, Version 10.0, with the questionnaires numbered according to the order in which they were returned. The respondents were asked whether they had a profession, trade or skill, other than farming, and then asked what their profession is. Those who answered ‘no’ to the first question were classified as a ‘farmer only’. An answer of ‘yes’, with the skill listed, was then categorised according to the categories used in the Australian and New Zealand Standard Industrial Classification (ANZSIC). Where more than one skill was listed, the respondent was classified as having the higher-level skill. This did mean that people could be classified according to a profession in which they spent the lesser part of their time. Where the response was ‘yes’, but either there was no skill listed or the answer was not clear enough to allow a categorization, the respondents were excluded from analyses concerning their profession, trade or skill.

Methods of analysis

In undertaking the analyses, attempts were made to identify the socio-economic characteristics of respondents with significant relationships to various aspects of tree planting and management attitudes and behaviour.

The main methods of analysis used were:

- factor analysis, in which specific statements were grouped, based on the responses in the Likert scales, to create fewer factor scales
- significant difference of means (ANOVA) - where data relating to landholder or property characteristics could be sub-divided into discrete categories, for example yes/no questions, there was a comparison of means to check for population differences in regard to scores on the various scales created through the application of factor analyses
- regression analyses, testing for correlations between various continuous data, for example property size and the factor scales
- creating categories of landholders based on a combination of significant variables and then using differences of means to examine whether different landholder types had different attitudes to farm forestry.

A 5% significance level was adopted for the last three forms of statistical analysis.

Some exploratory analysis was undertaken; however, the results from these are too detailed to be easily reported, and some of the relationships identified contribute little to this chapter, though the findings may be of interest to those involved in some types of extension work and in research on the sociology of agricultural production. The exploratory work included:

Chi-square tests of all Likert scale responses, that is, responses to statements about reasons for and barriers to farm forestry, in relation to characteristics of the respondents and their properties;
Chi-square tests of all Likert scale responses against each other, that is, to determine whether scores in response to one statement area associated (positively or negatively) with scores for another statement.
Testing for differences between means of all Likert scale responses in relation to the characteristics of the respondents and their properties, where those characteristics are expressed as categorical differences.

Some of the findings provided ideas for future research, while others provided some depth of analysis. For example, where there is a significant correlation between a variable and one of the factor scale scores, it is possible to examine the results of that variable in relation to each of the statements that make up the factor scale. Some of these findings will be reported in the author's forthcoming PhD thesis. In the interests of brevity and readability, only the results relating to the factor scales have been reported in this chapter. The significant findings from the various types of analyses are described.

5.3 Results of the Factor Analysis

There were three main reasons for undertaking a factor analysis of the topics, as represented by the statements in the questionnaire. First, it simplifies the subsequent analysis, so that the 10 or 12 statements are reduced to two or three factors (Green *et al*. 1988, p. 554). Second, it reveals areas of general concern, which helps to understand better the broad concerns of landholders. Third, it effectively creates larger scales, so that instead of five-point scale, based on one question, a set of three questions creates a 15-point scale. This, it can be argued, results in a more subtle gradation of responses. For reporting purposes, the final means are divided by the number of statements in each factor, to reduce all results to a standard measure (out of five). The factor analysis groups the statements based on the frequency with which respondents place similar scores on each of the statements. The grouped statements are then given names that represent or summarise the items included in the scale. A principal components analysis has been used to create the factor scales. For each scale, a scale reliability test was run, with the Cronbach Alpha statistic reported. This tests the inter-item correlation, and statistics greater than 0.7 indicate a relatively reliable scale has been identified, although a statistic of less than 0.7 is considered by some to be acceptable if the research is exploratory, as is the case here (Hair *et al.* 1992, p. 449).

Before considering the factor analyses, the mean scores for the specific statements are shown so as to provide an indication of landholders' responses to each of the statements. The mean scores for those statements relating to the topic 'reasons for establishing plantations' are presented in Table 5.2. There is no obvious relationship between the types of statements and their relative scores, although the three statements with the highest mean scores are not directly related to income but are associated with property planning decisions that have impacts on overall production.

Table 5.2 Mean scores for statements of reasons for establishing plantations

Statement	Number of observations	Mean
Minimise land degradation by establishing ground cover	711	3.87
Establish shelter belts for stock or crops	716	3.79
Make better use of low-fertility country	705	3.75
Increase total farm income	706	3.45
Increase the value of property	710	3.73
Make better use of unused parts of property	704	3.59
Provide habitat for wildlife	717	3.49
Provide income for later in life	702	3.30
Diversify income	696	3.24
Make property look better	707	3.11
Less labour intensive and easier to manage	703	3.11
Provide timber for on-farm use	714	3.07
Reduce total tax paid	694	2.63

The results for the principal components analysis of the statements included in the topic 'reasons for establishing plantations' are reported in Table 5.3. The scores in the right-hand columns indicate the strength of the relationship of the statement to the factor while the alpha result indicates the reliability of the scale. According to the alpha result, the farm management scale could be considered as not particularly reliable as a scale. The final statement is ungrouped because of its negative relationship with all of the factors.

Table 5.3 Factor matrix for the reasons for establishing plantations

Standardised item alpha	Scale name	Statement	Factor 1	Factor 2	Factor 3
0.8801	Economic	Provide income for later in life	0.835	0.199	0.058
		Increase total farm income	0.823	0.174	0.069
		Less labour intensive and easier to manage	0.756	0.200	0.207
		Diversify income	0.797	0.108	0.316
		Increase the value of the property	0.585	0.243	0.451
		Reduce total tax paid	0.578	0.098	0.347
0.7592	Environmental	Provide habitat for wildlife	0.239	0.797	0.071
		Minimise land degradation by establishing ground cover	0.240	0.731	0.248
		Make better use of low-fertility country	0.457	0.452	0.385
0.679	Farm management	Provide timber for on-farm use	0.202	0.046	0.761
		Establish shelter belts for stock or crops	0.066	0.401	0.707
		Make better use of unused parts of the property	0.336	0.217	0.652
	Ungrouped	Make property look better	-0.061	-0.670	-0.150

The mean scores for the statements of the topic 'barriers to establishing plantations' are reported in Table 5.4. The statements with the higher scores are concerned with the perceived returns from timber, the potential inflexibility of land-use choice resulting from timber production and concern about government regulation of the resource. Scores for the statements relating to risk and management of a plantation are relatively low.

Table 5.4 Mean scores for statements of barriers to establishing plantations

Statement	Number of observations	Mean
There is too much uncertainty about future returns from timber	715	3.78
It is more important to be able to quickly change enterprises	716	3.72
Future government regulations will restrict production opportunities	710	3.70
Requires too much upfront capital	710	3.68
Annual income is more important than long-term income	717	3.61
It is more profitable to graze or farm than to plant trees	713	3.58
Not enough knowledge about trees in region	712	3.33
The risk of fire damage to trees is too high	710	3.16
The risk of pest damage to trees is too high	710	2.75
The risk of storm damage to trees is too high	712	2.65
It would be difficult to learn to manage plantations	709	2.49
There is not enough knowledge about suitable tree species for the region	713	2.33

The results for the factor analysis of the barriers statements and the reliability tests for the scales are presented in Table 5.5. The final statements are ungrouped because of the relatively low values in relation to each of the factors. The Cronbach Alpha tests suggest that the knowledge scale is not reliable; however, subsequent results are reported.

Table 5.5 Factor matrix for the barriers to establishing plantations

Standardized item alpha	Scale name		Factor 1	Factor 2	Factor 3
0.7596	Economic	It is more profitable to graze or farm than to plant trees	0.788	-0.020	0.205
		There is too much uncertainty about future returns from timber	0.717	0.240	-0.019
		It is more important to be able to quickly change enterprises	0.708	0.197	0.101
		Future government regulations will restrict production opportunities	0.531	0.245	-0.147
		Annual income is more important than long-term income	0.671	0.091	0.303
0.7123	Risk	The risk of storm damage	0.098	0.783	0.179
		The risk of fire damage	0.202	0.751	0.039
		The risk of pest damage	0.071	0.564	0.453
0.441	Knowledge	There are no suitable species for my area	-0.032	0.038	0.845
		There is not enough knowledge about suitable tree species for the region	0.228	0.257	0.561
	Ungrouped	Requires too much up-front capital	0.383	0.531	-0.097
		It would be too difficult to learn to manage plantations	0.098	0.520	0.122

The results indicate that:

- The mean ratings for individual statements indicate that landholders are more concerned about economic impediments to farm forestry than they are about risk and knowledge barriers. Economic reasons for farm forestry are considered important but the most supported reasons are to do with resource protection and farm production issues;
- There are six factor scales, with three for reasons and three for barriers. The statements grouped as *Environmental Reason, Risk Barrier* and *Knowledge Barrier* appear to have 'face value', in that the statements seem to fit the label. The *Economic Barrier* and *Economic Reason* factors include direct financial issues and other statements that have indirect economic implications; and
- The factor scales for *Economic Reason*, *Environmental Reason*, *Economic Barrier* and *Risk Barrier* are reliable scales.

5.4 Results of the Statistical Analyses

A number of statistically significant relationships between personal and property characteristics and attitudes were found. Because some of these do not contribute directly to the main analysis in this chapter they are not discussed. Many of those relationships are, however, of potential interest to extension personnel, and so a summary of the findings is included. The details of these findings are available from the author and will be discussed in a forthcoming PhD thesis.

The statements in the summary below report situations in which significance levels of 5% or lower were achieved:

1. Females had higher scores on the *Total Reason* scale and on the three factor scales, most notably *Environmental Reason*.
2. Older respondents had lower scores on all reasons scales with a significant difference between ages on the *Economic Reason* scale.
3. Those with higher levels of final education (e.g. diploma or degree) had higher scores for *Total Reason*, *Economic Reason* and *Environmental Reason*, than did those with primary or secondary school education. In addition, those whose highest level of formal education is at the secondary or primary level had higher scores on all barrier scales than did those with a degree or diploma.
4. Those respondents who reported having a profession, skill or trade, and those classified as a manager, administrator, professional, associate professional and clerical or service worker, gave significantly higher ratings to all scales in the topic 'reasons for establishing plantations' than did those classified as a farmer only, intermediate production and transport worker, or tradesperson or related worker. This latter set of categories was also associated with significantly higher ratings on the scales *Total Barrier*, *Economic Barrier* and *Knowledge Barrier*.
5. The longer the period of time respondents have been involved with property ownership or management, the lower the scores for the *Total Reason*, *Economic Reason* and *Environmental Reason* scales and the higher the scores for the *Total Barrier* and *Economic Barrier* scales.
6. Those who believe they will pass the property on to friends or family are more likely to have lower scores for the *Total Reason* and *Environmental Reason* scales, but they also have lower ratings for the *Total Barrier* and *Economic Barrier* scales.

There were also some notable differences in ratings on the various scales, between those who have direct or indirect experience with trees and those who have not. Those people who identified themselves as having plots of trees that could be suitable for native timber production gave higher ratings for the *Farm Management Reason* scale and lower ratings for the *Knowledge Barrier* scale than those who reported having no plots of trees suitable for native timber production. There are also significant differences between those with direct experience of tree planting and those who have none.

Those who have planted trees in the last 15 years have higher ratings for all the reasons scales than those who have not planted trees in that time (Table 5.6).

Table 5.6 Respondents who planted trees in the last 15 years and reasons for establishing a plantation

Have you planted trees on your property in the last 15 years?		n	Mean ratings			
			Total reason	Economic reason	Environmental reason	Farm management reason
Yes		431	3.52	3.36	3.80	3.54
No		212	3.24	3.04	3.48	3.36
Total		643	3.43	3.25	3.69	3.48
ANOVA	F		12.836	12.091	14.129	4.285
	Sig.		0.000	0.001	0.000	0.039

Amongst those who have planted trees, there were differences in the ratings of various scales according to the respondents' stated purpose of the plantings.

1. Those who planted trees specifically to provide shelter for stock or crops had higher ratings for *Total Reason* and *Farm Management Reason* than did the rest of those who planted trees.
2. Those who planted trees to improve the environmental aspects of waterways had higher ratings for the *Environmental Reason* than the rest of those who planted trees.
3. Those who planted trees to protect soil had higher ratings on *Environmental Reason, Total Reason* and *Economic Reason* than did the rest of those who planted trees.
4. Those who planted trees to encourage wildlife had higher ratings on the *Environmental Reason* and *Total Reason* scales than did the rest of those who planted trees.
5. Those who planted trees with an intention of harvesting had lower ratings for all scales in the topic 'barriers to plantation establishment'.

This information about the socio-economic characteristics of landholders' with different levels of interest in tree planting can help extension personnel to identify people who are more likely to be interested in joint ventures or in establishing research or demonstration plots. In addition, it provides policy-makers with a greater understanding of the policy environment.

5.5 Identifying Significant Differences in Income, Property and Production Characteristics

The second stage of analysis was to identify any socio-economic characteristics that could be used to categorise the respondents into a set of landholder types. Where there were categorical data, the mean ratings were compared for significant differences and where there were continuous data, regressions were used. Again, many significant results were obtained, some of which confirm relationships revealed by other analyses. These confirmatory findings are noted but the results are not fully reported in the interests of brevity.

In general the greater time spent in off-farm employment, the higher the mean scores on *Total Reasons* and *Economic Reasons* for establishing plantations, as indicated in Table 5.7. Tests for significant differences in mean ratings for various scales between specific groups have not been conducted here because the purpose is just to identify the significant characteristics and then use them to create categories of landholders. From Table 5.7, the greatest disparity in mean ratings is between those who spend less than five hours a week in off-farm employment, and those who spend more than 30 hours a week so engaged. There were a few respondents who spent less than five hours a week in paid employment but did not engage in considerable agricultural activity. It is presumed that these people were retirees or owned businesses and saw themselves as not being 'in paid employment'.

Table 5.7 Time spent in paid employment and reasons for establishing plantations

Time spent in off-farm employment	n	Mean ratings			
		Total reason	Economic reason	Environmental reason	Farm management reason
Less than 5 hrs/wk	343	3.30	3.14	3.53	3.36
5 - 15 hrs/wk	43	3.42	3.21	3.88	3.51
15 -30 hrs/wk	55	3.49	3.32	3.77	3.48
More than 30 hrs/wk	198	3.64	3.49	3.94	3.66
Total	639	3.43	3.27	3.70	3.47
F		5.777	4.625	7.248	3.678
Sig. level		.001	.003	.000	.012

The proportion of income derived from farm activities is significantly correlated with all reasons scales and all of the barrier scales except *Risk Barrier*. The results of analyses presented in Table 5.8 indicate that the higher the proportion of income from farm activities, the lower the ratings for the reasons scales, while the higher the proportion of income from farm activities, the higher the ratings for the barrier scales.

Table 5.8 Proportion of income derived from farm activities and the ratings of importance given to the scales in the topics reasons for and barriers to, establishing plantations

Dependent variable	R square	*t*-statistic	Significance level
Total reason	0.022	-3.640	0.000
Economic reason	0.012	-2.840	0.005
Environmental reason	0.041	-5.117	0.000
Farm management reason	0.011	-2.793	0.005
Total Barrier	0.019	3.382	0.001
Economic Barrier	0.032	4.568	0.000
Knowledge Barrier	0.014	3.144	0.002

There is also a relationship between total income and barriers to establishing plantations, as indicated in Table 5.9. This suggests that those with higher incomes tend to have lower *Total Barrier* and *Economic Barrier* scores. Taken together, the analyses reported in Tables 5.8 and 5.9 suggest that those with a low dependency on agricultural income and a high income would have generally higher reasons scores and lower barrier scores. Landholders with these characteristics will tend to be near the major centres and labour markets. To explore this further, respondents were categorised according to the proportion of income earned from properties and total income.

Table 5.9 Total income and economic barriers to the establishment of plantations

Scale	R square	*t*-statistic	Significance level
Total Barrier	0.033	-4.512	0.000
Economic Barrier	0.015	-3.112	0.002

The respondents were divided into three sets, according to dependency on agricultural income, and then each set was divided into high and low income to create six final categories. A more comprehensive categorisation, discussed below, supersedes this analysis, so analysis of the typology based on total income/source of income is not reported in detail. The analysis did, however, qualify some of the findings from the regression analyses reported in Tables 5.8 and 5.9:

1. Higher income recreational landholders have higher scores for the *Total Reason* and *Environmental Reason* scales, and lower scores for the *Total Barrier* and *Economic Barriers*, than do lower income landholders. That is, the income effect indicated by the regression relationship holds true between the two recreational categories.
2. The higher income part-time farmers are not significantly different with regard to reasons for establishing plantations, from their lower income counterparts. They did have higher barrier scores however.
3. The higher income full-time farmers had lower *Total Reason* and *Economic Reason* ratings than did the lower income counterparts, and they also had higher ratings for *Total Barrier* and *Economic Barrier*.

The above results indicate that 'commercial' farmers, especially those with high incomes, gave lower ratings for *Total Reason* and *Economic Reason* and higher ratings for *Total Barrier* and *Economic Barrier* than did those who derive little or no income from properties. To further develop the concept of a 'commercial' farmer, variables including those representing property characteristics and farm business activities were analysed to assess their relationship with scales indicative of respondents' attitudes to plantations.

The first variable considered was property area in Table 5.10. The results of regressions analyses indicate that those with larger properties are likely to have lower scores for the scales *Total Reason* and *Environmental Reason*.

Table 5.10 Log of the property area and the factor scales

Dependent variable	R square	*t*-statistic	Significance level
Total reason	0.014	-2.991	0.003
Environmental reason	0.041	-5.393	0.000

A comparison of means for the *Environmental Reason* scale also showed that those who owned more than one property were likely to have a lower score than those who owned only one property. It is presumed that this variable is another measure of – or related to – total property size, and possibly to sources of income.

In terms of what respondents produced from their properties, there was only one significant factor (Table 5.11). Those who owned livestock were more likely to have higher ratings for the *Total Barrier* and *Economic Barrier* scales, than those who had no livestock. Livestock is a broad category and includes pigs, fish and poultry, as well as sheep and cattle. Therefore, there is a case for sub-categorisation.

Table 5.11 Mean scores for barriers to establishing plantations by livestock ownership

Ownership of livestock	n	Mean scores			
		Total barrier	Economic barrier	Risk barrier	Knowledge barrier
No	49	35.694	16.224	8.373	5.404
Yes	632	38.995	18.508	8.568	5.667
F		12.142	19.111	0.370	1.350
Sig.		0.001	0.000	0.543	0.246

This section of the chapter has highlighted some of the variables that appear to be associated with differences in attitudes to the reasons for, and barriers to, establishing farm forestry plantations. From the various tests of significance, several variables have been identified, including:

- level of income
- proportion of income from agriculture
- time spent in paid off-farm employment
- size of property
- type of agricultural activity (although this was limited to only one type of production being a significant factor).

In order to simplify the analyses, and reflect combinations of these factors that are found in the study site, a set of farmer types was created.

5.6 Analysis of Attitudes to Farm Forestry Plantations by Farmer Type

The respondents were classified into landholder type categories. The categorisation was based on combining some of the variables that seemed to be relevant, while keeping in mind some of the farm types that are found in the study regions. Through classifying respondents, at least partially, by producer activity and property scale, the landholder types can be associated with particular areas of a region, which can thus assist in constructing a spatial analysis of possible farm forestry scenarios. The classifications are described in Table 5.12.

The main four criteria for classification were the extent of production, time spent on and the proportion of income from farm activities, and proportion of time in paid employment. The importance of the level of off-farm employment was in some cases overridden by the scale of farming operations. If the level of production was high, for example 4,000 sheep or 200 cattle, but the time spent in paid employment was 5-30 hours, these cases were shifted into the ‘commercial’ categories rather than being classed as ‘part-time’. There were 10 of these cases. The area range was not a criterion for classification, but a result of the classification.

Differences between farmer types were examined statistically using ANOVA and least significant differences (LSDs) between means. The LSD outputs are arranged to show where single categories or sets of categories have significantly higher scores than another category or set of categories. The test of categories against the reasons scales show that there are, in general, differences between the ‘low production’ categories (low production landholders, recreational farmers and part-time graziers) and other categories (Table 5.13).

Table 5.12 Categorisation of farm types

Classification	n	Range of total property area	Production range	Proportion of time in paid employment	Income from farm
Non-production landholders	73	4-200 ha[a]	From no activity up to 20 cattle or equivalent stock	More than 15 hours	10% or less
Recreational farmers	165	10-306 ha	Up to 80 ha of grain or up to 80 head of cattle or equivalent activity	More than 15 hours	0-35%
Part-time graziers	134	30-3300 ha	Up to 700 head of cattle, but most in 80-200 head range	5-30 hours	10-70%
Part-time mixed farmers[b]	45	40-700 ha	40-300 ha of grain, some with irrigation and/or 10-250 cattle or equivalent combinations	5-30 hours	10-70%
Intensive livestock farmers	44	40-1720 ha	Feedlot cattle, pigs or chickens of an obviously commercial scale	More than 30 hours	70% or more
Commercial crop farmers	67	80-2100 ha	Predominantly grain and cotton production	More than 30 hours	70% or more
Commercial mixed farmers	29	130-1900 ha	Mix of grazing and crop production	More than 30 hours	70% or more
Commercial graziers	177	150-2900 ha	Predominantly grazing activity	More than 30 hours	70% or more

a. There were five larger properties outside this range

b. This category includes part-time crop farmers. There were only five of them so they were included with part-time farmers who had both crop and stock

Table 5.13 Mean ratings for scales of reasons for establishing plantations by landholder categories

Landholder type	n	Mean rating			
		Economic reason	Environmental reason	Farm management reason	Total reason
All Categories	655	3.3	3.7	3.5	3.4
Low production landholders (LP)	61	3.5	4.1	3.5	3.7
Recreational farmers (RF)	153	3.4	3.9	3.6	3.6
Part-time graziers (PG)	118	3.3	3.9	3.6	3.6
Part-time mixed farmers (PF)	40	2.9	3.5	3.4	3.2
Intensive livestock producers (IP)	35	3.0	3.5	3.6	3.3
Commercial grain farmers (CF)	61	3.3	3.5	3.2	3.3
Commercial mixed farmers (CM)	25	3.4	3.5	3.2	3.4
Commercial graziers (CG)	154	3.1	3.3	3.3	3.2
ANOVA F		2.054	6.635	2.160	3.220
Sig		0.038	0.000	0.029	0.001
Least square difference		LP>PF.IP.CG RF.PG >PF.CG	LP.RF> PF.IP.CF.CM.CG PG>PF.CF.CG	RF>CF.CM.CG PG>CM.CG	LP.RF> PF.CF.CG PG>PF.CG

The LSD tests indicate where there are differences in the mean ratings of different categories. Low production landholders tend to rate economic reasons more highly than do part-time farmers, intensive livestock producers and commercial graziers, while recreational farmers and part-time graziers tend to have higher ratings than do part-time farmers and commercial graziers. The low production landholders, the recreational farmers and the part-time graziers tend to have higher scores for all reasons, than do the other categories. For the *Environmental Reason* scale, the low production landholders and the recreational farmers gave significantly higher ratings than did all the other groups, except for the part-time graziers. For this reasons scale, the part-time graziers gave significantly higher ratings than the part-time farmers, the commercial grain farmers and the commercial graziers. Recreational farmers tended to have higher ratings for the *farm management* scale than did each of the three commercial categories, while part-time graziers gave significantly higher ratings than did commercial mixed farmers and commercial graziers. For the *Total Reason* scale, low production landholders and recreational farmers gave significantly higher ratings than did the part-time farmers, commercial crop farmers and commercial graziers, while part-time graziers gave significantly higher ratings than did part-time farmers and commercial graziers.

This first analysis indicates landholder types that have a greater interest in plantations. A further objective is to anticipate variations in attitudes to the specific purposes of plantations. Therefore, another test was undertaken to detect variations in responses to specific reasons statements, as represented by the scales. The mean ratings for the various landholder types are reported in Table 5.14, with the significance results shown in Table 5.15.

The right-hand column of Table 5.16 presents the pairwise comparisons. The points below summarise the findings that are relevant to the later discussion:

1. The 'income' statements, relating to direct income, future income and diversifying income, generally have lower scores than those relating to farm management or environmental protection. There are significant differences between the three low-production categories, low production landholders, recreational farmers and part-time graziers and the other landholder types.
2. All groups gave high ratings for *minimising land degradation*, relative to their scores for other statements, but the three lower production types had significantly higher ratings than did the other types.
3. Those landholder types where livestock is the predominant agricultural activity have comparatively higher ratings for *establishing shelter belts* as a reason for establishing plantations. In particular, the intensive livestock producers, recreational farmers and part-time graziers had significantly higher ratings for this reason than other landholder types.
4. The three low-production landholders and the commercial crop farmers gave higher ratings than other groups for each of the scales, *making use of low-fertility areas* and *making use of unused parts of the property*.
5. Commercial producers have high scores for *increasing the value of the property*, relative to their scores for other statements, but low-production landholders gave higher ratings than commercial graziers and part-time farmers, while part-time graziers and recreational farmers gave higher ratings than commercial graziers.
6. For the habitat statement, the low-production landholders gave higher ratings than almost all other groups, while recreational farmers gave a higher score than the commercial groups and the part-time mixed farmers.
7. The only statement for which the three low-production groups had comparatively low scores, was with regard to *making the property look better*.
8. Tax benefits had relatively low ratings for almost all groups, but the low production groups had the highest comparative scores amongst the groups.

The final analysis undertaken was to check the mean ratings for the barrier scales by landholder types. In general, the low-production types had the lowest scores for the *Total Barrier*, *Economic Barrier* and *Knowledge Barrier* scales.

Table 5.14 Mean ratings for specific reasons for establishing plantations by landholder type

Reason for establishing plantations	Mean rating								
	Total	Low production landholders	Recreational farmers	Part-time graziers	Part-time mixed farmers	Intensive livestock producers	Commercial grain farmers	Commercial mixed farmers	Commercial grazing
Minimise land degradation	3.87	4.40	4.16	4.10	3.58	3.83	3.63	3.68	3.33
Establish shelter belts	3.79	3.55	4.02	3.98	3.69	4.08	3.47	3.43	3.63
Use of low-fertility sites	3.75	4.04	3.96	3.91	3.58	3.63	3.77	3.71	3.34
Increase value of property	3.73	4.04	3.81	3.86	3.50	3.76	3.72	3.64	3.52
Make use of unused sites	3.58	3.67	3.72	3.76	3.50	3.59	3.69	3.48	3.28
Provide habitat for wildlife	3.49	4.03	3.68	3.61	3.23	3.20	3.28	3.07	3.25
Increase total income	3.44	3.41	3.54	3.58	2.98	3.25	3.44	3.75	3.36
Provide income later in life	3.31	3.55	3.52	3.29	3.09	2.95	3.14	3.41	3.17
Diversify income	3.24	3.29	3.31	3.47	2.89	2.85	3.32	3.15	3.12
Make property look better	3.12	2.94	2.87	3.15	3.39	3.05	2.92	3.00	3.42
Less labour intensive	3.11	3.55	3.29	3.08	3.07	2.90	3.23	3.25	2.79
On-farm timber	3.07	3.34	3.11	3.22	2.93	3.21	2.55	2.71	3.07
Tax benefits	2.63	2.85	2.88	2.80	2.33	2.28	2.67	2.68	2.38

Table 5.15 Summary of statistics for differences in mean ratings for reasons statements by landholder type obtained from ANOVA

Reason for planting trees	F	Sig.	n	Least significant difference
Minimise land degradation	8.665	0.000	700	LP>IP.CM.CF.PF.CG RF.PG>CF.PF.CG
Establish shelter belts	3.028	0.002	705	IP.RF.PG> LP.CG.CF.CM
Use of low-fertility sites	3.449	0.001	694	LP.RF.PG.CF>CG
Increase value of property	1.979	0.047	699	LP> CG.PF PG .RF>CG
Make use of unused sites	1.609	0.118	693	PG.RF.CF.LP>CG
Provide habitat for wildlife	3.908	0.000	706	LP>PG.CF.CG.PF.IP.CM RF>CF.CG.PF.IP.CM PG>CG
Increase total income	1.286	0.247	695	CM.PG.RF>PF
Provide income later in life	1.533	0.142	691	LP>IP RF>IP.CG PG>IP.PF.CG
Diversify income	1.461	0.168	685	CG>LP.CF.RF
Make property look better	2.473	0.012	696	PF>RF LP>PG.IP.CG
Less labour intensive	2.439	0.013	692	RF.CF>CG LP>CF.CM
On-farm timber	2.024	0.041	703	RF.PG.IP.CG>CF LP>CG
Tax benefits	2.559	0.009	683	RF>PF.IP.CG PG>CG

Note: Categories are in descending order, based on the total mean rating for each statement.

Table 5.16 Mean scores for barriers to establishing plantations by landholder type

Landholder types		Mean score			
	n	Economic barrier	Risk barrier	Knowledge barrier	Total barrier
All Categories	679	3.67	2.85	2.82	3.63
Low production landholders (LP)	70	3.35	2.80	2.59	3.78
Recreational farmers (RF)	163	3.52	2.87	2.74	3.95
Part-time graziers (PG)	125	3.79	2.92	2.76	3.86
Part-time mixed farmers (PF)	42	3.68	2.79	3.03	3.97
Intensive livestock producers (IP)	39	3.72	2.85	2.94	4.03
Commercial grain farmers (CF)	61	3.77	2.90	3.12	3.84
Commercial mixed farmers (CM)	26	3.77	2.79	2.80	3.93
Commercial graziers (CG)	156	3.78	2.81	2.88	3.88
ANOVA F		3.973	0.364	3.356	2.662
Sig.		0.000	0.940	0.001	0.007
Least significant difference		PG.CG.CF>LP.RF PF.CM.IL >LP	No significant differences	CF>CG.PG.RF.LP PF>PG.RF.LP IL.CG>LP	PG.CF.CG>RF.LP IL>LP

The key points from this analysis are:

1. The commercial types and the part-time farmers have significantly higher scores for the *Economic Barrier* scale, than do the three lower production categories;
2. There are no significant differences between groups with regard to the *Risk Barrier* scale;
3. Commercial farmers, part-time farmers and intensive livestock producers have significantly higher scores for the *Knowledge Barrier*, than did the low production types; and
4. For the *Total Barrier* scale, commercial farmers, commercial graziers, part-time farmers and intensive livestock producers have significantly higher scores than do the low production landholders and the recreational farmers. In addition, the part-time graziers have a significantly higher score for this scale, than do the low-production landholders and the recreational farmers.

5.7 Discussion of Results

Reports of analyses of previous surveys of landholders attitudes to farm forestry suggest that the economic reasons for planting trees, such as to increase income or diversify production, are generally ranked lower in importance by landholders, than those relating to land and water protection, aesthetic appearance and habitat development and those who were planting trees were planting them for non-economic reason (Harrison *et al*. 1994, Herbohn *et al*. 1998). In addition, commercial landholders – who are more dependent on agricultural activities for income – tend to rate most reasons for planting trees lower and most barriers to planting trees higher, than do other landholder types. Analysis of responses to this survey indicate that attitudes to farm forestry vary with gender, age and education level. The project goal for this chapter was to ascertain whether categories of landholders, created from a combination of variables that have been reported to have a relationship with landholders attitudes to farm forestry, would differ in their attitudes to farm forestry.

If a combination of high scores for scales relating to reasons for plantation establishment and low scores for scales relating to barriers to plantation establishment signify a predisposition for landholders in this region to consider establishing plantations, then:

1. The three lower production groups – low-production landholders, recreational farmers and part-time graziers – are generally more predisposed to consider farm forestry than the other groups. This supports the findings of the preliminary analyses in this chapter of single variables, previous survey work and the experience of forestry extension personnel. However, the part-time graziers are more like the commercial groups in relation to the barriers to undertaking farm forestry.
2. Even a relatively small amount of agricultural production is associated with a difference in attitudes. The low-production landholders differ from commercial groups on almost all tests for differences in responses, while for a few tests, there are no significant differences between recreational farmers and part-time graziers and the commercial groups. That is, those with even a small level of agricultural activity may have similar attitudes to commercial farmers on some issues.
3. Part-time mixed farmers are more like the commercial groups than the three low-production types. This may be because many are running operations that they hope will be, or were at one point, commercially viable. Crop production signals a greater degree of engagement in farming activities than small numbers of stock. Therefore, these types of part-time farmers tend to have the attitudes and interests similar to those of the commercial crop farmers.
4. Economic reasons for establishing plantations are not a high priority, based on the scores for individual statements, for any of the farmer types, although they tend to rank comparatively higher for the commercial crop farmers. However, the commercial farmers, especially grain farmers, consider that there are high economic barriers to establishing plantations. This means even though commercial farmers might require a commercial reason for establishing a plantation, they do not believe that it will be commercially viable to do so.
5. Of all the landholders surveyed, the three low-production categories, especially the low-production landholders, are most open to considering environmental reasons for establishing plantations, and in particular indicate the greatest willingness to establish plantations to provide habitat for wildlife. Commercial crop farmers are more open to environmental reasons than commercial graziers, intensive livestock producer and part-time farmers. Commercial graziers

and part-time farmers attached the lowest scores to environmental reasons for establishing plantations.

6. Land protection as a reason for establishing plantations has the highest level of support as an average of the scores given by all respondents. This reason is strongly supported by almost all landholder types defined for this study, relative to their support for other individual statements, with the three low-production groups having the highest overall scores for this reason.
7. Shelter belts as a reason for establishing plantations are also relatively well supported and are understandably a greater relative priority for those with livestock. Commercial grain farmers and commercial mixed farmers do not rate this reason as particularly important. This may be related to the lack or ambiguity of evidence of crop protection benefits from shelter-belts in the northern, dryland cropping regions.
8. *Making use of low fertility areas* as a reason for establishing plantations is the third highest rated reason for establishing plantations, with the three low-production farmer types placed significantly higher ratings on this reason than did the commercial graziers. Landholders in general may view forestry as an activity best located on poor soils. The exception here is the commercial graziers who may routinely graze low-fertility areas already.
9. The three lower production farmer types have the higher scores for *making use of unused parts of the property* as a reason for establishing plantations, with commercial graziers having the lowest overall score. This means that the commercial farmers are not that interested in using unused parts of their farms. Presumably, graziers already have the capacity to use most of their properties because most areas can be grazed at some time. Commercial crop farmers would have some unused areas, such as those adjacent to waterways and those in paddock corners. They do not seem to have a particular interest in making use of these and this may be because they are not interested in devoting the time to a small-scale, low return (as they see it) enterprise, when their turnover from crops is high.

If correct, the above conclusions have some implications for the way farm forestry will develop across agricultural landscapes, if indeed it develops at all.

5.8 Implications of the Results for Land-use in Agricultural Landscapes

Based on the preceding results and discussion, a number of implications for land-use patterns in these regions are hypothesised.

1. There will not be a rapid increase in the area of farm forestry in the broadacre agricultural landscapes.
2. If more landholders engage in tree planting, then this may contribute to an increased interest in small-scale plantations. There is however, no way of ascertaining from this study whether experience with trees is the result of a person having different attitudes, or whether the experience leads to the change of mind.
3. Any expansion in the number of growers will primarily rely on smallholders, especially those with higher incomes, professional backgrounds and off-farm income, and also those with some pre-existing interest in, or experience with, trees.
4. Production from tree plantations may be restricted if landholders initially establish them mainly on poor soils.
5. Some commercial producers may establish shelter belts, but are not strongly supportive of using parts of their properties that are not currently used for conventional production.
6. The more commercial farmers, excluding the graziers, view soil protection as a reason for establishing plantations. This may provide one opportunity to promote farm forestry, although it must be remembered that landholders do not always recognise land degradation problems on their own farms (Chamala *et al.* 1982).

Across the agricultural landscapes in these regions, plantations will most likely be nearer the Great Dividing Range, where smallholders are most numerous. Plantations will be small, most likely scattered, and in some cases productivity may be quite low. This is because landholders, including

the low-production groups, see plantations as primarily serving functions that tend to be associated with 'mosaic' plantings. Assuming that landholders regard most land degradation as being confined to limited sites within a property, and given that minimising land degradation is seen as being one of the most supported reasons for establishing plantations, then those who act to minimise such degradation will, at least initially, plant small and perhaps irregularly shaped plots. Shelter-belts will most likely be isolated strips on the landscape rather than applied across the majority of farms, and in some cases farms have only patches of low-fertility soil. Therefore, if landholders act according to the priorities indicated by the respondents to the survey, then the result will be a mosaic of forestry pieces, rather than an orderly aggregation.

5.9 Outcomes from the Survey

This survey has extended the work of other researchers to medium rainfall areas and responses indicate that attitudes amongst landholders in these broadacre areas have similar attitudes to forestry as those in the near-coastal regions. The methods used have some limitations, especially relating to the 'selection' of a sample. There were also some specific statements that could have been included, most notably one relating to salinity control as a reason for having plantations, and possibly one on waterway protection. A survey on this scale would not normally be an option for catchment or community groups. When taken with other survey work, the findings do provide community groups with at least some hypotheses with which to work, given the relative conformity between survey findings.

More particularly, the results of this survey can be used:

1. To identify those people likely to have a greater predisposition to farm forestry, so that extension personnel can use this information to locate potential growers and joint venture partners.
2. By policy-makers in order to gain an appreciation of the policy environment, particularly the extent of, and particulars of, the resistance to farm forestry amongst some types of landholders, especially those who hold large areas of land that may be suitable for plantations. One goal of the Farm Forestry Program is to expand the area of farm forestry to achieve multiple benefits, including lowering water tables and improving water quality. If these benefits are to be achieved then some plantations will have to be located by geography rather than by landholder initiative. In such cases, the people implementing a regional forestry plan would need to anticipate the responses of key landholders.
3. To create spatial representations of possible landscape changes, based on the preferences of landholders and their likely land-use choices. While this work does not reveal exactly where plantations might be in the landscape, some conclusions are possible, given that there are concentrations of different types of landholders in sub-regions.
4. For the ranking of reasons and barriers and the aforementioned spatial representations as inputs to the MODSS process, discussed elsewhere in this report.

5.10 Summary

An increase in the area of land devoted to plantation forestry on private farms could have some on-farm and social benefits, including conservation and regional economic benefits, as noted in Chapter 2. Responses to the survey indicate that the rate of uptake of farm forestry in the inland cropping/pastoral zone is relatively low. It would appear that farm forestry will remain a relatively minor activity in landscapes dominated by extensive crop production and grazing activity, or even where there is more intensive production occurring. These conclusions are based on the statistical analysis of some 750 landholders from five shires on the Darling Downs in Queensland and one shire on the New England Tableland in NSW. Therefore, it is not necessarily representative of the inland medium rainfall areas. Nor were landholders stratified in any way so there is also potential for a response bias. The respondents were categorised into landholder types, based on the type and extent of their agricultural activity and the extent and source of their income. An analysis of the attitudes of landholder types suggested that those who are commercial or part-time farmers are less supportive of reasons for establishing plantations and tend to believe that the barriers to that activity are greater than is the case with other landholders. While the low-production landholders have a greater

predisposition to consider forestry, generally even they do not see it as primarily a commercial activity. Therefore, based on these findings, it is concluded that there will be little expansion of farm forestry activity in broadacre agricultural landscapes.

The research has provided information about landholders' attitudes that can be used in processes of community engagement for land-use planning by those involved in land administration and conservation activities. In particular, the priorities of landholders, the types of plantations they may prefer based on their priorities and their concerns about farm forestry can be taken into account, both in advance of informal engagement processes, and in more formal MODSS type work. These results suggest that landholders are likely to favour plantation options that fit around cropping and grazing activities, even where those activities are conducted at a sub-commercial level. In particular, most landholder types tend to see plantations as having a conservation function.

References

Aitkin, D. (1988), 'Countrymindedness – The Spread of an Idea', *Australian Cultural History*, Goldberg, S. and Smith, I., eds., Cambridge University Press pp. 50–57.

Bailey, G. (2001), *Plantation Forestry Enterprise Profile: Warwick, Clifton and Cambooya Shires*, Queensland Forestry Research Institute, Yarraman.

Barr, N. and Cary, J. (1992), *Greening a Brown Land: The Australian Search for Sustainable Land Use*, Macmillan Education, South Melbourne.

Barr, N. and Cary, J. (2000), *Influencing Improved Natural Resource Management on Farms: a Guide to Understanding Factors Influencing the Adoption of Sustainable Resource Practices*, Bureau of Rural Sciences, Canberra.

Bolton, G. (1981), *Spoils and Spoilers*, Allen and Unwin, Sydney.

Bonyhady, T. (2000), *The Colonial Earth*, Miegunyah Press, Carlton.

BRS (Bureau of Rural Sciences), (2000), *National Farm Forestry Inventory*, Canberra.

Chamala, S., Coughenour C. and Keith, K. (1983), *Study of conservation cropping on the Eastern Darling Downs: a basis for extension programming*, Department of Agriculture, The University of Queensland, Brisbane.

Chamala, S., Keith, K. *et al*. (1982), Adoption of commercial and soil conservation innovations in Queensland: information exposure, attitudes, decisions and actions, Department of Agriculture, The University of Queensland, Brisbane.

Cockfield, G. (1994), From Closer Settlement to Rural Adjustment, Unpublished Masters Thesis, University of New England, Armidale.

Green, P., Tull, D., and Albaum, G. (1988), *Research for Marketing Decisions*, 5th edn., Prentice Hall, Eaglewood Cliffs.

Hair, J., Anderson, R., Tatham, R. and Black, W. (1992), *Multivariate Data Analysis*, 3rd edn., Macmillan Publishing, New York.

Hamilton, N. A. (1991), *Attitudes and Behaviours of Farmers and Other Stakeholders Involved in Southern Queensland Farming Systems*, Queensland Department of Primary Industries, Dalby.

Harrison, S., Sharma, P. and Lamb, D. (1994), Progress in farm forestry in the Obi Obi Valley, Community Forestry Seminar, Dorroughby Field Studies Centre, Dorroughby.

Harrison, S. and Eono, J-C. (1996), *Attitudes to tree planting and assistance schemes by Queensland landholders*, Managing and Growing Trees Training Conference, Department of Natural Resources, Brisbane.

Herbohn, J.L., Harrison, S.R., Emtage, N.F. and Smorfitt, D.B. (1998), 'Attitudes of landholders to farm forestry in North Queensland and implications for policy development', proceedings of the IUFRO conference *Integrating Environmental Values into Small-Scale Forestry*, Vancouver.

Lines, W. J. (1991), *Taming the Great South Land*, Allen and Unwin, North Sydney.

Lockie, S. and F. Vanclay (2000), *Critical Landcare*, Centre for Rural Social Research, Wagga Wagga.

Tonts, M., C. Campbell and A. Black (2001), Socioeconomic Impacts of Farm Forestry, Rural Industries Research and Development Corporation, Canberra.

Wear, R. (1991), Agrarian Myth: Its History and Use by the Australian Country Party, The University of New England, Armidale.

6. Landholder Attitudes to Commercial Production of Native Forestry

G. Cockfield

This chapter contains an analysis of landholder attitudes' to the potential for the commercialisation of native timber resources by private landholders in the medium rainfall areas. The analysis supplements the work on plantations in Chapter 5 and aims to provide information about landholder priorities that could be incorporated into a Multi-objective Decision-Support System (MODSS). It may also provide information that helps forestry extension personnel and policy-makers understand the attitudes and priorities of landholders. The chapter starts with a brief discussion of the reasons for considering the commercial potential of native forests on private land, followed by an outline of the methodology used to gather information about landholders' attitudes to utilising the native forest resource. The results are then discussed in light of previous studies, and some conclusions drawn from the analysis.

6.1 The Potential for the Increased Utilisation of Native Forests on Private Land

While much current policy focus is on establishing plantations on substantially modified landscapes in order to develop high production plots that also provide some net social benefits, there is a case for encouraging the management of native timber for commercial purposes. This is because:

- legislative restrictions on land clearing may encourage some landholders to consider the sustainable use of existing native timber stands
- native forestry can yield medium-term and in some cases short-term returns, potentially earlier than the time until the returns from plantation forestry
- there is a considerable area of native timber in the low to medium-rainfall areas that could, with some preparatory work, be managed for native timber production.

Obvious barriers include uncertainty or concern about legislative restrictions and the uncertain economic benefits of applying current recommended management practices, to lower-value species, such as Cypress Pine (Cant 2001).

There is a considerable native timber resource base in inland regions such as the Darling Downs and the New England Tableland. For example, of Queensland's production of approximately 220,000 m^3 of Cypress timber, 40% is processed in the Darling Downs area, while a further 48% is processed in the adjacent south-west region, and an unknown amount from these regions is also processed in the south-east region (QDPI 1998). About 30% of the total Cypress production for the state is drawn from private sources. In addition, 29,000 m^3 of hardwood from privately-owned native forests is processed on the Darling Downs, compared with approximately 16,200 m^3 of plantation timber. Despite the volumes of timber sourced from privately owned native forests in these regions there does not appear to be a great level of interest in native forestry activities by private landholders. In some cases the initial and continuing maintenance costs of native forestry operations may not be justified by subsequent returns (Cant 2001). Further, some landholders may have little interest in forestry, having a strong attachment to conventional production. Some may even be hostile to maintaining timber stands that are seen as harbouring animals that consume pasture and crops on their properties. Finally, there might also be a preference for cleared landscapes because these are a sign of 'progress' and good farm management.

The research objectives for the study reported in this chapter are to:

- identify why landholders may be reluctant to undertake timber production in their native forest areas
- identify some of the reasons why landholders might consider such production
- ascertain whether attitudes to native forestry production vary with landholder types
- investigate whether those landholder who have native tree stands on their properties are likely to consider native timber production.

6.2 Research Methodology

The methodology adopted follows that outlined in Chapter 5, involving a postal survey of a random sample of landholders in a number of local government areas on the Darling Downs and New England Tableland. Questions about native vegetation management were included in the questionnaire discussed in Chapter 5, and questionnaire testing was described in that chapter.

Methods of analysis

Some exploratory analysis of relationships between variables in the dataset was undertaken and many statistically significant results were observed. The exploratory analyses included chi-square tests of independence between responses to all questions and information about the respondents and their properties, and a comparison of responses to all statements against each other using regression analyses. Following the initial round of analyses, a second round was undertaken, concentrating on the variables that were identified as having numerous significant relationships.

The statistical techniques used in the second round of analysis included:

1. Factor analysis applied to responses to the attitudinal variables in order to create two sets of scales for the topics reasons for, and barriers to, native timber production.
2. Significant difference of means (ANOVA) tests. Where data relating to a landholder or their property characteristics could be divided into discrete categories, for example landholders with previous experience in native forestry operations and those without previous experience, there was a comparison of each category's mean responses to the attitudinal variables and other socio-economic variables to test for differences between the categories.
3. Regression analyses were used to identify significant correlations between a number of continuous variables, for example property size, and the factor scales.
4. The definition and testing of a landholder typology, using as defining criteria a combination of characteristics which the aforementioned analyses showed to be significant. A series of tests were used to assess the similarities and differences in the attitudes and socio-economic characteristics of the various landholder types.
5. A probability level of less than 5% was used to signify significant differences for all of the statistical testing where appropriate.

The average ratings for each of the statements relating to the topic 'reasons for considering native timber production' are reported in Table 6.1. As with the plantation analysis the two statements that relate to resource protection have relatively high scores, whereas those statements relating to income have the lower scores.

Table 6.1 Mean scores for reasons for considering native timber production

Reason	n	Mean
To minimise land degradation	699	3.93
To make better use of land with limited capacity for other forms of production	695	3.86
To provide timber on-farm use	699	3.43
To Increase total farm income	689	3.33
To diversify income	687	3.22
To provide income for later in life	679	3.18

A principal components analysis was used to extract the factors, and these were subjected to a varimax rotation, the rotation being found to converge in three iterations. The results of the analysis of responses to the statements included in the topic 'reasons for considering native timber production', along with the alpha statistics, are indicated in Table 6.2. With Factor 1, there are three statements relating to income and so there was a presumption that the underlying factor was 'financial' or 'economic' in nature. *Providing timber for on-farm use* was not so clearly a direct economic statement but this could still be considered a production reason for undertaking native timber production. The alpha result suggests this is a reliable scale. With Factor 2, the scale was named *Conservation Reason*, based on the score for the statement *minimising land degradation*. However, there is an economic aspect to this as the landholders may wish to minimise land degradation in order to maintain future production. Nonetheless, if conservation is taken to mean conservation of the natural resources, then the label is applicable. The second statement is less easily categorised as a *Conservation Reason*, because at face value it implies maximising production for all parts of the property. On the other hand, 'better use' may also mean putting land to its most appropriate use that has a conservation aspect. The factor scores, being in the medium range for both scales, tend to reflect this, with the final grouping based on the higher score for Factor 2. This scale may be less reliable than the economic scale, as suggested by the alpha statistic.

Table 6.2 Reasons for considering native timber production grouped by factor analysis in order of strength of relationship from rotated component matrix

Standardized item alpha	Scale name	Statement	Factor 1	Factor 2
0.8368	Economic reason	Increase total farm income	0.837	0.235
		Provide income for later in life	0.825	0.266
		Diversify income	0.790	0.364
		Provide timber on-farm use	0.681	0.052
0.6618	Conservation reason	Minimise land degradation	0.100	0.932
		Better use of land with limited capacity	0.499	0.662

The *Economic Reason* scale has a maximum score of 20, while the *Conservation Reason* scale has a maximum score of 10. The combined *Total Reason* scale therefore has a maximum score of 30. For the purposes of comparison in the subsequent tables, these scale scores are all reduced to scores in a range from one to five.

The mean scores for the statements relating to barriers to native timber production are reported in Table 6.3. There is concern amongst the respondents about the risk of governments curtailing future native timber production. The 'opportunity cost' statement, *it would be more profitable to graze or farm*, also has a relatively high score. The statements relating to the management and marketing of native timber have the lowest scores.

Table 6.3 Mean scores for barriers to native timber production

Barrier	n	Mean
Government regulations will stop or limit future native timber production	713	3.72
It would be more profitable graze or farm than manage native timber	716	3.46
There are low returns from native timber	721	3.31
Retaining woodland would maintain or increase pest species	715	3.10
It would be difficult to find markets	714	2.63
It would be difficult to learn to manage native forests	712	2.40

The principal components analysis of the responses to the statements in the topic 'barriers to native timber production' identified two factors underlying responses as indicated in Table 6.4. For the two scales constructed from scores for responses to statements in the topic 'barriers to native timber production', the maximum scale scores are 20 for *Economic Barriers*, 10 for *Farm Management Barriers*, and 30 for *Total Barriers*. For the purposes of presentation and comparison, all scale scores in the subsequent tables were divided by the number of statements included so that they are all calculated in a range from one to five.

Table 6.4 Results of the factor analysis of responses to statements included in the topic 'barriers to native timber production'

Standardised item alpha	Scale name	Statement	Factor 1	Factor 2
0.6692	Economic Barriers	Retain woodland maintain or increase feral pests	0.718	0.050
		More profitable graze or farm	0.710	0.205
		Low returns from native timber	0.693	0.305
		Govt regs stop/limit native timber production	0.655	-0.070
0.6467	Farm management barriers	Difficult to find markets	0.090	0.847
		Difficult to learn manage native forests	0.110	0.841

6.3 Results of the Statistical Analysis

Some of the significant results of tests used to assess relationships between variables that were detected during the analyses are not directly relevant to the discussion in this chapter. They may, however, be of interest to forestry extension personnel and policy-makers, and are summarised below.

1. Female respondents were more likely to give a higher score on the *Conservation Reason* scale for managing native forestry.
2. Those whose highest level of formal education is a diploma or degree gave higher scores to *Conservation Reason* than did those with whose highest level of formal education is at the secondary and primary level.
3. Based on a classification of respondents according to their information about having a profession, trade or other 'non-farm management' related skill, it was found that managers, administrators, professionals, associate professionals, and clerical and service workers had higher scores for the *Conservation Reason* and *Total Reason* scales than did Farmers, Tradespersons and Related Workers and Intermediate Production and Transport Workers. If occupation indicates membership of a social class, then this suggests that there are differences in attitudes amongst classes.
4. Those who own or manage more than one property tend to have a higher score on the *Economic Barrier* scale than do those who own or manage only one property.
5. The longer the time of involvement with property ownership or management, the lower the score on the *Total Reason*, *Economic Reason* and *Conservation Reason* scales and the higher the scores for the *Total Barrier* and *Economic Barrier* scales.
6. Those who intend to pass the property to family or friends had lower scores for the *Conservation Reason* scale than did those who did not intend to pass on the property or were unsure about whether or not they will do so.
7. Those who had planted trees in the last 15 years, with a view to harvesting them later, had lower scores for the *Management Barrier* scale.
8. Of those who planted trees in the last 15 years, the respondents who planted for the purposes of waterway or soil protection, had higher scores for the *Conservation Reason* scale than all others who reported planted trees primarily for other reasons. In addition, those who planted for soil protection also had lower scores for the *Economic Barrier* scale than did all others who planted trees primarily for other reasons.

These results reveal that there are differences in attitudes to the management of native vegetation for timber production amongst rural landholders, and that specific personal characteristics or experience with tree planting may be a signifier of a greater pre-disposition to manage native vegetation for timber production.

Differences in attitudes as denoted by income, and property and production characteristics

In this section the statistical tests are used to identify variables where there are significant differences in mean scores between the categories of respondents, for the constructed attitudinal scales. Those variables having a significant relationship with the attitudinal variables will then be used as criteria for the classification of landholders into the typology derived in Chapter 5.

Those respondents who spent less than five hours per week in paid employment had significantly lower scores for all reason scales than did those respondents who worked more than 30 hours per week in paid employment (see Table 6.5).

Table 6.5 Time spent in paid employment

Time spent in paid, off-farm employment	n	Mean rating		
		Total reason	Conservation reason	Economic reason
Less than 5 hrs	346	3.33	3.73	3.14
5 – 15 hrs	41	3.53	3.89	3.34
15 –30 hrs	57	3.54	4.07	3.28
More than 30 hrs	201	3.72	4.11	3.53
Total	645	3.48	3.89	3.29
ANOVA	F	6.461	4.762	6.226
	Sig.	0.000	0.003	0.000
	LSD	Less than 5>15-30, More than 30	Less than 5>More than 30	Less than 5> More than 30

Attitudes to timber production in native forest areas also vary with the proportion of income derived from agricultural activities. The greater the proportion of income derived from such activities, the lower the ratings for items in the *Total Reason* and *Conservation Reason* scales and the higher the ratings items in the *Total Barrier* and *Economic Barrier* scales, as shown in the summary of the results of a regression analysis in Table 6.6.

Table 6.6 Proportion of income derived from farm activities and ratings for reason and barrier scales

Dependent variable	R square	*t*-statistic	Significance level
Total reason	0.020	-3.447	0.001
Conservation reason	0.032	-4.486	0.000
Total barrier	0.018	3.334	0.001
Economic barrier	0.032	4.519	0.000

Attitudes also vary with net income from all sources. Those with higher incomes tended to have lower scores for the *Total Barrier* and *Economic Barrier* scales, as shown in Table 6.7.

Table 6.7 Net income and ratings for reason and barrier scales

Dependent Variable	R square	*t*-statistic	Significance level
Total barrier	0.010	-2.513	0.012
Economic barrier	0.011	-2.707	0.007

Property size did not a have a significant relationship with any of the constructed attitudinal scales, but undertaking particular forms of agricultural production, including crop or fodder production or having livestock, were statistically significant factors in relation to at least some of the constructed attitudinal scales. Those who grew crops had lower scores for the *Economic Reason* and *Total Reason* scales and higher scores for the *Economic Barrier* and *Total Barrier* scales, as indicated in Tables 6.8 and 6.9.

Table 6.8 Grain production and ratings for reasons for undertaking native timber production

Respondent grows grain	n	Mean score		
		Total reason	Conservation reason	Economic reason
No	440	3.57	3.94	3.39
Yes	224	3.32	3.80	3.08
Total	664	3.49	3.89	3.29
F		8.563	2.487	10.343
Sig.		0.004	0.115	0.001

Table 6.9 Grain production and ratings for barriers to undertaking native timber production

Respondent grows grain	n	Mean score		
		Total barrier	Management barrier	Economic barrier
No	458	3.06	2.53	3.34
Yes	237	3.17	2.49	3.51
Total	695	3.10	2.52	3.39
F		4.316	0.362	8.755
Sig.		0.038	0.547	0.003

Those who grow fodder crops have higher scores for the *Economic Barrier* and *Total Barrier* scales as shown in Table 6.10.

Table 6.10 Fodder crops production and ratings for barriers to undertaking native timber production

Respondent grows fodder crops	n	Mean score		
		Total barrier	Management barrier	Economic barrier
No	421	3.04	2.52	3.31
Yes	267	3.18	2.51	3.52
Total	688	3.10	2.51	3.39
F		8.618	0.004	13.692
Sig.		0.003	0.95	0.000

Those who have livestock are also more likely to have higher scores for the *Economic Barrier* and *Total Barrier* scales, as shown in Table 6.11.

Table 6.11 Livestock ownership and ratings for barriers to undertaking native timber production

Respondent owns livestock	n	Mean score		
		Total barrier	Management barrier	Economic barrier
No	46	2.92	2.64	3.05
Yes	650	3.11	2.51	3.42
Total	696	3.10	2.52	3.39
F		4.071	1.052	11.314
Sig.		0.044	0.305	0.001

These tests suggest that undertaking any of the three activities of livestock ownership, grain production and fodder crop production is associated with at least some resistance to the idea of

managing native vegetation for timber production. Given that attitudes also vary with time spent in paid employment, level of income and the proportion of income from farm activities, it was decided to use a combination of these factors as criteria to define a landholder typology.

Analysis of attitudes to native timber production by landholder type

The respondents were classified into the categories described in Table 6.12. The area range is not a criterion for classification, but a result of the classification. The three main criteria for classification are the extent of production, the proportion of income from farm activities and proportion of time in paid employment. If the level of production was high, for example 4,000 sheep or 200 cattle, though the time spent in paid employment was 5-30 hours, these cases were shifted into the commercial categories. There were 10 of these cases.

Table 6.12 Categorisation of landholders by production, income and employment characteristics

Classification	n	Range of total property area	Production range	Proportion of time in paid employment	Income from farm
No production landholders	73	4-200 ha[a]	From no activity up to 20 cows or equivalent stock	More than 15 hours	10% or less
Recreational farmers	165	10-306 ha	Up to 80 ha of grain or up to 80 head of cattle or equivalent activity	More than 15 hours	0-35%
Part-time graziers	134	30-3300 ha	Up to 700 head of cattle, but most in 80-200 head range	5-30 hours	10-70%
Part-time mixed farmers[b]	45	40-700 ha	40-300 ha of grain, some with irrigation and/or 10-250 cattle or equivalent combinations	5-30 hours	10-70%
Intensive livestock farmers	44	40-1720 ha	Feedlot cattle, pigs or chickens of an obviously commercial scale	More than 30 hours	70% or more
Commercial crop farmers	67	80-2100 ha	Predominantly grain and cotton production	More than 30 hours	70% or more
Commercial mixed farmers	29	130-1900 ha	Mix of grazing and crop production	More than 30 hours	70% or more
Commercial graziers	177	150-2900 ha	Predominantly grazing activity	More than 30 hours	70% or more

[a.] There were five larger properties outside this range
[b.] This category includes part-time farmers with both crops and stock plus five respondents with crops only.

The statistical analysis is a one-way ANOVA comparison which compares the mean ratings for the scales by category of landholder. There is also analysis of least significant difference (LSD) which indicates a difference in means between the particular categories of landholder. The LSD outputs are arranged to show single categories or sets of categories that have significantly higher scores than another category or set of categories. The data are presented as a table with the summary statistics followed by a table ranking the landholders by mean ratings for each scale. For the reason scale tables, the rankings are in descending order, while for the barrier scale tables, the rankings are in

ascending order. This arrangement is designed to place those groups more likely to consider native forest production at the top of each of the ranking tables, as was done for the analysis in Chapter 5.

Tables 6.13 and 6.14 show that the lower-production landholders (including no production landholders, recreational farmers and part-time graziers) have higher mean scores for all the reason scales. The commercial crop farmers have the lowest scores for each of the scales.

Table 6.13 Mean ratings for reasons scales by landholder type

Landholder type	n	Mean rating		
		Conservation reason	Economic reason	Total reason
No production landholders	66	4.12	3.52	3.72
Recreational farmers	151	4.00	3.32	3.55
Part-time graziers	123	4.13	3.42	3.66
Part-time mixed farmers	39	3.79	3.17	3.38
Intensive livestock producers	38	3.78	2.93	3.22
Commercial crop farmers	58	3.41	2.76	2.97
Commercial mixed farmers	25	3.68	3.31	3.43
Commercial graziers	153	3.75	3.35	3.47
All categories	663	3.89	3.28	3.48
ANOVA F		3.70	2.63	3.25
Sig.		0.000	0.008	0.001

Table 6.14 Ranking of land use types by descending order of mean ratings

Conservation reason	Economic reason	Total reason
Part-time graziers (PG)	Low production landholders	Low production landholders
No production landholders (NP)	Part-time graziers	Part-time graziers
Recreational farmers (RF)	Commercial mixed farmers	Recreational farmers
Part-time mixed farmers (PM)	Commercial graziers	Commercial mixed farmers
Intensive livestock producers (IP)	Recreational farmers	Commercial graziers
Commercial graziers (CG)	Part-time mixed farmers	Part-time mixed farmers
Commercial mixed farmers (CM)	Intensive livestock producers	Intensive livestock producers
Commercial crop farmers (CF)	Commercial grain farmers	Commercial grain farmers
Pairwise comparison of means according to least significant difference		
PG.NP.RF>CG>CF	NP.PG.CG>IP.PM RF>CF	NP.PG>IP.CF RF.CG.PM>CF

Commercial crop farmers also have the highest score for all the barrier scales, as shown in Tables 6.15 and 6.16. The no production landholders and recreational have the lowest scores for the *Economic barrier* and *Total barrier* scales. Part-time graziers have a relatively high *Total Barrier* score. On this test and for this set of barrier scales, they are more like commercial landholders than low-production landholders.

Table 6.15 Mean ratings for reasons scales by landholder type

Landholder type	n	Mean rating		
		Management barrier	Economic barrier	Total barrier
No production landholders	63	2.55	3.06	2.89
Recreational farmers	160	2.52	3.27	3.02
Part-time graziers	127	2.60	3.42	3.14
Part-time mixed farmers	43	2.38	3.48	3.12
Intensive livestock producers	42	2.64	3.49	3.21
Commercial crop farmers	59	2.70	3.62	3.31
Commercial mixed farmers	27	2.24	3.44	3.04
Commercial graziers	163	2.45	3.50	3.14
All categories	694	2.52	3.40	3.10
ANOVA F		1.519	3.849	2.539
Sig		0.147	0.000	0.010

Table 6.16 Ranking in ascending order of land use types by barriers mean scores

Management barrier	Economic barrier	Total barrier
Commercial mixed farmers	Low production landholders	Low production landholders
Part-time mixed farmers	Recreational farmers	Recreational farmers
Low production landholders	Part-time graziers	Commercial mixed farmers
Commercial graziers	Part-time mixed farmers	Part-time mixed farmers
Recreational farmers	Intensive livestock producers	Part-time graziers
Part-time graziers	Commercial mixed farmers	Intensive livestock producers
Intensive livestock producers	Commercial graziers	Commercial graziers
Commercial crop farmers	Commercial crop farmers	Commercial crop farmers
Pairwise comparison of means according to least significant difference		
Not significant	CF.CG>RF.NP	CF>RF.NP
	CM.IP.PF.PG>NP	CG.IP.PG>NP

The results suggest that commercial crop farmers are especially resistant to considering native timber production but this might not be resistance so much as lack of applicability. A lower proportion of crop farmers have native timber stands as shown in Table 6.17. The information in this table was based on respondents answering the question: “Do you have areas of native woodland that you think could be suitable for native timber production, either now or in the future?”

The grazing categories have the highest proportions of respondents with native vegetation areas considered potentially suitable for timber production. Based on the earlier tables, this group has comparatively high scores for the *Economic Reason* and *Total Reason* scales, and relatively low scores for the *Management Barrier* scale but they also have high scores for the *Economic Barrier*

and *Total Barrier* scales. This suggests they believe there are reasons for undertaking native forestry activities, and it can be done, but it is not worth doing. It is possible that attitudes vary within the categories, based on experience with native forestry. The following section describes the results of tests for significant differences in scores on the constructed attitudinal scales and respondents' previous experience in native forestry activities.

Table 6.17 Number and proportion of each landholder type with native vegetation areas considered potentially suitable for timber production

Landholder type	Number with native timber	Proportion of total in category (%)	Number in category
Non-production landholders	40	55.6	72
Recreational farmers	70	43.8	160
Part-time graziers	76	58.9	129
Part-time mixed farmers	18	40.9	44
Intensive livestock producers	21	50.0	42
Commercial crop farmers	13	20.0	65
Commercial mixed farmers	15	51.7	29
Commercial graziers	106	62.0	171
All categories	367	50.8	722

Analysis of a variation in attitudes based on experience with native trees

The respondents who said they had areas of native forest that may be suitable for commercial timber production, had a higher score on all the reasons scales than the group of people who did not have such areas, as shown in Table 6.18.

Table 6.18 Mean scores for reasons scales by presence of native timber stands on property

Presence of native forest areas suitable for native timber production	n	Mean score		
		Total reasons	Conservation reason	Economic reason
Yes	343	3.69	4.03	3.52
No	306	3.25	3.74	3.02
Total	649	3.49	3.89	3.29
F		31.859	13.781	30.937
Sig.		0.000	0.000	0.000

The group with native timber also had a lower score for the *Management Barrier* scale, than those without native timber, as shown in Table 6.19. Only the management barrier ratings are significantly different. With regard to one statement included in the *Economic Barrier* scale, *the potential for future government regulation to limit native timber production*, there was a significant difference between the categories. Those with suitable areas have a higher mean rating for that statement than do those without suitable areas (F = 14.1, probability = 0.000). This suggests that the fear of regulation is a barrier to those who have thought about the possibilities of native timber.

Table 6.19 Mean scores for barriers scales by presence of native timber stands on property

Presence of native forest areas suitable for native timber production	n	Mean score		
		Total barrier	Management barrier	Economic barrier
Yes	352	3.08	2.43	3.40
No	325	3.13	2.62	3.39
Total	677	3.10	2.52	3.40
F		1.25	9.068	0.093
Sig.		0.264	0.003	0.761

Of those landholders who have areas of native vegetation they consider potentially suitable for timber production, those who believe they have the tenure that allows them to harvest that timber, have higher scores for all scales, as shown in Table 6.20.

Table 6.20 Ratings for barriers scales by harvest rights for native timber stands on the property

Have rights to harvest timber	n	Mean score		
		Total reason	Conservation reason	Economic reason
Yes	332	3.65	3.98	3.48
No	46	3.25	3.62	3.11
Total	378	3.60	3.93	3.44
F		7.468	5.901	4.562
Sig.		0.007	0.016	0.033

Those who believe they have tenure that allows harvesting have a lower score for the statement *it is more profitable to graze or farm* than those who do not have such tenure (F 8.921, probability 0.003).

Finally, those who have harvested native timber in the last 10 years have higher scores for the *Total Reason* and *Economic Reason* scales, as shown in Table 6. 21. Those who harvested native timber had a high score for *providing timber for on-farm use* as a reason for managing native trees for timber production than did those who did not harvest any timber (F 21.8 and significance 0.000).

Table 6.21 Ratings for reasons scales by harvesting experience

Have you harvested native timber in the last 10 yrs?	n	Mean score		
		Total reason	Conservation reason	Economic reason
Yes	231	3.73	3.99	3.60
No	156	3.45	3.91	3.22
Total	391	3.62	3.96	3.45
F		4.462	0.351	5.524
Sig.		0.012	0.704	0.004

6.4 Implications for Landholders' Native Vegetation Management Behaviour

Several surveys in Australia have examined landholders' attitudes and their management practices specifically in regard to private native vegetation. These include Jenkins (1998), who examined attitudes in the wheatbelt of Western Australia, Northern Forestry Services and Bureau of Rural Sciences (BRS) (1999), who examined attitudes in the north-eastern regions of New South Wales, and Hamilton *et al.* (2000) who examined attitudes and native vegetation management practices of landholders in northern Victoria. There was also a survey of landholders' attitudes to native forest remnants in the Catlins region of New Zealand reported by Wilson. (1992). In addition, some of the surveys relating to attitudes to plantations, discussed in Chapter 5, included questions relating to native vegetation (Emtage 1995, Specht and Emtage 1998).

Reviewing reasons for establishing plantations

According to survey work by Emtage (1995) and Specht and Emtage (1998), landholders appear to want trees on their properties to fulfil the same general functions regardless of whether they are planted or native forest areas. Factor analysis of the ratings of importance given to various functions of native forest areas revealed that the basic functions or uses of trees for 'commercial', 'conservation' and 'shelter' purposes are seen by landholders as applying to native vegetation as well as for planted trees (Specht and Emtage 1998).

In their national survey, Wilson *et al*. (1995) asked landholders to identify up to three reasons for maintaining native forests and woodlands and the results are shown in Table 6.22. The top three reasons, based on frequency of nominations by respondents, relating to land protection, shelter belts and nature conservation, along with the aesthetic value of native vegetation, are consistently given a high rating of importance in surveys of landholders attitudes to native vegetation (Wilson 1992, Jenkins 1998, Specht and Emtage 1998, Hamilton *et al.* 2000).

Table 6.22 Landholders' main reasons for maintaining native forests and woodlands

Main reason for planting	Proportion of all Australian landholders (%)
Rehabilitate degraded land and/or protect from future degradation	29
Provide shelter or shade	78
Conserve native vegetation and wildlife	37
Produce sawlogs for sale	6
Produce pulpwood for sale	0
Produce non-wood products for sale	0
Produce other/unknown wood products for sale or own use	22
Produce fodder	4
No reason to clear	21
Other	7

Source: Wilson *et al.* 1995

Similarly, from the survey discussed in this chapter the statement with the highest mean score related to *minimising land degradation*, as shown in Table 6.1, although it should be noted that there was no specific shade or shelter statement in the native timber section of the questionnaire.

The degree of importance placed on the use of native vegetation for 'stock shelter' varies between studies. While Wilson (1992), Wilson *et al.* (1995) and Hamilton *et al.* (2000) reported that landholders value native forest areas most for the shelter they give to their stock and crops, this function was not highly regarded by respondents to the survey reported by Specht and Emtage (1998). The differences in the relative degree of importance landholders place on the use of trees for shelter in the various studies could be due to one or a combination of differences between the regions studied, or differences in the methods employed by the studies and their consequent response rates. With regard to regional differences, there are clear differences in the climates of the areas studied. In colder areas such as Victoria and southern New Zealand the use of native vegetation for shelter is reported to be higher than 'conservation' uses (Wilson 1992, Hamilton *et al.* 2000), unlike studies of landholders in tropical and sub-tropical regions (Emtage 1995, Specht and Emtage 1998, Emtage *et al*. 2001). Studies in tropical and sub-tropical regions all report that landholders rate the use of private native vegetation for 'conservation' functions highest. One argument against this explanation for the differences in the findings of the studies is the consistency in the ratings of importance placed on the use of trees for the 'provision of shelter and shade' across all states and climates reported by Wilson *et al.* 1995. The ratings for the use of trees for shelter and shade in Queensland reported by Wilson *et al.* 1995 are, lower than those for other states (at least for planted trees), but not significantly different at the 5% confidence level.

The studies of Wilson (1992), Wilson *et al.* (1995) and Hamilton *et al.* (2000) achieved response rates of greater than 75%, whereas the studies undertaken in the tropical and sub-tropical areas had response rates of less than 50%. It is possible that the differences in the relative importance ascribed to the use of trees for shelter reported by different studies is due the variation in the types of landholders that responded to the surveys. It is likely that those who respond to self-administered mail surveys about farm forestry are more favourably disposed to farm forestry than those who do not respond. There is probably a greater proportion of non-commercial or 'hobby' farmers in the respondents to studies in northern New South Wales (of Emtage 1995, Specht and Emtage 1998, Emtage and Specht 1998) and south-east and far north Queensland (of Harrison *et al.*1994, Emtage *et al.* 2001) relative to those in the other study areas. These types of landholders have been found to be more interested in planting and managing trees for conservation reasons relative to larger-scale full-time landholders, as will be discussed further in the following section. It is possible that these regions have a higher proportion of rural residential landholders than other regions in Australia and therefore it is to be expected that there would be more of such landholders as respondents. As non-response bias was not assessed in these studies it is not possible to ascertain the truth of this potential explanation. The low response rates achieved by the above-mentioned studies means it is difficult to extrapolate the survey findings to the broader community.

A number of studies have emphasised the multiple functions played by native forest areas. They conclude that native forest areas are frequently located on steep land which is considered unsuitable for grazing in normal times and land managers utilised these areas for grazing in extreme circumstances such as prolonged drought or extreme cold (Wilson 1992, Emtage and Specht 1998, Jenkins 1998, Hamilton 2000). Just as landholders may use their native forest area for grazing in times of extreme drought, they may consider logging some areas of their forests in times of prolonged low or negative returns to their agricultural activities. Like the ratings of importance attached to the use of planted trees for 'commercial' purposes, the use of native vegetation for directly commercial applications such as to produce commercial timber or supply fenceposts are consistently rated lowest in importance in all surveys. For the results discussed in this chapter, the three statements directly relating to income had the three lowest mean scores, as shown in Table 6.1. The statement relating to the *provision of timber for on-farm use* had a slightly higher score. However, this is out of only six questions and so is more limited than some other studies. This sample contained a surprisingly high proportion of landholders who have harvested and sold timber

from their native forest land. Of the respondents in the sample for the study discussed in this chapter, 36% (270) had harvested some native timber from their properties in the last 10 years with 48% (121) of those respondents having sold some for commercial returns and the balance using the timber on farm.

Wilson (1992) found that the native vegetation was often left on a property because the land was not useful for other purposes, being too steep or shaded for the growth of good pastures. There are reported to be wide differences in the proportion of landholdings under native vegetation within that region according to the topography. In areas which are accessible and reasonably flat, there is reported to be less than 1% of native vegetation remaining on agricultural land compared with 15% of land in the more undulating areas of the region (Wilson 1992, p. 174). Emtage and Specht (1998) made similar observations after interviewing farmers in the northern rivers region of New South Wales. Farmers in that region also reported maintaining areas of native forest on land that was not suitable for cropping or grazing, and identified areas of less productive soils in the region which they considered 'appropriate' for forestry activities. The finding in this survey that the statement *to make better use of land with limited capacity for other types of production* as a reason for retaining native vegetation had the second highest score (3.86) in this survey so this tends to support the observations from the other studies.

A review of barriers to managing native trees for timber production

A number of surveys have examined the landholders perceptions of potential problems associated with the management of native forest areas on private land (Emtage 1995, Specht and Emtage 1998, Northern Forest Services and BRS 1999, Hamilton *et al.* 2000). The questions used to assess landholders' perceptions of this topic were varied, however, making comparisons of their findings difficult. In general, the problems associated with the management of native forest areas were not rated as highly as the importance of the functions they were seen to fulfil. For example, Specht and Emtage (1998) reported that the mean rating of importance for various reasons for managing native vegetation by all respondents ranged from 4.2 (out of 5) for 'soil protection' to 2.8 for commercial timber. On the other hand the mean rating of importance for various problems with managing native vegetation ranged from 2.9 (out of 5) for 'endangered species habitat' to 1.9 for 'damage to equipment' (Specht and Emtage 1998, p. 23).

In this survey, the mean 'reasons' scores ranged from 3.93 out of 5 to 3.18 while the mean barriers scores ranged from 3.72 to 2.4. The barrier scores are generally lower with one exception – the statement relating to concern about government regulation, which had the highest mean score. *Uncertainty about the legislative requirements affecting native vegetation management* was also reported as the major concern of 69% of respondents by the Northern Forest Services and BRS (1999), followed by *Where to obtain professional management advice* (49%), the *Negotiation of timber sales to maximise returns* (43%), and the *Ability to negotiate environmental regulations and controls* (40%). It might have been supposed that the concern about the potential constraints of government legislation in some of the surveys, particularly those in the Northern Rivers region of New South Wales and far north Queensland, could be especially affected by the regulation of native forest areas in those regions, including World Heritage listing of some areas. This survey was conducted in areas where there were no major controversies and yet there is still strong concern about government regulation.

In this survey, management and marketing concerns have the lowest scores, whereas some forestry extension personnel are concerned about a perceived lack of forestry management skills and marketing knowledge. Perhaps landholders are confident in their abilities to manage any form of primary production and regard marketing as secondary to production. These are issues that might be further explored. In previous surveys, the potential 'problem' of native vegetation harbouring agricultural pest species was seen as a minor problem by most landholders (Jenkins 1998, Specht and Emtage 1998, Hamilton *et al.* 2000). In this survey, this statement had a mean score of 3.1,

suggesting some concern. There may be differences in attitudes related to numbers of wild pigs, wild dogs and kangaroos in the inland areas surveyed, but there is little scope for comparison across surveys.

A review of socio-economic variables

Previous surveys have identified variables that seem to be associated with different attitudes to farm forestry in general, with some identifying differences in attitudes to the management of native vegetation. Age and levels of formal education are consistently reported to be related to the way that landholders manage trees on their properties. Generally, older landholders and those with lower levels of formal education are more likely to clear native vegetation (Wilson 1992, Emtage 1995, Specht and Emtage 1998, Hamilton *et al*. 2000). However, Wilson (1992) qualified these findings with the observation that landholders whose family had a long contact with their properties were more likely to adopt conservation-orientated management strategies (p. 180). He reasons that the landholders with long-term contact with their properties may build-up a sympathy with their land and remnant habitats and that long-term residents have a better understanding of forest ecology. Further, he argues that long-term landholders tend to control areas of land that are more viable for agriculture in that they are flatter, have better soils and are more accessible. This contrasts with new-arrivals of any age who tend to own land that is more remote, less accessible and heavily wooded where survival of agricultural enterprises has always been more difficult (Wilson 1992). In this survey, there was no significant relationship between age and scale scores. With regard to the 'legacy' motive, the only significant relationship was between intention to pass on the property and a lower score for *Conservation Reason*. This study does not support the contention that the landholders in the regions covered by this survey would consider native timber production to provide a 'legacy'. Those with higher levels of education had higher scores for *Conservation Reason*, as did those working in professions, associate professions and clerical jobs.

Previous studies have also sought to classify landholders in a number of ways. Hamilton *et al*. (2000) segmented their respondents according to property size and then examined a number of attributes of the 'smallholders'. They reported that the owner/managers of the smaller properties tend to choose to live on a rural property more for lifestyle reasons rather than employment and income. They tend to have lived on the property less time and to work more off-farm than those with larger properties.

They further differ in that, compared with the larger property owners, the smallholders:

- are less knowledgeable about the issues affecting remnant vegetation management
- value remnant vegetation more highly for recreation, aesthetics and habitat
- are more highly educated
- manage smaller remnants with more weeds and less wood on the ground
- are more likely to utilise technical advice and extension options from various programs
- are less likely to use their remnants for the shelter and grazing of stock and timber production
- are less likely to belong to community groups such as Landcare or Soilcare (Hamilton *et al*. 2000).

These findings in terms of the socio-economic characteristics affecting vegetation management values and practices are broadly consistent with the findings of Specht and Emtage (1998) and Emtage *et al*. 2001). This survey was not comprehensive enough to cover all those issues, but the category of landholders that engage in little or no native forest production had the highest mean scores for the reasons scales and the lowest barrier scores. Hamilton *et al*. (2000) concluded that while the smaller landholders have value systems that support conservation of remnant vegetation, a combination of lack of time and knowledge about remnants means that they do not always carry out appropriate conservation management practices.

In other studies, landholders have been segmented according to attitudes to forestry management (Emtage 1995, Emtage and Specht 1998) or according to management and marketing of the resource

(Fulton and Race 2000). For this survey, the landholders were segmented according to the scale of the property, the activities undertaken and the time spent in agricultural activity. This approach to segmentation was chosen to reflect the spatial representation of possible future resource use. That is, certain types of landholders manage different parts of a region. The commercial farmers generally control the most fertile soils, with relatively low gradients, while commercial graziers have the larger holdings with a mix of soil types.

If the statistically significant results from this survey reflect likely landholder behaviour, then there are some general conclusions that can be made.

1. Those who have the native timber resource, or at least believe they have it, do see some reasons, both conservation and economic, for commercial exploitation of the resource. They are also more likely to believe silviculture can be done (the management barrier). However, they still seem to be concerned about the economic barriers, and they are also concerned about the potential for government regulation preventing harvesting of the resource.
2. Those who have experience with harvesting native timber believe there are economic reasons for managing native trees for timber production, although they are most interested in providing timber for on-farm use.
3. Low-production landholders and recreational farmers are most open to considering native timber production and about half of the respondents in those categories did have some native vegetation areas considered potentially suitable for timber production. However, they also tend to have small property areas, and presumably relatively small stands of timber.
4. The part-time graziers, those with small to medium sized herds, are less likely than the other low-production categories mentioned above, to consider native timber production. Their ratings are closer to those of the other categories with grazing animals.
5. Commercial landholders, especially those with grain, are the least interested in commercial timber production from native forest areas. Commercial mixed farmers and commercial graziers are more likely than other types to acknowledge the commercial possibilities, but they also are concerned with the economic barriers.
6. Those who believe they have the tenure that allows them to harvest native forests are more likely to consider native timber production.

These conclusions suggest that the respondents to this survey are unlikely to undertake extensive commercial native timber production. Those landholders who have particular characteristics that predispose them to consider native forestry and those who believe they have some resource security will engage in some activity. Some smallholders may be interested in native forest production, but given small plots and possibly poor quality resources, it would require considerable extension effort and landholder education to facilitate the development of an industry based on small-scale activity. It may also be difficult to provide evidence of an economic benefit for the adoption of forestry management practices. Thompson's (1999) analysis of the economics of native stands of Cypress and eucalypt production found that the cost of an initial thinning could be as high as $200 a hectare. When later income was discounted, returns from timber were estimated to be negative in some cases, with positive outcomes being associated with an increase in grazing capacity resulting from the initial thinning (Thompson 1999, pp. 55-70)

6.5 Summary

There are extensive areas of native forests in the inland agricultural and pastoral regions, especially when compared with the small areas of plantation establishment. If more private landholders were to manage the native forests for timber production this could provide an increase in timber supplies sooner than would be the case following plantation development. This was the rationale for a survey of some 750 landholders from five shires on the Darling Downs in Queensland and one shire on the New England Tableland in NSW to examine attitudes to native timber production. The analysis is has involved a categorisation of the respondents into landholder types, based on the type and extent of their agricultural activity and the extent and sources of their income.

The responses to the survey suggest that while some of those who hold the larger areas of native timber – namely the commercial landholders – do see some economic potential in native timber production, they do not believe that it is an economically viable enterprise at least in comparison with crop and stock production. Commercial landholders do not see conservation benefits as a reason for managing native tree stands for timber production. On the other hand, as with plantations described in Chapter 5, it is the low production landholders and the recreational farmers who have the most interest in timber production, although they are likely to have less of the resources to undertake this activity. Based on these findings, it is concluded that there will be little expansion in the area of managed native farm forestry activity in broad acre agricultural and pastoral landscapes covered by the survey. Some commercial landholders may consider undertaking native timber production if it can be shown that combined grazing and timber production results in a net increase in income, although some landholders may still be reluctant to consider managing trees because of a lack of interest in the activity and, in some cases, hostility to trees in production landscapes.

This study provides information about landholders' attitudes that can be used in extension programs on rural land management issues. The priorities of landholders, including the types of plantations they may prefer, based on their priorities and their concerns about farm forestry can now be better considered, both in advance of informal engagement processes, and in more formal MODSS type work. It is concluded that the categorisation of landholders based on existing production activities, while useful as a first round of analysis, may be improved by a typology defined by the characteristics of the native timber resource on the properties. That is, perhaps landholder attitudes vary according to the quality, type and extent of the native timber resource they hold, the commercial potential of the tree stand, or even criteria such as the perception of negative impacts from native vegetation on crop and pastoral production.

6.7 References

Cant, M. (2001), Native Forestry Project Officer, Department of Natural Resources, personal communication.

Emtage, N. (1995), The role of federally funded revegetation programs in meeting Australia's commitments under the UNEP Convention for the Conservation of Biological Diversity, Faculty of Resource Science and Management, Southern Cross University, Lismore.

Emtage, N. and Specht, A. (1996), *Revegetation Programs: a case of niche marketing*, Conservation outside the Reserve System, Centre for Conservation Biology University of Queensland.

Emtage, N. and Specht, A. (1998), *Landholders perceptions of farm forestry in the Northern Rivers Region of New South Wales: Overview report*, Northern Rivers Regional Plantation Committee, Ballina.

Emtage, N.F., Harrison, S.R. and J.L. Herbohn (2001), 'Landholder Attitudes to and Participation in Farm Forestry Activities in Sub-Tropical and Tropical Eastern Australia', in S.R. Harrison and J.L. Herbohn, eds., *Sustainable Farm Forestry in the Tropics*, Edward Elgar, Cheltenham, pp.195–210.

Hair, J., Anderson, R., Tatham, R. and Black, W. (1992), *Multivariate Data Analysis*, 3rd edn., Macmillan Publishing, New York.

Fulton, A. and Race, D. (2000), 'Farm forestry in Australia: Why do landholders get involved?', in J.L. Herbohn *et al*., eds., *Developing Policies to Encourage Small-Scale Forestry*, Proceedings of the Kuranda IUFRO Research Group 3.08 Symposium, The University of Queensland, Brisbane, pp. 100–108.

Hamilton, S., Dettmann *et al*. (2000), Landholders perceptions of the remnant vegetation on private land in the box-ironbark region of Northern Victoria, Environment Australia: Biodiversity Group, Canberra.

Harrison, S., Sharma, P. and Lamb, D. (1994), Progress in farm forestry in the Obi Obi Valley, Community Forestry Seminar, Dorroughby Field Studies Centre, Dorroughby.

Jenkins, S. (1998), Native Vegetation on Farms Survey 1996, Environment Australia: Biodiverity Group, National Research and Development Program on Rehabilitation, Management and Conservation of Remnant Vegetation, Canberra.
Northern Forestry Services and Bureau of Rural Sciences (1999), Private Forest Management Intent Survey in the Northern NSW CRA Regions, NSW CRA/RFA Steering Committee, Sydney.
Queensland Department of Primary Industries (1998), *An Overview of the Queensland Forest Industry*, Queensland Department of Primary Industries, Brisbane.
Specht, A. and Emtage, N.F. (1998), *Landholders' Perceptions of Farm Forestry in the Northern Rivers Region of New South Wales*, report to the Northern Rivers Regional Plantation Committee, Ballina.
Thompson, D. (1999), Agroforestry from existing timber resources in the Northern Tablelands, RIRDC/LWRRDC/FWPRDC Joint Venture Program: 99/151, Canberra
Wilson, G. (1992), 'A survey of landholders to native forest on farmland', *Journal of Environmental Management*, 34, 117–136.
Wilson, S., Whitham J. *et al*. (1995), 'Trees on farms', *Farm Surveys Report*, Australian Bureau of Agricultural and Resource Economics, Canberra.

7. Segmentation Techniques Used in Development of Agriculture and Forestry Extension Programs

N. Emtage

This chapter reviews the literature on the identification of landholder typologies that can be used to assist the design and delivery of extension programs. Australian researchers have developed typologies of landholders based on a variety of criteria. The methods used have differed according to the theories used to guide the research and the 'clients' or 'sponsors' of the research. The landholder types they describe, however, have a number of similarities. In this chapter, the rationale for developing landholder typologies is first discussed before reviewing the various approaches that have been used by Australian researchers and comparing their findings.

7.1 Rationale for Developing Landholder Typologies

Australian governments at all levels are promoting sustainable agricultural practices and farm forestry in an effort to achieve objectives in relation to environmental protection, biodiversity conservation, regional development and reduction in timber imports (Commonwealth of Australia 1992 a, b, 1997). Private land that has been inappropriately cleared in the past is the focus of the government efforts to promote the private plantation estate. Australian governments see the expansion of farm forestry as a way of achieving a number of these public objectives simultaneously. The problem facing governments is that the majority of private landholders in highly productive sub-tropical and tropical regions of eastern Australia have been less than enthusiastic about plantation development on their land despite active promotion of and assistance for farm forestry by State government land and forest management agencies. Landholders lack of response to many of these promotions has convinced governments of the need to understand better landholders' visions of the appropriate role for farm forestry on freehold land, including their motivations for planting, perceived impediments to planting, and the types of incentives they desire. The situation is complicated by the variations in attitudes and socioeconomic circumstances within the rural community. Some landholders are enthusiastic about farm forestry while others are firmly opposed to plantation development on private farm land.

Many researchers and extension personnel have argued that decision-makers and extension providers need to understand better the variety of socioeconomic circumstances and value systems of the various sectors in the community, how these differences affect their land management attitudes and behaviour and how the differences lead to variation in the impacts of policies and programs across the community (Chamala 1980, Byron and Boutland 1987, Chamala *et al.* 1987, Raintree 1991, Emtage 1995, van den Ban and Hawkins 1996, Howden *et al.* 1998, Specht and Emtage 1998, Emtage and Specht 1998, Guerin 1999, Fulton and Race 2000, Howden and Vanclay 2000). It is desirable to have extension personnel consider the individual circumstances of landholders, yet policy-makers cannot hope to take every individual into account when designing extension programs.

Anthropologists, marketing professionals and those tracking public opinions seek clusters or groups of people in the community with similar attitudes and use typologies to describe the characteristics of the various groups they have defined. Typologies are a means to help understand and describe the variation in the community by improving understanding of how various combinations of socio-economic characteristics 'lead' to or result in differing land management behaviour. Such an approach can help to target extension programs, and communication strategies and strategic plans for the development of the timber industry and conservation planning at a regional scale (Chamala 1980, Byron and Boutland 1987, 1987, Raintree 1991, Emtage 1995, van den Ban and Hawkins 1996,

Howden *et al.* 1998, Specht and Emtage 1998, Emtage and Specht 1998, Guerin 1999, Fulton and Race 2000, Howden and Vanclay 2000). Typologies can further help to understand how programs will affect landholders in differing social and economic circumstances, and help to match the needs of potential timber suppliers to timber processors and assist in understanding potential regional timber industry structures (Race 1999, Fulton and Race 2000).

In designing a methodology to classify farmers it is important to choose a system that will fit with the intuitive understanding of intra-community variation by extension workers and development program designers, will be useful in aiding the design and implementation of development programs, and preferably can be replicated in other regions without the need for extensive fieldwork. Howden and Vanclay (2000, p. 206) have argued that 'if a classification of social behaviour is to have theoretical and practical utility, it must possess sociological explanatory power and predictive capacity'. Classifications should also have social legitimacy, a property all too often missing from structure-based classifications imposed (etic) rather than derived (emic). From farmers' perspectives, classification schemes based on wealth, size (*of property*) or adoption behaviour have little explanatory power, predictive capacity or social legitimacy' (words in italics added by the author).

The practice of defining landholder typologies in respect to their land management practices is becoming more common in Australia. Previous studies have defined landholder types according to their management of perennial pastures (Barr 1996), their 'farming style' (Vanclay *et al.* 1998, Howden *et al.* 1998) and their cattle breeding practices (Kaine and Lee 1994). A number of surveys in Australia have employed segmentation techniques to help describe the variation in farm forestry attitudes and practices in the community. Emtage (1995), Specht and Emtage (1998) and Emtage *et al.* (2001) have employed the use of cluster analysis techniques to develop typologies of landholders and assist in analysing and describing landholders' responses to surveys. Fulton and Race (2000) also emphasise the importance of developing regional landholder typologies in order to assist the strategic development of regional timber industries, and have devised a 'typical' typology matching landholders to various industry structures to illustrate the concept. There are a number of similarities between the typologies these researchers have developed, and there would appear to be some potential for the development of a broad system of typologies that relates to general land management practices. The findings of the approaches are summarised below along with their advantages and disadvantages.

7.2 Typologies of Landholders in Australia

The term 'typologies' can be used to describe the development of archetypal descriptions of various 'typical' landholders (Fulton and Race 2000, Emtage *et al.* in prep.). Other terms have been used to describe similar approaches including 'segmentation' (Chamala 1987, Vanclay 1995, Barr 1996), 'farming styles' (Vanclay *et al.* 1998, Howden *et al.* 1998) and 'target groups' (Chamala *et al.* 1980, Chamala 1987, Vanclay and Lawrence 1995). The differences in terminology between the various researchers who have attempted to devise typologies of Australian landholders reflect differences in their theoretical approaches.

A wide range of techniques has been used to define typologies of landholders in the rural community (Table 7.1). Some researchers have sought for farmers to describe themselves and other farmers in the community, such as the definition of 'farming style' by Vanclay, Howden and others. Another technique has been to test for differences in attitudes or behaviour in terms of one or two land management variables and then assess if these differences relate to other socioeconomic differences. Barr (1996) described the market segments for perennial pastures based on landholders attitudes to perennial pastures, while Emtage and others used attitudes to tree planting as the basis for defining types of landholder with differing interests in tree growing in eastern Australia (Emtage 1995, Specht and Emtage 1998, Emtage *et al.* 2001). Race (1999) described potential landholder types in Australia, mainly based on the size of the property operated, specifically in relation to the development of regional timber industries. Fulton and Race (2000) discussed the various socioeconomic factors affecting plantation development in regard to the characteristics that the timber industry should

identify to target efficiently landholders for partnership programs, and described a broad typology of landholders matched to various potential regional timber industry structures. Rogers (1995) and others devised a system of landholder typologies based on the propensity of landholders to adopt new practices. Finally, Kaine and Lee (1994) tested whether it was possible to group farmers usefully according to their beef cattle breeding practices.

Table 7.1 Methods, applications and study areas of research using segmentation or typology methodologies to group rural landholders in Australia

Study authors	Area studied	Basis for segmentation	Application
Kaine and Lee (1994)	Victoria	'Farming context'[a]	Facilitation of farm enterprise development
Emtage (1995)	Richmond River Catchment (north-east New South Wales)	Ratings of importance for various reasons for planting trees on private landholdings	Development of farm forestry extension and assistance programs and public policies
Rogers (1995)	International	Propensity to adopt new practices	Development of any or all extension and assistance programs
Barr (1996)	North-east Victoria, south-west New South Wales	Pasture management attitudes and practices	Development of perennial pasture management extension and assistance programs
Howden *et al.* (1998)	North-east Victoria, south-west New South Wales	'Farming style'[b]	Development of rural extension and assistance programs.
Specht and Emtage (1998)	Northern Rivers region (north-east New South Wales)	Ratings of importance for various reasons for planting trees on private landholdings	Development of farm forestry extension and assistance programs and public policies
Fulton and Race (2000)	Australia-wide	Type (size, location) of farm enterprise and landholder characteristics	Development of farm forestry extension and assistance programs and public policies
Emtage *et al.* (in prep.)	Far North Queensland	Ratings of importance for various reasons for, and restrictions to, plantation development on private landholdings	Development of farm forestry extension and assistance programs and public policies

[a.] 'Farming context' is a concept developed by Crouch 1981 (cited by Kaine and Lee 1994), referring to the stage of development of a farming enterprise, i.e. the degree to which a farming enterprise utilises 'innovative' or 'best' management practices.

[b.] 'Farming style' is a concept developed by van der Ploeg (1990) (cited by Howden *et al.*1998, Vanclay *et al.* 1998, Howden and Vanclay 2000), referring to the strategy of farm management adopted by a landholder.

Grouping landholders using innovation adoption theories

The theories describing the diffusion of innovations have been used as the basis for extension practices in Australia for the last three decades. These theories apply many of the concepts developed by social psychologists in an attempt to explain the process by which new ideas become known in a community and new practices are adopted (Rogers 1995). It is thought that there are a number of distinct types of people in a community in terms of the way they respond to new ideas and practices.

The theories of innovation adoption and social psychology describe the tendencies for people to communicate with others who share and reinforce their own world-views (Scott 1991, Spence 1994, Rogers 1995). Theories of innovation adoption also describe a common process whereby new ideas are spread through the community as illustrated in Figure 7.1. It is thought that new ideas and

practices are initiated and tested first by the 'innovators', then they spread to 'early adopters' and 'opinion leaders', and finally to the 'early' and 'late' majorities (Spence 1994, Rogers 1995).

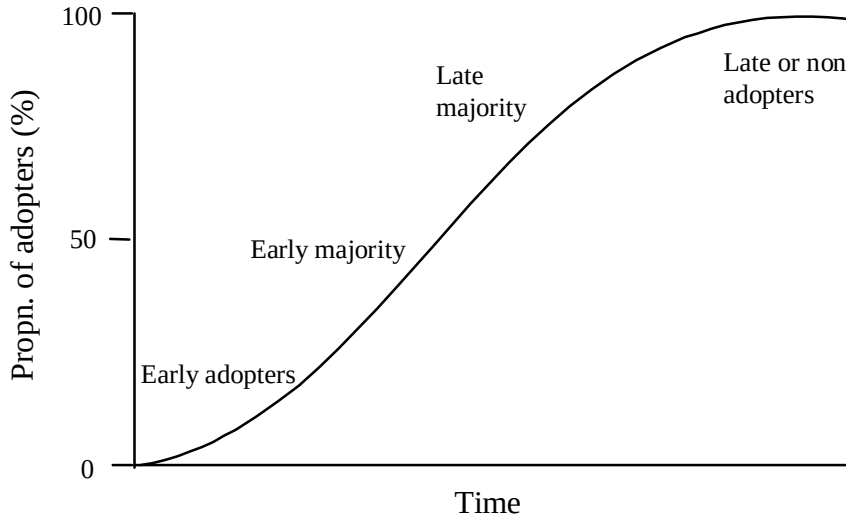


Figure 7.1 The S-curve of the adoption of new practices over time

Source: Rogers (1995).

Using hundreds of studies of the adoption of various innovative practices in many different countries, innovation adoption theorists have made a number of generalisations about the socioeconomic characteristics of each of these types of landholders (Rogers 1995). These generalisations are presented in Table 7.2.

Although extension sciences have been criticised for treating the rural community as a homogenous entity, through the use of innovation adoption theories they have 'in some ways invoked diversity on the basis of innovativeness' (Vanclay *et al.* 1998, p. 85). It has been argued that the application of innovation adoption theories have at times been flawed, on the grounds that '…this was not a true form of diversity because extension, at least in traditional models, presumed that innovations were universally applicable and would be universally adopted' (Vanclay *et al.* 1998, p. 85; see also see Vanclay and Lawrence 1995). This approach fails to recognise the diversity of belief systems in communities. Instead, differences in behaviour are explained as resulting from different perceptions of risk and different socio-economic circumstances.

Some of the criticism made by Vanclay and Lawrence (1995) of the use of innovation diffusion theories by extension services arises where the theories have been used as an excuse to decrease overall extension budgets by concentrating extension efforts on the 'early adopters' and 'opinion leaders' in the belief that the messages would eventually trickle down to other landholders. This would seem, however, to be a criticism of the way in which these theories are applied rather than of the theories themselves.

Table 7.2 Landholder types as described by innovation adoption theorists

Landholder type	Typical characteristics
Innovators	People of this type are said to like experimentation and risk taking and are termed 'venturesome'. They enjoy frequently trialling new ideas and practices. They are seen as eccentric by other landholders in terms of their ideas and behaviour. They are usually highly educated but not wealthy due to their constant changing of practices and lack of focus on wealth accumulation. They typically have a dispersed friendship network that extends beyond their local area, are keen information seekers and have the most cosmopolitan worldview.
Early adoptors	These types of landholders are often defined as the 'opinion leaders' in the community and are termed 'respectable'. They are typically relatively well educated and control landholdings of medium to large size which they may have inherited. They typically have sufficient resources to allow them to experiment with new practices. Because they have control over larger landholdings, don't deviate greatly from 'normal' practices and have a strong history of land management they have the respect of the 'majority' in the community who look to them rather than the more eccentric 'innovators' for advice and ideas.
Early majority	Landholders of this type are interested in using the most productive practices on their landholdings but typically have less resources to trial new practices and a lower capacity to translate abstract research results to local farming conditions. This group watches the activities of the 'opinion leaders' and takes up practices they believe have been successful. They can be termed 'deliberate'.
Late majority	This type of landholder is typically more conservative than the above landholder types and can be termed 'sceptical'. They prefer to see widespread adoption of a practice in their area before they are confident to adopt it. They typically have less resources than the above types for experimentation and are unwilling to adopt practices until almost all risk associated with them have been removed.
Non-adoptors	This type of landholder has been termed 'laggards' and 'traditional'. They are thought to be the most local in their worldview and poorly connected in the social system. They have a high degree of skepticism about change and change agents. Many are in tight financial circumstances and unwilling to trial new practices until all uncertainty is removed.

Source: Adapted from Rogers (1995).

Grouping landholders by farm enterprise structures

Kaine and Lee (1994) sought to improve understanding of how differences between farm business enterprises affected landholders ability to adopt innovations in the cattle breeding industry. The theories underlying their work include the concepts of an agricultural knowledge and information system (AKIS) and that of farming contexts. The theory of agricultural knowledge and information system holds that knowledge about farming practices can originate from many sources including researchers, farmers and extension workers and is spread through networks. According to Kaine and Lee (1994, p. 2), the AKIS concept 'allows for multi-directional flows of information among a network of participants and for the control of the system to be shared between those mainly involved in the generation of new knowledge and those who are mainly concerned with the application of that knowledge'. The concept of AKIS is an alternative to that of linear information transfer described by innovation diffusion theorists such as that of Rogers (1995). One advantage of the AKIS concept over the linear model of diffusion is that it gives greater recognition to the potential for new practices to originate from many sources. A remaining problem according to Kaine and Lee (1994, p. 2) is that the AKIS model and other 'network' models of information diffusion '…do not explicitly allow for the possibility that new information is not equally 'valuable to all farmers. The assumption that new information is inherently valuable will only hold to the extent that new ideas apply equally across all farming contexts'.

The concept of 'farming contexts' is drawn from the work of Crouch (1981, cited by Kaine and Lee 1994). It is taken to mean the 'resources, practices and technologies currently used by a farmer in production and the key attributes of the farmer such as his or her business and farming aspirations and objectives' (Kaine and Lee 1994, p. 2). Thus, if an innovation in farming practices will only lead to an increase in production when used in conjunction with other specific practices, then the innovation will be more valuable to those already using those other practices than those who are not. Therefore, Kaine and Lee (1994) hypothesised, the range of farming 'contexts' suitable for innovations will become more restricted as the innovations become progressively more advanced, i.e. adoption of innovations becomes an increasingly ordered and structured process.

To test this hypothesis Kaine and Lee examined the adoption of confined calving of heifers and cows by cattle breeders in southern Australia. They classified farms into five groups such that producers within each exhibited similar attitudes toward confined calving and followed similar management practices (other than confined calving). Statistical tests were used to assess whether there were differences between the proportions of each group who practice confined calving. The results of these tests revealed significant differences between groups, with one group in particular displaying a high rate of adoption of confined calving. Kaine and Lee then made a series of recommendations of how to accelerate adoption of the practice by members of the other groups based on differences between these groups and the 'progressive' group in terms of the other attributes measured in the study.

Kaine and Lee (1994) recognised the similarities between their approach and that of market segmentation and the potential utility of such an approach. They stated that:

> …if farms are classified into groups on the basis of differences in production 'context', then each group could be interpreted as representing a different 'segment' in the 'market' for agricultural innovations and extension services...In short, we believe that by classifying farmers into groups or segments extension services and farm advisory services may be able to identify those groups of farmers that are more likely and less likely to adopt an innovation. Given the set of set of practices that are functionally related to a particular innovation, the mixture of practices that have been adopted will differ across segments. Armed with this information, extension organisations may design programs, based around different 'packages' of practices and techniques, which are tailored to the specific needs of segments (Kaine and Lee 1994, p. 55).

Kaine and Lee (1994) saw three additional potential applications of their research. The first is the possibility of facilitating links between farmers in similar situations (i.e. networks) within the groups or segments they identified. Such networks could assist extension services in determining the path of development required by groups members to reach the next stage in farm development. The second application is the identification of potential paths of farm development to reach the ultimate point in farm productivity and sustainability at a particular time. The third application is the potential to enable extension services to estimate better the outcome of extension programs, a task often asked of those running extension programs, yet one that it is difficult to carry out.

Studies of landholders using farming style theory

Farming style theory has been proposed as an approach for conceiving and understanding diversity in agriculture. Howden *et al.* (1998) applied the concept of 'farming styles' to develop a comprehensive set of landholder types in the broadacre cropping areas of south-east Australia. Farming styles can be defined as '…socially constructed types that reflects the worldviews and strategies of one configuration of farming practices for a particular commodity (or common combination of commodities) in a particular region' (Howden and Vanclay 2000, p. 295).

Farming style theories were developed by van der Ploeg and others in Europe. These theories basically state that '…within a farming community there is a discrete set of styles (or strategies of farming) which farmers are acutely aware of, and from which they actively choose a specific strategy to guide their own management' (Vanclay *et al.*1998, p. 86). Howden and Vanclay (2000, p. 297) cited van der Ploeg (1993, p. 241) as stating:

> Farming styles refers to a cultural repertoire, a composite of normative and strategic ideas about how farming should be done. A style involves a specific way of organising the farming enterprise: farmer practice and development are shaped by cultural repertoire, which are in turn tested, affirmed and if necessary adjusted through practice.

One of the criticisms of the application of farming style theories by van der Ploeg and others in Europe is the use of market orientation as a primary basis for classifying farmers into distinct styles (Vanclay *et al.*1998, Howden and Vanclay 2000). The European group used the extent of intensification and scale of operations as the basis from which to begin classifying various farming styles. Vanclay and others argued that emic approaches (where the farmers describe themselves in their own terms) should be used rather than presenting them with word 'portraits' of potential styles which they rate as being like or unlike themselves. Vanclay and others attempted to modify the application of the farming styles methodologies to make them truly emic or ethnographic rather than impose 'expert' interpretations of farming styles onto the landholders. As these researchers reported, their efforts were only partially successful.

The aim of the research undertaken by Howden *et al.* (1998) was to '…test the applicability of farming styles theory in the Australian context, as a suitable classification procedure to assist in targeting of the products of agricultural research…' (Howden *et al.* 1998, p. 109). Relatively homogenous groups of landholders were initially defined by a series of focus groups where landholders were asked to characterise themselves as farmers, to identify the way they differed from other farmers in their area, and to describe the styles of the other farmers in their area. The resulting categories of farmers defined in these focus groups were then compared and summarised by a group of public and private agronomists. While over 20 different types of farmers were identified in this process, it was concluded that more than 80% of landholders fell in six main categories (Table 7.3). It was indicated that the researchers saw the descriptions as 'archetypes' or 'ideal' representations rather than as discrete entities.

Howden and Vanclay (2000) have questioned the practicality of farming styles typologies due to differences between the findings of van der Ploeg and those of Howden *et al.* (1998), internal inconsistency in the descriptions of the types by different landholders and a lack of supporting evidence from case studies. Howden *et al.* (1998) reported that the various focus groups used different language to describe the same styles, and different focus groups described different landholder types.

The differences among farmers' own interpretations of farming styles and the need for expert interpretation of their descriptions was taken by Howden *et al.* (1998) as indicative that the farming styles are analogous to the idea of farming sub-cultures. These authors argued that '… a style is possibly a sub-cultural grouping with its own socially constructed reality…(and)…the range of styles may reflect class and education differences…' (Howden *et al.* 1998, p. 123). The primary evidence for this is the lack of common language between farming groups, with the exception being the use of 'adopter categories' (e.g. 'innovative' and 'progressive') as described by innovation adoption theorists. According to Howden and Vanclay (2000), these were the only styles that were not described disparagingly. Howden and Vanclay (2000) further reported that farmers were unwilling to be identified with styles that were perceived to be socially undesirable. They stated that:

> The styles do exist as part of farming discourse in general terms; all farmers, and people associated with farmers, have images about farmers and farming they have constructed. They are aware, at some level, of the normative judgements applied by various groups. … the mythologising of styles can work as a form of social control (Howden and Vanclay 2000, p. 307).

Table 7.3 Characteristics of different types of landholders in the broadacre cropping belt of southeast Australia developed using farming styles concepts

Category	Degree of contact with researchers and other change agents	Level of risk adopted	Key influences	Views of other landholders
Innovative	High – used to trial new practices	High – like to try new ideas	Look to the 'big picture'	Forefront of change, take some unnecessary risks.
Progressive	High	Medium – trial 'proven' practices	Strong economic/business orientation	Seen by many as the 'best' farmers.
Middle of the road	Medium	Medium – low	Other landholders. Like the farming 'way-of-life', have inherited land.	Seen as 'average', follow-on' or 'practical' farmers.
Lifestyler	Medium-low	High – low	Personal approaches; some new to land, others are retired farmers.	Adopt 'strange' management. Annoying if they challenge neighbours' practices or fail to control weeds.
Resource limited-structural	Medium – low	Low	Small and often unviable farm size. Low financial and information capital limits practices.	Some lack of business skills and ability to cope with new information.
Traditional	Low	Low	Follow well-known practices, often those of their parents.	Seen as 'old-fashioned', living in the past.

Source: Based on Howden *et al.* (1998).

Howden and Vanclay (2000) have also reported on a re-examination of the groups of landholders using a series of case studies. When they attempted to locate specific examples of the various groups to use for case studies, the extension agents who were assisting them had considerable difficulty in naming actual farmers to exemplify many of the categories. Howden and Vanclay (2000) reported that the farmers were frequently able to identify with aspects of a number of different styles, sometimes selecting seeming opposing styles as 'most like themselves' during the case study interviews. The extension agents and farmers still thought, however, that the notion of farming styles is valid.

Howden and Vanclay (2000, p. 308) stated that 'to some extent, the heuristic styles represent dimensions or continua on which farmers locate themselves (although subconsciously), and for which a mythologised style, or parable, is a characterisation of a polar extreme'. Thus they concluded that the styles they had described were in fact myths or stereotypical constructs in which landholders saw elements of themselves and selected parts to emulate in devising their individual strategies rather the styles being descriptions of actual people or management strategies. They did not totally reject the concept of farming styles and the potential this has to understand better the sociology of Australian agriculture. They concluded that the current limitations of the concept are more of a methodological problem and that 'focus groups are not an appropriate technique for identifying "real" tangible farming styles, which may or may not exist' (Howden and Vanclay 2000, p. 309).

Existence of farming sub-cultures

Another theoretical basis for examining the variations in land management attitudes and practices is the application of the idea of farming sub-cultures as described by Vanclay and others (Vanclay 1995, Vanclay and Lawrence 1995). The concept of farming sub-cultures is similar to that of farming styles. Farming sub-cultures are said to be a collection of landholders who share similar concepts of what is involved in 'good land management'. The concept of 'good land management' differs between landholders, being socially constructed and defined through interaction between farmers, through participation in extension activities, and through the rural media (Howden and Vanclay 2000, p. 297).

One difference between farming styles and farming sub-cultures is in terms of the degree to which it is thought that landholders' decisions are influenced by factors outside of their control. Howden and Vanclay (2000) argued that farming style theorists place too great an emphasis on the degree to which people are free to control their own behaviour in the face of political, economic and environmental factors that are beyond their control. Instead they argued that all peoples' actions are guided to some extent by sub-cultural norms as well as political, economic and environmental factors, together with individual rationality. They stated that it is normal and rational for people to act to achieve their goals in a way that avoids social ostracism even if this may be maladaptive in terms of maintaining their landholding in the face of political or environmental change. No full explanation of the concept of farming sub-cultures by Vanclay has been found nor any typology of the farming sub-cultures in Australia in the literature review for this study.

Market segmentation analysis

Previous research has identified the potential for the use of some of the techniques employed by market segment research to assist those designing and administering rural development programs (Chamala 1987, Vanclay *et al.* 1998), although little has been published about the approach (Emtage 1995, Emtage and Specht 1996). Market segmentation is an analysis technique used by commercial firms to guide their marketing strategies and resource allocation between products and markets (Dillon *et al.*1990). In this sense, market segments are groups of consumers who respond to a given marketing strategy in a similar manner, or who exhibit differing sensitivities to some marketing-mix element. Market segmentation can be used, for example, to assess how various types of people will respond to new packaging or advertising, or to a new product. It is suggested that market segmentation is a necessary part of any effective marketing strategy, because products cannot be correctly 'positioned' in a market, or targeted to particular groups of consumers, if the reactions of different parts of the market to different products and marketing strategies are unknown (Dillon *et al.* 1990).

Market segmentation methods were used by Barr (1996) to examine the potential adoption of perennial pastures. Barr (1996) examined landholders reactions to perennial pastures as a 'product'. The perceived benefits of the various uses for trees on private lands were used as the basis for clustering respondents by Specht and Emtage (1998) and Emtage *et al.* (2001). Analysis of variance and chi-square tests were then used to define differences in the tree-planting attitudes and the socio-economic characteristics of each group.

Landholder typologies defined according to strategies for management of perennial pasture

Barr (1996) described a typology of landholders derived from an examination of 22 studies (including five segmentation studies) of landholders' pasture management attitudes and practices in northern Victoria and southern New South Wales. The research methods used for that paper are similar to market structure analyses. The 'product' was taken to be perennial pastures and Barr examined how various types of landholders have used perennial pastures in the past and will respond to different extension messages in the future. The studies that did not use segmentation were used to supplement the information gleaned from the segmentation studies. Barr looked for consistencies among the findings of the segmentation studies and identified seven distinct groups of landholders with different socio-economic characteristics, and different attitudes and approaches to land management (Table 7.4).

Table 7.4 Typical landholder types in the northern Victoria – south-west NSW region

Landholder group	Level of risk	Key influences	Farm practices	Proportion of sample
The committed	Medium to high	Keen information gatherers and high awareness able to translate into behavioural change. High interest in production and profit	Use perennial pastures and rotational and strategic grazing routinely. Good understanding of production agriculture	5 – 15%
The pasture dabblers	Medium	Have off-farm work or business interests for financial security. Information and time poor.	Only third or less of land under perennial pasture. Active cropping.	15%
The crop focussed	Medium to high	Intent on cropping.	Use pasture to rest crop land. No perennial pastures.	Only in mixed-crop zones.
The belt tighteners	Low	Follow commodity trade closely. Risk adverse. Translate awareness to action (trials) before attitude change.	Mainly grazing, set stocking used. Overstate their level of perennial pastures.	30 – 40%
The sceptics	Low	Often have large landholding. Low trust in 'outside' information	Low set stocking rate, no perennial pastures	10 – 20%
The comfortable group	Low	Older people with no beneficiaries, large holdings. Seek to reduce active management.	Low energy management. Often in beef production.	20 – 40%
The retreatists	Low to high	Younger people with families. Very little time. High interest in aesthetics. Some interest in capital gains. Near urban areas.	Little interest in pasture improvement. Greater than average interest in tree planting.	Little available data.

Source: Adapted from Barr (1996).

Barr (1996) concentrated on the implications of using the understanding of various landholders types to anticipate the likely adoption of low-input pastures. He did not explicitly address the rationale for using such an approach or discuss the implications for rural extension in general terms. He argued that the various levels of enthusiasm for and adoption of perennial pastures by landholders in various 'groups' are rational given their social and economic circumstances. He noted differences in groups with regard to stage of life-cycle and differences in terms of the area of land owned and the extent of reliance on the farm for income. For example the 'comfortable group' are those who have reasonably large farms and are becoming older with no prospects of inter-generational transfer of the farm and thus they are seeking to minimise the labour demands of farm management. Their situation contrasts with the 'retreatists' who live near urban areas, have a heavy reliance on off-farm income and young families so that they also have limited opportunities to carry out management activities. This group also has different management objectives, being more interested in activities like tree planting which have the prospect of capital gain through improvement of amenity values as well as timber production.

Barr (1996) reported that some of the studies he reviewed revealed differences in the decision-making process used by the various landholder groups and differences in their information-seeking behaviour. For example the 'committed' landholders were thought to have a confident and information-rich decision-making style where awareness of an innovation in land management practices leads to attitude change which then leads to a behavioural change. This contrasts with the 'belt-tighteners' whose adoption of innovations is characterised by awareness leading to behavioural change (i.e. testing new ideas) which then leads to an attitude change. The 'committed' group were also noted to be the most keen to seek out new information. The other factor that is emphasised as differing between the groups is their attitudes to risk. Again the committed group are reported to be the best equipped to deal with risk through the gathering of information as well as through ownership of reasonably large farms. The 'sceptics' on the other hand are reported to be highly risk adverse, and because of their control of large properties, use conservative farming methods that do not necessarily maximise economic returns on a per hectare basis.

7.3 Landholder Types in Relation to Tree Planting and Management

A number of authors have discussed the application of ‘user groups’ or ‘typologies’ to ensure effective design and implementation of agroforestry and agriculture development programs (Belsky 1984, Chamala 1987, Ooi 1987, Raintree 1991, Vanclay and Lawrence 1995, Vanclay *et al.* 1998, Emtage *et al.* 2001, Fulton and Race 2001). Raintree (1991), following Rocheleau (1986), applied the term ‘user groups’. This approach was developed as part of the need to develop what was termed a ‘users perspective’.

The rationale for defining different user groups within the community is that they have different attitudes and values, are in different socioeconomic circumstances, and thus have different needs and wants. In relation to the adoption of farm and community forestry, Raintree (1991, p. 8) stated ‘It is … obvious that the different uses of trees have different degrees of relevance to different users and that the socioeconomic attributes the individual user (as conditioned by his or her position within the social structure) must somehow influence and set limits on the relevance of particular trees’. Raintree (1991) recommended the definition of a set of internally homogenous user groups as a starting point for the design of any agroforestry systems. Tree growing technologies can then be matched to the user groups, and finally tree species to the technologies. Table 7.5 summarises various ways that landholders can be classed, including by tenure and type of production, by landholding size, by farming system type, by economic orientation and by type of participation. As well as foresters and farmers, the table includes processor, vendors and consumers classifications.

The basis of the typologies developed by Emtage and others is to group landholders with similar attitudes to farm forestry. Clustering is based on ratings of the importance of various reasons for and restrictions to tree planting and management in the Northern Rivers of New South Wales and Far North Queensland (Emtage 1995, Specht and Emtage 1998, Emtage and Specht 1998, Emtage *et al.* 1991). The landholder groups in NSW and Far North Queensland were then tested to assess whether they differed in terms of their average socioeconomic characteristics and planting behaviour. In these studies, five types of landholders are described which differ significantly in their attitudes to farm forestry and in some socioeconomic characteristics. The types range from landholders on relatively large properties with a long history of land management and a low interest in tree growing, to those on smaller properties with shorter periods of land management and high interest in tree growing.

The typology of landholders was tested in the Northern Rivers region using a series of interviews with members of each different landholder type. These types were defined using responses to questions relating to the importance of planting and managing trees for various purposes in an earlier questionnaire. Specifically, five interviews were carried out with members of each type plus five interviews with respondents who were not classified in a group, using the clustering method (Emtage and Specht 1998). These interviews largely confirmed the understanding of the characteristics of the distinct types and provided further insight into their land management strategies and the potential role of tree planting and management. In the Far North Queensland study, Emtage *et al.* (in prep.) presented the results of a landholder survey to a group of farm forestry extension personnel. Prior to being shown the results of the cluster analysis and subsequent analyses to examine the characteristics of each group and differences between groups, the extension personnel were asked to define and briefly describe common types of landholders in the north Queensland region. Table 7.6 illustrates these groups. The extension personnel were then shown the results of the cluster analysis and split into three teams to assess if the groups they had earlier defined matched the groups found through cluster analysis. They were also asked to recommend communication strategies and incentive programs that might appeal to members of the various groups.

Table 7.5 Some methods of defining the forest users and farm and community forestry clientele

User category	Comments
Producers	
Forest producers	
By tenure/type of forest production	Professional foresters, private forest owners, etc
Foresters	Hunters, foragers, shifting cultivators, herders etc
Traditional forest users	Illegal in formal law but may have rights in common law
Encroachers, poachers etc	Paid for labour, may engage in other exploitative activities
Forest labourers	
Farmers	
By size of landholding:	
Medium-large farmers	Exact size limits vary from area to area
Small farmers	Exact size limits vary from area to area
Landless and marginal farmers	Depend on wage labour and gathering
By farming system type:	
Long-fallow shifting cultivation	R-value ≤ 10(see note below)
Bush fallow cultivation	R-value 10-33
Short fallow cultivation	R-value 33-66
Permanent arable cropping	Field cropped annually
Multiple cropping	More than one crop/year
Perennial crop plantation	Usually tree crops, often internationally traded commodities
By economic orientation:	Production for own consumption or informal exchange
Subsistence	Most common orientation of small farmers
Mixed or 'subsistence plus'	Production for cash sale
Commercial	
By type of tenure/participation:	Freeholder, owner operator, absentee landowner etc
Land owner	Tenure usually secure but rights limited
Usufruct right holder	All forms of rent, lease or sharecropping
Tenant	Based on informal reciprocity rather than formal exchange
Borrower	Full or part-time, continuous or temporary
Farm labourer	illegal occupier but some rights usually recognised
Squatter	
Livestock producers:	modern commercial extensive range management
Ranchers	traditional nomadic, semi-nomadic or transhumant herders
Pastoralists	part time herding in combination with cropping
Agropastoralists	limited livestock production closely integrated with cropping
Mixed farmers	
Processors	
Urban industry:	Located in cities or large towns
Modern, formal sector	Large-scale, high tech industries like pulp, rayon, chemicals
Traditional, informal sector	Small to medium-scale artisans and workshops
Rural industry located in rural areas, villages or small towns:	
Medium-scale	Usually modestly capitalised and labour intensive
Small-scale	Cottage or small-scale group enterprises providing full or part-time employment
Vendors	
Formal sector	Medium/large scale, adequate working capital and storage
Informal sector	Small/medium scale, lack of capital and storage
Consumers	
Urban	Large politically influential populations
Rural	Farmers, rural industry workers, retired persons and members of the remittance economy

Note: the R-value classifications are based on Ruthenburg (1971), cited in Raintree (1991).
R-value = (cropping period + (crop + fallow period)) × 100.
This is equivalent to the percentage of land in cultivation at any one time.
Source: Raintree (1991).

The ‘retired professionals and hobby farmers’ groups and the ‘traditional’ group appear to represent the extreme positions of landholder types. They have the smallest and the largest landholdings respectively, and are at the extremes of the range in the proportion of income from the landholding, and the length of time over which the landholding has been managed. Furthermore, ‘retired professionals and hobby farmers’ have the lowest proportion of their land used for cropping, the highest proportion under native forest, and the least average hours per week labour input from the family (Emtage *et al.,* in prep.). As well, this type has the highest level of past tree planting activity, and the highest proportion who intend to plant trees for mixed timber production, aesthetic and environmental reasons in the future (Emtage *et al.,* in prep.).

Table 7.6 Classification of landholder types in the north Queensland region by farm forestry extension personnel

Group name	Key characteristics
Progressive second generation farmers	Have inherited land (and debt); have similar enterprises as parents but greater education, more emphasis on conservation farming.
High intensity farmers	Very commercially orientated, often involved in banana growing and or sugar crops, seek to maximise land under crops.
Traditional farmers	Follow old style farming practices, large land size.
Retired professionals	People with high education and strong financial position who retire to the land as a lifestyle choice.
Experienced/ comfortable farmers	Largely debt-free, older, running profitable landholdings with minimal direct labour inputs (i.e. use contractors regularly).
Absentee landholders	Often become retired professionals with high incomes and education, little time. Often use land as tax break, frequently employ managers. Considerable variation in strategies used.
Marginal farmers	On poorer quality land running marginally profitable enterprises. Many desperately seeking information and /or methods that will allow them to run the landholding profitably.
Hobby farmers	Smaller landholdings providing small proportions of landowners income. Frequently well educated and in ‘good’ jobs but with considerable variation.
Conservationists	Land management dominated by very strong conservation ethic.

Source: Emtage *et al*. (in prep.)

Fulton and Race (2000) strongly supported the technique of using broadly defined groups of landholders to assist the development of strategies to increase participation in farm forestry activities. Their rationale for doing so differs slightly from the approach taken by Emtage and others. They argued that the main purpose of identifying such types is to assist government and industry to identify which types of landholders are most likely to adopt farm forestry. The advantage of this approach, they argued, is that it can make the extension programs more efficient by targeting specific types of landholders (Fulton and Race 2000). Emtage and others have argued on the other hand that the identification of types with differing social values and socio-economic circumstances should be used to ensure that the differing requirements of the various landholder types are being catered for by public assistance and development schemes. That is, they have argued that the identification of landholder types should be used to ensure that public programs are inclusive of a greater range of landholders rather than seek to make them more exclusive. They have also argued that such groups can be used to assist in the development of regional conservation strategies (Emtage and Specht 1998).

Fulton and Race (2000) developed a guide typology of landholders which matches these types with various sectors in the timber industry, alternative plantation designs and various potential marketing arrangements, as presented in Table 7.7. The typology is intended as a guide only, and Fulton and Race (2000) stated that regional studies are required to identify local variations. Note that the landholders include all those who could potentially be involved in the development of timber plantations on private and public land including urban investors and municipal governments.

Table 7.7 Typology of farm forestry landholders and industries

Industry	Landholder	Marketing arrangement	Design
Small-scale specialty timber sawmill	Commercial farmers with some silvicultural experience; Small-scale landholders.	Market brokers.	Timberbelts; small woodlots (1-5 ha).
Medium-scale hardwood sawmill	Commercial farmers with considerable forestry expertise; Small-scale urban investors.	Grower cooperative; Forest management team; 'Marketing' joint ventures.	Timberbelts; woodlots (2-10 ha).
Large-scale integrated softwood and MDF mill	Commercial farmers with under-utilised land; Small-scale urban investors; Corporations and government with under-utilised land.	Joint ventures with industry sharing the establishment costs and undertaking much of the forest management; Grower cooperatives; Forest management team.	Woodlots and small plantations (10-40 ha).
Large-scale pulpwood mill	Commercial farmers with under-utilised land; retiring farmers; Corporations and government with under-utilised land; urban investors.	'Lease' joint ventures; Grower cooperatives; forest management team; market broker.	Wide timberbelts, woodlots and plantations (10-100 ha).

Source: Fulton and Race (2000).

7.4 Comparing Landholder Typologies

Comparison of the groups defined through cluster analysis of landholders rating for reasons for planting trees by Emtage and others with the groups identified according to pasture management by Barr (1996), according to 'farming styles' by Howden *et al.* (1998), and with groups identified by innovation adoption theorists, shows remarkable similarity in their socio-economic characteristics (Table 7.8). Researchers from different institutions, looking at different aspects of land management, and using different theoretical bases, developed the typologies separately. The typologies described by Barr (1996), Howden *et al.* (1998), Specht and Emtage (1998) and Emtage *et al.* (in prep.) all include a traditional or conservative type, a smallholder or hobby farmer type, a progressive type, a resource limited type and a comfortable type. The socioeconomic characteristics of these typologies appear to be similar to the ideal types described by innovation adoption theorists. This suggests that landholder types identified by the aforementioned studies and the theories of innovation adoption have the same basis.

There are several socioeconomic factors that have been reported to differentiate between the landholder types in all of these studies. These factors include the economic characteristics of the landholding such as size and productivity and the degree of dependence of the landholder on the property for income, social characteristics such as the history of family ownership of a landholding and the family size, structure and time in life-cycle, and personal characteristics such as the level of formal education. Landholders' attitudes to land management issues such as the legitimate role of governments and the relative importance of biodiversity conservation are likewise similar between similar landholder types described by different authors.

Vanclay (1995), Howden and Vanclay (2000) and Vanclay *et al.* (1998) discussed the theoretical perspectives that underlie the studies that have been reviewed in this paper. Howden *et al.* (1998) aimed to produce landholders own descriptions of landholder types but were forced to use 'experts' to interpret the farmer descriptions they gathered using workshops. Specht and Emtage (1998) adopted the names of the main landholder types described by Howden *et al.* (1998) because names were needed and these appeared to match the essential characteristics of the landholder types defined in the Northern Rivers region. Emtage *et al.* (2001) used a group of practicing extension personnel to aid the

interpretation of their study, as well as to communicate the results of the survey to them. Barr (1996) was able to apply names to the groups he described without the use of terms that are applied by innovation adoption theorists. Nevertheless, the types described by Barr (1996) appear similar to those described by innovation adoption theorists.

Table 7.8 Names of groups from previous studies of farming styles, innovation adoption and market segments

Group – Barr (1996)	Style – Howden *et al.* (1998)	Group name – Emtage *et al.* (in prep.)	Innovation adoption categories
The committed	Progressives/ innovators	Progressive second generation	Early adopters
The pasture dabblers	Lifestylers	Retired professionals, hobby farmers, absentee farmers	Early majority
The crop focussed	Diesel burners	High intensity	
The belt tighteners	Resource limited – structural, middle of the road	Marginal	Late majority
The comfortable group	Middle of the road	Experienced/ comfortable	
The sceptics	Traditional	Traditional	Late or non-adopters
The retreatists	Lifestylers	Retired professionals, hobby farmers, absentee farmers	Varied

A number of implications arise from the findings of these studies. All of the researchers stress the utility of segmentation techniques to help understand and describe the range community attitudes and socioeconomic circumstances in the community and the way these attitudes and circumstances influence land management behaviour. The methodology applied to define the typologies has varied between studies from market structure and enterprise structure analyses, to quantitative and qualitative surveys, varying according to the objective of the research. Where the research has been industry focused, such as the studies of Kaine and Lee (1994) and that of Fulton and Race (2000), the needs of the research sponsor can affect the choice of methods used to ensure industry requirements are met. In the case of the beef industry and the timber industry, knowing which types of landholders are likely to have compatible objectives and business structures that suit them for specific roles in these industries can greatly assist industry in developing partnerships with landholders, and developing communication and strategic plans for the industry members. In other cases, the aim of the research has been to illustrate the diversity of landholders in the rural community to assist in the promotion of sustainable land management practices (Barr 1996, Specht and Emtage 1998, Howden *et al.* 1998, Emtage *et al.* in prep.). These studies have produced landholder typologies that try to illustrate the full range of landholder variation on the rationale that because landholders are in differing economic circumstances and have differing value systems, policies and programs will have differing impacts upon them. These authors argue that public policies need to take account of these variations in order to be efficient and to ensure social equity.

The definition of landholder types can be imposed according to one or more identifiable characteristic, including characteristics of the landholding, or based on psychographic or attitudinal data collected using surveys. One of the most useful outcomes of applying segmentation techniques is the insight they provide into the way that personal, social and economic characteristics combine to produce different land management objectives and strategies.

The similarities of the landholder types described in the studies raises the question of whether these ‘ideal types’ are representative of fundamental social units in the rural community. Not only were the studies undertaken using differing techniques, but also they cover several dissimilar regions in Australia. Are they self-perpetuating ‘cultures’ or ‘sub-cultures’, with shared belief systems,

characteristic behaviour patterns and identifiable icons or 'social classes'? The similarities in land management attitudes and practices across age groups reinforces theories holding that landholders learn their practices from their families and those in their social group. Various sub-cultures or classes in society have different perceptions of the importance of various issues and the 'correct way' to respond to them. Their objectives for land management are related to their economic circumstances and their personal skills as well as the state of the economy and environment around them. Their land management objectives are also partly determined by their value system, which in turn is affected by their family and peers.

The notion of what is meant by the term 'good land management' varies between landholders, as Vanclay (1995) has argued. Understanding the influence of the socially constructed ideals of 'agrarianism' and 'conservation' could be important in helping to understand the reason why people in similar circumstances in terms of their land resources act in different ways to the same responses. It appeared from the qualitative parts of the studies in the northern rivers region that two fundamental philosophies of land management existed (Emtage and Specht 1998b). The first was the traditional ideal of 'agrarianism' that emphasised the importance and nobility of productive farming in a manner that does not degrade the environment. The second ideal was the newer concept of 'conservationism' which emphasises the aesthetic and biodiversity conservation values of land management. Most people appeared to fall in between the two extreme positions but these extremes appear to provide ideal or at least stereotypical reference points for many in the community, and there were a few people who expressed what may be termed 'classic' expressions of these extremes.

There is reason to believe that the landholder typologies that have been described could be used to assist land management extension planning at a national scale. Fulton and Race (2000) cautioned that the regional differences in landholder types and circumstances are great enough to warrant the need for assessment of landholder variation in each region. Specht and Emtage (1998) also concluded that studies of landholders' land management attitudes and behaviour is most appropriate at a regional scale, partly because the environmental and market access conditions are less varied at this scale. Yet the comparison of studies undertaken in a variety of regions shows there are many similarities in landholder types across regions. These similarities may be a chance for public land management agencies to develop a more sophisticated database of land management approaches in Australia to assist the design and implementation of rural policies in areas such as biodiversity conservation. It may be possible to develop some indicators of the various landholder types that would help to speed up the development of the understanding of landholders' management approaches in regions that have not yet been extensively studied.

7.5 Conclusions

It is clear that many Australian researchers interested in rural extension see a role for landholder typologies to assist in the design and delivery of extension programs. As outlined in this chapter, various methods can be used to construct landholder typologies. These methods vary according to the theoretical approach used by the researcher and the purpose of the research. The main function of typologies is to improve the understanding and description of the diversity of landholders' values, attitudes, behaviour and socioeconomic circumstances in rural communities. The application of typologies offers the opportunity to improve the efficiency of extension programs through greater understanding of the circumstances in which landholders are operating and the potential to thus tailor the programs to specific needs and to target communications. For private industries seeking partnerships with specific types of landholders, typologies can assist in identifying the landholders of interest and ways to design the programs to stimulate landholders' interest. In the public sphere the application of typologies offers the chance to improve the equity of extension programs by explicitly describing variation in the community and designing programs to suit. It can be argued that typologies are artificial in that it can be difficult to identify specific examples of various types as reported by Howden *et al*. (1998). In response it can be argued that the similarities in the landholder typologies, which were developed independent of each other using a variety of methods and approaches, suggests

that they are reflective of fundamental variations between landholders within regions throughout rural Australia.

It is concluded that the limitations of typologies should be remembered and typologies should not be expected to represent every variation of landholders in a community. Typologies can potentially assist in the design of extension programs at regional and possibly at national levels where their application offers distinct advantages over the use of simple averages to describe the characteristics of rural landholders. While typologies can assist industries to target specific landholders and can assist the development of suites of programs to address common issues, they cannot replace the need for those offering advice to landholders to develop an understanding of the landholders' individual circumstances. It can only be hoped that the use of typologies will lead to the development of suites of public and private extension programs that are tailored to the variety of needs and circumstances of landholders. Once suites of programs are available, or variation in programs is enabled to account for variations in the needs and circumstances, it will then be up to the landholders and their advisors to select appropriate programs for their own needs.

7.6 References

Commonwealth of Australia (1990), 'Ecologically sustainable development', a Commonwealth discussion paper, Australian Government Publishing Service, Canberra.

Commonwealth of Australia (1992), *National Strategy for Ecologically Sustainable Development*, Australian Government Publishing Service, Canberra.

Barr, N. (1996), 'Conventional and low-input pasture improvement – a review of recent market research', *New Zealand Journal of Agricultural Research*, 39: 559–567.

Boyd, H.W., Westfall, R. and Stasch, S.F. (1989), *Marketing Research*, Irwin, Boston.

Byron, N. and Boutland, A. (1987), 'Rethinking private forestry in Australia', *Australian Forestry*, 50(4): 236–252.

Chamala, S., Van den Ban, A.W. and Roling, N. (1980), 'A new look at adopter categories and an alternative proposal for target grouping of farming community', *Indian Journal of Extension Education*, 16(1&2): 1–18.

Chamala, S. (1987), 'Strategies to overcome communication deficiencies in achieving sustainable farming systems', *The Journal of the Australian Institute for Agricultural Science*, 53(3): 164-169.

Dargavel, J., Jackson, G. and Tracey, J. (1995), 'Environmental events in the forests of northern New South Wales: a second order', *Australian Journal of Environmental Management*, 2(1): 224–233.

Dillon, W.R., Madden, T.J. and Firtle, N.H. (1990), *Marketing Research in a Marketing Environment*, Irwin, Boston.

Emtage, N. (1995), *Landholders' Perceptions of Planting and Managing Trees*, B.App.Sci. Hons. thesis, Faculty of Resource Science and Management, Southern Cross University, Lismore.

Emtage, N., J. Herbohn, S. Harrison and D. Smorfitt (in prep.), *Landholders' Perceptions of Plantation Development in Far North Queensland*.

Emtage, N.F. and Specht, A. (1998a), 'Landholders' perceptions of farm forestry in the northern rivers region of New South Wales', in *Plantations and Regrowth Forestry: a Diversity of Opportunities*, in R. Dyason, L. Dyason and R. Garsden, eds., Proceedings of the Biennial Conference of the Australian Forest Growers, Southern Cross University, Lismore, pp. 345-369.

Emtage, N.F. and Specht, A. (1998b), *Landholders' Perceptions of Farm Forestry in the Northern Rivers Region of New South Wales: Overview Report*, Report to the Northern Rivers Regional Plantation Committee, Ballina.

Fulton, A**.** and Race, D. (2001), 'Farm forestry in Australia: why do landholders get involved? In *Developing Policies to Encourage Small-Scale Forestry*, in J.L. Herbohn, *et al.*, eds., proceedings of the Kuranda IUFRO group 3.08 Small-scale Forestry conference, School of Natural and Rural Systems Management, The University of Queensland, Brisbane.

Gibbs, D.M.H. (1992), **'**Economic impacts of the New South Wales Rainforest Policy Decision of 1982 on the timber industry of the Far North Coast', *Australian Forestry*, 55: 80–89.
Guerin, T.F. (1999), 'An Australian perspective on the constraints to the transfer and adoption of innovations in land management', *Environmental Conservation*, 26(4): 289–304.
Harrison, S.R., Herbohn, J.L. Emtage, N.F. and Smorfitt D. (1998), 'Landholder attitudes to farm forestry incentive schemes in north Queensland', Proceedings of the *Managing and Growing Trees Conference*, Kooralbyn.
Harrison, S.R., Sharma, P.C. and Lamb, D. (1994), 'Progress in farm forestry in the Obi Obi Valley', Paper presented to the *Farm and Community Forestry Seminar*, Dorroughby Field Studies Centre, Dorroughby.
Herbohn, K.F., Herbohn, J.L. and Harrison, S.R. (1998), 'A spectrum of small scale forestry initiates in Australia: The role of environmental versus commercial values', *Integrating Environmental Values into Small Scale Forestry*, IUFRO Symposium, Vancouver, 16–20 August 1998.
Howden, P., Vanclay, F. Lemerie, D. and Kent, J. (1998), 'Working with the grain: farming styles amongst Australian broadacre croppers', *Rural Society*, 8(2), 109–127.
Howden, P. and Vanclay, F. (2000), 'The mythologisation of farming styles in Australian broadacre cropping', *Rural Sociology*, 65(2): 295–310.
Kaine, G.W. and Lee, J.W. (1994), *Patterns in Innovation: An Analysis of the Adoption of Practices in the Cattle Breeding Industry*, The Rural Development Centre, University of New England, Armidale.
Race, D. (1999), 'Regional farm forestry industries: potential dimensions and possible outcomes', *Australian Forestry*, 62(2): 182–192.
Reeve, I. (1994), 'Property and participation: an institutional analysis of rural resource management and Landcare in Australia', *Rural Society*, 4(2): 25–35.
Raintree, J.B. (1987), 'The state of the art of agroforestry diagnosis and design', *Agroforestry systems*, 5: 219–250.
Raintree, J.B. (1991), *Socioeconomic Attributes of Trees and Tree Planting Practices*, Food and Agriculture Organisation of the United Nations, Rome.
Rogers, E.M. (1988), *Social Change in Rural Societies: An Introduction to Rural Sociology*, Prentice-Hall, New Jersey.
Rogers, E.M. (1995), *Diffusion of Innovations*, The Free Press, New York.
Scott, J. (1991), *Social Network Analysis: a Handbook*, Sage, London.
Specht, A. and Emtage, N.F. (1998), *Landholders' Perceptions of Farm Forestry in the Northern Rivers Region of New South Wales*, report to the Northern Rivers Regional Plantation Committee, Ballina.
Spence, W.R. (1994), *Innovation: The Communication of Change in Ideas, Practices and Products*, Chapman and Hall, Melbourne.
Stewart, A. and Reid, R. (1994), 'The design and development of agroforestry and farm forestry options to match farmer needs in the Otway ranges', in *Faces of Farm Forestry*, Proceedings of the 1994 Australian Forest Growers Conference, Launceston.
Vanclay F. (1995), 'Actors and structures in Agriculture: reflections of an Australian in Wageningen', in F. Vanclay, ed., *With a Rural Focus: TASA '94 Conference proceedings*, Centre for Rural Social Research, Charles Stuart University, Wagga Wagga, pp. 89–128.
Vanclay, F.M. and Lawrence, G. (1995), *The Environmental Imperative: Eco-social Concerns for Australian Agriculture*, Central Queensland University Press, Rockhampton.
Vanclay, F., Mesiti, L. and Howden, P. (1998), 'Styles of farming and farming sub-cultures: appropriate concepts for Australian rural sociology?', *Rural Society*, 8(2): 85–108.
Van den Ban, A.W. and Hawkins, H.S. (1996), *Agricultural Extension*, Blackwell Science, London.
Wilson, G. A. (1992), 'A survey of landholders to native forest on farmland', *Journal of Environmental Management*, 34: 117–136.
Wilson, S.M. and Yannick, D.T. (1995), *Trees on Farms: Survey of Trees on Australian Farms: 1993–4*, ABARE Research Report 95.7, ABARE, Canberra.

8. Spatial Representations of Possible Sites for Farm Forestry Plantations within an Agricultural Landscape

G. Cockfield

In this chapter, a method of identifying possible sites for future farm forestry plantations is discussed. Spatial representations of current and possible agricultural activities in the landscape are used to inform land-use and conservation planning. The criteria for selecting sites are derived from a combination of the conclusions from the landholder survey discussed in Chapter 5, government policy goals as stated in selected policy documents, and feedback obtained from a Multi-objective Decision Support System (MODSS) process discussed elsewhere in this report.

The purposes of the analysis in this chapter are to:

- develop a means of identifying potential forestry sites in a sub-region or catchment, for use in planning by catchment management or local government groups
- develop a spatial representation of potential forestry sites in a sub-region or catchment, to provide information to people engaged in consultation activities, such as the MODSS process
- model the changes in the value of agricultural output that would result from the conversion of land to forestry use. This is designed to provide further information to policy makers as to whether there are sound economic reasons for pursuing the goal of increasing the area devoted to farm forestry.

It should be noted that achievement of the last of these objectives is severely limited by the lack of relevant biophysical data relating to forestry production in the study region, namely the Hodgson Creek Catchment, south-west of Toowoomba on the eastern Darling Downs. Therefore, the estimates are indicative only. In addition, the analysis is based on estimates of what could be produced in the way of conventional crop and livestock production from the region, not what is currently produced. A closer integration of the spatial component with the actual production would require a detailed on-ground survey, and given rotational land-use, would involve a highly complex model. An additional problem is that an infinite number of combinations of land-use activities and their locations across various locations in the region are possible. Therefore, the analysis compares the spatial distribution and value of broadacre, dryland cropping and pastoral activity with scenarios in which some land is used for plantations.

This comparison has been undertaken by creating a representation of current land-use for the study area, based on existing spatial data sets and some interpretation of satellite imagery, and then adding possible farm forestry scenarios to create new land-use combinations for the catchment. The farm forestry scenarios were initially developed from the preferences of landholders as deduced from the survey response data discussed in Chapter 5, and from advice from local forestry extension personnel and Queensland State and Federal government policy goals in relation to farm forestry. The initial set of scenarios were then presented to a stakeholder group, as discussed in the MODSS section of this report, and modified according to their feedback, after which the modified scenarios were presented to an expert panel. The feedback from that exercise was used to refine and simplify the scenarios and these are the ones to be primarily considered in this chapter.

8.1 Research Methodology

The Hodgson Creek catchment was chosen as the study site because:

- useful data in relation to land-use were available, this area having been studied extensively in relation to agricultural production and conservation issues;
- there is a variety relevant landholder types, ranging from commercial crop farms in the west to non-production landholders in the east;
- there is a variety of land types, ranging from alluvial plains to basaltic uplands; and
- it is predominantly an agricultural landscape, with little remnant vegetation, and most areas have been extensively modified.

Figure 8.1 indicates the location of the study area, the major waterways and the areas that are considered at risk from salinity due to rising groundwater levels.

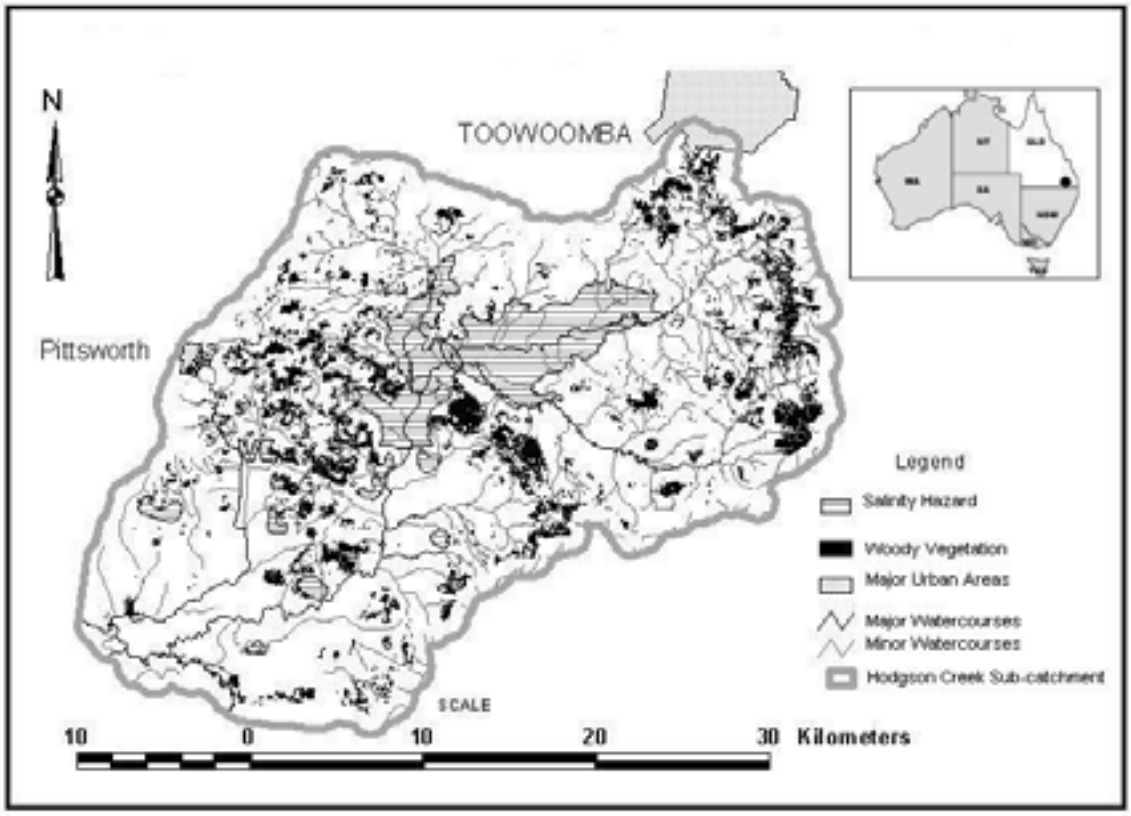


Figure 8.1 Location of the Hodgson Creek catchment on the Darling Downs of Queensland with selected features.

Source: Adapted from GIS information compiled by the Queensland Department of Natural Resources and Mines.

The total area of the catchment is approximately 81,000 ha and the mean annual rainfall ranges from 720 mm in the west to about 850 mm in the east. There are small areas of remnant native vegetation in the centre of the catchment, with some more heavily wooded areas along the range in the north-east.

Data used in the analysis

Seven acquired data sets were used to build the database, namely:

- Landsat 7 ETM+ satellite imagery
- a land-use data set compiled from a ground-based survey in 1999, covering actual land-use for the central and eastern part of the catchment
- a digital elevation model (DEM)
- the DCDB, showing roads, property boundaries and waterways
- an agricultural management unit map
- an existing salinity outbreak map
- a foliage projective cover map developed by the Queensland Statewide Land Cover and Tree Study (SLATS) (DNR, 1999).

The on-ground survey was undertaken in 1999 as part of a project investigating agrochemical use on farms. It covered about 60-70% of the eastern part of the catchment. With the exception of the Landsat 7 image and the DEM, all primary datasets were obtained from the Queensland Department of Natural Resources and Mines (NRM) and were produced by the procedures reported by Carberry and Walker (1993). The DEM was derived from both 1:10,000 and 1:25,000 contour and drainage map data. The satellite imagery was obtained from the Australian Centre for Remote Sensing (ACRES) as an ortho-corrected image.

As part of another project, the imagery for the whole catchment was processed to create a land-use and vegetation cover map. All of the visible and non-thermal infrared bands, including the Normalised Differenced Vegetation Index (NDVI) image, were included in a supervised image classification (Apan *et al.* 2001). This classification was inferred, rather than confirmed, so it was decided that the land-use survey was more accurate and therefore this information was used for those parts of the catchment for which it was available. Thus, the eastern 60-70% of the image of current land-use is based on the survey work, and the west is inferred from the image, confirmed to some extent by a limited ground survey.

Creating representations of land-use in the catchment

The base layer for the analysis was a representation of the existing land-use. This is necessarily a simplified representation of actual land-use because the cost and time involved in ground-truthing to obtain greater detail would have been high. Even then, with land-use rotations and without a comprehensive interview process to determine landholders intentions, it would only have been possible to capture a snapshot of land-use at a particular time. Consequently, this is really a representation of broad land-use possibilities, based on conventional production. It should be noted that over time the organised collection of data from key local people would produce a better representation of rotations, allowing for more accurate land-use classifications.

The broad classifications from the 1999 ground survey formed the basis for current land-use, being the most detailed available. The land-use categories are:

1. **Cash crops:** Includes all annual grain and fibre crops, with dominant crops being wheat barley and sorghum.

2. **Vegetables:** Irrigated vegetables, including broccoli, lettuce and cauliflower.

3. **Fodder crops:** Mainly oats in winter and feed sorghum in summer.

4. **Lucerne:** Irrigated lucerne used for hay production and for dairy production.

5. **Ley:** Areas identified as having once been cropped, but not in use for either agricultural or pastoral activity in the year of survey. Some ley areas are almost permanently in that state, being part of rural residential or hobby farms, or floodway paddocks. However, spot-checking has revealed that some patches have since reverted to cash or fodder crop production. On the other hand, there are areas that have been classified as improved or native pasture that support little or no grazing activity and so could be classified as ley areas.

6. **Modified pasture:** Not necessarily sown pasture, but areas that have been cultivated and are now returned to a mixture of introduced and native species of grasses. It is assumed that this could be used for grazing, though there are some patches that support little or no grazing.

7. **Native pasture:** This is assumed to have had little direct modification, although in reality there are invasive plant species in most of these areas. This means that carrying capacity varies.

8. **Urban areas:** Designated towns and villages.

9. **Stud farms:** Specialised livestock holdings.

10. **Native vegetation:** Areas of woodland of more than 2 ha.

11. **Minor drainage:** Small waterways and watercourses, as classified by the NRM.

12. **Major drainage:** Larger waterways, including creeks and rivers.

13. **Roads:** Major and minor roads, including road verges.

It should be noted that with crop rotations and the lack of ground-truthing in the western side of the catchment, there would be some overlap between the fodder and cash crop categories. Most patches were left as cash crop, given the dominance of the alluvial plains soils in this part of the catchment. Similarly, there was no obvious distinction between native pasture and modified pasture. It was therefore postulated that native pasture predominates where the slope is greater than 20 degrees and the agricultural management units are unsuitable for cultivation. An analysis was run for the surveyed part of the catchment and a high degree of correlation was found between these factors and native pasture patches. This was then applied to the remaining areas of the catchment to create more native pasture patches, leaving the remaining patches as modified pasture.

Creating a production capability layer

In order to estimate crop, pasture and timber yields, and to identify areas that are entirely unsuitable for timber production, a production capability layer was created. It would have been possible to develop production estimates based on each of 18 Agricultural Management Unit (AMU) categories. For simplicity, and given the current uncertainty about soil suitability and timber production, the AMUs were aggregated into five categories, as indicated in Table 8.1.

Table 8.1 Agricultural management units and production capability

AMU ID	Name	Production capability	Category number
11	Waco	Alluvial clays High crop production capability. Would also be suitable for Western White Gum production	1
13	Ramsey		
1	Irving-Purrawanda	Heavy to medium clays Medium to high crop production capability with some limitations relating to depth, structure or moisture-holding capacity. Some of these characteristics may also limit timber production.	2
10	Charlton-Craigmore		
16	Elphinstone-Talgai		
24	Yargallen		
2	Kenmuir-Purrawanda	Lighter clay/loams and loams. Suitable for occasional cropping and some structural decline with cultivation. May be suitable for Spotted Gum on higher areas or otherwise White Gum. Possible production limits due to poor moisture holding and difficulties with establishment where there has been structural decline.	3
4	Burton		
5	Southbrook		
15	Homestead		
12	Mallard	Some types can be cropped, but generally limited fertility, can have poor structure and limited moisture holding capacity. Possibly limited suitability for trees especially where there is structural decline.	4
14	Pechey-Palmtree		
18	Toolburra		
20	Mixed not stoney		
22	Not named		
3	Kenmuir Stoney	Low fertility. Presumed to be unsuitable for both stock and timber production	5
19	Mixed stoney		
23	Boundary		

Source: Carberry and Walker (1993).

Soil scientists could develop a more detailed set of categories but this would also increase the complexity of the overall analysis of land-use in the catchment. Production would depend on the combination of the AMU and specific crop and pasture types and these have not been identified. In addition, there are limited data relating to soils and timber production for the region. More accurate and detailed investigation would most appropriately be carried out at the sub-catchment (a sub-set of the catchment) scale or once sites had been identified as being potentially suitable for timber production.

8.2 Developing Plantation Scenarios

The key assumptions used to develop the scenarios were developed from the survey work discussed in Chapter 5, advice from forestry extension personal in the region, and government policy and research documents (including NPAC 1991).

From the integration of those factors, the following criteria were developed.

- Plantations should have some commercial potential to produce a resource that will replace native forests as a source of timber (NPAC, 1991).
- There are threshold fertility requirements, thus ruling out the least fertile soil types in the study region, despite the apparent preferences of landholders to view forestry as an activity to be located on poor soils.
- There must be sufficient area of forestry to produce marketable quantities of timber. For example, if a viable minimum annual output from a region is 10,000 m^3 and the yield from a western plantation is estimated to be 400 m^3 (1 m^3/stem and a final stand density of 400 stems per hectare or sph), then this would mean a minimum harvested area of 25 ha per year. A sustainable system, assuming a 32-year rotation, would require 780 ha of forestry.
- Stands must be clustered to some degree so there are economies of scale in harvesting and post-harvest handling. This assumes that some form of cooperative marketing would develop in the future.
- Most fertile farmland will remain in crop production, at least in the medium term, because of the higher revenue generated by crops and the cultural preferences of farmers.
- Plantations should ideally contribute to the protection of production resources, especially soil and water.

While habitat benefits are of interest to some government agencies and smallholders, it was considered too difficult to easily identify the extent of these, as there is limited information about the habitat benefits of plantations in the region. The recommended tree species, while native, are not indigenous to the area. With further research on benefits derived from plantations of various size and in various location of plantations, this information could be used to modify the scenarios discussed in this chapter to incorporate consideration of habitat benefits.

A spatial analysis of the Hodgson Creek Catchment on the Darling Downs was undertaken using these assumptions. Geographical information system (GIS) technology was used for this analysis, for four main reasons. First, relevant data were available in an ArcView format. Second, GIS software such as ArcView are becoming reasonably easy to use. Given data preparation, and perhaps some guidance by experts, the approach taken here could be replicated or adapted by stakeholders with only moderate computer skills. Third, the GIS analysis allows relatively rapid estimation of changes in agricultural output, given a change in land-use. Fourth, GIS representations of land-use and land-use change seem to appeal to landholders as an aid to planning and discussion of natural resource use (Reeve and Black, 1993, p. 131). With the criteria in mind, some specific land-use categories were created.

Identifying erosion hazard areas

The digital elevation model (DEM) layer, with slope expressed in degrees, was converted to a set of categories expressed as percentage slope, as in Table 8.2. The first four categories were based on the slopes generally used for agricultural analysis. Erosion risk increases if the slope is greater than 5%, and cultivation is not recommended due to erosion risk if the slope is greater than 12%. This categorisation allowed for identification of all areas with a slope greater then 12% where cropping is taking place. Extra categories were added, 12-20%, 20-30% because it may be possible to establish plantations on slightly steeper slopes, without adding significantly to the erosion hazard.

Table 8.2 Land gradient categorised by percentage slope

Slope (%)	Code
0-1	1
1-5	2
5-8	3
8-12	4
12-20	5
20-30	6
30-40	7
>40	8

Creating a mask of unsuitable areas

Using the key land-use types and the production capability categories, areas considered unsuitable for plantations were nominated, then isolated from the original layer, and ultimately combined in one category to create a mask for cutting any initial results for potential plantation sites to produce a final layer of possible sites.

The 'unsuitable areas' were:

- all roads, including verges and road reserves
- areas where the slope is greater than 30%
- major waterways, in which the main channels were assumed to be 20m wide, with a 20m buffer zone added to each side, create a total width of 60m – this buffer was created because farm forestry is not generally recommended to close to waterways, and in some jurisdictions is not allowed
- minor waterways, buffered to produce a total width of 40m
- native vegetation, assuming there would be little social support for removing the remnant vegetation for plantations
- urban areas
- specialised agricultural areas, including areas of lucerne and vegetables and stud farms – the assumption was that these are high value activities, unlikely to be displaced by plantations; there are only a few small patches in these categories anyway
- low fertility soils (category five from the production capability classifications).

Each theme was merged with the cumulative set to create a mask. Then, each time a set of potential forestry sites was developed, these were cut with the mask before being added to a land-use layer.

Creating a salinity revegetation layer

The first criterion was the potential to contribute to reducing land degradation, and in particular to offset some of the adverse effects of rising watertables which is a land degradation problem in the catchment subject to much current attention. The priority revegetation sites were identified by mapping the recharge and discharge zones using techniques adapted from the work of Bui (2000). Potential recharge zones are assumed to correspond to map units with high permeability and to drainage areas. Potential discharge zones are assumed to correspond to soil map units with low permeability and poor drainage located in low spots of the landscape. The rest of the soil map units are assumed to be transmission areas. The interpretation and reclassification tasks were aided by geology, drainage and vegetation maps, including soil survey reports by Thompson and Beckmann (1959), Macknish (1979) and Carberry and Walker (1993).

Bui's (2000) methodology was refined for this study by incorporating slope information in estimating the final recharge and discharge boundaries. Because some portions of the soil map units

corresponding to recharge areas were found in flat areas where drainage is poor, the slope information was used to clip these poorly drained areas. Hence, soil units typically associated with recharge zones but located on valley floors and with less than 3% slope were classified as transmission or discharge zones. The DEM was used to calculate the slope and the sub-catchment boundary layers. The latter aimed to subdivide the study area into smaller sub-catchments so that the relative extent (area) of salinity outbreaks per sub-catchment could be quantified. As one of the revegetation prioritisation criteria, the severity of salinity – by concentration within an area in each sub-catchment – was ascertained by overlaying the sub-catchment boundary layer with that of the salinity map. The recharge areas were divided into high priority and moderate priority, with the high priority areas being those in which the current land-use is some form of pasture or the land is too steep for cropping. The medium priority areas are those currently used for cultivation or urban purposes. These categories are shown in Figure 8.2.

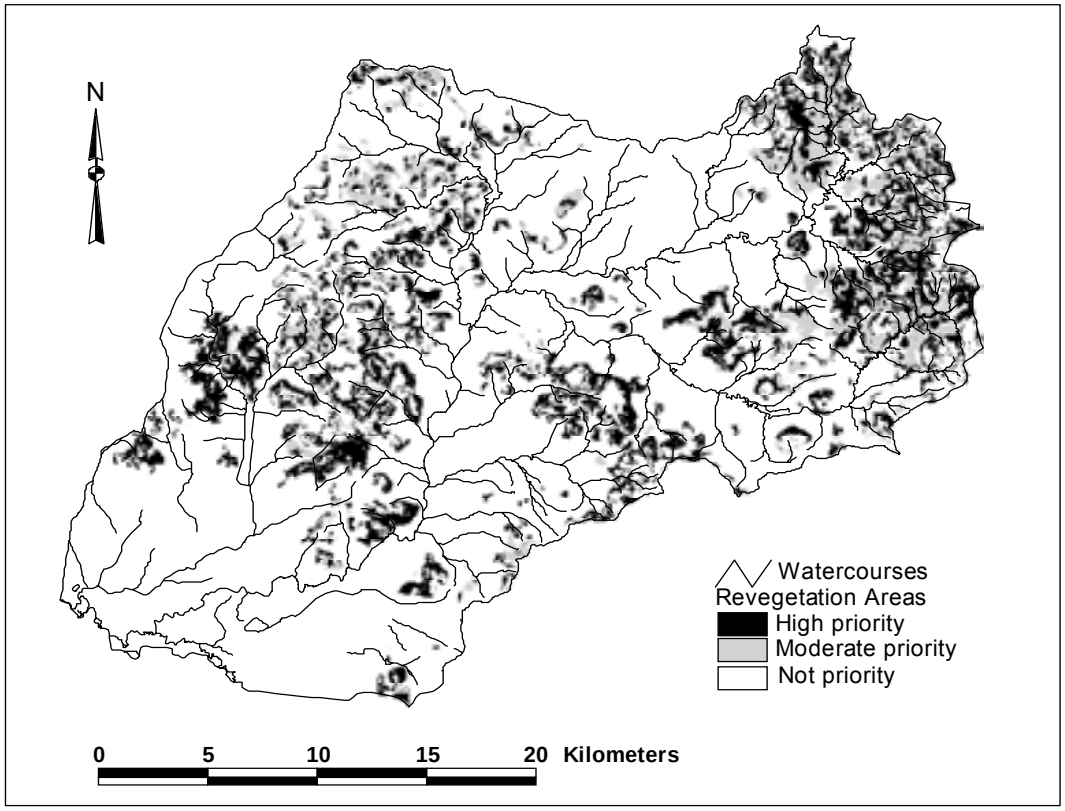


Figure 8.2 Possible revegetation areas by priority, based on salinity hazard and current land-use

It is possible to further subdivide the high priority areas, based on the severity of salinity in each sub-catchment (Apan *et al*. 2001) This ranking was determined through GIS by attribute querying of the recharge and pasture/grassland areas followed by an overlay of the results by the combined sub-catchment boundary layer and salinity map. The priority classes were determined by ranking and reclassification (using an equal interval technique) based on the total area affected by salinity per sub-catchment. Validation of the classification results was conducted by generating 32 sample points (using a simple random sampling program for ArcView), and assessing the agreement (using cross-tabulation) between the prioritised revegetation sites and the sites identified from field information and individual map layers.

Preliminary scenarios

In preparation for the MODSS process, a number of scenarios were developed to present to stakeholder and expert groups. These scenarios were developed by identifying land-use types that satisfied particular criteria and then assuming that those were converted to plantations, to create the following scenarios:

1. An approximation of current land-use.
2. Making better use of existing (native) vegetation, following from the discussion in Chapter 6.
3. Planting the high and medium priority salinity hazard areas.
4. Riparian vegetation enhancement, based on strip plantations adjacent to waterways.
5. Shadeline plantings, which are shelter belts planted along fence-lines or where there is a break in soil types or land-use activities. No spatial representation for this category was developed, because there was no easy way of identifying where these would be placed in the landscape.
6. Agroforestry which would include grazing and plantations in combination.
7. Conversion of non-cropping areas, which would involve converting grasslands to plantations.
8. Private medium-scale plantations in which it is assumed that blocks of 200 to 500 ha would be converted to forestry.
9. Landscape-scale plantations whereby there would a large corporate investment in plantations for a total of 2000-3000 ha. This is outside the brief of the research project, but there was interest in gathering some qualitative data on the reaction to such a proposal, given the concern about such developments in other agricultural areas (Tonts *et al*. 2001).

Some scenarios were not considered realistic but were included in the initial discussions in order to gather a wide range of feedback. Estimates of the change in the value of production for the whole catchment were presented with each scenario. A modified set of scenarios, accompanied by some economic data, was presented to an expert panel, as discussed in Chapter 15. Based on the two rounds of discussions, survey data, and preliminary economic output calculations, a number of scenarios were eliminated from further consideration.

The native vegetation option was eliminated because of the limited areas available and lack of commercial potential in most stands. Landholders liked the idea of shadelines but this was not considered a practical commercial option. Agroforestry attracted the interest of both landholders and forestry extension personnel and researchers, but the estimates of economic returns suggested that the separation of grazing and commercial plantations resulted in a better outcome for both producers and for the regional economy. The conversion of pasture to plantations resulted in a degree of change that landholders' thought was too great. Given the preference for livestock production, even amongst part-time graziers, as discussed in Chapter 5, such conversion is not considered likely. The conclusions from Chapter 5 tend to rule out the medium-scale plantations, given that landholders and especially those with larger holdings are not likely to be interested in extensive plantations. Finally, the corporate investment scenario was not considered further, given that it is outside the brief of the research.

This process effectively left the recharge areas and the riparian scenarios. However, in the initial discussions the recharge area scenario, participants were concerned about the proportion of the catchment that would be converted to plantations, while there was concern about the feasibility and

conservation implications of riparian plantings. The economic estimates showed that if these scenarios were realised, there would be a considerable drop in economic output for the catchment. Much of the loss comes from displacing crop production. It was also observed that ley areas comprised about 10% of the catchment and this land could be used without a reduction in overall output.

Therefore, the scenarios were revised and combined to create two new scenarios based on three criteria:

- low opportunity cost, involving relatively little displacement of agricultural activity – this is a reflection of the apparent preference of landholder engaged in conventional enterprises to continue these enterprises
- some amelioration of the potential problems of salinity and waterway degradation
- a minimum total area of forestry within sub-region, in order to try to ensure a reasonable flow of timber.

The two new scenarios are now outlined.

Scenario 1 - A minimal plantings scenario

This first scenario favours the first criterion, while satisfying the third and taking the other one into account. The minimum output criterion was based on a yield of 150 m^3/ha, derived from a final stem count of 150 stems/ha and a millable yield of 1 m^3/stem. This is relatively conservative, but given the state of research on yields, this was considered reasonable by extension personnel and advisers. If the minimum throughput for a small mill is 15,000 m^3/yr, this could be maintained by harvesting 100 ha every year. With an average rotation of 35 years, assuming some variation in growth rates, the minimum total area for sustainable forestry would be 3,500 ha.

In order to meet the first two criteria, two new land-use categories were created, one based on the intersection of ley areas and riparian areas and the other based on the intersection of ley areas and high priority salinity sites. In other words, this was an attempt to identify those areas where plantations would not displace existing production but would provide some land protection benefit. The ley land-use theme was extracted from the current land-use map. Then it was intersected with the high priority salinity layer. The intersection then became the potential *ley/salinity plantations* land-use. This was cut with the non-suitable mask and then patches of less than 2 ha were eliminated, on the basis that while small patches are not to be dismissed, they would not be an initial priority. The final result added to the original map to become land-use type 14.

For the riparian areas, the original buffered major waterways were extended by a further 200 m either side of the original buffer. This was done by adding cells to the original buffer (20 to each side). This was then intersected with the ley areas, and the resulting potential sites were cut with the non-suitable layer, and patches of less than 2 ha were eliminated, to leave a set of possible *ley/riparian* sites.

The assumption here is that these two land-use types identify the ‘highest’ priority areas for this region. In another region, the criteria might involve windbreaks services or conservation value, but these were chosen on the basis of landholder preferences and current policy directions. These would also be the areas that could attract some forms of external assistance, whether that be by way of credits, subsidies or partnerships. It was assumed that these priority areas would be supplemented by more stands in the ley areas, given that many of the ley sites are in the east of the catchment and probably owned or managed by recreational or low-production landholders who may be more easily persuaded to consider plantations. Therefore, the three categories of *ley/salinity*, *ley/riparian* and *selected ley areas* should generate enough area for the minimal scenario. However, the first two categories did not yield a large aggregate area, and so it was assumed that 3000 ha of additional ley areas would be put into plantations in order to develop a critical mass.

Scenario 2 - A medium-scale scenario

This scenario for the study site is based on an expansion of the possible areas for forestry, keeping in mind the same criteria as for the minimal scenario, but allowing for some greater displacement of existing grazing activity, and to a lesser extent some farming activity. The land protection criterion is considered to be more important and the benefit of this is that there is likely to be a greater forestry resource base, ensuring an increase in annual output in the future. Essentially, this scenario involves adding three more plantation possibilities to the minimal scenario. When these three scenarios were completed, they were temporarily converted to one land-use type, and then areas of less than 5 ha were removed, using the method outlined above. The assumption here was that with a larger total area, the aim would be to encourage larger stands.

The first plantation category was simply the *balance of the high priority salinity area*, appropriately trimmed. This became land-use type 16. The second category was *riparian plantation possibilities*. However, this was not the balance of the riparian areas, but rather the balance of areas adjacent to the major waterways that were currently in pasture rather than crop, but were adjacent to crops. The reasoning here is to identify areas in the riparian zone that are unlikely to be grazed regularly, if at all, which in effect are the areas between crop land and the waterway. Thus, plantations on these areas would have a relatively low opportunity cost

The *riparian plantation possibilities* were derived by first expanding the buffered major waterways, as described above. Then, using Map Calculator, areas adjacent to both the original buffered waterways and crops were identified and extracted. These areas were then intersected with existing land-use types, native and modified pasture, to create some current 'grass buffers'. These were further intersected with the waterway extended buffer zone, and the intersection extracted as the potential riparian plantations sites. This was then cut with the mask that excludes land not suitable for forestry. The results were effectively strips, up to 200 m wide, adjacent to the buffered major waterways, on areas that are currently under some form of pasture. This is land-use type 17. The logic is that this minimises the displacement of crop production, and provides some waterway and water quality protection, assuming there is some form of integrated waterway buffer system. It is to be noted that there is still a closer waterway buffer area that could be established with suitable water filtering grasses to complement the plantations. In addition, this 'outer buffer' plantation layout reduces the potential for regulatory restrictions on riparian zone timber extraction.

The final plantation possibilities category is that of erosion hazard plantations. This is a relatively small category based on substituting current cropping that is being undertaken on slopes greater than 12%. This category was created by identifying and extracting the cash and fodder crop categories from the current land-use map, intersecting them with slope categories greater than 12% and then cutting the resulting intersection with the non-suitable mask. Another 1500 ha of ley plantings was added to this scenario, on the grounds that smallholders would over time develop more plantations of their own accord.

Calculating changes in the value of agricultural output

Agricultural output resulting from the introduction of plantations is estimated by adding area estimates from a GIS analysis to an Excel spreadsheet containing price and production estimates. The calculations rely on some simplifying assumptions and research parameters, on the grounds that estimating real output would require considerable work in ground-truthing actual production in the study area. These parameters and assumptions include:

- returns from intensive livestock production, vegetables and lucerne are excluded from the calculations
- crop returns are based on the average return from a set rotation that includes grain and legume crops, and five crops produced in four years
- crop and stock prices are based on prices offered to farmers at the farm gate
- beef yields are based on estimates produced by a local beef husbandry adviser (Clarke 1997).

Therefore, this is an estimate of returns from the catchment, based on simple dryland production, and would probably be an underestimate of total agricultural output. However, for this analysis, the important figures are the change in output associated with forestry.

The calculations for the plantations are based on the conservative assumptions that:

- the harvest cycle will be 35 years on average
- the final stem count will be 150 stems/ha
- the yield will be 1 m^3/stem on good soil, declining somewhat on the poorer soils
- the average timber price will be \$50 m^3.

To determine output, tables were generated showing the amount of land-use activity taking place on each of the production capability types. For example, there might be 10,000 ha of crop on category 1, meaning that will result in a maximum average crop yield or a maximum timber yield and so on. An estimated of an edited table for the minimal plantings scenario is presented in Appendix 8.1.

8.3 Estimates of Changes in Land-use

As expected, the minimal plantings scenario does not displace any existing activity, while the medium-scale plantings mainly displace grazing, as shown in Table 8.3. However, the impact on salinity and water quality would be limited, given the relatively small area that covers the riparian zone or the high priority salinity area.

Figure 8.3 presents the distribution of potential forest stands under the minimal plantings scenario. Plantings are relatively scattered, although there is a tendency for them to cluster in the north-east of the catchment, reflecting the location of low-production cropping and recreational blocks. The medium-scale plantings could potentially provide a much greater social benefit, given the more extensive coverage of high-priority salinity areas. In addition, the stands (or aggregations of stands) would be much larger and there is a more obvious concentration that would contribute to a reduction in harvesting and handling costs, and perhaps be sufficient to induce the development of local processing. The distribution of possible sites under a medium-scale scenario is shown in Figure 8.4.

Table 8.3 Area of different land-use categories

Land-use category[a]	Area (ha)		
	Current land-use	Minimal plantings	Medium-scale plantings
Crops	33003	33003	32845
Fodder crops	1630	1630	1583
Total Crops	*34,634*	*34,634*	*34,428*
Modified pasture	19024	19024	15055
Native pasture	5849	5849	4789
Total pasture	*24,873*	*24,873*	*19,844*
Native vegetation[b]	*6740*	*6740*	*6740*
Ley areas	*7576*	*4010*	*5511*
Ley salinity plantings		346	346
Ley riparian plantings		219	219
Other salinity plantings			2909
Other riparian plantings			2293
Erosion hazard plantings			34
Additional ley plantings		3000	1500
Total forestry		*3565*	*7301*

[a]. Excludes all categories that were not considered for forestry.

[b]. It is assumed that much of the native vegetation in this area sustains light grazing.

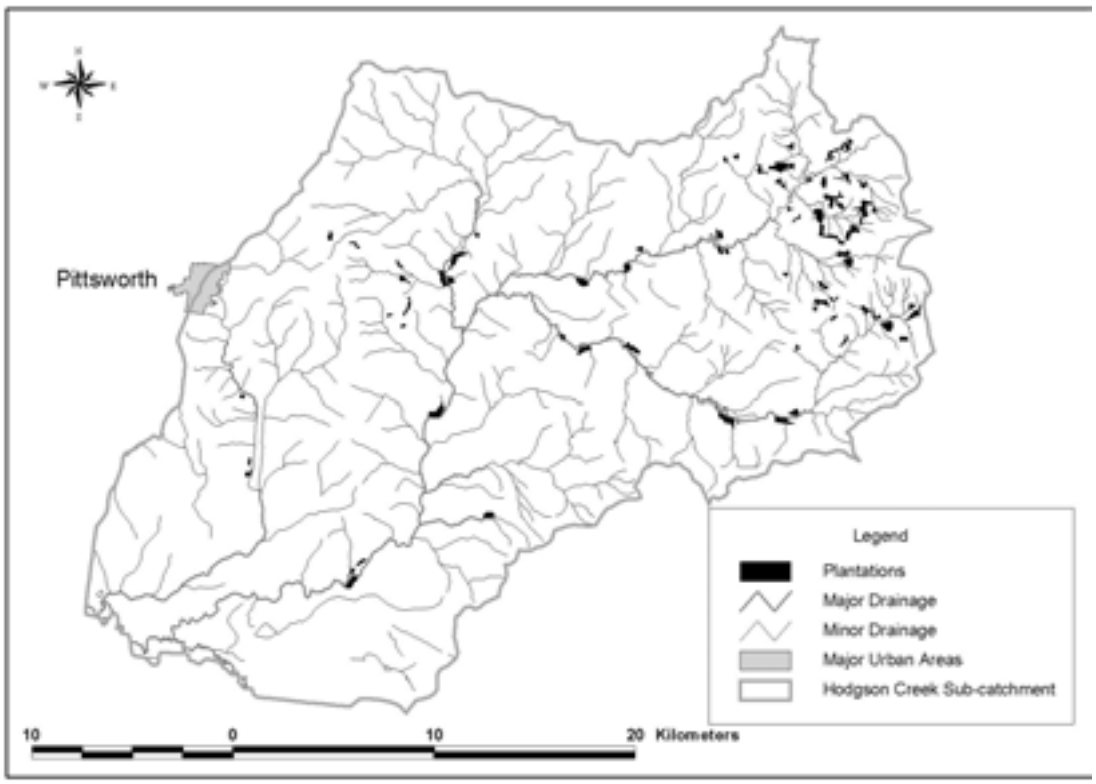


Figure 8.3 Forestry patches for a minimal plantings scenario

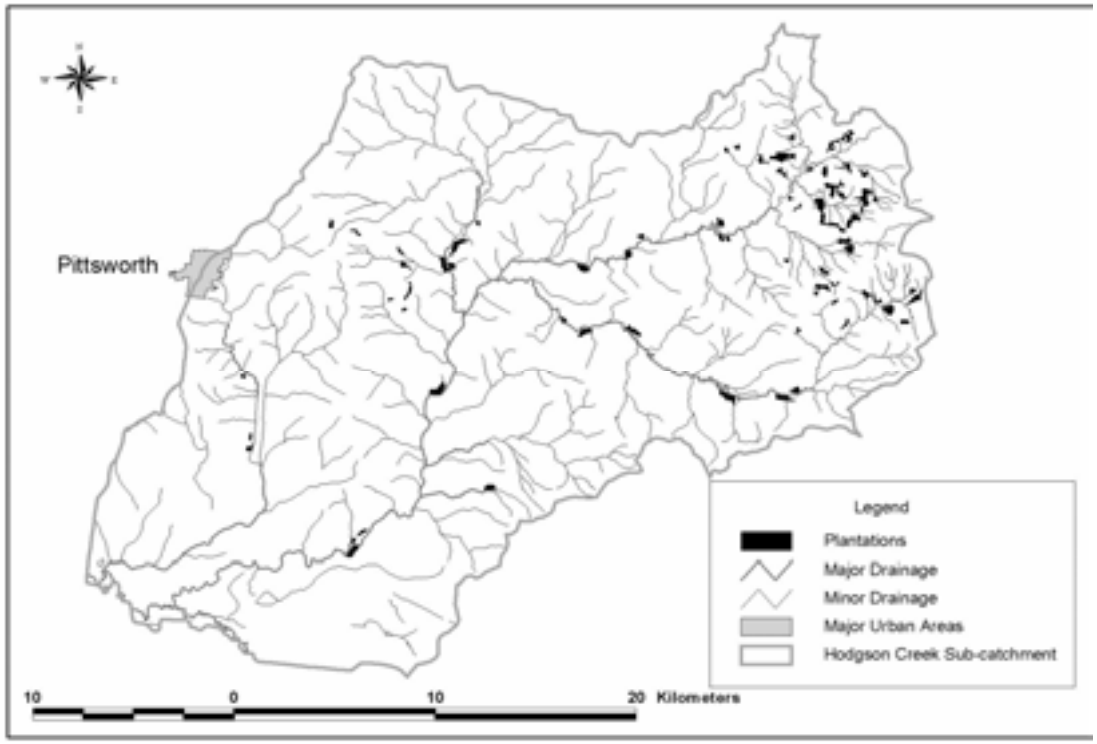


Figure 8.4 Forestry patches for medium scale plantings

The drawback with the medium-scale scenario is that the opportunity cost of the medium-scale plantings is greater than expected and the value of the changes in agricultural output are shown in Table 8.4.

Table 8.4 Value of output for dryland cattle and crop production

Output	Current land-use ($1000)	Minimal plantings ($1000)	Medium-scale plantings ($1000)
Total value of annual agricultural output up to 30 years	21430	21430	20570
Total value of annual timber output in a steady-state regime after 30 years	0	762.3	1540
Total annual value of all output after 30 years	21430	22190	22110
Change in short-term annual output, from current output (up to 30 years)	0	0	-855.7
Change in long-term annual output (after 30 years)	0	762.3	685.3

As expected, the minimal plantings scenario has the benefit of maintaining existing production, while providing an increase in total output once the plantations are being harvested on a sustainable basis. The medium-scale plantings scenario seems to result in a short to medium term loss, as expected, but the long-run annual net gain is less than the short-run losses. That is, even without discounting, it would take longer than a full growing cycle after first harvesting to recoup the lost income. The situation for the long-run impact of the medium-scale plantings does improve with a reduction in the harvest cycle time, so that a harvest cycle of 30 years results in a net increase in the value of annual output of $942,142. Alternatively, much the same outcome could be achieved with timber price of $\$57/m^3$.

8.4 Discussion and Implications

The analysis provides some useful indications of the changes in output that could result from various changes in land-use and provides an idea of the spatial distribution of a new form of land-use, based on certain criteria.

However, there are some limiting factors, including:

- The lack of spatial representations of land-use in some regions. There was relatively complete spatial information for the study area. However, an attempt to replicate the work in a catchment in the New England area was ultimately stymied by a lack of land-use data. It should be noted that resource agencies are generally increasing the amount of spatial data they hold.
- The lack of accessibility for spatial data. In some cases relevant spatial data exist but are not readily available, either due to lack of metadata or, in some cases a reluctance by agencies to share data.
- The lack of spatially orientated production data, with most production data collected at the minimum on the basis of a local government area.
- The dynamism of land-use, with production regimes changing according to weather conditions and commodity prices. This is especially true for an area such as the study area, where a range of crop and stock options are regarded as substitutes in production.
- The limited biophysical data for production rates for tree species in inland regions, such as the study area.

These limitations mean the analysis undertaken here has limited accuracy for local decision-making on land-use, such as land-use planning by local authorities. Nonetheless, with more land capability information and current land-use data and better biophysical data for tree growth, this approach could be used for the identification of desirable locations for forestry. Improving the accuracy of the

economic analysis is more difficult, given the dynamism of land-use and the uncertainty about commodity prices, especially timber future timber prices.

Despite the limitations, the initial economic analysis does give cause for reflection on the likelihood of net gains if current enterprises are displaced for forestry. At this stage, there is no evidence to support the case for there being significant net economic benefits in such a move. This does not mean there is not individual landholder benefit, nor that there are not conservation benefits. Rather, it points to the difficulty of arguing for such a change on economic grounds alone, particularly where the environmental benefits have not been quantified. If markets for ecosystems services, such as carbon sinks and water quality improvement develop, then the economics of farm forestry may be more favourable. This is a very limited economic analysis and some further input/output analysis is being undertaken. In anticipation of results from these analyses, there will be some flow-on from the initial forestry establishment phase, but there will be a long period, perhaps 20 years, of little input before the regular harvesting of timber commences. In addition, the degree of local benefits will depend on the location of the processing infrastructure. A larger area of plantations displaces more existing production, but is more likely to support local processing, providing more than 30,000 m^3/yr. On the other hand, the 15,000 m^3/yr minimal plantings scenario allows for the maintenance of existing agricultural output and still produces a greater long-run net gain.

8.5 Suggested Further Research

This analysis seems to provide a useful way to process and present spatial and economic information. It is easily understood by landholders and community groups, and with continuing work on the collection of spatial data, such an approach could be more widely used. With regard to further work on the analytical method, it is intended that the following activities will be undertaken:

- some ground-truthing of the current land-use classes, especially checking whether designated ley areas are still not being used for conventional production.
- the regional economic impact for each scenario will be estimated from a regional input/output table
- an estimate will be made of the economic returns to be derived from providing expert advice to landholders, running an annuity payment system and developing a credit payments system to encourage plantations in a region
- the approach will be shown to a local authority that covers much to the study site, and for which the planning officer is interested in assessing the potential of the model to support land-use planning decisions on forestry.

Suggested further work on this approach to analysing forestry in the regional landscape could include:

- Undertaking a land-use survey to identify additional areas that currently support little or no agricultural production. Such areas could include grass patches in cultivation and grassland buffer zones around houses and livestock facilities. There may be a considerable aggregate area of such sites, some of which could support small plantations.
- Reviewing similar spatial analysis research programs to gather ideas on improving the accuracy of the spatial data to be used as the bases of the analyses.
- Liaising with local landcare and catchment management co-ordinators to arrange meetings at which landholders can consider the model and provide feedback on the accuracy of the land-use map, and comment on the realism of the rotations, yields and carrying capacity, in order to add temporal production patterns to the model.
- Using the Australian Farm Forestry Financial Model (discussed in Chapter 9) to predict financial return from forestry for farms in the region and then using that information to update production data and estimates of the value of output.
- Integrating the Plantgro files into the spatial representation of a region.
- Estimating possible social benefits.
- Integrating outputs from this approach into a MODSS framework.

8.6 Summary

In this chapter a method of analysing the spatial distribution and economic impact of an expansion in the area devoted to farm forestry within a catchment or sub-region has been discussed. The analytical work depends on there being suitable spatial data or the resources to undertake extensive data collection and processing work for a defined area. Given the almost infinite number of potential land-use combinations, the method relies on using criteria to produce a limited number of possibilities. In this analysis, the development of land-use scenarios was based on information about landholder attitudes, government policy documents and expert and local knowledge. The initial nine scenarios were eliminated or modified through a MODSS process and by the re-examination of the initial criteria. It would be feasible to use less formal processes of consultation with landholders and other stakeholders to modify scenarios, but there was some value in testing the more formal approach.

The results of the economic analysis for this case study suggest that it would be difficult to argue that plantations result in a clear economic advantage, especially in the short to medium term. This is largely because of the opportunity cost of displacing existing production. However, the spatial analysis showed that there is a considerable area of land within the catchment that is not being used for agricultural or pastoral purposes. This analysis may even have underestimated the area of land that supports little or no production. If this line of thinking is pursued, the focus remains on developing a mosaic of small plantations across the landscape, as discussed in Chapter 5. This will mean a low opportunity cost in terms of production, but it may also mean there is a limited contribution to conservation and land protection benefits.

8.7 References

Apan, A., Raine, S., Cockfield, G., Le Broque, A. and Paterson, M. (2001), *Mapping and Prioritising Revegetation Sites for Dryland Salinity Management*, unpublished paper, University of Southern Queensland, Toowoomba.

Bui, E. (2000), 'Risk Assessment in the Face of Controversy: Tree Clearing and Salinization in North Queensland', *Environmental Management*, 26(4): 447-456.

Carberry, D. and Walker, R. (1993), *Hodgson Creek: A Situation Statement*, Queensland Department of Natural Resources, Toowoomba.

Clarke, M. (1997), *Beef Production on the Darling Downs*, Queensland Department of Primary Industries, Brisbane.

Department of Natural Resources, (1999), *Digital Raster Images of Land cover*, Statewide Land Cover and Trees Study, Brisbane.

Macknish, S. (1979), *Land Evaluation of an Area of Basaltic Soils Near Pittsworth on the Eastern Darling Downs*, Technical Bulletin No. 36, Division of Land Utilisation, Queensland Department of Primary Industries, Brisbane.

NPAC (National Plantations Advisory Committee) (1991), *Integrating Forestry and Farming: Commercial Wood Production on Cleared Agricultural Land* Volume 1, National Plantations Advisory Committee, Canberra.

Reeve, I. and Black, A. (1993), *Australian Farmers' Attitudes to Rural Environmental Issues*, Rural Development Centre, Armidale.

Thompson, C. and G. Beckmann. (1959), *Soils and Land-use in the Toowoomba Area, Darling Downs Queensland Soils*, Soils and Land-use Series No. 28, CSIRO, Melbourne.

Tonts, M., Campbell, C. and Black, A. (2001), *Socioeconomic Impacts of Farm Forestry*, Rural Industries Research and Development Corporation, Canberra.

Appendix 8.1: Calculating value of agricultural output

Grain crops

Land use category	Production capability	Yield ratio	$/ha	Ha	Output ($1000)
1	1	1	590	10,460	6,173
1	2	0.9	531	16,578	8,803
1	3	0.8	472	4,569	2,157
1	4	0.7	413	692	286
1	5	0.5	295	704	208

Beef production

Land use category	Production capability	Stocking rate hd/ha	No. of days	Kgs /day	Kgs/ha gained	$/kg	$/ha	Ha	Output ($1000)
3	1	2.2	180	0.8	317	1.2	380	140	53
3	2	2.1	180	0.8	302	1.2	363	896	325
3	3	2	180	0.8	288	1.2	346	427	148
3	4	1.8	180	0.8	259	1.2	311	78	24
3	5	1.5	180	0.8	216	1.2	259	89	23
6	1	0.7	365	0.6	153	1.2	184	2,304	424
6	2	0.6	365	0.6	131	1.2	158	7,016	1,106
6	3	0.5	365	0.6	109	1.2	131	3,721	489
6	4	0.4	365	0.6	88	1.2	105	1,464	154
6	5	0.3	365	0.6	66	1.2	79	4,519	356
7	1	1	365	0.5	182	1.2	219	304	67
7	2	0.8	365	0.5	146	1.2	175	805	141
7	3	0.6	365	0.5	109	1.2	131	942	124
7	4	0.4	365	0.5	73	1.2	88	744	65
7	5	0.25	365	0.5	46	1.2	55	3,055	167
10	1	0.25	365	0.3	27	1.2	33	499	16
10	2	0.23	365	0.3	25	1.2	30	872	26
10	3	0.21	365	0.3	23	1.2	28	530	15
10	4	0.18	365	0.3	20	1.2	24	635	15
10	5	0.12	365	0.3	13	1.2	16	4,205	66
Total annual value of agricultural production									21,430

Timber production

Land use category	Production capability	Stems/ha	Yield/stem	Yield/ha	$/cu^3	$/ha	Ha	Output ($1000)
14	1	150	1	150	50	7500	55	416
14	2	150	1	150	50	7500	184	1,377
14	3	150	1	150	50	7500	27	206
14	4	150	0.9	135	50	6750	79	530
14	5	150	0.8	120	50	6000	1.5	9
15	1	150	1	150	50	7500	107	803
15	2	150	1	150	50	7500	96	722
15	3	150	1	150	50	7500	15	116
15	5	150	0.8	120	50	6000	0.2	1
Add. Ley	1	150	1	150	50	7500	400	3,000
Add. Ley	2	150	1	150	50	7500	2,000	15,000
Add. Ley	3	150	1	150	50	7500	600	4,500
Total timber area							3,565	
Total value of timber								26,680
Value of annual timber production								762
Total annual value of all production								22,192

9. The Design and Structure of the Australian Farm Forestry Financial Model

J. Herbohn, D. Thompson, N. Emtage and S. Harrison

The Australian Farm Forestry Financial Model (AFFFM) is a powerful tool for the financial appraisal of farm forestry options. The AFFFM originated from financial modelling work undertaken through the Rainforest CRC and CARE Ltd. It is a whole-farm financial model developed in modules using Visual Basic as the programming language, and provides estimates of key financial criteria including net present value (NPV), land expectation value (LEV) and internal rate of return (IRR) and annuities. It also provides details of the impacts of forestry options on cash flows and the business cash position. Included in the AFFFM are substantial datasets for establishment and maintenance costs, growth rates and potential timber products of a number of tree species, for three regions. The following sections outline the scope of the AFFFM including its structure, assumptions, input parameters and key variables. Subsequent chapters describe in further detail the development of the growth modelling components (Chapter 10), the processes for developing and testing the model (Chapter 11) and two case studies involving the application of the AFFFM (Chapter 12).

9.1 Background to the Development of the AFFFM

The impetus for the development of AFFFM came from the initial recommendation to combine the four separate research proposals as outlined in Chapter 1. Two of these proposals – those submitted by CARE Pty Ltd and the Rainforest CRC/UQ/JCU research group – involved further development of existing financial models. The proposal from CARE Pty Ltd was to develop the AGROFARM spreadsheet models into a stand-alone decision-support system with tree growth modelling capacity. The proposal from the Rainforest CRC was to extend and refine the Australian Cabinet Timbers Financial Model (ACTFM) beyond its previous focus on rainforest species in north Queensland and include other farm enterprises. The two groups jointly developed the AFFFM as part of the current project. The design and structure of the AFFFM was based on the ACTFM and incorporates the simplified form of the whole-farm financial modelling used in AGROFARM.

A number of choices were faced when developing the AFFFM. The first decision to be made was the framework or programming language that was to be used in the construction of the model. The predecessors to the AFFFM (the ACTFM and AGROFARM) were both developed in Excel, and people wishing to use these models needed access to this spreadsheet package. The ACTFM made extensive use of Visual Basic macros, button bars and forms to aid users in moving about within the spreadsheet and to automate a number of functions. The ACTFM was originally developed with Excel for Windows 3.11. Major problems were experienced when the ACTFM was subsequently converted into newer versions of Excel. Some functionality was lost and the package became unstable when it was transferred to computers using newer operating systems. As increased functionality was added to the ACTFM, there was a marked increase in the time required by the model to recalculate financial variables. In effect, the ACTFM exceeded the capacity of Excel to undertake the required calculations. The choice was made to program the new model, the AFFFM, in Visual Basic. This overcame the problems of transportability between versions of Excel and the problems of exceeding the capacity of Excel.

As discussed in Chapter 3, it is crucial to identify the target audience when developing a model such as the AFFFM. The AFFFM is pitched primarily at farm forestry advisers, researchers and computer literate farmers, with the explicit purpose of improving their ability to estimate the returns from farm forestry investments. The AFFFM is differentiated from other similar tools through the inclusion of growth projections for a number of species in the New England, south-east Queensland and north

Queensland. The inclusion of these data was considered critical to making the model useful to the target audience, many of whom do not have ready access to reliable growth data.

Other models have recognised the link between physical variables in a farming system and forestry (e.g. the effect of trees on land degradation or stock shelter), but have ignored important financial links, such as the impacts on cashflow, debt and equity which result from forestry investment. Discussions with farmers in the New England region have revealed they are comfortable with the physical impacts of trees on their farm business and have embraced environmental plantings, but uncertainty about financial impacts is a disincentive to commercial tree investment. In particular, the large up-front establishment costs associated with do-it-yourself forestry can have important debt and cashflow implications.

Recent changes have been made to Australian taxation legislation in respect to the deductibility of expenses incurred in undertaking farm forestry operations. An important component of being eligible to claim these deductions is for farm foresters to be able to demonstrate that they are carrying on a business with the reasonable expectation of profit. As such, one further application of the AFFFM is as a tool to demonstrate the likely profitability of farm forestry for taxation purposes.

The AFFFM also has considerable scope as an educational and extension tool in workshops held to encourage farm forestry. In particular, it can be used to illustrate the financial performance and cashflow patterns of alternative forestry options for landholders with an interest in farm forestry. It could be used as a useful adjunct to the type of technical information usually delivered in farm forestry courses. The developers' experience has been that such courses generally have limited economic content and the ability to experiment with the financial outcomes of alternative plantation and native forestry scenarios would add value to these courses. Interest in using the model in workshops has already been expressed by Greening Australia staff in south-east Queensland.

9.2 Scope of the AFFM

The AFFFM is a 'whole-farm' model. This means that the model captures the essential physical and financial elements of the whole-farm system. The AFFFM has been constructed using a modular approach. Separate modules have been developed for each of the main activities involved with a farm forestry operation (i.e. plantations, native forests, agriculture and farm finances). Modules have also been developed for presentation of outputs of the financial analysis.

Being a whole-farm model, the AFFFM can be used to investigate the financial effects of adding a forestry enterprise to an existing farm business. This is regarded as being a considerable improvement on models that only consider the forestry investment in isolation. The AFFFM can also be used to predict financial performance of plantations, native forests and even agricultural activities in isolation.

Early prototypes of the model included considerably more detail on the overall farm structure than the final version. Potential users who examined early versions commented that there was too much detail for their purposes and too much data entry was required. Therefore, this information was simplified. In particular, an 'Advanced Livestock' data screen was removed and the livestock herd and flock dynamics were simplified. Similarly, the model output options and sensitivity analysis screens were simplified.

The AFFFM includes both plantation forestry and native forestry options as well as the ability to model planting of trees in either a woodlot or a shelter-belt configuration. The inclusion of native forestry is important in the geographic regions of interest because native forestry is a key land-use option for both regions. Tree planting purely for conservation has not been explicitly included in the model, though this can be simulated within the current structure by modifying the appropriate input data.

The ability to estimate timber yields in alternative locations was viewed as an important step forward in farm forestry financial modeling because most models developed to date – except the Agroforestry Estate Model (AEM) of Middlemiss and Knowles (1996) – rely on the user having mean annual increment (MAI) estimates and yield tables at their disposal. The AEM has separate yield table generation software (STANDPAK) available.

The possibility of adding tree growth estimation code to AFFFM was examined, but found to be beyond the scope of this project. As an alternative, experts in two regions provided lists of the most suitable plantation species and, based on soils and climate data for key locations, tree growth suitability ratings were generated using the PlantGro model (Hackett 1988, 1991a, b). These suitability ratings were then matched to timber yield tables and incorporated into the model as look-up tables. Users can therefore select a combination of New England or south-east Queensland species, a soil type and a location, and the model will return a suitability rating. Users can then load the appropriate yield table for that suitability rating. Alternatively, users can enter their own tree growth and yield estimates. The capacity for the user to enter their own estimates will be important where the model is used outside the two focus regions because PlantGro data are available only for climate stations within those two regions. Estimates of growth rates of 31 species from north Queensland obtained previously from a Delphi survey of experts (Herbohn et al. 1999) were also included in the AFFFM.

It was also anticipated that tree growth algorithms for native forests could be utilised in the model, but this was not possible. State Forests of New South Wales declined to provide their FRAMES model to the project and there were no suitable Queensland models available. Therefore, simple MAI estimates are used in AFFFM to generate native forest yields. Where a landholder has sections of native forest with differing growth potentials, this is catered for in AFFFM through the capacity to specify up to five separate native forest areas for the farm business.

9.3 Input Parameters, Assumptions and Key Variables

The AFFFM is a financial model. The analysis undertaken is restricted to a purely financial analysis of the private cashflows relevant when landholders are considering farm forestry activities. Key outputs include NPV, IRR, business cash position (equals bank balance), annual cash flows, an equivalent annual return value, and land expectation value (LEV). The model will display financial performance indicators for the ‘with’ and ‘without’ forestry situations so that users can quickly ascertain if adding a forestry enterprise improves financial performance over the current farm business structure.

Discussions with potential users and previous experience with farmers interested in forestry has revealed many farmers are more comfortable with information showing simple costs and returns and the timeframe in which they occurred (as opposed to the standard forestry financial measures NPV, IRR, LEV, annuity equivalents). For this reason, the model generates a series of cashflow estimates in a text file. Some of these also appear graphically. The figures in the text file include an overall business cash position (essentially, this tracks all costs and revenues and therefore tracks the businesses bank balance), as well as cash flows (equivalent to enterprise gross margins) for the various enterprises (agriculture, plantations, native forestry). Providing these data in a text file allows users to bring the data into a spreadsheet for further manipulation and comparison. The provision of some simple graphical functions allows the user to investigate rapidly the effect of the ‘with’ and ‘without’ forestry scenarios on business cash position (i.e. a cumulative measure of performance) and the annual cash flows (i.e. a non-cumulative measure of performance at each year of the forestry planning horizon).

Other costs and revenues provided include finance costs, capital expenditure, overhead expenses and other farm and off-farm income. The capability also exists to include an allowance for ‘living

expenses', which essentially represents the landholder's withdrawal of funds from the farm business for family and personal reasons. It is important to include this otherwise business cash position will be inflated and unrealistic.

A basic assumption used in the AFFFM is that all prices (e.g. establishment and continuing maintenance costs, timber and other revenues) change at the same rate as that of inflation. This has two important implications. First, it means that a 'real' discount rate is used when discounting cash flows. (Choosing an appropriate discount rate and converting nominal discount rates to real discount rates is discussed in Chapter 3). Second, assuming prices change at the same rate as inflation, and that a real discount rate is used, means that present day costs and returns do not need to be adjusted for the effects of inflation if they are used in future periods.

The effects of taxation have not been included in the model. This is a limitation of the model but was done because of the complexity and changeable nature of the taxation environment. It is planned to develop a simple tax module in a future version of the model.

The input parameters required for each of the farm forestry activity modules in the AFFFM are listed in Table 9.1. Considerable flexibility has been built into the forestry modules which allows users to enter data in a number of alternative forms.

Table 9.1 Parameters of the Australian farm forestry financial model

Farm activity	Basic parameters	Advanced parameters
Plantations	Species used (names) Plantation size(s) (ha) Plantation density (sph) Percent of hectare per species Mean annual increment(s) (m^3/ha/yr) Harvest age(s) (years) Stumpage price(s) ($) Establishment costs ($) Maintenance costs ($) Harvest costs ($) Annual costs ($)	Harvest cycles (three harvest ages per species) Plantation product mix per harvest cycle (as % of standing volume) and product prices Series of plantations Time between plantation establishments Number of plantations to be established Plantation design (woodlots/shelterbelts)
Native forestry	Forest area(s) (ha) Mean annual increment (m^3/ha/yr) Maintenance costs ($) Stumpage price(s) ($)	Non-commercial thinning costs and timing Timber products and recovery rates
Agriculture (livestock)	Carrying capacity (DSE/ha) Stock numbers (No. of head) DSE ratings (DSE/head) Gross margins ($/DSE)	Improvement in DSE with shelter (%)
Agriculture (crops)	Crop type(s) (names) Crop area(s) (ha) Gross margin(s) ($/ha)	
Farm finances	Overhead costs ($) Capital costs ($) Off-farm income ($) Other farm income ($)	Loan(s) ($) Interest rates – loans, savings, overdrafts

An underlying assumption of the AFFFM is that the costs and returns to the various enterprises remain static. Exceptions to this assumption can occur in the case of the interactions between grazing and plantation establishment. The model assumes by default that where both agricultural enterprises and plantations are assessed in a scenario, the plantations are established on grazing land (except if the user chooses the option to establish plantations on otherwise 'unused' land). Where establishment of plantations on grazing land reduces the farms' total stock carrying capacity below the level required to maintain the stock levels specified by the user, the model calculates the yearly stock carrying capacity and automatically adjusts stock numbers (and thus the total livestock gross margins) to levels within

the farms carrying capacity. Stock levels may also be increased automatically if the user specifies that shelter from plantations will lead to a greater carrying capacity for the farm despite loss of land for grazing through the establishment of plantations.

9.4 Default Data Used in the Model

The AFFFM contains default data for costs of plantation establishment which can be loaded by users. The data available are based on information for the New England region and the Community Rainforest Reafforestation Program (CRRP) in north Queensland. The New England data are based on information supplied by a local contractor (Farm Forestry Plantations) while the CRRP data are based on experiences of staff involved with establishing 2000 ha of tropical cabinet timbers as part of the Community Rainforest Reforestation Scheme, combined with data from Clarke (1996) and Moore (1992). The default costs for each of these regions are set out in Tables 9.2 and 9.3.

Table 9.2 Default data for New England hardwood plantations

Non-recurrent cost	Year of operation	Amount ($/ha)
Road and firebreaks	0	100
Clearing residual vegetation	0	105
Burning	0	10
Fencing	0	20
Pre-cultivation weed control	0	70
Soil preparation	0	195
Weed control pre-plant	0	70
Planting stock	0	350
Planting	0	160
Initial fertiliser	0	110
Refilling	0	150
Weed control post-plant	1	70
Young age fertiliser application	3	110
Over spray	0	190
Slashing	0	20
Pre thin 1 inventory	10	20
Pre thin 1 marking	10	20
Pre thin 2 inventory	20	20
Pre thin 2 marking	20	20
Pre clear fall inventory	30	20
Pre clear fall marking	30	20
Total (yrs 0 - 30)		1850

Recurrent cost	Year of operation	Amount ($/ha)
Protection (fire, pests etc)	0 - 30	15
Administration	0 - 30	5
Insurance	0 - 30	10
Total		30

Table 9.3 Default data for CRRP hardwood plantations

Non recurrent cost	Year of cost	Amount ($/ha)
Planning and design	0	75
Incidental clearing	0	160
Site preperation and cultivation	0	265
Cover crop establishment	0	90
Pre-plant weed control	0	90
Cost of plants	0	450
Planting and refilling	0	645
Post plant weed control	0	540
Fertilizer	0	85
Fencing	0	560
Post plant weed control	1	1310
Post plant weed control	2	810
Post plant weed control	3	215
First prune (plus certification)	4	880
Second prune (plus certification)	8	650
Third prune (plus certification)	12	865
Thinning	8	500
Harvest marking and inventory	a	55
Total		8245

Recurrent costs	Year of cost	Amount ($/ha)
Protection and management	0 - 30	40

[a.] Timing of harvest cost varies with species.

These costs should be treated as being indicative only and are not directly comparable. The weed control costs for north Queensland (i.e. the CRRP costs) are much higher than for New England, reflecting the greater weed problems in the tropics. The CRRP pruning costs also include a component for pruning certification which is not included in the New England costs. The AFFFM also contains default growth data for species in northern NSW, south-east Queensland and north Queensland (discussed in Chapter 10).

9.5 Structure of the AFFFM

The AFFFM comprises modules for each of the main activities involved with a farm forestry operation (i.e. plantations, native forests, agriculture and farm finances). Modules have also been developed presentation of outputs of the financial analysis. A series of ‘forms’ (screens) are linked by the use of button bars. Screenshots of the main screens within the AFFFM are provided in Figure 9.1 and are labelled with an uppercase letter. The AFFFM is activated by clicking on the ‘Start’ button on the ‘Australian Farm Forestry Financial Model’ brought up when the program is started (A). Clicking on the ‘Start’ button brings up the ‘Farm Structure’ screen (B). From this screen, the main modules of the program are accessed. These modules are ‘Agriculture’ (C), ‘Native forests’ (D), ‘Plantations’ (E), ‘Farm finances’ (F) and ‘Activity options’ (G). From these screens, the main parameters of the model are set, by entering the figures directly, accessing other screens through button bars or loading default data or saved scenarios from drop-down menus. The additional screens which may be accessed from the ‘Agriculture’, ‘Native Forests’, ‘Plantations’ and ‘Activity Options’ are summarised in Table 9.4.

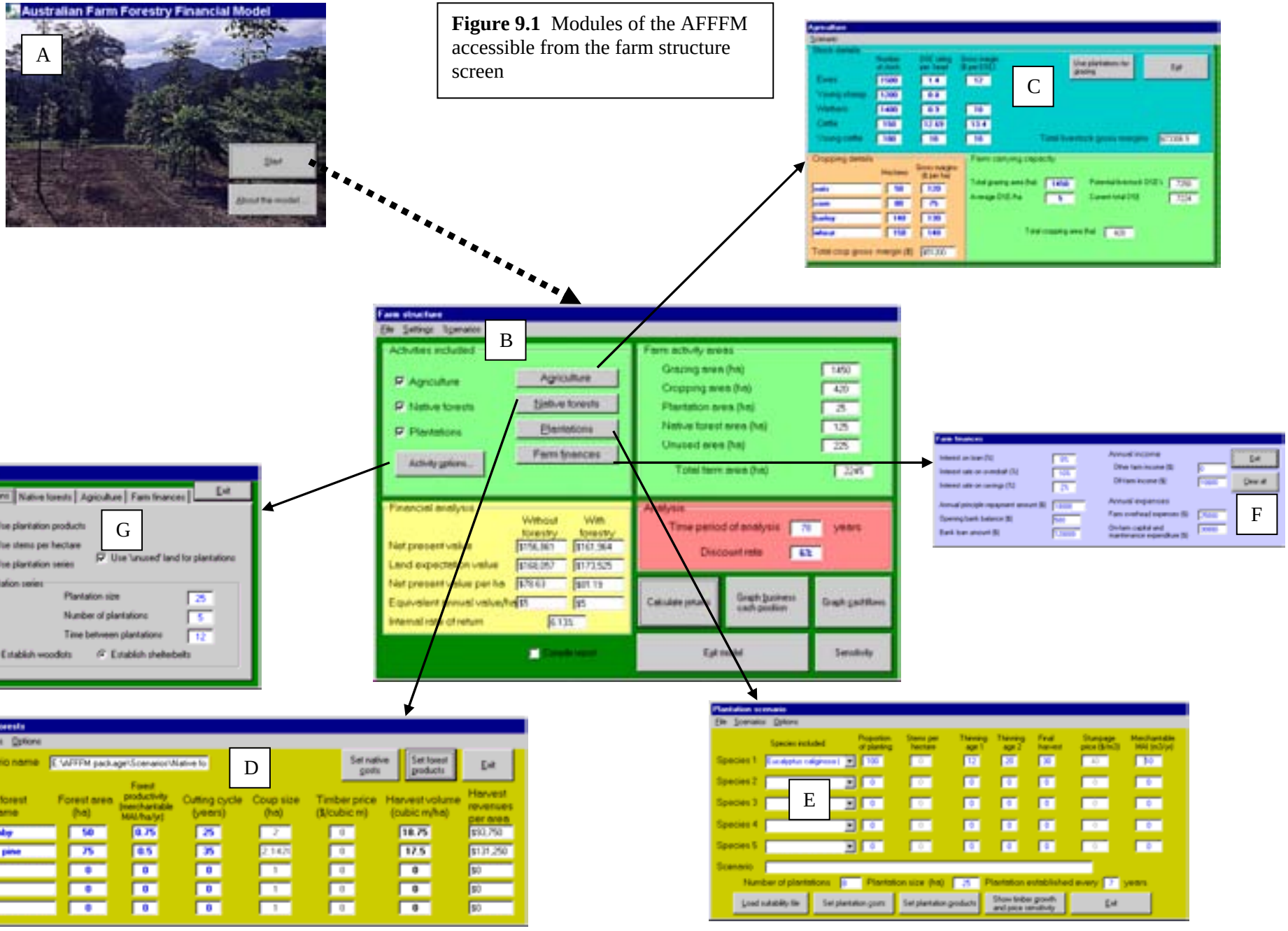


Figure 9.1 Modules of the AFFFM accessible from the farm structure screen

The ‘Farm structure’ screen also has a button bar that provides users with the ability to graph business cash position and cashflows (H). Basic information is also provided on this screen on the results of the financial analysis ‘with’ and ‘without’ forestry and a summary of farm activity area. Potential users of the model are referred to the ‘AFFFM Users Manual’ by Emtage *et al*. (2002) which is available for downloading from the RIRDC website.

Table 9.4 Additional features of the AFFFM that are accessible via button bars in the ‘Agriculture’, ‘Plantations’, ‘Native Forests’ and ‘Farm structure’ screens

Module screen	Additional screens accessible from module screen	Description of function
Native forests	Native costs by area	Screen to allow users to specify the costs associated with native forestry enterprises.
	Native forest products	Screen to allow users to specify the timber product mixtures, their prices and the ‘recovery rate’ associated with native forestry enterprises.
Plantations	Suitability ratings	Screen allows users to specify the relevant climate and soil for the scenario being considered then run through the species list for the area to assess the suitability rating for each combination. Users can then choose to load the relevant data into the plantation module.
	Plantation costs	Screen to allow users to specify the costs associated with plantation enterprises.
	Plantation products	Screen to allow users to specify the timber product mixtures and their prices for up to three harvests for plantation enterprises.
	Sensitivity of NPV to timber growth and price	Allows users to set a percentage rate to increase and decrease timber growth rates and prices to assess the effects on the NPV of a scenario.
Agriculture	Understorey grazing	Allows users to specify the percent of normal grazing carrying capacity available from grazing under plantations for the first 29 years of a plantation
Farm structure	Options	Allows users to alter the various options for the different activities included in a scenario.

9.6 Concluding Comments

The development of the AFFFM has been a challenging task and the product that has resulted represents considerable effort by many people. It has been a complex task to develop the conceptual framework for the model and then translate this into a useable product. Much thought has gone into the tradeoffs between functionality and ease of use. Throughout the development, input has been sought from potential users to guide model development. The developers seek additional feedback and would welcome comments from anyone who uses the model.

9.7 References

Clarke, F.B. (1996), 'Pruned stand certification in Australia', *Farm Forestry and Plantations*, 1996 Australian Forest Growers Conference, Mt Gambier, pp. 232- 236.

Emtage, N., Harrison, S., Herbohn, J. and Thompson, D. (2002), *The Australian Farm Forestry Financial Model – Users Guide*, Rural Industries Research and Development Corporation, Canberra.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1999), Potential performance of rainforest and eucalypt cabinet timber species in plantations in North Queensland, *Australian Forestry*, 62(1): 79-87.

Middlemiss, P. and Knowles, L. (1996), *AEM Agroforestry Estate Model, User Guide for v .4.0.*, New Zealand Forest Research Institute, Rotorua.

Moore, P. (1992), *Rainforest Timbers and Cabinetwoods: Marketing Considerations*, paper presented to Mt. Mee forestry field day, Brisbane: Queensland Forest Service.

10. Growth Modelling Components of the AFFFM

J. Davidson and J. Herbohn

When developing the AFFFM, a conscious decision was made at an early stage to populate the model with as much data as possible. By doing so it was felt that the model would be more useful to a wider range of users. A module was developed which contains information about potential growth rates, harvest ages and log prices for a number of suitable timber species for the Atherton Tableland, the Darling Downs and the New England Tableland regions of eastern Australia. Data on the potential growth rate, harvest age and product mixtures for tree species suitable for plantations on the New England Tablelands and Darling Downs were generated using the Plantgro program. Users of the model from these areas can choose to load the appropriate values for the various species by specifying the location and soil type of the planned plantation. Data on the potential growth rate, harvest age and timber price for 31 species of cabinet timbers in Far North Queensland were also included. These data were obtained from a previous survey of forestry experts undertaken by Herbohn *et al*. (1999). This chapter outlines the process through which growth data used in the AFFFM were collected.

10.1 Plantgro Estimate for South-east Queensland and New England tablelands

The Plantgro program (Hackett 1991a) was selected for predicting tree performance under a variety of conditions. Plantgro was originally developed at CSIRO Division of Water and Land Resources (Hackett 1988, 1991b) and later marketed commercially under licence by Iris Media Software Division, Brisbane (MSDOS Version 2.0, Iris Media 1994) and over 500 copies of the software were sold worldwide. The appeal of Plantgro to its users is its predictive power, ease of use and especially its relevance to a wide range of problems to which it provides practical solutions (e.g. see Davidson 1996, Hidayat 1996). Its strength lies in the core program that can be applied without modification in any country or locality. The soil, climate and plant files are the components that vary and can be supplied from an existing library of files, or compiled to suit the task at hand. For this project, a beta copy of Plantgro Version 3.0 for Windows supplied by Clive Hackett was used.

Plantgro uses information on 12 important soil factors, including pH, nitrogen and phosphorus levels, and 11 climate factors including monthly maximum and minimum temperature, precipitation evaporation and solar radiation. The core program includes a simple water-balance modelling subroutine, as well as light and temperature modelling subroutines. A valuable attribute is the 'fuzziness' in the relationships which are used to determine Limitation Ratings (LR) on a 0 to 9 scale, where 0 limitation indicates ideal growing conditions, 8 indicates highly unsuitable conditions, and 9 means the plant will probably die rapidly (Suitability Rating or SR is the opposite of LR, for example LR0 SR9, LR9SR0, meaning at SR9 the plant will be growing optimally, while at SR0 it will probably die rapidly). Individual factors are combined into an overall rating (the Greatest Limitation Rating, GLR) using Liebig's Law of the Minimum, where the most limiting factor determines the level of plant (tree) performance (Davidson 1996). For this project, since trees as long-lived perennial plants were under consideration, GLRs were obtained on a monthly basis across a calendar year, and averaged for the 12 months to obtain an Annual Greatest Limitation Rating (AGLR), except in the case where at least one month delivered a GLR of 8 or 9, for which the AGLR was automatically set at 8 or 9 respectively. Examples of Plantgro tree, climate and soil files can be found in Booth (1996, pp. 86-91).

Development of tree files

The first step was to choose the tree species to be included in the system. Initially, a somewhat dated survey by CARE was available of people in the timber industry who were asked to rank species that they preferred for processing or planting on the Northern Tablelands. It was difficult to judge how much weight should be given to these survey results. New England Blackbutt and the several Stringybark species seemed reasonable candidates. Brush Box and Tallowwood were suggested but these are not Tableland species. *Pinus radiata* (an exotic) should have scored higher given that it is likely to be the only possibility west of the New England Highway east of the Cypress Pine country. Cypress Pine itself is unlikely to be a candidate for planting, though natural stands on private lands are in need of better management for timber production.

State Forests of New South Wales (SFNSW) records of species and provenance trials of eucalypts over a wide geographic range and elevations from 15 m to 1100 m above sea level were examined. About 64 species are represented in these trials. Data are readily available for those trials established from 1961-1991 (Johnson and Stanton 1993). Unfortunately, there were only two trial sites at altitude of relevance to the present project. In December 1972, a 'High Altitude Eucalypt Trial' (G18005) was established in Mt. Boss State Forest in stands of eight different species planted in 1969. In 1990, at age 21 years, *Eucalyptus delegatensis* and *E. regnans* had failed completely, while *E. laevopinea* and *E. fastigata* had a low survival rate, both 39%. *E. campanulata* and *E. saligna* had higher survival rates, or 86% and 76% respectively, but somewhat slower diameter growth than *E. obliqua* (61% survival). 'Mila Routine Site Tablelands Species Trial' (SEL1301 (R32281), Bondi State Forest, is one of seven small replicated trials near Bombala. The Mila trial is on 'routine' ex-pasture, with granite parent rock. *E. nitens*, *E. viminalis* and *E. globulus* ssp *globulus* were the best after one year.

Most other SFNSW data come from only two eucalypt species, *E. pilularis* and *E. grandis*, neither of which are candidates for the Tablelands and Downs localities in this project, but these data do provide some insights into growth performance of eucalypts generally with respect to different site qualities. There is no information on planted *Callitris glaucophylla* since this species is not generally planted, having rather prolific natural regeneration which requires careful management.

Given the generally poor nutrient status of unfertilised Australian soils, it is desirable that some nitrogen fixing species be included in the list, either to be used alone or planted in mixtures with the eucalypts. Chief amongst these are the acacias.

Information from Kristen Williams of the Queensland Department of Natural Resources and Mines (NRM) reveals that there are some species from South East Queensland, which are common with species of the Northern Tablelands, NSW. These include *Corymbia maculata*, *E. microcorys*, *Lophostemon confertus*, *E. crebra*, *E. sideroxylon* and *E. saligna*. The additional species to be included for South East Queensland and estimates of their potential growth rates were decided upon in December 2000 by an expert panel of Kristen Williams, Paul Ryan and John Davidson, taking into account additional opinions from Queensland foresters and others with some knowledge of species performance.

E. saligna was chosen as the pilot species for development the biological part of the project. *E. grandis* (Coffs Harbour high altitude provenance) was included as a check species since a tested plant file was already available, although it would be unsuitable at most localities on the Northern Tablelands and those included in the current study from South East Queensland.

The species which have been included are:

Acacia mearnsii (Black Wattle)	*E. laevopinea* (Silvertop Stringybark)
Acacia melanoxylon (Blackwood)	*E. macroryncha* (Red Stringy Bark)
Corymbia maculata (Spotted Gum)	*E. nitens* (Shining Gum, Silvertop)
Corymbia variegata (Spotted Gum) (Qld)	*E. saligna* (Sydney Blue Gum)
Eucalyptus andrewsii (New England Blackbutt)	*E. viminalis* (Ribbon Gum)
E. argophloia (White Gum) (Qld)	*E. youmanii* (Youman's Stringy Bark)
E. caliginosa (White Stringybark)	*Pinus radiata* (Radiata Pine)
E. grandis (Flooded Gum) (Coffs Hbr high)	

Methods of creating Plantgro tree files and assigning yield information to Plantgro LRs were described in detail by Davidson (1996), including ways of using existing published information such as that provided in Webb *et al.* (1984), Brown *et al.* (1989), Booth and Pryor (1991) and Eldridge *et al.* (1994).

Climate files developed for the modelling

Climate files corresponding to the following locations have been compiled in the system. No advantage was found in having a finer grid of locations for the target areas at this stage.

Armidale	Barraba	Baradine	Bingara
Bundarra	Collarenebri	Dalby	Deepwater
Glenn Innes	Goondiwindi	Gunnedah	Guyra
Inverell	Ipswich	Killarney	Moree
Mungindi	Narrabri	Quirindi	Stanthorpe
Tamworth	Tenterfield	Texas	Toowoomba
Walcha	Wallangarra	Warialda	Warwick

Soil files developed for the modelling

Forty-eight soil files have been prepared and included. Thirty-one have general soil names based on soil texture. The other 17 have the names corresponding to soil orders and suborders of the Australian Soil Classification (as in Isbell 1996). The latter have average properties of such orders and suborders where found on the Northern Tablelands of NSW and in South East Queensland (Table 10.1). These soil files were originally drafted by Warwick McDonald, a visiting American soil scientists, in the CSIRO Division of Water and Land Resources, Canberra, in the mid-1990s. Median data were compiled from the CSIRO soil profile database. For this project the soil files were modified to reflect soils in the target areas that had been fertilised with nitrogen, phosphorus and potassium and cultivated to the extent allowed by the quantities and costing of these activities in the financial model. That is, the limitations caused by generally low values of these nutrients, and heavy texture, in most of these natural soils was reduced artificially by cultivation and application of fertiliser. All Available Water Capacities and Drainable Water Capacities were estimated. Infiltration depths are approximate, because they are difficult to validate with existing data.

10.2 Identifying the Soil Type at a Forestry Site

To use Plantgro, it is necessary to be able to identify the soil type at a chosen planting site. This section provides a practical guide on how to classify the soil type. Basically, three steps are involved:

1. From the menu of locations, choose the location nearest the proposed tree planting location. This will load the corresponding climate file.

2. Examine the soil on an exposed face such as in a road cutting, quarry, trench or pit, or in a hole dug with an auger. Such an exposure is called a *profile*. A soil profile is normally examined to a depth of 1-2 m or down to bedrock if shallow. There are two ways to enter the soil menu, namely, by determining the dominant soil texture in the profile as described below, or by seeking professional help to classify the soil into its Australian Soil Classification Order and Sub-order and choosing this from the menu.

Table 10.1 Soils and their coding in Plantgro soil files

Soil Name	Depth (cm)	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Clay-heavy	200	Very sticky, gleying common	4	70	35	200	7.2	0	0	50	150	0	2	2	0	12	12	8	8	0
Clay-heavy	65	Very sticky, gleying common	4	70	35	65	7.2	0	0	10	55	0	2	2	0	12	12	8	8	0
Clay-light	200	Black/brown, sticky when wet, some gley	5	70	35	200	7.2	0	7	50	150	0	4	4	0	17	17	13	13	0
Clay-light	50	Black/brown, sticky when wet, some gley	5	70	35	50	7.2	0	7	20	30	0	4	4	0	17	17	13	13	0
Clay-medium	10	Black/brown, some gleying, sticky	5	40	20	10	6.5	0	0	7	3	0	3	3	0	15	15	13	13	0
Clay-medium	200	Black/brown, some gleying, sticky	5	40	20	200	6.5	0	7	50	150	50	3	3	7	15	15	13	13	40
Clay-medium	60	Black/brown, some gleying, sticky	5	40	20	60	6.5	0	7	20	40	50	3	3	7	15	15	13	13	40
Clay-swelling	200	Black, cracks when dry	3	70	35	200	7.2	0	0	50	150	0	1	1	0	12	12	8	8	0
Clay-swelling	75	Black, no structure, cracks when dry	3	70	35	75	7.2	0	0	30	45	0	1	1	0	12	12	8	8	0
Gravelly/stoney	100	Red/orange, gritty	6	10	8	100	5.5	0	7	46	60	50	6	6	7	4	4	40	40	40
Gravelly/stoney	50	Red, gravel and stones visible	6	10	8	50	5.5	0	7	0	50	30	0	6	7	0	4	0	40	0
Loam	200	Brown/grey, gritty	6	40	20	200	5.5	0	15	50	150	75	4	4	6	16	16	16	16	40
Loam	50	Brown/grey, gritty	6	40	20	50	5.5	0	15	20	30	75	4	4	6	16	16	16	16	40
Loam+clay (Clay loam)	100	Dark grey, some red/brown	5	40	20	100	5.5	0	0	20	80	0	4	4	0	17	17	13	13	0
Loam+clay (Clay loam)	200	Dark brown, some gleying	5	40	20	200	6.5	0	0	50	150	0	4	4	0	17	17	13	13	0

Soil Name	Depth (cm)	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Loam+sand (Sandy loam)	200	Loam with a high proportion of sand	6	40	20	200	6.0	0	7	50	150	75	4	4	6	13	13	18	18	40
Loam+sand (Sandy loam)	75	Dark brown loam with a high proportion of sand	6	60	30	75	6.0	0	7	20	55	75	4	4	6	13	13	18	18	40
Peat (Organic)	100	Undecomposed organic matter in profile	6	5	3	100	3.5	0	0	50	50	0	8	2	0	12	5	8	1	0
Peat (Organic)	60	Dark brown, undecomposed roots	6	5	3	60	4.5	0	0	30	30	0	8	2	0	12	5	8	2	0
Rocky	35	Young soil, large particle size	6	5	3	35	5.5	0	7	10	25	50	7	7	7	2	2	40	40	0
Rocky	75	Young soil, large particle size	6	5	3	75	4.5	0	7	30	45	50	7	7	7	2	2	40	40	40
Sand+clay (Clayey sand)	200	Clay gives some structure	6	10	8	200	5.5	0	7	50	150	50	4	4	7	13	13	16	16	40
Sand+clay (Clayey sand)	75	Clay gives some structure	6	30	20	75	5.5	0	7	20	55	50	4	4	7	13	13	16	16	40
Sand+loam (Loamy sand)	100	Predominantly sand with some silt	6	60	30	100	5.5	0	7	30	70	50	4	4	7	9	9	22	22	40
Sand+loam (Loamy sand)	75	Predominantly sand with some silt	6	40	20	75	6.5	0	7	20	55	75	4	4	7	9	9	22	22	40
Sand – compacted	200	No plasticity, feels dry and gritty	6	1	1	200	5.5	2	7	50	150	100	5	5	7	7	7	25	25	40
Sand – compacted	50	Structureless, feels dry and gritty	6	1	1	50	6.5	2	7	30	20	100	5	5	7	7	7	25	25	40
Sand – loose	200	Low organic matter, little structure	6	1	1	200	5.5	0	7	50	150	75	5	5	4	4	4	35	35	22
Sand – loose	50	Low organic matter, little structure	6	1	1	50	7.2	0	7	20	30	75	5	5	4	4	4	35	35	22
Silt	100	Alluvial, often found on stream banks	3	10	8	100	5.5	0	7	20	80	0	3	3	0	15	15	14	14	0
Silt	200	Alluvial, often found on stream banks	3	10	8	200	5.5	0	7	50	150	0	3	3	0	15	15	14	14	0
AACH	100	Red Chromosols (Red Earths)	5.5	16.9	3.2	100	6.3	0	1	17	76	30	4	3	5	3	11	5	15	7
AADE	116	Red Dermosols (Red Podzolics)	5.5	9.7	2.2	116	5.9	0	5	18	95	32	3	3	4	3	12	4	15	8
AAFE	150	Red Ferrosols (Kraznozems)	4.5	11.4	2.7	150	5.8	0	2	15	13	20	3	3	3	3	15	13	16	4
AAKA	160	Red Kandosols (Red Earths)	5.5	12.7	1.2	160	6.2	0	1	14	134	55	4	4	5	2	18	4	31	15
ABCH	100	Brown Chromosols (Non-calcic Brown Soils)	4.5	15.5	2.3	100	6.1	0	1	18	63	20	5	2	5	2	8	6	12	6

Soil Name	Depth (cm)	Description	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
ABDE	115	Brown Dermosols (Prairie Soils)	5.5	8.8	1.3	115	5.6	0	5	20	89	30	3	3	5	3	11	3	12	6
ABFE	107	Brown Ferrosols (Chocolate Soils)	5.5	29.5	2.9	107	5.7	0	3	10	97	155	3	3	3	3	10	2	11	5
ABKA	110	Brown Kandosols (Brown Earths)	5.5	10.6	1.3	110	5.9	0	2	20	84	53	4	4	5	3	11	6	16	8
ABSO	99	Brown Sodosols (Solodised Solonetz)	4.5	25.3	3	99	6.2	0	0	15	75	30	5	2	5	2	9	5	12	6
ABVE	121	Brown Vertosols (Brown Clays)	4.5	8.4	5.3	121	8.0	0	0	10	110	30	2	2	4	1	16	1	17	6
ACCH	122	Yellow Chromosols (Yellow Podzolics)	5	12.2	1.8	122	6.3	0	0	18	75	38	5	2	5	2	8	6	12	8
ACSO	122	Yellow Sodosols (Yellow Podzolics)	5	14.3	1.5	122	6.4	0	0	11	99	31	5	2	5	1	10	4	15	9
ADSO	121	Grey Sodosols (Solodised Solonetz)	5	14.6	2.1	121	6.3	0	0	16	96	30	5	2	5	2	12	5	15	7
ADVE	175	Grey Vertosols (Grey Clays)	4.5	16.7	6.3	175	7.8	0	0	10	158	43	2	2	4	1	18	1	19	7
AEVE	137	Black Vertosols (Black Earths)	4	17	7.4	137	7.1	0	1	10	127	26	2	2	5	1	15	1	15	7
DTHY	110	Oxyaquic Hydrosols (Non-gleyed Organic Soils)	4	4.8	3.7	110	5.5	0	0	10	90	65	4	4	5	2	10	3	20	20
EDHY	140	Redoxic Hydrosols (Mottled, Gleyed Organic Soils)	3	6.8	1.6	140	5.5	0	0	20	112	45	4	3	5	3	12	5	16	8

Column Headings: 1: Aeration (Class, 1-6 nil to good); 2: Base saturation (% of Cation Exchange Capacity); 3: Cation Exchange Capacity (meq./100gm soil); 4: Depth overall (cm); 5: pH; 6: Salinity (dS/m); 7: Slope (degrees); 8: Depth A Layer (cm); 9: Depth B Layer (cm); 10: Depth I (Infiltration) Layer (cm); 11: Texture A Layer (Class, 1-8); 12: Texture B Layer (Class, 1-8); 13: Texture I Layer (Class, 1-8); 14: Available Water Capacity A Layer (%) (Plant available water – cm/m); 15: Available Water Capacity B Layer (%) (Plant available water – cm/m); 16: Drainable Water Capacity A Layer (%) (cm/m); 17: Drainable Water Capacity B Layer (%) (cm/m); 18: Drainable Water Capacity I Layer (%) (cm/m).

Soil texture can be determined in the field by the farmer, by following a number of simple steps. First break off a piece of soil, crush it and work it with a little water in the hand until all the lumps are broken and the mixture is moist without being sticky. Soil texture is placed into one of several classes, namely sand, loam, clay and intermediate classes. The classification of texture is made from the feel of moist soil between the fingers and thumb and the palm of the hand.

The following is a guide as to how to classify soil texture:

Sand	does not cohere (hang together), and is coarse to the touch
Loamy sand	cohesion just perceptible; a cast can just bear handling without breaking up
Sandy loam	coheres, yet is easily friable; individual sand grains can be felt
Loam	both friable and coherent; sand grains cannot be felt in a moist sample
Sandy clay loam	like a clay loam, but sand grains can be felt
Clay loam	somewhat friable, but also somewhat plastic, rolls out into a ribbon between the palms of the hands while a loam breaks up
Sandy clay	like a clay, but sand grains can be felt
Clay	tough and plastic, rolls out into a ribbon between the palms of the hands, the ribbon can be bent into a circle without breaking up.

These classes approximately correspond to farmers' normal usage. 'Loam', however does not imply rich in humus in the sense gardeners use the word. The terms 'light' and 'heavy' represent the sandy and clayey ends of the series respectively; they have nothing to do with specific gravity or weight of the soil (clay actually weighs less than an equivalent volume of sand), but do refer to the ease or difficulty of digging or cultivating sandy or clayey soils. The above list refers to texture after any gravel or stone has been set aside. This may have to be included in the description (e.g. *gravelly loam*). Some soils with a smooth feel when moist are called *silty*, e.g. *silty loam, silty clay loam.* Clay is divided into *light, medium* and *heavy* (or *swelling*).

The importance of soil depth for tree growth is reflected in the ability to choose shallow and deep phases of the same soil from the menu. The simulation could be run with both shallow and deep choices from the menu to determine whether the depth of soil is really a limiting factor in a particular case.

3. Choose the species from the menu. Since the same SR from two or more species can represent more or less timber production, depending on their relative growth rates, the simulation should be run several times in order to determine the best species for wood production at the proposed planting site.

10.3 Estimates of Tree Growth Rates in North Queensland

Extensive experience has been gained in recent years in the growing of rainforest and eucalypt species through the Community Rainforest Reforestation Program (CRRP) that has operated in the Wet Tropics of North Queensland since 1993. A Delphi survey was used by Herbohn *et al*. (1999) to collect estimates from forestry experts of the growth rates of a number of species commonly grown in the CRRP. This was done primarily to provide estimates of growth and harvest age to be incorporated in the Australian Cabinet Timbers Financial Model (ACTFM) and which has now been subsumed into the AFFFM. The following sections outline how the growth estimates for the north Queensland species were obtained and draws heavily from Herbohn *et al*. (1999).

The Delphi survey procedure

The Delphi method was employed to provide estimates of (a) mean annual increment or MAI (m^3/ha/year) and (b) time to harvest (years) of 31 species. Harvest age and MAI are the two key biological variables needed to estimate yield and harvest scheduling parameters for use in financial models. Species have been selected on the basis that they were (a) listed in Russell *et al*. (1993) and planted under the CRRP, or (b) they are among the most common species planted under the CRRP. Species included are predominantly those which occur naturally in North Queensland (mostly rainforest species along with a number of eucalypts common to the area but not occurring in rainforest), as well as a limited number of native species found in sub-tropical Australia and one exotic species.

Opinions were obtained from 13 individuals with extensive experience in growing of Australian tropical and sub-tropical rainforest species for either timber production or restoration. Individuals generally had either extensive field experience or had undertaken research involving native rainforest and tropical eucalypt species. Participants included representatives of the Queensland Department of Primary Industries (Forestry), Queensland Department of Natural Resources and Mines, CSIRO, The University of Queensland, James Cook University of North Queensland, Griffith University and Southern Cross University.

Participants were provided with a table listing the 31 selected species and asked to provide estimates of their 'best guess' of optimal rotation period (years) for each species along with estimates of 'shortest time to harvest' and 'longest time to harvest'. Estimates were also requested for the 'best guess' for expected yield (m^3/ha/year) along with estimates of 'highest yield expected' and 'lowest expected yield', based on the 'best guess' rotation period. In this section, participants were asked to assume that the trees would be planted on relatively fertile basaltic soils near Atherton, that average annual rainfall would be between 1500 - 2000 mm, the initial planting density would be around 660 stems per hectare (sph) and suitable thinning regimes would be applied. Where available, estimates of rotation time and average growth rate from Russell *et al*. (1993) were provided. The questionnaire also contained a section on favoured planting regimes and mixtures of species, the effects of mixed species plantings on yields of individual species, and the likely differences in potential yields between plantation managed by farmers as opposed to professional foresters. A copy of the survey form distributed to participants is available on request.

Survey forms were distributed to participants followed by a visit by one of the research team. Responses for the estimates of growth rates and harvest ages of the 31 selected species were then collated and averages calculated. A summary table including the group averages was prepared and distributed to participants along with their original estimates. Participants were invited to review their original estimates of growth rates and harvest ages in light of the group averages and to provide any appropriate revisions or comments. Few revisions were received in this second survey round, after which the Delphi process was terminated.

Performance estimates obtained in the Delphi survey

Estimates of harvest ages and MAI provided by forestry experts are summarised in Table 10.2. Expected growth rates of most rainforest species are modest compared to those for eucalypts. Eucalypt species accounted for seven of the 10 fastest growth rates of species listed. This is not surprising given the high growth rates recorded for a number of eucalypt species in plantations elsewhere in Australia and overseas (e.g. Goodwin and Candy 1986, Pohjonen and Pukkala 1988, West and Mattay 1993, Moore *et al*. 1996).

The estimates of potential growth rates and harvest ages of eucalypt and rainforest cabinet timber species produced in the current study represent the best available at present. These estimates must however be treated with some degree of caution. While the Delphi method is useful for assembling and quantifying expert opinion, it does have some limitations. The Delphi method was chosen for this study because of a lack of reliable growth data associated with the performance of many of these species under plantation conditions. It is difficult to assess the reliability of estimates of growth and harvest age obtained from application of this method. Of the 31 species included, extensive growth data based on past performance are available only for Hoop Pine (*Araucaria cunninghamii*) and, to a lesser extent, some of the eucalypt species. There is close agreement between the MAI estimates of Hoop Pine provided by experts in this study, estimates provided by Russell *et al*. (1993) and actual volumes reported for mature hoop pine plantations (aged over 50 years) on the Atherton Tablelands reported by Gnan (1992). There is less experience of performance under commercial production for the other species.

The closeness of the estimates for Hoop Pine lends some support to the reliability of estimates for other species. There is however no such external check available to assess the reliability of performance estimates of other species, and caution needs to be exercised in the use of these. This is particularly relevant for those estimates based on the views of a small number of respondents and who provided widely divergent estimates (as indicated by large standard errors). Furthermore, there can be considerable differences between potential productivity and realised (harvestable) production. For example, *E. grandis* is highly susceptible to wood borer which can render the stem virtually unsaleable for sawlogs.

Table 10.2 Estimated average growth rates (MAI) and harvest ages of timber species grown under the Community Rainforest Reforestation Program in North Queensland

Species	MAI (m^3/ha/year)		n	Harvest age (years)		n
Eucalyptus grandis	20.8	(5.7)	6	31	(1.1)	11
Acacia mangium	20.7	(2.3)	7	24	(2.2)	9
Araucaria cunninghamii	20.5	(3.7)	10	44	(1.4)	12
Eucalyptus camaldulensis	18.8	(2.1)	5	28	(0.9)	8
Elaeocarpus angustifolius	18.4	(4.0)	7	34	(2.2)	13
Eucalyptus cloeziana	17.4	(1.6)	9	35	(2.8)	11
Eucalyptus pellita	16.5	(2.2)	6	31	(2.7)	9
Eucalyptus citriodora	16.3	(2.3)	5	32	(1.6)	10
Eucalyptus tereticornis	16.2	(2.6)	7	32	(1.8)	9
Eucalyptus cloeziana (poles)	16.1	(1.7)	4	26	(2.2)	10
Eucalyptus microcorys	15.8	(3.3)	4	31	(1.5)	9
Agathis robusta	16.0	(5.0)	9	46	(2.1)	13
Melia azedarach	13.7	(4.1)	6	31	(3.7)	9
Flindersia brayleyana	13.5	(4.0)	6	43	(3.6)	10
Acacia melanoxylon	12.3	(3.0)	5	30	(2.4)	10
Eucalyptus drepanophylla	11.0	(1.3)	5	44	(7.6)	9
Cedrela odorata	10.4	(0.7)	6	38	(2.1)	10
Flindersia bourjotiana	10.3	(3.8)	4	53	(4.8)	6
Flindersia pimenteliana	9.0	(5.0)	3	55	(5.6)	6
Toona ciliata (australis)	8.9	(3.4)	4	49	(4.7)	8
Blepharocarya involucrigera	8.7	(2.1)	4	48	(3.4)	7
Gmelina fasciculiflora	8.6	(3.6)	3	54	(4.9)	6
Flindersia schottiana	8.5	(3.5)	4	48	(3.4)	9
Grevillea robusta	8.2	(0.8)	6	35	(1.7)	10
Flindersia ifflaiana	8.0	(4.5)	3	57	(5.6)	6
Cardwellia sublimis	7.6	(3.2)	4	58	(4.5)	8
Paraserianthes toona	7.1	(2.1)	2	55	(11.8)	6
Castanospermum australe	5.6	(1.2)	5	67	(7.1)	9
Ceratopetalum apetalum	5.0	--	1	113	(20.3)	3
Endiandra palmerstonii	4.5	(2.5)	2	156	(63.6)	5
Beilschmiedia bancroftii	2.9	(1.9)	2	102	(18.0)	5
Flindersia australis	--	--	0	58	(6.3)	4

Note: 'n' represents the number of participants providing estimates for each parameter. Standard errors are reported in parentheses.

10.4 Summary

This chapter has documented the process involved in the development of growth estimates of a range of species which have been included in the AFFFM as default data. Growth estimates for species suitable for the Darling Downs and New England Tableland areas were obtained using the Plantgro program. Users of the model from these areas can choose to load the appropriate values for the various species by specifying the location and soil type of the planned plantation. Data on the potential growth rate, harvest age and timber price for 31 species of cabinet timbers in Far North Queensland obtained by Delphi survey have also been included in the AFFFM.

10.5 References

Booth, T. H. (1996), *Matching Trees and Sites*, Proceedings of an international workshop held in Bangkok 27-30 March 1995, ACIAR, Proceedings No. 63, Canberra.

Booth, T. H. and Pryor, L. D. (1991), 'Climatic requirements of some commercially important eucalypt species', *Forest Ecology and Management*, 43(1-2): 47-60.

Brown, A. G., Wolf, L. J., Ryan, P. A. and Voller, P. (1989), 'TREDAT: a tree crop database', *Australian Forestry*, 52(1): 23-29.

Davidson, J. (1996), 'Developing Plantgro plant files for forest trees', in *Matching Trees and Sites*, Booth, T. H. (ed), Proceedings of an international workshop held in Bangkok 27-30 March 1995, ACIAR, Canberra, pp. 93-96.

Eldridge, K. G., Davidson, J., Harwood, C. and van Wyk, G. (1994), *Eucalypt Domestication and Breeding*, Clarendon Press, Oxford.

Gnan, A. (1992), *Plantation Volume Growth Summaries from Growth Plots in Queensland*, Production Support Branch, Queensland Forest Service, Brisbane.

Goodwin, A.N. and Candy, S.G. (1986), 'Single-tree and stand growth models for a plantation of Eucalyptus globulus Labill in northern Tasmania', *Australian Forest Research*, 16(2): 131-144.

Hackett, C. (1988), *Matching Plants and Land: Development of a General Broadscale System from a Crop Project for Papua New Guinea*, CSIRO Division of Water and Land Resources, Natural Resources Series No. 11, CSIRO, Melbourne.

Hackett, C. (1991a), *Plantgro: A Software Package for Coarse Prediction of Plant Growth*, CSIRO, Melbourne.

Hackett, C. (1991b), 'Mobilising environmental information about lesser-known plants: the value of two neglected levels of description', *Agroforestry Systems*, 14(2): 131-143.

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1999), Potential performance of rainforest and eucalypt cabinet timber species in plantations in North Queensland, *Australian Forestry*, 62(1): 79-87.

Hidayat, P. (1996), 'The use of Plantgro in forest plantation planning in Indonesia', in *Matching Trees and Sites*, in T. H. Booth, ed., Proceedings of an international workshop held in Bangkok 27-30 March 1995, ACIAR, Canberra, pp. 97-100.

Iris Media (1994), *Plantgro: MS DOS Version 2.0*, Iris Media, Brisbane.

Isbell, R. F. (1996), *The Australian Soil Classification*, CSIRO, Melbourne, Australia.

Johnson, I. G. and Stanton, R. R. (1993), Thirty Years of Species and Provenance Trials in New South Wales, Research Paper No. 20, Research Division, Forestry Commission of New South Wales, Sydney.

Moore, R.W., Siemon, G.R., Eckersley, P. and Hingston, R.A. eds. (1996), 'Sawlogs from 13 year old Eucalyptus globulus – management, recovery and economics', in *Farm Forestry and Plantations*, Proceedings of the Australian Forest Growers Conference, pp. 219-231.

Pohjonen, V. and Pukkala, T. (1988), 'Profitability of establishing Eucalyptus globulus plantations in the Central Highlands of Ethiopia', *Silva Fennica*, 22: 307-321.

Russell, J.S., Cameron, D.M., Whan, I.F., Beech, D.F., Prestwidge, D.B., and Rance, S.J. (1993), 'Rainforest trees as a new crop for Australia, *Forest Ecology and Management*, 60(1-2): 41-58.

Webb, D. B., Wood, P. J., Smith, J. P. and Henman, G. S. (1984), 'A guide to species selection for tropical and subtropical plantations', Tropical Forestry Papers No. 15, 2nd rev. edn., Commonwealth Forestry Institute, Oxford.
West, P.W. and Mattay, J.P. (1993), 'Yield prediction models and comparative growth rates for six eucalyptus species', *Australian Forestry*, 56(3): 211-225.

11. Development, Testing and Presentation of the AFFFM

N. Emtage

This paper outlines the various stages of development and testing which were applied to the Australian Farm Forestry Financial Model to ensure that the model is free of errors and operates without problems on personal computers. Testing proved to be a challenging task, and repeatedly revealed the need to make changes, particularly with respect to the user interface and freedom from 'crashes' when attempts were made to use the model in ways not envisaged by the developers.

11.1 Development of the AFFFM

Initial development and testing of the AFFFM was undertaken by David Thompson and Nick Emtage. Nick Emtage undertook the initial programming of the plantation module under supervision by Dr Herbohn and Dr Harrison based on the concepts used in the previous farm forestry financial models developed for the Rainforest CRC (Herbohn *et al*. 1998). The agriculture, native forests and farm finances modules were also developed by Nick Emtage, in conjunction with David Thompson and other staff at CARE. Following testing of the AFFFM by students at The University of Queensland, a professional programmer, Greg Hood, was employed to assist in the development of an on-line help system for the model and to assist with the packaging and deployment of the model.

The AFFFM was developed as a set of modules relating to the various activities covered by the model, viz. plantations, native forestry, agriculture and farm finances. Eleven versions of the model were compiled and tested prior to the release of the current version. The plantation module was the first to be developed, together with the main reporting form of the model to allow assessment of the model. Initial work concentrated on replicating the earlier models developed by members of the project team for the Rainforest CRC (Rainforest Cooperative Research Centre). Once this module worked satisfactorily, further development of the plantation module was undertaken to extend the functionality of this module to reflect the data available for the model from the work being done by John Davidson with the Plantgro program and the projected users requirements. This development required extending the capacity of the model to allow three harvest ages rather than one, and to specify multiple products from each harvest rather than only one 'stumpage' price for all timber produced by the hypothetical plantations.

Several different methods were tested for incorporating the 'suitability ratings' from the Plantgro software package into the AFFFM. These included linking the AFFFM to text files and the incorporation of the data in the AFFFM program code. The system used in the current version utilises a combination of data embedded in the program code to look-up the suitability ratings for particular species, soil and climate combinations, and the linking of text files that contain the data about the growth rate, harvest ages and potential products from various harvests for the included species at different suitability ratings.

Development of the agriculture, native forest and farm finance modules began concurrently with the extension of the plantation module. A series of meetings were held in Armidale between Nick Emtage, David Thompson and the other staff of CARE in 1998 and 1999 to discuss the concepts to be used, the required functions and organisation of these modules. The growing complexity of the model led to the development of more sophisticated reporting formats such as the use of graphics and printing of variable values to text files. It also led to the development of modules to track the values of each variable throughout a scenario to check that the model was operating as

intended. This module was dropped from the current version of the model because none of users of the AFFFM, apart from Nick Emtage, had used this function.

The agriculture module initially had two alternative data entry screens to cater for differing levels of data availability and sophistication of analysis. The 'advanced' data entry screen (that allowed specification of variable costs for a greater number of stock types) was subsequently dropped from the model after testing of the module by users outside the project team revealed they did not require this level of sophistication. Further tests and analysis by staff at CARE led to the development of the sections of the AFFFM relating to interactions between plantations and agriculture. These functions included the ability to specify the level of stock shelter from planted trees and the allowance for grazing under plantations. The staff at CARE Ltd, including David Thompson, also provided information about the best way to organise the farm finances module based on their practical experience in owning and operating landholdings in the New England Tablelands region plus their experiences in working with local farmers in their professional capacities.

Comprehensive details of the model structure, user interface screens, model outputs and other features of the model are to be found in a separate report titled "The Australian Farm Forestry Financial Model – a Users Guide" compiled by Nick Emtage and others.

11.2 Testing of the AFFFM

Nick Emtage and David Thompson undertook initial testing of the AFFFM. The tests involved assessment of the calculations made by the model through comparison of the results with those of other models where possible, the definition of simplistic scenarios to verify data manipulation within the model, and tests of the effects of various functions and combinations of functions on the outputs of the model. The model was further tested by the developers replicating the results of published studies of small-scale forestry enterprises, and by setting up case studies of real life farms using the model.

Various people not connected with the project also tested the AFFFM user interface. The model was presented at a series of seminars and workshops for the purposes of publicising the AFFFM software package and demonstrating the results of analyses using this package.

Researchers who requested and received early versions of the model included:

- QFRI and DPI personnel in far north Queensland
- CSIRO personnel involved in plant physiology studies based in Brisbane
- the Private Forestry Development agency in NSW
- NSW agriculture personnel
- Private Forests North Queensland (PFNQ) officers (the regional plantation committee for Far North Queensland)
- Western Australian researchers investigating crop diversification strategies.

The model has been demonstrated at a number of conferences, seminars and meetings including those involving:

- researchers from the Rainforest CRC at the Rainforest CRC Annual Conference, Cairns, August 2000
- RIRDC staff and researchers interested in farm forestry financial modeling, Canberra, July 2000
- researchers in the Department of Forestry at the Visayas State Agricultural Collage (now Leyte State University), Leyte, Philippines, Feb 2001
- landholders, researchers, politicians and timber industry personnel at a workshop "Farm Forestry: what's in it for me", Mareeba, December 2001
- members of the project research group and invited guests at regular project meetings over the course of the research project (between 1998 and 2002)

- landholders and timber industry workers who visited a stall at the agricultural exhibition held in Toowoomba (1999) manned by members of the project research team.

In general, the extent of feedback from researchers was disappointing. Despite requests for feedback about the model, those who assessed early versions of the AFFFM provided little if any feedback. In part this may have been due to the informal nature of the requests for feedback, the instability of early versions of the model, and the lack of on-line help. Furthermore, many of the people requested to test the model did not have a reason to use the model as part of the work activities.

Shortcomings of an early version were thoroughly documented by the University of Queensland student groups, who have undertaken comprehensive testing and reporting on the model.

11.3 Reviews of the AFFFM Outside the Project Team

The familiarity of the project team with the model made it difficult to appreciate the problems and difficulties faced by new users of earlier versions of the model and thus testing by members of the project team were only partially effective. This problem was compounded by the lack of feedback from people outside the team to whom the model had been given.

The most critical assessment of the AFFFM resulted from it being exposed to two student cohorts in the Agribusiness Program at The University of Queensland in 2001 and 2002. Students enrolled in ABUS 3002 Project Appraisal II were required to complete an assessable assignment in which they had to develop a scenario using the model involving agriculture, some forestry and farm financing details. The students spent considerable time collecting and entering data to run the model, something that the research groups appear not to have tried. The students then analysed the results of the scenarios and assessed the functionality of the model. They were asked to list problems with the model and recommend ways to overcome these problems. Students enrolled in the same course in 2002 were also asked to complete an assessable project using the updated AFFFM.

In summary, the students reported that their main concerns were errors in the program code that led to the model shutting down unexpectedly, the lack of on-line help facilities, and the inability to save all the settings they had entered for scenarios. These problems were examined and subsequently fixed. The project team decided to engage the services of a computer programmer to create the on-line help system, assist the elimination of errors in the model that were beyond the programming capabilities of the project team and to assist in compiling and distributing the program.

The presentation of the model to meetings and seminars has been reasonably effective in publicising the model among researchers and those involved in farm forestry extension. Such presentations and even workshops have not, however, proved effective in generating the critical review of the model that is vital to improve its functionality as there is typically insufficient time at these seminars to present anything more that a brief overview of the model functions.

The information from student reports enabled the most serious errors to be traced and removed, and provided valuable feedback about the conceptual framework and user interface of the model. Informal reports from researchers who have seen the various versions of the model developed subsequent to the student evaluations have stated that it is much improved. The student's comments in 2002 also revealed that the model is more stable than it was in earlier versions, but there were still concerns about the level of forestry knowledge required to operate the program and some difficulties in understanding how to get the analyses started. These comments reinforce that there is a need for a period of intensive hands-on training for new users of the model to become acquainted with it.

11.4 Target Users of the AFFFM

The primary target users for the model identified by the project team changed slightly over the course of the project. While the project team initially thought that the model would be primarily used by landholders, the complexity of the model and users' reactions led to a decision that the model should be primarily targeted at farm financial advisors and those involved in forestry and agricultural extension. It was reasoned that the model is best suited to those who could potentially use it repeatedly rather than use it for assessing a single farm enterprise. While the model has improved in terms of user friendliness and stability, the information requirements are still demanding, and it is expected that users will require at least a few hours to become proficient in operating the model. Once the data for typical agricultural and forestry enterprises in a region have been collated and entered as scenarios into the model, the effort required to modify variables to reflect the circumstances of landholdings in the region will be far less than that needed if all the data for a scenario must be collected. It is still possible that landholders may wish to use the model themselves.

The student assessments highlighted a number of factors in relation to the data requirements of the model that have implications for potential adoption. One is that many users are unlikely to be expert in or even familiar with all the enterprises included in the model. Users from different backgrounds with different skills (e.g. foresters, agronomists, landholders) are likely to be able to estimate reliably values for some aspects of the model but be less able to estimate others. The agribusiness students who assessed the model were well informed about the concepts involved in modelling agricultural returns, as would be expected. In terms of the forestry aspects of the model they were almost totally reliant on the data embedded in or linked to the model. This is partly due to their lack of investigation into forestry growth, yield and price parameters, but it also indicates that it is unlikely that others with a predominantly agricultural background will be encouraged to use the model without the inclusion of case-specific forestry data. Resources on the web sites of state agricultural agencies provide sufficient information about returns to agricultural enterprises to be able to place data in the agricultural module of the model, and many landholders and their financial agents have detailed information about the financial costs and returns for agricultural enterprises. The same cannot be said for forestry data. There is a paucity of published data about many species of trees suitable for plantation development, their growth rates, harvest ages and the costs involved in establishing, maintaining and harvesting trees. The lack of data is perhaps even more acute in relation to native forestry operations. Most available forestry data are fragmented, cover limited ecological and biophysical ranges, lie in obscure publications such as scholarly journals or departmental records, and their format is often not suitable for use in the model. The compilation of suitability ratings for species for plantation development in the New England Tablelands and Darling Downs regions has created a valuable source of data for people in these regions. These data are unique in that this is the first time data on many of these species has been collated, analysed and made publicly available. For the model to be widely applied outside these regions, it is likely that further regional assessments of growth rates need to be undertaken using Plantgro or similar methods so that additional forestry information can be added to the model.

11.5 Distribution of the AFFFM Software

The regional approach to farm forestry development adopted by Australian governments provides opportunities to manage the distribution and adoption of the model. The establishment of regionally-based groups, Regional Plantation Committees, throughout Australia to oversee the development of private forestry can provide several services. They can be used as a network through which to distribute the model. They can further assist the adoption of the model by acting as advocates and agents for the development of data relating to the forestry aspects of the model, by applying for and managing funds to research species they identify as having potential in their region. They may subsequently act as central libraries to store and distribute such data in regions. Other organisations could play a similar role if agents within them were trained to operate the AFFFM.

It is proposed that the distribution of AFFFM software will be through web-based and postal methods. Non-profit groups involved in environmental management and farm forestry research and extension will be sent free copies of the AFFFM software. Other groups or individuals that wish to acquire a copy of the package shall be able to access it from a web site. Publicity releases will be sent to rural media outlets. The New England Tablelands and Darling Downs regions shall be the regions most targeted, with other regional and urban areas covered by publicity in the Land newspaper, ABC radios' Country Hour program, and other NSW and Queensland State and regional newspapers.

Groups that could be sent copies of the model on CD ROM include:

- federal and state government departments and agencies involved in environmental management and farm forestry (specifically to extension services and agronomists)
- Australian universities with forestry schools
- non-profit organisations involved in farm forestry and tree planting including the Australian Forest Growers, Trees for Life (SA), Greening Australia and others
- regional plantation committees
- regional farm forestry associations
- timber growing cooperatives
- regional catchment management committees
- regional landcare committees
- rural accounting associations
- farm advisor associations and farm lobby groups.

The model software will also be available from website of the School of Natural and Rural Systems at The University of Queensland, with links from other websites. Possible sites from which the model will be linked include Rainforest CRC, RIRDC, Regional Plantation Advisory Committees, Universities and State government departments concerned with land management in NSW and Queensland.

11.6 Providing Support for AFFFM Users

One difficulty in the distribution and widespread adoption of the AFFFM is the lack of continuing funding to support the generation of data for additional regions, and also to support the maintenance of the program itself. While the model has been tested extensively, it is not possible to guarantee that minor errors do not remain in the program code. Another question arises over training and technical support for the AFFFM users: Which organisations or individuals will be responsible for these tasks? Those that adopt the AFFFM? Can members of these organisations be trained to handle program use in their organisations?

It is recommended that records be kept of the distribution of the AFFFM. The list of those using the model could play a vital role in future surveys that could help to:

- identify errors
- assess functionality
- assess adoption rates
- identify user types profiles and needs.

With no assured funding to maintain and further develop the model and no agency taking up these responsibilities, it will be up to the AFFFM developers to prove that the model has utility in assessing the financial implications of farm forestry development and has broad support in the community. If such survey data are able to generate sufficient evidence for support of the AFFFM they may justify the development of more regional databases as those developed for the New England Tablelands and the Darling Downs. It is recommended that a record be kept of those individuals and organisations that are sent CD-ROMs of the AFFFM, and that web sites that provide access to the AFFFM keep a register of those who have downloaded the package.

11.7 References

Herbohn, J.L., Harrison, S.R. and Emtage, N. (1998), *Australian Cabinet Timber Financial Model*. Computer software based on Microsoft Excel, including Draft Manual, Department of Accounting and Finance, James Cook University of North Queensland, Cooperative Research Centre for Tropical Rainforest Ecology and Management, Townsville.

12. Case Studies Using the AFFFM

D. Thompson, N. Emtage and G. Cockfield

One of the primary functions of the Australian Farm Forestry Financial Model (AFFFM) is to allow landholders and their advisors to explore the potential impacts of forestry development on overall farm profitability, financial position and cashflows. In this chapter, two case studies of real-life landholdings are presented. The first examines the development of native forestry operations on a landholding in the New England Tablelands region, and the second examines the development of a hardwood plantation on a landholding in the Darling Downs region. These case studies illustrate the data input requirements and the nature and interpretation of the output from the model.

12.1 New England Tableland Native Forestry Case Study

This case study illustrates the AFFFM can be used to investigate the financial implications of managing a private native forest for timber production. The data for this case study farm were collected in 1999 during the course of a previous RIRDC-funded project (Thompson 1999).

The case study farm is located in northern NSW and falls within the boundaries of the Uralla Local Government Area (LGA). This is a family-owned business which operates with a high level of off-farm income. The operational features of this business are set out in Table 12.1. The dominant commercial native timber species on the farm are native hardwoods (see Figure 12.1).

While there is a range of eucalypt species on the farm, those of most commercial interest are:
- silvertop stringybark (*Eucalyptus laevopinea*)
- red stringybark (*E. macrorhyncha*)
- Youmans stringybark (*E. youmannii*)
- New England blackbutt (*E. andrewsii*).

These species are commonly taken by sawmills in the region which pay stumpage of about $\$25/m^3$, the price varying according to stand size, timber quality, site access and distance from the mill. The farm has a small fixed sawmill on site and the species mix currently put through the mill is approximately 80% stringybark species and 20% blackbutt. The owners are interested in processing their own timber on-farm for sale to local building supply firms. This would attract a sawn timber price of at least $\$320/ m^3$. Expansion of the current sawmilling operation for this purpose would require hiring additional labour, of two men for three days per week, to assist with timber sawing and one man for four days per week to assist with cutting and mill maintenance (i.e. 10 man days per week). The cost of this labour is estimated at $120 per day plus loadings for workers compensation and compulsory superannuation of 24%. On the basis of a 60% recovery (which assumes that only selected logs are milled), this corresponds to a labour cost of $\$89.65/m^3$ of roundlog put through the mill. There were also fuel and maintenance costs of $\$34/m^3$.

The farm manager would be largely responsible for cutting, de-barking and log snigging operations using existing farm machinery. Based on State Forests NSW estimates of harvesting costs of $\$15/m^3$ and the farm manager's estimates of fuel and maintenance costs of $6/ha, the total cost of the log harvesting operation is estimated as $156/ha.

Table 12.1 Case study farm structure

Item		Amount
Total farm area		978 ha
Approximate area available for existing native timber management		400-500 ha
Average carrying capacity (whole farm)		2.87 DSE/ha [a]
Additional carrying capacity generated following non-commercial thinning		1 DSE/ha for a period of 10 years after thinning
Dominant soil type		Granite based soils
Average annual rainfall		850 mm
Initial livestock numbers:	Merino ewes	800
	Merino hoggets	560
	Adult cattle	50
	Young cattle	35
Weaning rates:	Ewes	70%
	Cattle	70%
Wool production:	Ewes	3.5 kg/head
	Hoggets	1.5 kg/head
Farm labour situation		A full-time manager operator; casual assistance as required
Farm family expenses		$8,000 per annum
Opening equity level		69%

[a.] DSE - dry sheep equivalent, the amount of energy required to maintain one dry sheep for a 12 month period.

It is estimated that about 10 m^3/ha of harvestable timber might be extracted across the entire farm, although this varies considerably between different sites. Timber growth rates are estimated at about 1-2 m^3/ha/annum (State Forests of NSW 1998). For the purpose of this case study, the simplifying assumption was made that the 400 ha available for logging is divided into 10 coups with a regular annual harvest (i.e. 40 ha was logged every year, so each coup had a 10-year recovery period).

The management cycle thus becomes:

Each year, log and thin 40 ha removing 400 m^3 of logs and thinning the logged area at a cost of $112/ha (based on estimates by the farm owner and State Forests NSW). Thinning would be performed by chainsaw and brush cutter. Current stand density is estimated at between 200-300 stems/ha and this would be reduced to around 150 stems/ha.

Due to the lack of market opportunities for thinnings in the region at present, thinned timber would be pushed into piles using a tractor and left to break down naturally. As a result, no commercial thinnings revenue is realised.

Two scenarios are compared using the AFFFM, one selling timber at a stumpage price of $25/$m^3$ and the other sawing the timber on-farm and selling green sawn product for $320/$m^3$.

Modelling results - selling timber at stumpage prices

Samples of the model results are presented in Figures 12.1 to 12.3. For this analysis, the model was run over a 60-year planning horizon using a real discount rate of 6%. In Figure 12.1, the 'Financial analysis' section of the screen reports various financial performance measures for the with-forestry and without-forestry scenarios. In this case, there is a clear improvement in farm business performance for the first four performance indicators (NPV, LEV, NPV/ha and EAV/ha) when native forestry is included as a farm enterprise. The model could not calculate an IRR because all business cash flows were positive from the start of the analysis.

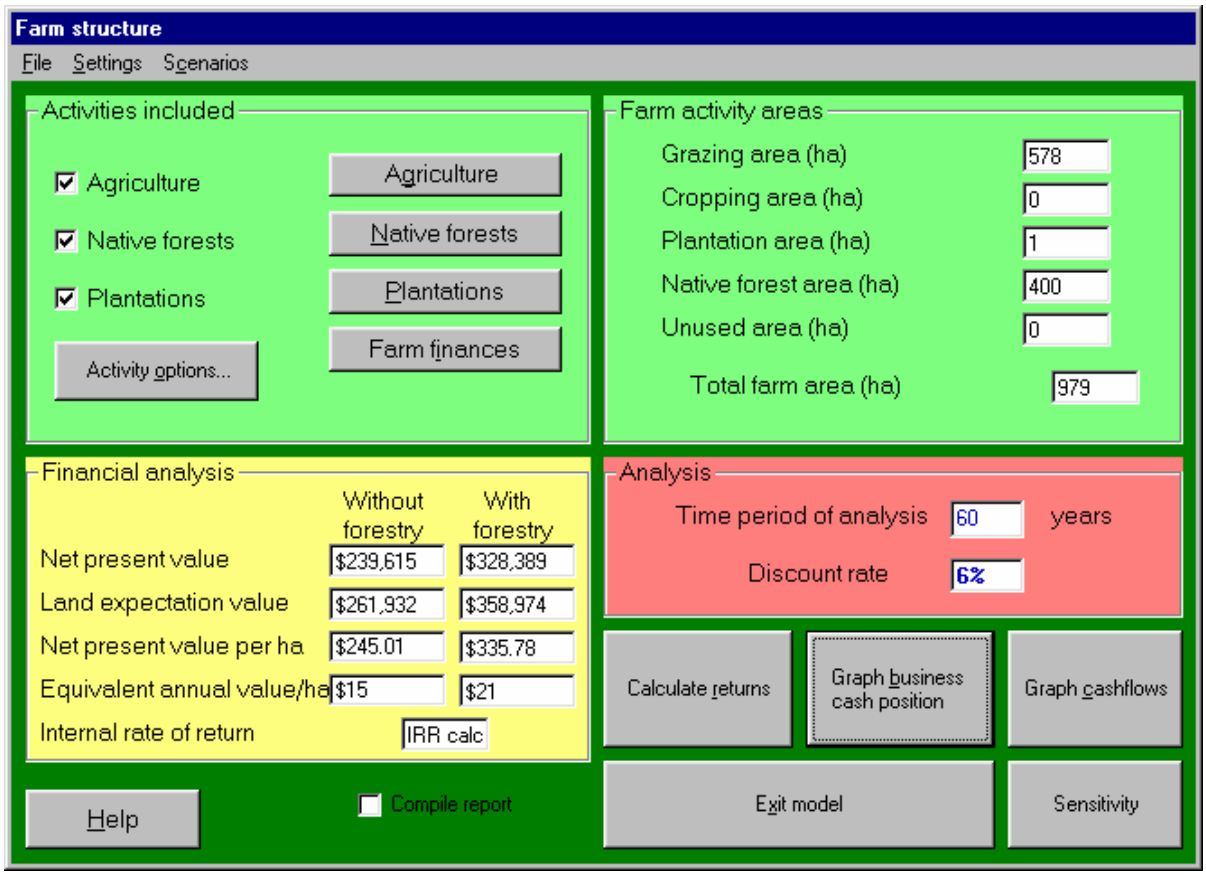


Figure 12.1 Financial analysis of the development of a native forestry enterprise on a New England Tablelands region

Figure 12.2 displays the business cash position (BCP) with and without forestry. BCP essentially tracks the businesses' bank balance and is useful for identifying any periods of negative balances which may cause cash flow problems, especially if overdraft limits are breached. In this case, starting from an assumed zero bank balance, annual cash flows are always positive, so the BCP increases. Initially, this increase is slower because a loan is being repaid and principal and interest costs have to be met. After Year 5, this loan has been fully repaid, hence finance costs fall to zero and BCP increases more rapidly. The bank balance is higher at all time periods where native forestry is added to the existing farm business enterprise mix. This is to be expected in the current example because the net cash proceeds from native forestry activities are positive for every year. This may not always be the case, especially where expenditure on silvicultural treatment is required in order to restore or improve the productivity of native forests that do not currently have harvestable timber.

Because of its cumulative nature, the BCP calculation simulates the bank balance reaching very high levels after 60 years (in excess of $2M with forestry). In reality, additional investments may be made on or off-farm which would offset this rapid rise in BCP.

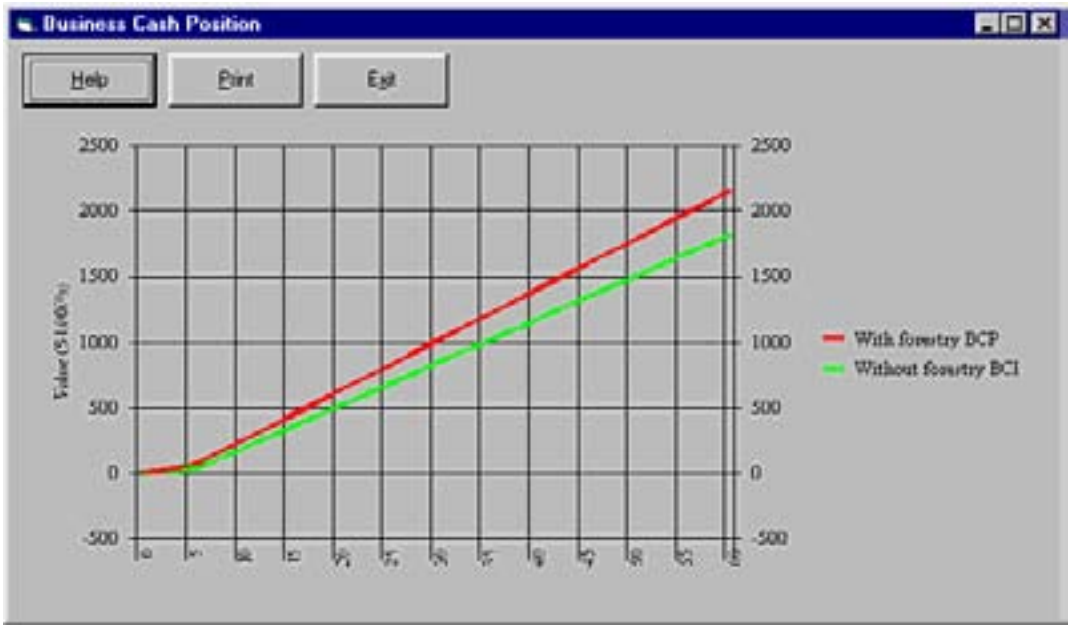


Figure 12.2 Projected business cash position of the farm enterprise with and without the development of a native forestry enterprise on a New England Tablelands region

The annual cash flows are illustrated in Figure 12.3. Unlike BCP, these are a non-cumulative measure and exclude finance costs. It can be seen from this figure that the native forestry enterprise is projected to increase the yearly revenue to the farm business by approximately $6,000 per year.

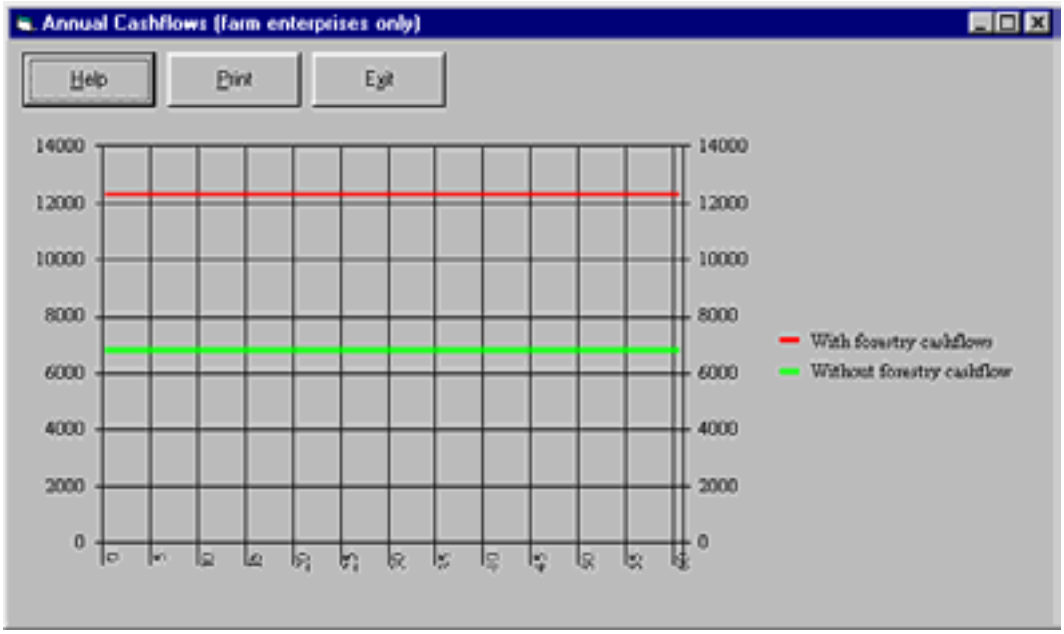


Figure 12.3. Annual cash flows of the farm with and without forestry investment

Modelling results - selling sawn timber

The results of the financial analysis where timber is sawn on-farm are presented in Figures 12.4 and 12.5. These results clearly demonstrate the superior financial performance that can be achieved where the forester is able to move along the value-adding chain and sell a processed product. The NPV with forestry has increased from $328,000 to $508,000 (Figure 12.4) and BCP climbs at a more rapid rate (Figure 12.5).

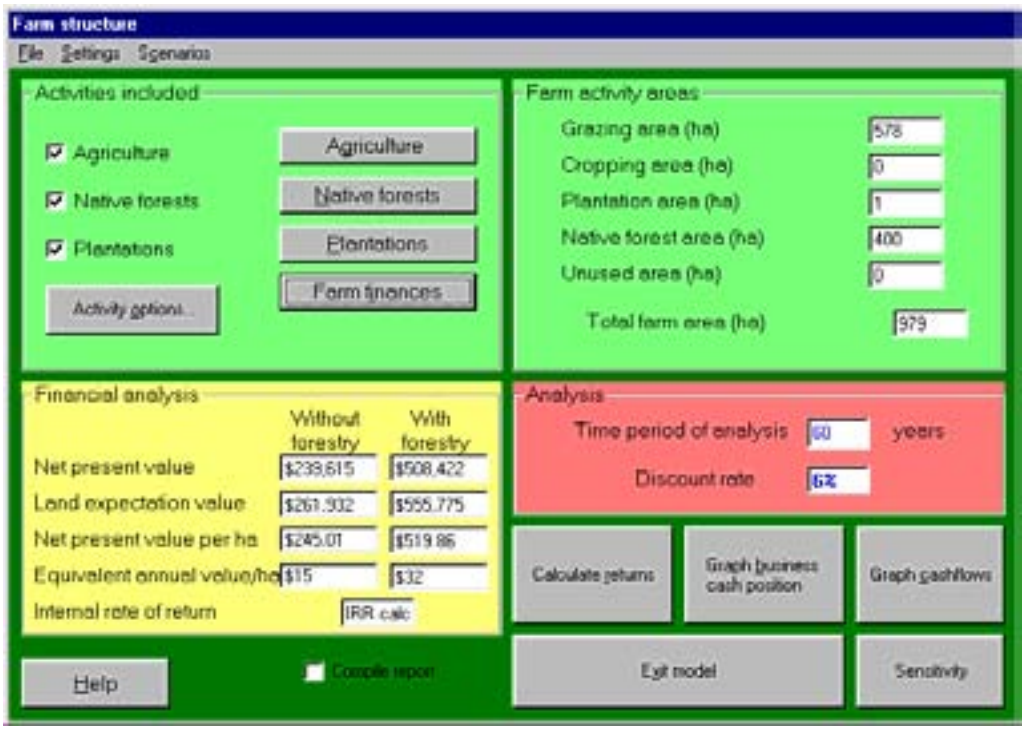


Figure 12.4 Financial analysis of the development of a native forestry enterprise on a New England Tablelands region when the landholder processes their own timber

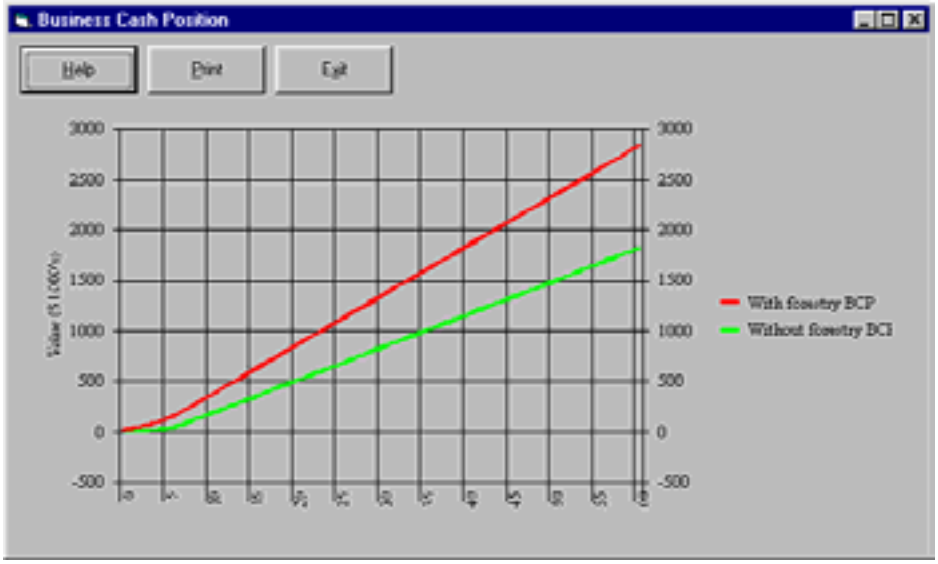


Figure 12.5 Business cash position of the farm business with and without the development of a native forestry enterprise on a New England Tablelands region, with on-farm

12.2 Darling Downs Plantation Enterprise Case Study

This case study examines the establishment of a plantation enterprise on a mixed cropping farm on the Queensland Darling Downs. The property size is approximately 800ha, 500ha of which is used for crops, and approximately 300 ha is used for grazing. Three scenarios are examined to assess some of the forestry options available for the landholders. In each of the scenarios 50ha of *Eucalyptus argophloia* (Western White Gum) is established on some of the grazing land operated by the landholders. Data used to populate the grazing scenario were derived in part from Clark (1997). The agricultural enterprises have been simplified for the sake of the analysis: a mixture of 4 crops is grown over a four-year rotation period. The gross margins for the four crop types have been averaged across the entire cropping area to give an average gross margin of $180 per ha per year. (Cockfield in prep.)

In each of the three scenarios the initial planting would be at 600 stems per ha (sph), thinned at the end of year two to achieve a final stand density of 200 species per hectare. For each scenario it is proposed that the timber from the plantation would be sold 'on the stump' for $50/m^3, with no commercial value from the early thinnings. The strategy behind the design of the proposed enterprise is to minimise silvicultural activities and costs (Allworth, pers comm.).

Under the first scenario (Scenario A) the establishment of a 50 ha plantation occurs in a single year and it is assumed that there are no shelter benefits from the plantation, and that no grazing occurs under the plantation. In the second scenario (Scenario B) it is again assumed that the establishment of the plantation occurs in a single year, but this time it is assumed that the plantation is configured as a series of shelterbelts that improve the carrying capacity (DSE/ha) of affected adjacent grazing land (85%) by 10%, and grazing occurs under the plantation after year 5. In the third scenario (Scenario C) shelter benefits and the potential for grazing under the plantation are calculated as for Scenario B, the difference being that the establishment of the 50ha plantation takes place over 60 years, with 10ha established every 15 years.

Table 12.2 Characteristics of the cropping and livestock enterprises, Darling Downs landholding

Item	Amount
Total farm area	800 ha
Approximate area available for cropping activities	500 ha
Total gross margin for cropping activities per year	$90,000
Farm family expenses per year	$30,000
Approx. area available for grazing or plantation establishment	300 ha
Average carrying capacity (whole farm)	3.2 DSE/ha [a]
Initial livestock numbers, young cattle	120
DSE rating per head, young cattle	8
Gross margin per DSE, young cattle	22
Total livestock gross margin per year	$21,120
Overhead costs per year	$50,000
On-farm capital and maintenance expenditure per year	$32,000
Farm family expenses (per annum)	$30,000

DSE - dry sheep equivalent, the amount of energy required to maintain one dry sheep for a 12 month period.

Table 12.3 Characteristics of the plantation enterprise, Darling Downs landholding

Item	Amount
Species used for plantation	*E. argophloia* (western white gum)
Plantation area	50 ha
Plantation MAI	7 m^3/ha/yr
Establishment costs	$1,800 /ha
Pruning costs (yr 1)	$85 /ha
Thinning costs (yr 2)	$360 /ha
Pruning costs (yr 6)	$270 /ha
Timber price (stumpage)	$50/ha
Harvest age (years)	30
Harvest volume	200 m^3

Analysis of the scenario outlined in Table 12.2 reveals that the inclusion of the 50 ha plantation reduces the NPV of the farming enterprise from approximately $390,471 to $310,421 at a discount rate of 7% (Figure 12.6). This indicates that the farm would be in a worse financial position if 50 ha of plantations were established. The plantation enterprise in the form that is defined in Table 12.2 is thus not financially viable if the landholders expect a return greater than 7%, the discount rate of used to analyse this scenario.

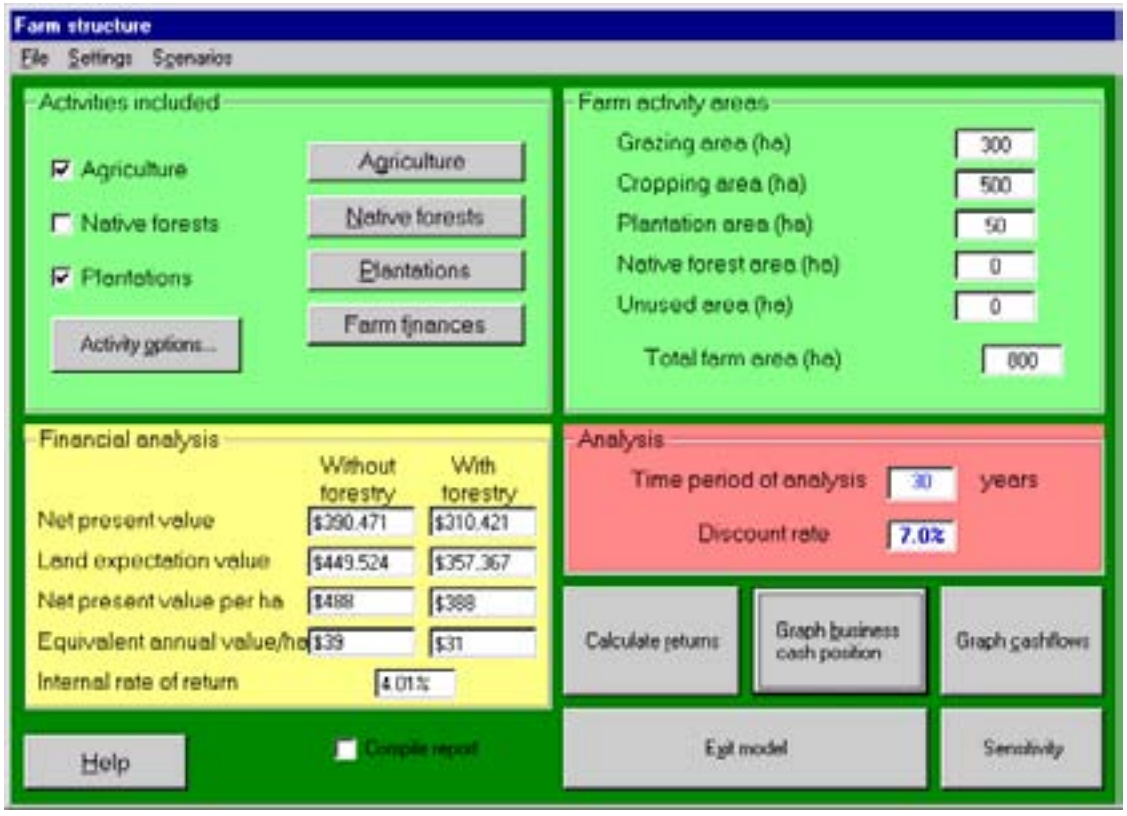


Figure 12.6 Analysis of a whole farm scenario in the Darling Downs based on cropping and plantation enterprises

The negative NPV for the plantation enterprise in this scenario is a result of a number of factors. The projected MAI of the plantation is low but realistic at 7m^3/ha, given the moderate rainfall in the area and the type of soil. Another factor affecting the projected financial viability of the plantation enterprise is the lack of financial returns for the plantation before the 30th year. The time required to produce timber that is acceptable to the present market means that the landholders must carry the costs of the plantation establishment and maintenance for a long period. The effect of discounting is illustrated by the business cash position of the scenario (Figure 12.7), which reveals that the business cash position of the farming enterprise with plantation development would eventually exceed that for the farm without plantations. This measure takes no account of the time value of money however (i.e. the values used to calculate the business cash position are not discounted like those for the NPV). It also reveals that the landholder would be in debt up to $200,000, a situation that may not be acceptable.

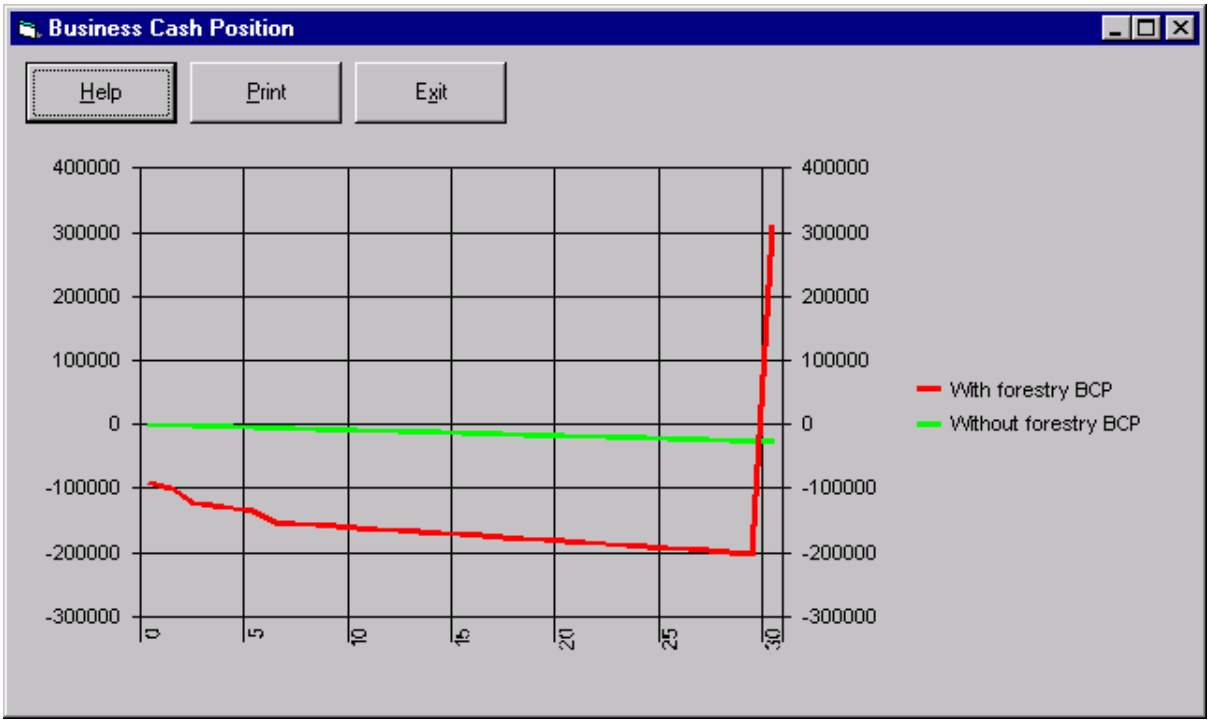


Figure 12.7 Graphical representation of the business cash position of the whole farm Scenario A in the Darling Downs

In the second scenario (Scenario B), it is assumed that the landholders can maintain a greater number of grazing animals due to the sheltering effects of the plantation and the further assumption that the landholder is able to graze under the plantation after the fifth year. The result of these assumptions is to lessen the decrease in returns to agriculture following plantation establishment, thus decreasing the difference in NPV of the 'with' and 'without' forestry cashflows (Figure 12.8). The IRR of the scenario is improved by 0.5% to 4.53% and the NPV of the 'with forestry' cashflows rises by $15,000. However the debt burden that the landholder would endure is still high as evidenced by the business cash position, which still peaks at around -$165,000 in the 29th year of the scenario (Figure 12.9).

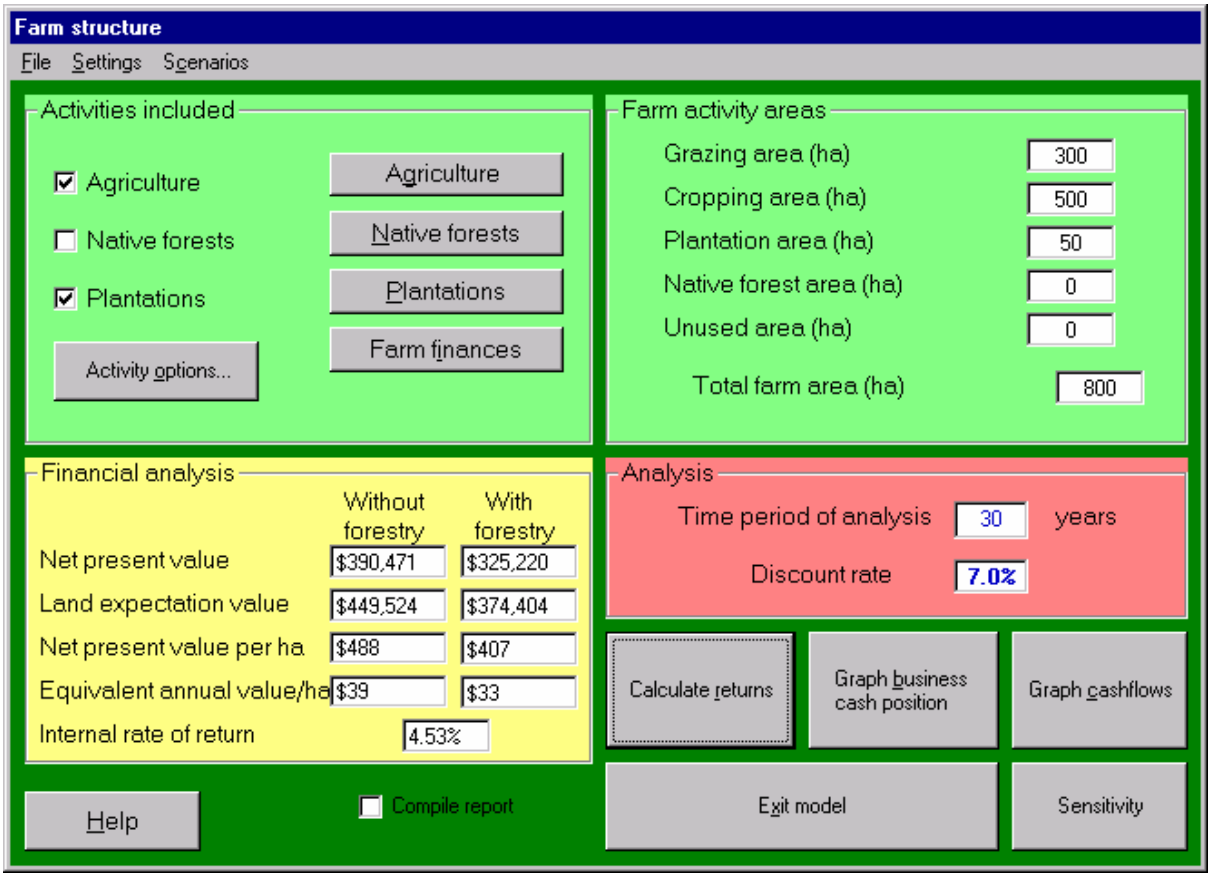


Figure 12.8 Analysis of the whole farm Scenario B in the Darling Downs

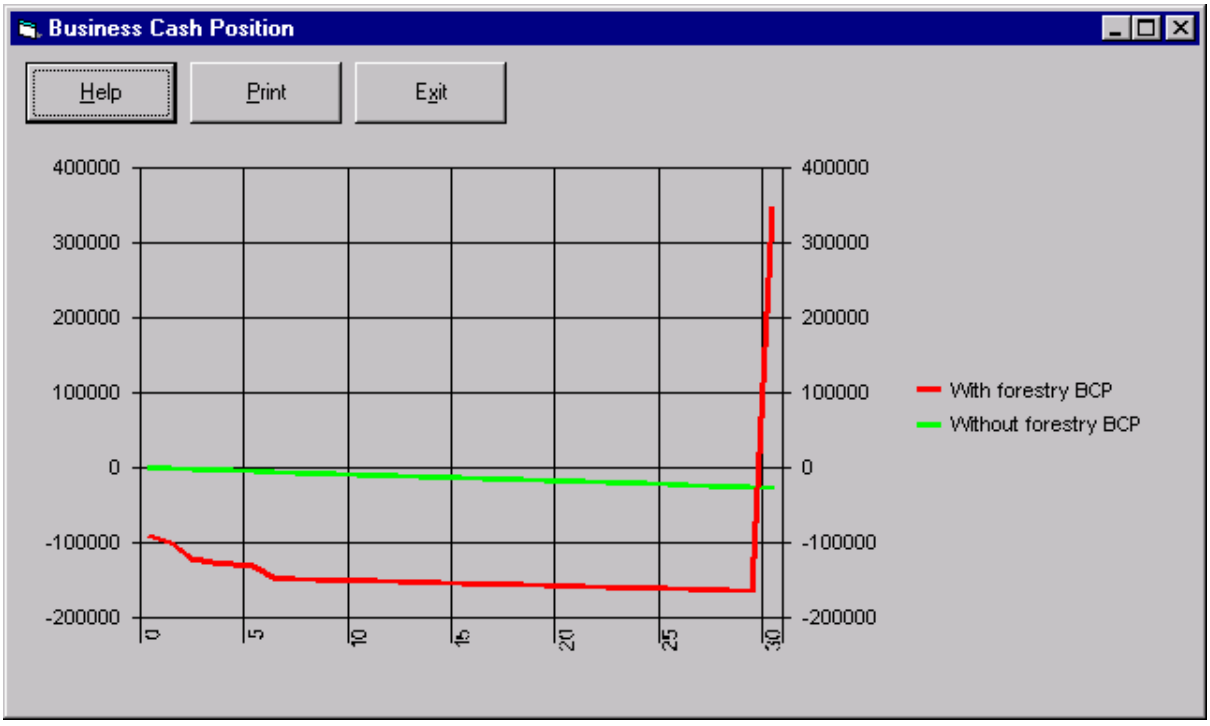


Figure 12.9 Graphical representation of the business cash position of the whole farm Scenario B in the Darling Downs

The capital required to establish 50ha of plantation in a single year could be difficult for the landholder to raise. In practice the returns to agriculture will vary according to fluctuations in climatic and market conditions. It is likely that landholder would want to establish plantations at times when returns to agriculture are higher so as to minimise taxation payments, and that the landholder would prefer to establish the trees over a number of years to reduce the size of the debt burden. In Scenario C the effects of staggering the establishment of the plantation are examined (Figure 12.10). It is assumed that the landholder establishes 10 ha of plantations in a shelterbelt configuration every 15 years. It is also assumed that there are shelter benefits and the plantation areas are grazed after 5 years as for Scenario B.

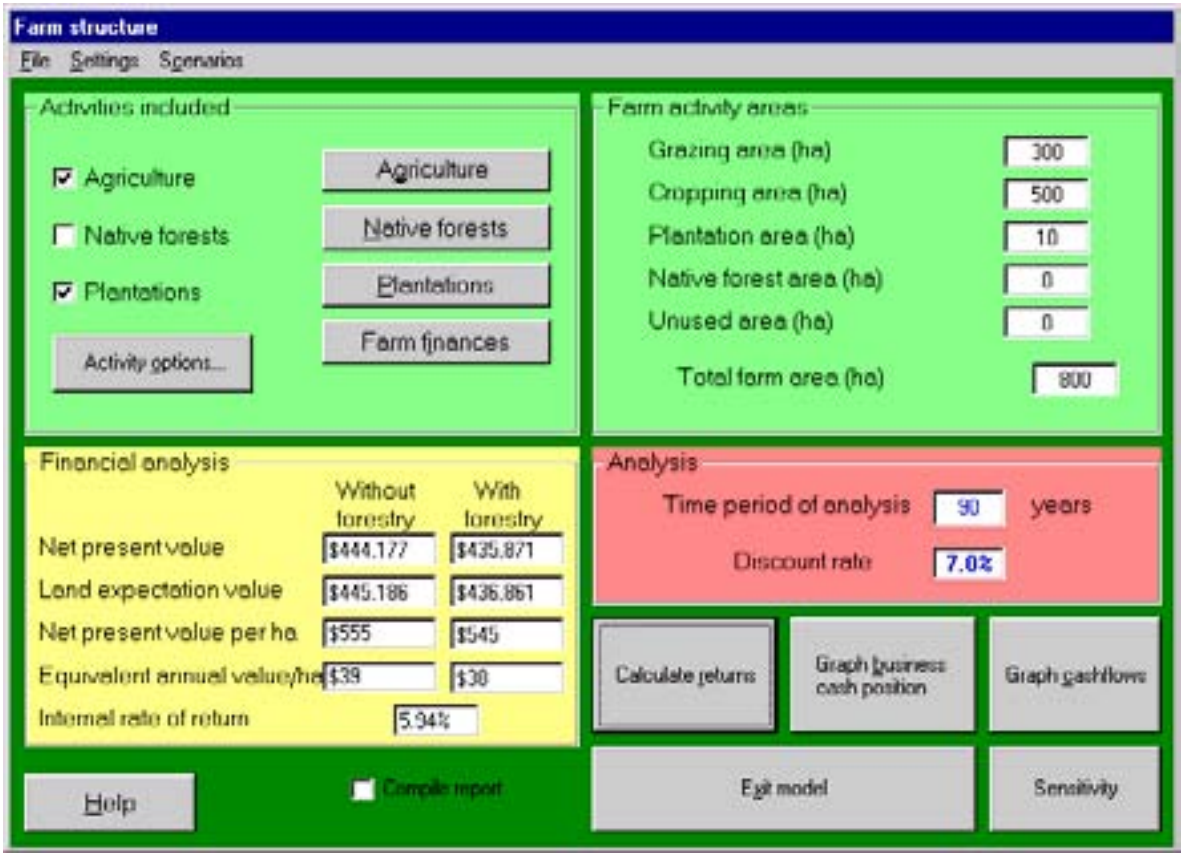


Figure 12.10 Analysis of the whole farm Scenario C in the Darling Downs

By staggering the establishment of the plantations a number of positive effects on the financial viability of the enterprise can be achieved. The level of debt is reduced so that a maximum of approximately $55,000 at year 29 (Figure 12.11), and the smaller area of plantations at any one time throughout the scenario reduces the displacement of agriculture relative to Scenarios A and B. The greater potential profitability of the third scenario is also reflected by the improved IRR at almost 6%, and the smaller gap between the NPV of the 'with' and 'without' forestry scenarios (Figure 12.10). The returns to the plantation enterprise are less than the discount rate of 7% and thus the NPV of the 'with' forestry scenario is lower than the 'without forestry'. If a decision were made on purely financial grounds the landholder would choose not to proceed with the investment, but it is well accepted that farmers do not act in a manner that could strictly be called economically rational. Without the cashflows from the plantation enterprises the whole farm enterprise would not be viable using the returns to agriculture and costs assumed in this case. The key question then, if it is assumed that the landholder wishes to retain their land, is whether the landholders have any other means improving the viability of their enterprises, or else whether they and their financiers are willing to wait 30 years for the returns from plantation development to turn-around their financial position.

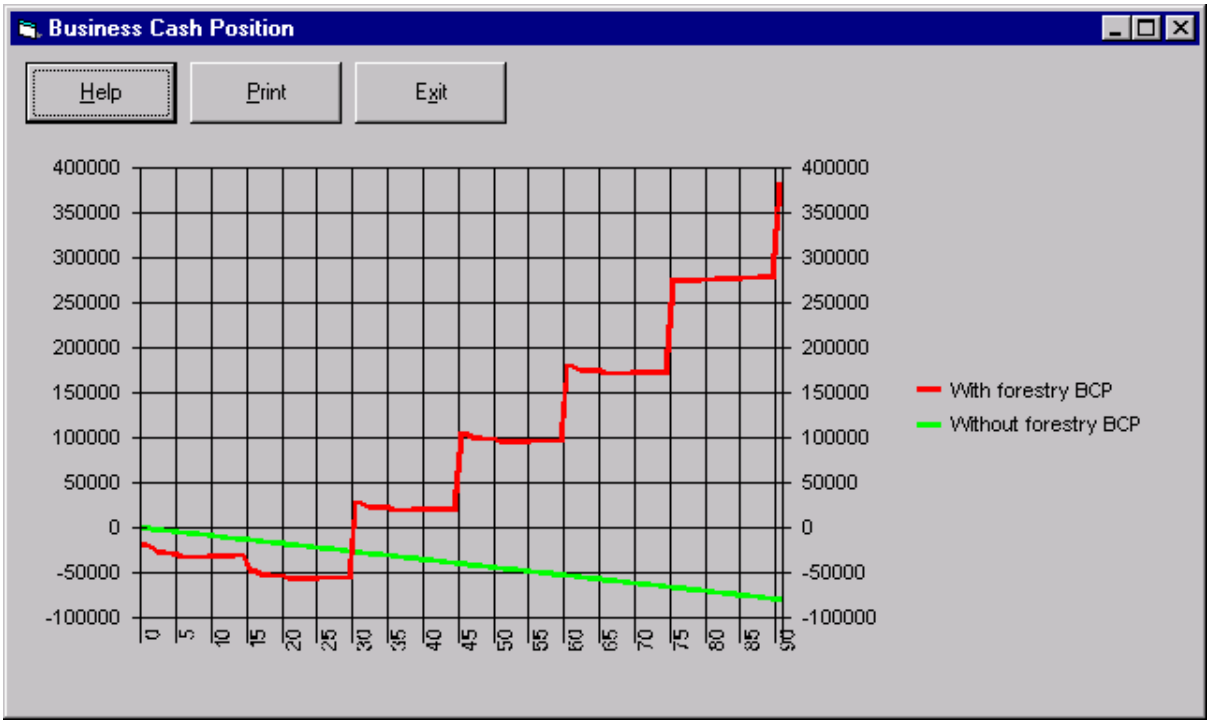


Figure 12.11 Graphical representation of the business cash position of the whole farm Scenario C in the Darling Downs

12.3 Discussion

The two case studies presented in this chapter illustrate some of the functions that are available in the AFFFM and some of the issues facing the development of farm forestry in the two regions. They are based on real-life farming situations. These case studies are not, however, meant to be representative of all the farming enterprises in these regions. The viability of the native forestry enterprise for the New England region contrasts with the plantation development scenario presented for the Darling Downs region. The difference is a reflection of the higher costs involved in establishing a plantation relative to establishing a native forestry enterprise, and the displacement of grazing activities and lack of early revenues for the Darling Downs plantation scenario.

These examples illustrate some of the key features of AFFFM which are designed to improve its usefulness to users including:

- the whole-farm nature of the model whereby forestry will displace some farming/grazing activities and this is reflected in the financial results displayed
- the ability to assess shelter effects and the effect of grazing under plantations
- the ability to stagger the timing of plantation establishment
- the automatic display of key financial parameters in tabular and graphical format
- the automatic display of with and without forestry scenarios.

Further exploration of the scenarios in these case studies using the AFFFM is possible. Some further scenarios that could be explored using the model include:

- use of plantation species suitability ratings for selected region-soil type combinations, which will automatically complete timber yield and harvest product tables
- exploration of potential effects of payments for environmental services such as carbon , biodiversity and salinity credits on financial returns
- exploration of markets for thinnings from the plantation to provide earlier revenue for the enterprise and the financial implications of value adding activities by the landholder
- exploration of the effects of loans and interest rates on financial returns
- examining the potential for leasing contracts or joint ventures with off-farm investors
- exploration of variations in returns to agriculture.

Ultimately the investor is in the best position to make an investment decision if the potential range of values for each of the costs and prices involved can be defined. The probability of reaching various levels of revenue can be calculated and reported, what is known as risk analysis of potential farm forestry development scenarios (Harrison et al. 2001). The AFFFM allows users to quickly develop, assess, save and retrieve scenarios to perform these tasks

12.4 References

Allworth, D. (2002) Forestry consultant and contractor. Toowoomba.

Clarke, M.R. (1997), *Beef cattle production on the Darling Downs*, Queensland Department of Primary Industries, Brisbane.

Cockfield, G.J. (in prep) *Farm forestry policy: from national gaols to catchment planning*. Thesis in preparation for a PhD through the Dept of Geography and Planning, University of Queensland.

Harrison, S.R., J.L. Herbohn and N.F. Emtage (2001) Estimating investment risk in small-scale plantations of rainforest cabinet timbers and eucalypts, chapter 5 in Harrison, S.R. and Herbohn, J.L. (eds.) *Sustainable Farm Forestry in the Tropics*. Cheltenham U.K., Edward Elgar, pp. 47-59.

State Forests NSW (1998), advisory forester, Armidale, personal communication.

Thompson, D. (1999), Agroforestry from existing timber resources on the Northern Tablelands, report to the RIRDC/LWRRDC/FWPRDC Joint Venture Program, Armidale.

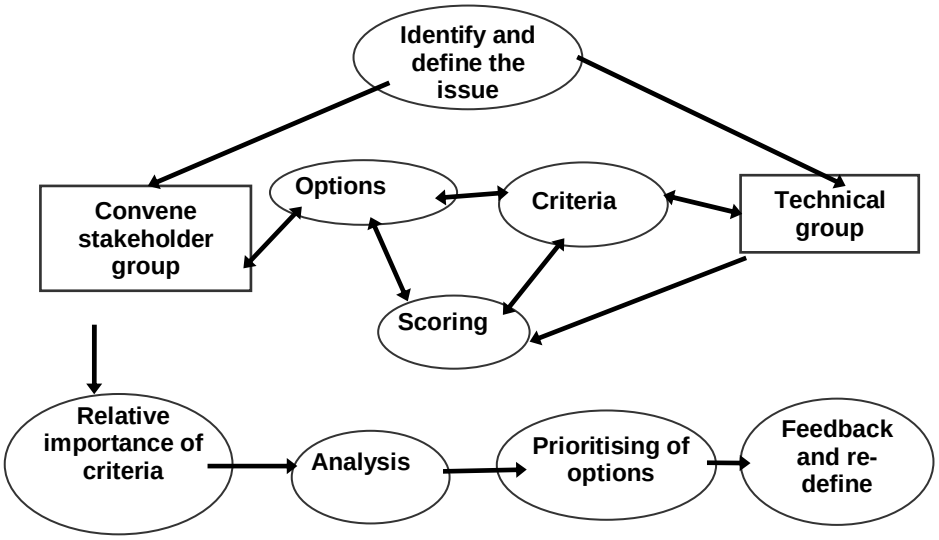
13. Principles and Methods for Developing a MODSS Process for Farm Forestry

I. Jeffreys and P. Lawrence

This chapter examines the application of a multi-objective decision-support system (MODSS) to farm forestry. A framework to aid and support decision-making in farm forestry and evaluate farm forestry options is proposed. This framework is developed from previous experiences of the authors and review of the relevant literature on MODSS, multi-criteria analysis (MCA) and community engagement and community participation. An example of a previous MODSS application and process is first described, before drawing on these and other sources to formulate a proposed process.

13.1 MODSS and MCA Applications in Natural Resource and Land-use Management

The processes of framing and analysing an issue using MODSS as described in Eisner *et al*. (2000) are as follows:



1. *Identify an issue or planning opportunity*. This should be an issue of direct relevance to stakeholders, one that does or will affect their lifestyle.
2. *Convene meetings of a Stakeholder Group and a Technical Reference Group*. The members of the stakeholder group would be persons who feel they are affected by the issue at hand. Care should be taken to be as inclusive as possible; extensive measures may be required to identify and include all interested stakeholders.
3. *Place the issue within a wider context*. Identify the factors that are relevant to address the issue.
4. *Stakeholders define options to be considered*. The definitions should include a detailed description of the properties of each option and possible interactions within the given context. Some technical input may be required in this process.
5. *Stakeholders define criteria against which the options will be evaluated*. Baselines are defined and possible data sources identified. Care should be taken to ensure the criteria are independent, using a series of ‘what if’ questions to gauge any interdependencies.
6. *Establish a technical reference.* This group considers and provides feedback on options and criteria.

7. *The options and criteria are placed into a table*. The way of formatting options and criteria is known as an *effects table*, and will be referred to in more detail later in this report. The technical reference group evaluates options against criteria. This process is also described as *scoring*, and the evaluations of options against criteria in the effects table are referred to as the scores. The effects table should be scored using all available data and information, e.g. data from models, statistical data, measured data (including spatial data) and expert opinion.
8. *Analysis the effects table*. The scores are analysed with the results presented to the stakeholder and technical reference groups for feedback and further considerations and discussions.

This process has been applied by the Queensland Department of Natural Resources and Mines (QNRM) in several resource planning projects. Two in particular have relevance to regional and whole-farm decision-making in farm forestry. The first is the application of MODSS to evaluate water infrastructure development options (dams and weirs) in the Burnett catchment in southern Queensland (Eisner *et al*. 2000). The Burnett catchment application followed the processes detailed above. In this study, stakeholder groups across industry, indigenous, environmental and agency interests, were convened and met extensively throughout the life of the project. The meetings engaged the stakeholders in the formulation of the decision criteria and provided feedback on the scoring of the options by the technical reference group. The technical reference group comprised mostly state agency staff with expertise in water resource engineering, planning, environmental, regional development and social science. The process of evaluating the options against the decision criteria, although arduous and at times technically complex, provided a high degree of transparency and opportunity for stakeholders to have input to the process.

The second QNRM application of this technique involved demonstrations with small groups involved in natural resource and land-use management. These were often local catchment management groups or Landcare groups. About 15 such demonstrations were given throughout southern and central Queensland. The process described in this section is drawn from experiences from many, although not all, of these workshops. The process of defining options and criteria was unchanged from the Burnett catchment application. Those attending the workshops completed the evaluation process. To complete an analysis in a half-day workshop, the number of criteria was limited normally to two or three for each perspective (economic considerations, environmental considerations, and social and cultural considerations). In the absence of technical input those present scored the effects table. Only crude scoring was undertaken, using categories of ‘good, average or bad’, or ‘high, medium or low’. This was represented on a three or five point scale. The highest score (three or five, respectively) was given to the best option, and the lowest score (one) to the worst, and the other options were assigned intermediate scores. Once the first set of scores was assigned, an initial analysis was performed. Those present evaluated the outcomes compared to their expected outcomes. Criteria were then added or removed, and importance orders and scores changed to reflect more closely the group’s expectations. This process is similar to action learning or experiential learning techniques (Dick 1997) or ‘learning by doing’ (Janssen 1991). The group defined scenarios, tested these scenarios and critically analysed their relative performance using the decision-support system. This process, especially when completed in a short workshop, did not produce definitive answers to given problems, but it increased and deepened the group’s understanding of the issues. When demonstrating decision-support system (DSS) tools to catchment management groups and Landcare groups, it was observed that ‘learning by doing’ was achievable within the time constraints and effective in communicating the benefits of decision-support tools for decision making.

Scenario development was omitted from the approach taken by Eisner *et al*. (2000), although this was largely due to the nature of the study. The focus placed on scenario development is one of the strengths about the analytical hierarchy process (AHP) as outlined by Saaty (1980). Saaty proposed the construction of hierarchies and networks, which break the components of the issues into clusters and sub-clusters and recognises the interactions between these clusters. This approach was also taken by Keeney (1988).

Janssen (1991) asserted the need for feedback in the development of MODSS analysis, at all stages of the development, recognizing that these processes aid robustness to the analysis and aid structuring of the MODSS. Janssen also asserted that MODSS should support the decision-making process by providing a single and integrated framework combining data management, simulation models, evaluation methods and sensitivity analysis. The process should also facilitate 'learning by doing' allowing the stakeholders to gain experience of how changing data and priorities affects the outcome, thus increasing their understanding of the problem and related issues.

13.2 An Expanded Process for MODSS in Farm Forestry

This section expands on the individual components as developed by Eisner *et al*. (2000) and discusses the application of a MODSS to farm forestry or other natural resource or land-use issues.

1. Identify the issues

When defining issues, the stakeholders should note that issues must arrive from somewhere and that they are a product of the socio-politic environment in which they exist. Eyestone (1978, p. 3) noted that '[an] issue arises when a public with a problem seeks or demands government action, and there is public disagreement over the best solution to the problem.' Issues arise due to a number of external factors including:

- economic forces (e.g. share market fluctuations, interest rates changes, employment and unemployment, business fortunes)
- media attention
- opinion polls
- legal shifts (court judgements)
- international relations (refugee arrivals, diplomatic representations over human rights issues, wars between other nations)
- technological development (e.g. the internet)
- demographic shifts (Bridgman and Davis 1998, pp. 32-33).

Specifically in the context of this study, issues arrive from environmental externalities and declining farmer incomes. Issues are not isolated events. 'They are mental constructs, abstractions from reality shaped by our values, perceptions and interests' (Bridgman and Davis 1998, p. 40). Issues should be identified from areas of pressing need, not just vocal advocacy. Issues should be relevant and of concern to the stakeholders. The process is unlikely to achieve a satisfactory outcome if it is seen as representing a government's agenda.

2. Identify stakeholders and convene stakeholder group

It is necessary to decide who are the stakeholders for a given issue. Prior to this, it is necessary to define a stakeholder. The definitions of stakeholders vary considerably from very constricted definitions to broad definitions. In a constricted view, stakeholders are defined as persons and groups that have a financial interest or have a contract with a given organization, those who directly influence an issue or organization, or those who are influenced by a decision. Other definitions include those with a 'legitimate interest' in a decision (Mitchell *et al.* 1997). This opinion is reflected in a group's legal standing to challenge planning decisions in court. In a recent case in the Supreme Court of Queensland (NQCC versus QPWS, 2000), the judgement afforded North Queensland Conservation Council leave to challenge a planning decision because they had shown special interest in the planning proposal, mentioning their opposition to this proposal, receiving state funding and had standing as a conservation organisation in the area. The World Bank defines stakeholders as those who are 'affected by the outcome – negatively or positively – or those who can affect the

outcome of a proposed intervention' (World Bank 1996). Although not articulating the nature of these effects, they specify that the poor and marginalised are often stakeholders directly affected by an activity. A broader definition of stakeholders includes all who self-define as having interest in the outcome of a planning process. Bridgman and Davis (1998, p. 74) asserted whilst identifying stakeholders 'there must be avenues for others to self-identify as parties to the consultation process.' A desire to seek and include the disadvantaged is also expressed by the Queensland Office of the Cabinet (1993 p. 11), which seeks 'to identify disadvantaged groups with an interest in the topic of the consultation and to ensure that such groups have the resources necessary to participate fully'. Given these statements, there is a risk that the disadvantaged and marginalised community members included in the stakeholder group will be marginalised within this group and the participatory process. It is important to avoid tokenism and ensure these members have meaningful input into the process. 'If participation of the poor and disadvantaged is to be effective, then it has to be on a basis which is independent of the control of not only government agencies but also the pre-existing power structure of local communities' (Adnan *et al.* 1992, p. 179). The stakeholder group may again be biased by time and resource limitations. Government and industry representatives will be paid by their respective organisations to participate in stakeholder meetings, while independent members of the community, including landholders, may not. Sitting fees may be a useful solution to this disparity.

When there is no definitive process for identifying stakeholders, the World Bank (1996) suggests the following questions may provide a guide.

- Who are the 'voiceless' for whom special efforts may have to be made?
- Who are the representatives of those likely to be affected?
- Who is responsible for what is intended?
- Who is likely to mobilize for or against what is intended?
- Who can make what is intended more effective through their participation or less effective by their non-participation or outright opposition?
- Who can contribute financial and technical resources?
- Whose behaviour has to change for the effort to succeed?

In the context of farm forestry in Queensland, Harrison and Qureshi (2000) identified a large number of potential stakeholders, noting that these could be divided into those affected financially or in terms of lifestyle, and those with an administrative involvement. Once identified, stakeholders need to be invited to join the stakeholder group.

3. Identify and convene technical experts and convene technical reference group

The technical reference group will advise on the science and knowledge required to quantify the impacts of the options against the decision criteria within the MODSS process. Depending on the scale, depth and perhaps most critically the budget of a study, this group's function could be supplemented by members of the stakeholder group. In larger studies, the technical reference group will need to possess the expertise to evaluate all of the options against the criteria. Given the diverse nature of natural resource and land-use management issues, the technical reference group will require expertise from a diverse range of disciplines. A typical study will include economic, environmental, social and cultural considerations. Expertise in all these areas will be required. It may be useful for the stakeholders to commence the problem definition before the technical reference group is assembled, to ensure the necessary coverage of broad expertise is achieved.

4. Identify goals and values

With regards to a given issue or planning opportunity, the goals and values of the stakeholders need to be identified. Because these aspirational goals are critical in defining what is to be achieved, the stakeholder analysis should attempt to address these issues at the commencement of decision-support modelling. Saaty (1980, p. 33) described all factors that influence decision-making as actors and states, referring to 'the environment actors, actor objectives, actor policies, and outcomes'. Problem definition can be aided by constructing hierarchies and networks. These reduce the issues into clusters and sub-clusters and recognise the interactions (Saaty 1980, pp. 11-16; Keeney 1988). Hierarchies can link the issue and the history of the issue and the objectives, goals and values of the stakeholders with criteria and possible solutions or options, alternatives or scenarios. Hierarchies will also aid in identifying and defining the options and criteria. This process can be carried out in a number of ways, such as developing questionnaires and conducting interviews, or convening workshops and focus groups where these issues are openly discussed and 'brainstormed'. Participants in such workshops should include both stakeholders and persons with technical knowledge.

All the MCA techniques discussed in Chapter 4 require discrete options and criteria to be developed. Once the initial work of defining the problem and issue in broad terms has been completed, the stakeholders and experts need to define the problem or issue in a format that can be analysed using MCA tools. The following steps provide a framework for developing options and criteria. The options and criteria then form the *effects table*, which serves as the foundation for the analysis.

The development of the effects table may be divided into a number of steps.

a. Define options

Stakeholders define the options to be considered. These must be feasible, and intended to fulfil the goals and objectives of the stakeholders. The options need to be clearly and extensively defined. Such definitions should include a detailed description of the properties of each option and their possible interactions within the given context. Technical input may be required in this process; however, this should be limited to advice rather than influence. It is crucial for the implementation of the preferred option that the stakeholders and community have ownership of the options.

b. Define criteria

The decision criteria are an abstraction of the values and goals of the stakeholders. They are the measures against which an option will be evaluated to ascertain whether it fulfils these goals and objectives. Like the options, the criteria need to be clearly defined, and baselines need to be established and defined. All parties to the process need to be clear about what the criteria represent (across time, space and function) and about the goals and objectives from which they are derived. This step is vital if new options or composites of existing options are to be included later in the MODSS process.

c. Obtain feedback on options and criteria

The technical reference group should consider the options and criteria defined by the stakeholder group, and provide feedback on these. This feedback should be general in its nature, principally as a feasibility assessment on the ability of the options to satisfy the issue under consideration rather than an extensive evaluation. The technical reference group should consider the relevance of criteria and the ability of the criteria to discern differences in the options. For example, a criterion that receives the same score for each option provides no additional information to the analysis and therefore can be removed. In addition, care should be taken to ensure the criteria are independent. Keeney and Raffia (1976, pp. 299-301) proposed a simple test which takes the form of a set of 'what if'

questions asked of the decision-maker or technical reference group: If the score for Criterion 1 is X what would the score for Criterion n be? If the score for Criterion 2 is Y what would the score for Criterion n be? If the decision-maker indicates a change in score for a given criterion relative to another, then the criteria are not independent. Keeney and Raffia assert that the decision-maker is likely to express any possible interactions before every possible question has been asked. Related criteria can be removed or combined. If possible, the technical reference group should seek feedback from the stakeholders before removing or changing criteria.

To aid the stakeholders define the options for the analysis, it has proved useful to incrementally build the analysis, and construct the problem in the MODSS framework of options and criteria. The basis of the MODSS/MCA process is evaluating options against criteria in the effects table. Most people would be familiar with an effects table or matrix as a structured approach to selecting a preferred item from a range of choices. An application of an effects table for selecting videotapes is presented in Appendix 13.1.

The first iteration may consist of a simple example using a limited number of criteria. Initially, three criteria could be selected to reflect the economic, social and environmental perspectives in natural resource and land-use management. Being an iterative process, the numbers of decision criteria tends to grow rapidly to accommodate the complexity of the issue. However, this exercise serves three purposes. First, it allows the stakeholders to explore and gain a better understanding of the issue in question. Second, it aids familiarity with the MODSS and MCA process, and the opportunities to explore what-if scenarios. Third, and perhaps most importantly, the effects table places a boundary of reference for the decision-support process.

5. Technical reference group evaluates options against criteria

Using all available data sources, the technical reference group evaluates the effects table. When using technical expert panels and expert opinion, the analyst should restate scores using logical statements about the relativities of the scores. The analyst may choose statements regarding the relative performance of options for a given criterion, for example, Option 2 outperforms Option 3. Alternatively, the rank order of performance, for example, Option 2 performs highest, the next highest is Option 3, then Option 1, and so on. This questions the experts' assumptions and can aid the development of a robust and defensible set of scores. The analyst should present initial results to the technical reference panel as soon as they are available. With the currently available tools this can be done during the workshop session in which effects table is developed. The technical reference group can then consider the analysis of the effects table and changes can be made. This process of responding and providing quick feedback is similar to that in the selection phase suggested by Janssen (1991).

6. Proposed process for analysis of the options

In the next step of the process, the analyst using a number of the MODSS and MCA tools evaluates the options considering the criteria defined by the stakeholders and scored by the technical reference panel, given the relative importance of the criteria assigned by the stakeholders. There are many methods available for such an analysis, a number of which were outlined in Chapter 4. The analysis can be split into two separate processes. First, relative weights are placed on the criteria. This recognises that some of the decision criteria are more important to the stakeholders than others, and should attract greater weights in the analysis. Second, the scores that the options receive against each criterion judging their performance against that criterion (the effects table) need to be aggregated. That is, the scores need to be combined to create an overall score for each option. The rank order centroid (ROC) technique (Edwards and Barron 1994) can be used to assign weights to the criteria given a statement of rank order importance elicited from the stakeholders. The ROC technique was chosen for this study because it is easy to elicit the rank orders from the stakeholders and the ROC technique has a strong theoretical basis (Edwards and Barron 1994). Two aggregation methods were

used, namely the weighted summation technique (Janseen 1991; Yakowitz *et al*. 1997) and the Electre II technique (Roy 1991). These aggregation techniques are highly complementary and together provide a rounded analysis. The weighted summation technique provides a sound measure of the overall performance, is logically simple and easily gains the acceptance of stakeholders. It is a compensatory aggregation method; that is, poor performance in any one criterion can be compensated by overall good performance in the other criteria. Electre II is a non-compensatory aggregation method; that is, poor performance in any one criterion will be reflected in the overall performance of the option. Electre II is a complicated method and is not easily communicated or understood by non-specialists. Consequently, the method has not received wide application in practical natural resource management issues outside of theoretical studies. Appendix 13.2 provides details of these techniques.

7. Presentation of the analysis results and obtaining feedback from stakeholders and the technical reference group

The analyst presents the results to the stakeholders and technical reference panel. Further iterations (as suggested by Janssen, 1991) can be conducted in response to the suggestions and feedback from the stakeholders. As this discussion is ideally a joint meeting of stakeholder and the technical reference panel, changes can be made immediately, and a number of further iterations can be made. Notwithstanding the earlier investment of time, it may be necessary to revisit the assumptions on which the problem is based in order to clarify the outcomes from the analysis, particularly if some results are contentious. Depending on the outcomes, it may be necessary to commence a further iteration of the process and apply the principles of adaptive management.

13.3 Summary

This chapter has drawn on previous MODSS experiences and applications to formulate a practical, yet structured approach when implementing a MODSS process to farm forestry decision-support. This process accommodates an integrated, multi-factor approach for assessing farm forestry options including economic, environmental and social considerations. The process merges the inputs and requirements from stakeholders, including landholders, the forestry industry, local and state government, with the best available scientific knowledge on forestry practices in Queensland.

13.4 References

Adnan, S., Alam A., Nural, S.M. and. Brustnow, A. (1992), *People's Participation, NGOs and the Flood Action Plan,* Research and Advisory Services, Dhaka.

Australian Consumers' Association, (2001), *Video Tapes – Performance Results*, CHOICE Online, Marrickville, http://www.choice.com.au/articles/a102716p5.htm, accessed 24 Feb. 02.

Barron, F. and Barrett, B. (1996), 'Decision quality using ranked attribute weights*, Management Science*, 42(11): 1515-1523.

Bridgman, P. and Davis, G. (1998), *Australian Policy Handbook,* Allen and Unwin, St Leonards.

Dick, B. (1997), *Action Learning and Action Research* [On line] http://www.scu.edu.au/schools/gcm/ar/arp/actlearn.html accessed 26 Feb. 02.

Edwards, W. and Barron, F.H. (1994), 'SMARTS and SMARTER: improved simple methods for multiattribute utility measurement', *Organizational Behavior and Human Decision Processes*, 60: 306-325.

Eisner, R., Lawrence, P. and. Jeffreys, I. (2000), *Use of MODSS (Multi-Objective Decision Support System) in the Burnett River Catchment Study*, Project report, Department of Natural Resources, Indooroopilly.

Eyestone, R. (1978), *From Social Issues to Public Policy*, Wiley, New York.

Goicoechea, A., Hansen, R. and Duckstein, L. (1982), *Multiobjective Decision Analysis with Engineering and Business Applications*, Wiley, New York.

Harrison, S.R. and Qureshi, M.E. (2000), 'Choice of Stakeholder Groups and Members in Multicriteria Decision Models', *Natural Resources Forum*, 24(1): 11-19.
Janssen, R. (1991), *Multiobjective Decision Support for Environmental Management*, Kluwer Academic Publishers, Dordrecht.
Janssen, R., van Herwijnen, M. and Beinat, E. (2001), *DEFINITE (Version 2) Decision Support System for a FINITE Set of Alternatives*, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.
Keeney, R. and Raffia, H. (1976), *Decisions with Multiple Objectives*, Cambridge University Press, Cambridge.
Keeney, R. (1988), 'Structuring objectives for problems of public interest', *Operations Research*, 36(3): 396-405.
Mitchell, R., Agle, B. and Wood, D. (1997), 'Towards a theory of stakeholder identification and salience: defining the principle of who and what really counts', *Academy of Management Review*, 22(4): 853-887.
Nijkamp, P., Reitveld, P. and Voogd, H. (1990), *Multicriteria Evaluation in Physical Planning*, North Holland Publishing, Amsterdam.
North Queensland Conservation Council Inc v Executive Director, Queensland Parks and Wildlife Service, (2000), *QSC 172*, Supreme Court of Queensland, Brisbane.
Office of the Cabinet, (1993), *Consultation: A Resource Document for the Queensland Public Sector*, GoPrint, Brisbane.
Roy B. (1991), 'The outranking approach and the foundations of ELECTRÉ methods', *Theory and Decision*, 31(1): 49-73.
Saaty, T. (1980), *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, McGraw-Hill, New York.
Simpson, L. (1996), 'Do decision makers know what they prefer?: MAVT and ELECTRE II', *The Journal of the Operational Research Society*, 47(7): 919-929.
Winterfeldt, D., von and Edwards W. (1986), *Decision Analysis and Behaviour Research*, Cambridge University Press, Cambridge.
The World Bank, (1996), *The World Bank Participation Sourcebook*, http://www.worldbank.org/wbi/sourcebook/sbpdf.htm.
Yakowitz, D., Wedwick, S. and Weltz, M. (1997), 'Computing multiple attribute value function ranges under a hierarchy of attributes with application to environmental decision making', *Proc. IEEE International Conference on Systems*, Management and Cybernetics, Orlando, pp. 323-328.

Appendix 13.1: A simple example of a multi-criteria analysis and effects table

A simple example of a multi-criteria analysis is presented in Table 13.A1. This example is adapted for an article on the website of the Australian Consumer Magazine, *Choice* (Australian Consumers' Association, 2001), in which various brands and models of videotapes available in Australia are evaluated against two criteria namely, performance and price. Price is expressed as the cost per videotape (as at September 2001). The performance criterion is an aggregation of two sub-criteria, namely, initial picture quality and long-term picture quality. These criteria were not considered to be equally important and a different weight was applied to each. For this example, picture quality received 70% of the weight and long-term quality 30%. The overall score has been calculated accordingly, i.e.

Overall score **(Initial picture quality × 0.7) + (Long-term picture quality × 0.3)**

Following this calculation, the videotapes were sorted in order of their overall performance, where high scores indicate high performance. The effects table of videotape brand (listed as rows) and the performance scores (as columns) is shown in Table 13.A1.

Table 13.A1 Videotape performance effects table

Brand and model	Performance			Price ($)
	Overall score (%)	Initial picture quality score (%)	Long-term picture quality score (%)	
TEAC X2 VHS E-180	71	70	73	3.95
ACME E-180 High Grade	68	74	53	2.79
JVC E-180SX	65	70	52	2.87
AKAI HQ E-180	63	70	47	2.99
HANIMEX E-180 High Grade	60	66	45	3.99
TDK SC-180	59	64	48	2.95
YAMANA SG Super Grade E-180	59	60	55	3.20
PALSONIC E180 VHS	58	68	35	2.99
BASF EQ-180 (A)	55	67	26	5.95
BASF SQ E-180	55	68	26	4.95
TEAC ASX E-180	55	60	42	3.95
SONY Super DX-E180	53	60	35	4.95
PANASONIC NV-E180PRA Premium	52	56	42	3.25
FUJI AG E-180 PAL/Secam	51	60	29	4.99
EXCEL Gold E-180 SGX Super Grade	45	52	29	3.20
MAXELL E-180GX Power Tape	42	46	34	3.99

Criteria descriptions

As in all examples, the criteria need to be clearly defined. This aids the evaluation process and allows further options to be added to the analysis and evaluated against the same baselines.

Picture quality

Prior to testing, the tapes were preconditioned for 24 hours at 23°C and 45% humidity. The tapes were rewound to even out stresses that may have occurred during shipping and storage. Tapes were used to record once only and then replayed, so the results do not necessarily reflect typical circumstances, where a tape is over-recorded and played several times. However, if the initial quality is low, it is unlikely to improve with use. Samples from more than one batch number were tested for each brand. The score shown in the table is the averaged result for the brand.

Picture quality takes into account the following measures:

- Dropout is when there is a momentary loss of signal (picture). On new tapes this is due to contamination or missing magnetic material (the coating may not be even or complete). The annoyance caused by dropouts depends on their duration and frequency. More than 100 detectable dropouts per minute would be practically unwatchable.
- Radio frequency – measured frequencies and strength and uniformity of the video signal.
- Signal to noise ratio is an indication of how much the maximum output signal exceeds the background ‘noise’. It is a measure of how much graininess, random specks or shifts in colour will appear in the picture.
- Frequency response tests indicate how well tapes record colour and details, such as finely divided black and white patterns.

Long-term score

Tapes were artificially aged to simulate five to 10 years of storage in a tropical climate, and underwent the same picture quality tests as at the initial stage. Signal-to-noise ratio and frequency response are not affected over time to the same extent as dropout and radio frequency, so only the latter two aspects were scored.

The scores for this test were not weighted as heavily as initial picture quality in the overall results because:

- the test was extreme, replicating use in a tropical or sub-tropical climate
- most people would not use standard-quality tapes for recording something they want to keep long-term.

Tests simulating storage of only two to five years showed little difference from the initial results.

Appendix 13.2: Detailed descriptions of weighting and aggregation techniques

This appendix presents a detailed description of the mathematics behind the MCA techniques used in this study. The techniques described are the Rank order centroid (ROC) weighting technique, the weighted summation aggregation technique and the Electre II aggregation technique. These MCA techniques are those proposed in Section 13.2 point 6 in this report.

Rank order centroid weighted technique

This technique is the same as the weighting technique used in the SMARTER (Edwards and Barron 1994) and the expected value method (Nijkamp *et al*. 1990). The technique assigns weights to the individual criteria according to a statement of importance or rank. These are usually in the form 'Criterion 1 is more important than Criterion 2, which is more important than Criterion 3' and so on, $Cr1 \geq Cr2 \geq Cr3 \ldots \geq Cr_n$. Given these statements a set of feasible weights can be defined, as well as a feasible area and a probability density function for all the feasible weights. For a simple case $Cr1 \geq Cr2 \geq Cr3$ there will be a triangular feasible area, which can be plotted in three dimensions, with the corner points at (0,0,1), (0,1,1) and (1,1,1). From this the probability distribution function of feasible weights can be defined. Changing the number of criteria will change the shape of the probability density function of the feasible weight set. These sets and distributions are the bases for this method. The rank order centroid (ROC) as used in the SMARTER technique (Edwards and Barron 1994) uses the centroid point of the probability density function as the weight for the criteria. The Expected Value Method (Nijkamp *et al.* 1990) as used in Definite (Janssen 1991 and Janssen *et al.* 2001) also uses the centroid value; the centroid value is also the most probable or expected value.

To convert the rank order into a set of ordinal weights there is a simple algorithm this is described by Edwards and Barron (1994). Given that in our simple example $Cr1 \geq Cr2 \geq Cr3$, the weight assigned to each criteria would follow a similar rule $w1 \geq w2 \geq w3$, were w1 is the possible weight applied to criterion 1 etc.

If $Cr_1 \geq Cr_2 \geq \ldots \geq Cr_n$

then $w_1 \geq w_2 \geq \ldots \geq w_n$

If k is the number of criteria

then
$$w_1 = (1+1/2+1/3+ \ldots +1/k)/k$$
$$w_2 = (0+1/2+1/3+ \ldots +1/k)/k$$
$$w_3 = (0+0+1/3+ \ldots +1/k)/k$$
$$w_k = (0+ \ldots +0+1/k)/k$$

More generally

$$w_k = (1/K) \sum_{I=k}^{K} (1/i) \qquad \textbf{(13.1)}$$

Table 13.A2, adapted from Edwards and Barron (1994), contains the weights calculated from Equation13.1, for a given number of criteria (2 to 9).

Table 13.A2 ROC weights for indicated number of criteria

Rank	Number of criteria							
	2	3	4	5	6	7	8	9
1	0.7500	0.6111	0.5208	0.4567	0.4083	0.3704	0.3397	0.3143
2	0.2500	0.2778	0.2708	0.2567	0.2417	0.2276	0.2147	0.2032
3		0.1111	0.1458	0.1567	0.1583	0.01561	0.1522	0.1477
4			0.0625	0.0900	0.1028	0.1085	0.1106	0.1106
5				0.0400	0.0611	0.0728	0.0793	0.0828
6					0.0278	0.0442	0.0543	0.0606
7						0.0204	0.0335	0.0421
8							0.0156	0.0262
9								0.0123

When two or more criteria are considered equally important, that is they have tied ranks, the weight given to each criterion is the average weight for the tied ranks. For example if $Cr_1 \geq Cr_2 = Cr_3$, that is Criterion 1 is more important than Criterion 2, which is equally important to Criterion 3. The weights would be assigned as follows.

$$Cr_1 = w_1 = 0.6111$$
$$Cr_2 = (w_2 + w_3)/2 = (0.2778+0.1111)/2 = 0.1945$$
$$Cr_3 = (w_2 + w_3)/2 = (0.2778+0.1111)/2 = 0.1945$$

Weighted summation aggregation technique

This is the simplest and most commonly used aggregation technique (Janssen 1991,Yakowitz *et al.* 1997); it is also described as the Multiattribute value (MAV) model (Barron and Barrett 1996). The value attributed to an option is the sum of the value the option receives for each criterion multiplied by the weight given to that criterion. The weighting of the criteria is derived from the weighting technique chosen by the decision-maker or embedded in the tool being used. The weighted summation it is one of many Multi-Attribute Utility Models (see Keeney and Raffia 1976), and whilst other models have a stronger theoretical basis they are rarely used being complicated and time consuming to calculate (Winterfeldt and Edwards 1986). However, with current computer technology and integrated MODSS software, time constraints and complicated algorithms are no longer an issue with regards to ease of analysis.

The additive value function (the weighted summation) takes the form:

$$V(w,v) = \Sigma_i \, w_i \, v_i \qquad \textbf{(13.2)}$$

where V = the weighted value or overall score for a given option
w_i = the weight for a given criterion i
v_i = the value or score for criterion i for a given option

This method is described as a compensatory method – i.e. poor performance is a criterion in compensated for overall good performance in the other criteria – and this is not always desirable. The weighted summation is a sound and mathematically simple measure of the overall performance of the options.

Electre II aggregation technique

The Electre technique (*El*imination *e*t *c*hoix *t*raduisant la *ré*alité or Elimination and choice corresponding to reality) (Roy 1991) is a non-compensatory aggregation method, that is poor performance in any one criterion will be reflected in the overall performance of the option. This makes this technique an ideal check against which to compare the results from the weighted summation technique. If the results are the same it can be assumed that the option has no critically poor performing criteria. If there is difference in the results the analyst should identify the poor performing criteria by looking at the raw data. Poor performance in an important criterion may be a fatal flaw in that option.

There are five versions of Electre being Electre I, II, III, IV and TRI. Electre I is designed for selection problems, Electre TRI for assignment problems and Electre II, III and IV for ranking problems. As this project focuses on assessing the relative performance of forestry options compared to current practice, it is appropriate to use Electre II, III or IV. However, the decision-support software application used in this study (*Definite*) uses the Electre II method; the analyses reported in the following chapters have been completed using the Electre II method. Therefore only Electre II will be described in detail, and comments made on the variations between the versions.

The following summary of the Electre II aggregation method is drawn from the detailed description provided by Goicoechea *et al.* (1982, pp. 197-214), Roy (1991) and Simpson (1996).

The first step in the Electre II method is to establish a complete rank order of the options using a number of tests. The first three of these are the indifference test, the preference test and the veto test. These are evaluated between two options for each of the criteria. These tests are now outlined.

1. The indifference test is designed for testing that Option A is indifferent to another Option B (notation *A**I**B*) for a given criterion. This allows for options with a small variation in score to be considered equal. An example could be the difference with a cup of tea with 1 gram of sugar and a cup of tea with1.1 grams of sugar. Numerically there is a difference but in opinion of the tea drinker there may be no difference. In Electre II the decision-maker sets the indifference measure q for each criteria. In our example q may equal 0.5 grams of sugar.

$$A\mathbf{I}B \;\; if \;\; | a_j - b_j | \leq q_j \qquad \textbf{(13.3)}$$

   where a_j is the performance (the score it receives in the effects table) of option A on criterion j, b_j is the performance of Option B on criterion j, and q_j the indifference measure. The indifference measure will be different depending on the score range of the criteria. In this study all the criteria are scored between 1 and 10, therefore the indifference thresholds will be set at the same level.

2. The preference test evaluates whether an Option A is preferred to another Option B (notation *A**P**B*), that is Option A outperforms or outranks Option B. This determines a strong or strict preference for Option A; that is, the score received by option A for criterion *j* is considerably better than that for option B. The preference threshold p_j is the level at which the decision-maker considers Option A to strongly outperform Option B.

$$A\mathbf{P}B \;\; if \;\; a_j > b_j + p_j \qquad \textbf{(13.4)}$$

where a_j is the performance of option *A* on criterion *j*, b_j is the performance of option B on criterion *j*, and p_j is the strong preference threshold. This test is applied to all the criteria and the results from all the criteria are considered further in the analysis.

3. The veto test evaluates whether an Option B is not preferred to another Option A; that is, the score received by option B for criterion *j* is considerably worse than that for option A (notation *B**P**A*). The Veto level v_j is the level at which Option B is not preferred to Option A. for any criterion. If the option B performs at a level that is lower than the performance of option A by greater than the Veto level for any criterion, Option B is always not preferred to Option A, regardless of the scores in the other criteria.

$$B\mathbf{P}A \;\; if \;\; a_j + v_j < b_j \qquad \textbf{(13.5)}$$

where a_j is the performance of option *A* on criterion *j*, b_j is the performance of option B on criterion *j*, and v_j is the veto measure. This test is applied to all the criteria. Failing this test in one criterion will result in Option B always being considered not preferred to Option A.

The performance of a set of two options for each criterion can be assigned. This can be categorised into four groups. The first is indifferent ***I*** group, the comparisons that fulfil equation 13.3, the second the strongly preferred ***P*** group, the comparisons that fulfil equation 13.4 or equation 13.5. The third group ***Q*** is a group of weak preference all those that fall between the indifferent set and the strong preference set. A fourth group ***R*** is created from the residual – those that failed all of the above tests – and these are deemed to be incomparable.

Using these threshold tests and the subsequent group Electre method builds an outranking relationship ***S***, for each criterion. This group (notation aS_jb) is the set for each criterion where option A is at least as good as Option B. therefore for criterion j:

$$aS_jb\text{: A is at least as good as B on criterion j if } \; a_j \leq b_j - q_j$$

$$\{aS_jb\} = \{aP_jb\} \; U \; \{aQ_jb\} \; U \{aI_jb\}$$

Using the groups *S*, *P*, and *Q*, Electre specifies values know as the concordance and discordance coefficients. The concordance coefficient is a measure of the strength of the argument *A is at least as good as B*, ***c(A,B)***. The discordance coefficient is the strength of the argument against; that is *A is not as good as B*, ***d(A,B)***. In many examples the criteria do not carry equal weight. As in this study some criteria are deemed to be of greater importance than others, weights are applied to each criterion using

the ROC method (described earlier in this appendix). These weights are included in defining the Concordance and Discordance indices.

$$c(A,B) = \Sigma P (w_j) / \Sigma (w_j)$$

Using ROC weighting method $\Sigma (w_j) = 1$, so, in this example

$$c(A,B) = \Sigma P (w_j)$$

The next stage of the Electre II technique requires the decision-maker to set concordance and discordance thresholds. The level of the concordance threshold c^* and the discordance threshold d^* are set according to the aims of the analysis. High levels are likely to filter out all but the better performing options, while lower levels will identify acceptable and unacceptable groups of options. The levels used in this analysis are the default levels in the decision-support tool, Definite, as described by Janssen *et al*. (2001).

The following decision rules are applied to the pairwise comparison of all the options against each other.

A outranks B if $c(A,B) \geq c^*$ *and* $d(A,B) \leq d^*$

A outranks B if $c(A,B) > c^*$ *and* $c(B,A) \geq c^*$ *and* $d(B,A) \leq d^*$

A and B are incomparable if

$c(A,B) \geq c^*$ *and* $d(A,B) > d^*$ *or*
$c(A,B) > c^*$ *and* $c(B,A) < c^*$ *or*
$c(A,B) \leq c^*$ *and* $c(B,A) < c^*$ *and* $d(B,A) < d^*$

Statements of outranking can be drawn from the outcomes of the decision rules. The statements of outranking can then be interpreted as an ordinal ranking of the options. Options that are incomparable or outrank the same group of options should be given equal ranking. These ranks can be displayed as lists of position or as histograms.

14. Adaptation of the MODSS Framework for Agroforestry Decision-Support in South-east Queensland

I. Jeffreys and G. Cockfield

This chapter outlines the MODSS process as applied in the south-east Queensland pilot study and Hodgson Creek case study. The process applied differs considerably from that proposed in Chapter 13 due to a number of reasons, but particularly limitations in access to key stakeholder groups and technical experts. The SEQ region comprises the area from Noosa in the north to the NSW border and west to Toowoomba shire. The SEQ study was designed as a pilot study to test the general applicability of the MODSS process for the evaluation of farm forestry options. Whilst no specific area was defined in the SEQ study, the participants were asked to consider an area in the medium rainfall zone, with broadacre agriculture as the dominant land-use. As the outcome of this study looked promising, the process was repeated in the Hodgson Creek sub-catchment. The generic south-east Queensland study was used as a starting point for the development of the Hodgson Creek study. The Hodgson Creek sub-catchment is situated in the eastern Darling Downs, which lies south-west of Toowoomba and is split between the shires of Pittsworth and Cambooya.

14.1 The Issue to be Addressed

The issue for the MODSS analysis in this study was defined in the original project brief. This issue statement is common to all the sections of the report:

> To address the uncertainty regarding the suitability, sustainability and profitability of alternative forestry options in relation to agricultural enterprise in different farm systems.

The scale of the application of the MODSS process was a major influence in the redefining of the issue. The MODSS was applied at the sub-catchment, this scale being deemed appropriate because concerns were raised regarding the practicability of developing an effects table for an individual farm. Concerns were also raised at landholder non-acceptance of the MODSS methods, especially eliciting criteria weights in the form of rank order preferences. Therefore the issue with regards to the MODSS analysis was redefined as:

> To address the uncertainty regarding the suitability, sustainability and profitability of alternative forestry options in relation to regional agricultural systems.

The target audience changed with the changing issue statement. The target audience of this analysis is no longer landholders, and is now catchment management organisations, Landcare groups, and local and state government policy and extension officers.

14.2 The Iterative Development of the South-east Queensland Study

Development of the MODSS is an iterative process. Simple analyses are defined in workshop settings with stakeholder and technical experts, and are subsequently developed into complex analyses with stakeholder-defined and expert-evaluated farm forestry options and criteria. This process promotes stakeholder ownership of the options, which will aid the future implementation of the options by the stakeholders. This supports a learning process, whereby the stakeholders gain deeper insight into the issues and problems and the pros and the cons of any proposed farm forestry plantings in south-east Queensland. This process aids the development of a comprehensive and robust analysis.

Due to the limited access to stakeholders, it was decided to hold a single one-day workshop of which the MODSS work was only a one section. This limitation was set because it was the opinion for the project management team that landholders were unlikely to attend more than a one-day workshop, especially as the project deals with hypothetical forestry options only. With this limitation, the process was adjusted to gain the maximum benefit from available contact with the landholders in Hodgson Creek.

The process was limited to two iterations. First, an initial analysis general to south-east Queensland was developed with the technical reference group; this included input from previous studies, regarding feasible forestry options and evaluation criteria, and the stakeholder survey (as described in Chapter 5). This analysis was presented at the stakeholder workshop. Feedback on the options and criteria were sought. The rank order preference of criteria was elicited from the stakeholders. The revised options and criteria were re-evaluated by the technical reference group. The composition of the group was changed for the second part of the study to include persons with specific knowledge of Hodgson Creek catchment.

14.3 Stakeholder and Technical Reference Groups

For the SEQ analysis, members identified for the technical reference group included experts with specific knowledge of farm forestry and farm management. These members were drawn from the Queensland Forest Research Institute (QFRI), the QDPI and an independent rural management consultancy firm. This group provided input into the first general south-east Queensland MODSS analysis. This group met once in a workshop held in December 2000, in Brisbane. In the following three months the members were individually interviewed to gain further input.

The various stakeholders in the Hodgson Creek area were identified. The group attending the stakeholder workshop comprised landholders in the Hodgson Creek catchment, representatives of the local Landcare group, local forestry industry representatives, officers from the Pittsworth shire council, and extension staff from the Queensland Department of Natural Resources and Mines (QNRM) and the Queensland Department of Primary Industries (QDPI). The workshop was held in March 2001 at the Felton hall, Felton, Queensland, located centrally within the Hodgson Creek catchment.

Members of the technical reference group were identified for the Hodgson Creek case study, based on their specific knowledge of the study area. Members of this group were drawn from the QDPI, the QNRM, and the Department of Economics and Resources Management of the University of Southern Queensland. Other invited groups, which did not provide members, included the local peak environmental group, the Queensland Parks and Wildlife Service and the Eastern Downs Regional Organisation of Councils. Two one-day focus group meetings were held in June 2001, in Toowoomba. In these two workshops, the technical reference group evaluated the options in the Hodgson Creek study.

14.4 Problem Definition

In the initial stage of the process involving farm forestry experts in SEQ, a generic initial analysis was chosen because at the time of the first MODSS analysis a number of sites were under consideration. The options were developed given the preferences of stakeholders inferred from the landholder survey (as discussed in Chapter 5) and refined by the technical reference group. The criteria were drawn from previous MODSS analyses, the landholder survey and the consensus opinion of the technical reference group. The options and criteria were discussed and refined in a focus group meeting involving the technical reference group and the project team. In the subsequent interviews with the group members, the options and criteria were developed further, and the wider implications of the options including their impacts on the local environment as well as other factors that affect the options were discussed. Criteria hierarchies were constructed, and the criteria were

placed in three groups, relevant to the economic, environmental and social perspectives. These were further separated into sub-groups representing a specific aspect of these broader perspectives. In these initial analyses, all the criteria were taken to be of equal importance, because there was currently no specific information with regards to the preferences of the stakeholders. The technical reference group members then individually evaluated this refined set of criteria.

The farm forestry options developed in the SEQ study were evaluated against the criteria, the results were summarised and presented at the stakeholder workshop for the Hodgson Creek study. In light of the feedback received, some options were substantially changed, while others were removed and new options added. A similar process occurred with the decision criteria. There were many additions to the criteria, the number increasing from 28 in the first analysis to 41 in the second. Given the feedback from the stakeholder workshop, the options and criteria were redefined for the Hodgson Creek study.

In defining the problem, the stakeholders also defined the relative importance of the criteria. A number of methods could have been used to elicit these weights, each with their relative strengths and weaknesses. In this analysis the Rank Order Centroid method was used, in which the stakeholders were asked to rank the criteria in order of importance. High-ranking criteria were considered of high importance, that is, having a greater impact on stakeholder decision-making than the lower-ranking criteria.

14.5 Evaluation Methods in South-east Queensland and Hodgson Creek

In the first MODSS analysis involving experts in farm forestry in SEQ, the options were evaluated using the expert opinion of the members of the technical reference group. The options and criteria were refined in the workshop from the initial options developed from the output of the stakeholder survey. No specific timescale was presented in the SEQ analysis. However, some impacts of some criteria were dependent on the timescale at which they were considered. Subsequently, the Hodgson Creek analysis was considered at two timescales. The effects table was scored in a series of interviews with individual members of the technical reference group. This produced four separate effects tables – one of each group member. Each member scored only the criteria they considered to be within their area of expertise, and not the whole effects table. Each criterion was scored by at least three of the experts. The scores were then aggregated to produce a single unified effects table. The process of aggregation involved several steps.

During the evaluation the experts were requested to quantify the confidence in their evaluations with regard to their level of expertise in the area of concern for each criterion. This self-assessment of expertise and the evaluation of the options against the criteria were used to aggregate the scores. The score chosen in the aggregate effects table was intended to represent the dominant view on this criterion. A Pearson's correlation analysis was preformed comparing the scores for a given criteria. Pairwise comparisons were undertaken for each possible combination of criteria, resulting in an r-value (the measure of similar patterns in the scores) for each combination of pairs of criteria. As a rough rule of thumb, r-values between criteria of greater than 0.7 were interpreted as representing a similar opinion in the scores of the criteria. These correlated criteria were averaged and their combined score was used in the final analysis. In the few cases where there was high divergence in opinion, the scores from the expert who ranked their confidence most highly were used.

In the second round, the Hodgson Creek technical experts with specific knowledge of the Hodgson Creek catchment scored the options and criteria. The effects table was scored by two focus groups. These tasks were facilitated by two members of the project team, who both expertise and experience in the development and history of the options being evaluated and the process of evaluating options in this manner. As performance of the options against many of the criteria over time was identified, this analysis was evaluated over two timescales. The group members defined the

first as the transitional period, i.e. the period during which a farm forestry industry is being developed in the catchment. This was also defined as the cost period, extending from year 0 to 10. The second time period was defined as the steady-state or equilibrium period. This is the period when a forestry industry has been developed in the catchment, plantings have matured and a rotation of felling and replanting has been established, from about year 30 or 40 onwards. It was assumed that further plantings would occur although not necessarily in the same areas. It was also assumed that the forestry industry would persist in the catchment.

14.6 Options and Criteria for MODSS with Experts in SEQ

This section outlines the options considered in the MODSS analysis in south-east Queensland. The descriptions of the options include a brief discussion of their impacts and possible strengths and weaknesses.

The forestry options

Option 1. An approximation of current land-use

It is beyond the capacity of the research project to produce an inventory of all current land-uses, given the variations at the individual property level. Therefore, this option is based on some assumptions about 'typical' uses. The study area has little irrigation, and is not suitable for cotton. The land ranges from fertile floodplain to low fertility uplands.

Major land-use categories include:

- Continuous cropping on fertile soils. The assumed crop rotation combines reasonable sustainability with profitability. The rotation is five crops in four years, including wheat, sorghum, chick peas and mung beans. In reality, the rotation would be varied according to rainfall deficits.
- Intensive livestock production, including pigs and poultry.
- Ley cropping on medium fertility soils. The rotation could consist of longer than normal fallow periods between crops or a pasture or a fodder crop phase.
- 'Boutique' or new industry farming, including grapes and specialist crops.
- Low intensity grazing on native and (often degraded) pastures.
- Rural residential blocks with a few domestic livestock.

Individual activities are allocated to land on the basis of soil type and location and could be undertaken by full-time farmers or by recreational farmers or investors. However, considering the conclusions of Chapters 5 and 6 it is most likely that the full-time farmers would be undertaking some combination of the first five activities, especially the first three. Conversely, recreational or part-time farmers are more likely to be engaged in the last three forms of land-use, with a few undertaking some boutique activity and some cropping.

Possible limitations of this option include:

- economic under-utilisation of some areas
- land degradation
- water degradation
- little contribution to conservation value
- low returns from some activities, especially grazing.

Option 2. Better use of existing vegetation

This is based on the idea that existing vegetation has some economic and social value. This would involve identifying species suitable for commercial or on farm timber uses, improving the value of

the stands through silvicultural activity and promoting managed regeneration. There is also the possibility of engaging in supplementary enrichment planting or facilitating seedling survival. Upon reflection, the study area appears to have few conventionally suitable tree species, and the native vegetation tends to consist of scattered, open woodlands.

Option 3. High-priority salinity prevention

Saline areas and areas at risk of salinity have been identified in the region. These are almost invariably associated with particular geological formations where two hills surround the low-lying area, leading to a watertable close to the surface. The proposal is to revegetate the hillsides, which are the recharge areas for the watertable. Most of these plantings would be of spotted gum.

The characteristics of these sites include:
- little or no vegetation
- little linkage to remnant vegetation
- generally low productivity grazing country
- low fertility, shallow soils with some erosion
- moderate slopes
- the sites belong to small numbers of landholders.

The potential advantages are:
- lower watertable and consequent reduction in the most pressing salinity threat (eventually)
- low opportunity cost, because existing high activity agriculture is not displaced
- some small conservation benefits
- some small additional water quality benefits
- likely perceived improved amenity (revegetates bare, degraded slopes)
- highly targeted use of government resources
- would enjoy high community support.

Possible limitations of this option include:
- establishment costs might be relatively high in some cases
- high costs borne by a few individual landholders
- landholders selected by ownership of a site, not by willingness to grow trees
- forestry growth rates may be comparatively low, especially initially
- limited regional economic impact because of relatively small areas
- limited contribution to development of regional forest industry.

Option 4. Riparian vegetation enhancement

This would involve planting trees adjacent to waterways, possibly in 20-30 m wide belts, at a slightly lower density than conventional plantations to permit grass growth. This option would affect a large number of landholders because of the number of large waterways and gullies and the allocation of land units in relation to the waterways and gullies. This would involve all types of riparian landholders. In some areas, planting costs might be high because of inaccessibility. The soil, though sometimes degraded, is reasonably fertile, so growth rates would be reasonable. The species choice for many areas is restricted to white gum because of the potential for flooding, although spotted gum is suitable for some of the areas adjacent to the headwaters. This option could potentially involve a large area of forestry.

The potential advantages are:
- reduction in the flow of contaminants into the waterways because farming and intensive grazing has been shifted back from the waterway
- possible reduction in water contaminants because of the trapping effect of the ground cover

- possible increased soil stabilisation and a consequent reduction in gully erosion because of the increase in ground cover.
- medium to low opportunity cost, because only some high activity agriculture is displaced
- potential for moderate increase in forestry area and a moderate increase in regional forestry industry
- moderate conservation benefits and greater benefits where there are linkages to native vegetation
- would generally lower the watertable and reduce salinity threat
- possible perceived improved amenity (limited impact on farm land).

Possible limitations of this option include:
- needs a high degree of co-operation and co-ordination to achieve a general planting
- small individual plantings could affect marketing and processing
- possible high proportion of landholders with limited interest because it targets all landholder types, not just those pre-disposed to forestry
- small areas per landholder would raise costs and reduce incentive to maintain stands
- possible higher costs in extra work to create a water-flow buffer, such as planting grass strips outside the plantation
- some reduction in water flows for downstream use.

Option 5. Shadeline plantings

It is apparent from the attitude surveys that shelter for stock is of interest to many of the respondents. Crop farmers often run stock to make use of stubble and peripheral grass grazing. In addition, many part-time and recreational farmers like to run livestock, despite the sometimes questionable economic returns. While there is some interest in the crop protection benefits of shelterbelts in southern cropping areas, there is debate about the benefits in the northern cropping zone, so most of the intended shadelines would be associated with areas currently being grazed. Fencing would be required in the medium term to protect the trees. The system would involve a planting configuration of four to five rows of trees, with some potential for understorey planting.

The potential advantages are:
- low opportunity cost, because existing high activity agriculture is not displaced
- likely linkages to native vegetation on roadsides and near waterways
- some conservation benefits
- possible perceived improved amenity (does not threaten farm land).

Possible limitations of this option include:
- high fencing costs
- small area development could be unattractive for marketing and processing
- some potential for later landholder disinterest hence poor management of trees
- possible higher-cost planting for small areas.

Option 6. Agroforestry (plantations and grazing)

This would involve the establishing of wide-spaced plantations, with room left for some native pasture regrowth, and perhaps pasture or fodder crop production in the alleyways on more fertile areas. This would be established on the medium-fertility lands, especially those used now for improved pasture or high-quality native pasture. While there is limited activity of this type in the northern cropping areas, it may be of future interest, given the desire amongst some landholders to maintain pastoral activities. There might also be some argument that this model is, to some extent, like some of the open woodlands of the pre-European era. This model is likely to be most attractive to part-time farmers who can set aside areas while the trees are establishing.

The potential advantages are:
- low opportunity cost, because existing high activity agriculture is not displaced
- potential for moderate increase in forestry area and a moderate increase in regional industry
- some linkages to native vegetation
- lower watertable and reduced salinity threat
- some water quality benefits, though not as many as would be the case if there were no stock
- some conservation benefits
- possible perceived improved amenity (maintains something of the agricultural landscape).

Possible limitations of this option include:
- loss of grazing in the start-up phase
- some potential for later landholder disinterest and later poor maintenance
- substantial reduction in water flows available for downstream use, especially irrigation.

Option 7. Conversion of non-cropping areas to plantations

This option is based on the idea that forestry might generally be more profitable than low intensity grazing and rural residential blocks that generally are underused, in terms of agricultural production. On larger farms, this would involve planting areas not fertile enough for mainstream cultivation or areas inaccessible to machinery. Forestry costs and tree species would vary according to the site.

The potential advantages are:
- low opportunity cost, because existing high activity agriculture is not displaced
- potential for large increase in forestry area and a large increase in regional industry
- likely linkages to native vegetation
- lower watertable and reduced salinity threat
- some water quality benefits, as there are unused areas adjacent to waterways
- some conservation benefits
- possible perceived improved landscape amenity (yet does not threaten farm land).

Possible limitations of this option include:
- needs a moderate degree of co-ordination and promotion to achieve a substantial take-up
- small area development could pose viability problems for marketing and processing
- some potential for later landholder disinterest
- some higher-cost planting in small areas
- substantial reduction in water flows available for downstream use, especially irrigation.

Option 8. Private medium-scale plantations

This option assumes more of a project approach to forestry, with larger blocks (of 200-500 ha) planted on medium to high-fertility country. This work might be undertaken by the landholder or by a leasee. At present there is no obvious move towards this form of forestry, but with improved genetic material and appropriate land prices, there may be some future interest.

The potential advantages are:
- potential for large increase in forestry area and a large increase in regional industry
- high likelihood of plantation maintenance
- efficiencies in planting and harvesting
- capacity for large volume sales
- some small conservation benefits (no necessary linkage to native vegetation)
- some water quality benefits
- some salinity benefits.

Possible limitations of this option include:

- moderate opportunity cost in terms of lost agricultural production
- some reduction in water flows available for downstream use
- some community concern about changing landscapes.

Option 9. Landscape-scale plantations

This option is based on a large-scale corporate investment, possibly covering much of a sub-catchment. At present, there is no obvious move towards industrial forestry in the project area, but with improved genetic material and appropriate land prices, there may be some future interest.

The potential advantages are:
- potential for a large increase in forestry area and a large increase in regional industry
- high likelihood of sound plantation maintenance
- efficiencies in planting and harvesting
- capacity for large volume sales
- some small conservation benefits (no necessary linkage to native vegetation)
- some water quality benefits
- some salinity benefits.

Possible limitations of this option include:
- high opportunity cost in terms of lost agricultural production
- substantial reduction in water flows available for downstream use
- high degree of community concern about changing landscapes
- reductions in employment and subsequent population decline and infrastructure closures.

While this option is not really small-scale or farm forestry, as defined in Chapter 2, it was included to elicit comment on a more dramatic change in land use.

Performance criteria for evaluating the forestry options

All the criteria were scored on scale of one to five, five being the best possible score. Because this was the initial iteration of the analysis, the options were all scored according to the considered opinion of the members of the technical reference group.

Economic criteria

Net farm production /income /enterprise diversity
Total regional farm net income
Forestry revenue
Relates to time scales and erratic nature of income, includes growth rates species and market issues
Return on investment / discounted cash flows
Expected net present value and internal rate of return
Average improved property value
Change in average improved property value in the study area ($/ha)
Establishment cost
Tree planting, fencing (note shape and circumference of planting), tracks and roads
Opportunity cost of land-use
Cost compared to the most profitable practice
Maintenance costs (including debt servicing)
Debt servicing ability, pruning, fertilising, spraying, weed/pest/fire control and insurance
Harvest and transport costs
Felling and transporting costs would be a function of distance to mills, and construction of transport or other infrastructure
Infrastructure costs
Cost of on-farm access tracks and fencing
Regional impact

Economic diversity, critical impacts on other industries, support services, services and infrastructure

Market opportunities / processing infrastructure

Access to mills, labour and suitable markets for potential products

Environmental criteria

Shelter effects

Shade and weather protection, prevention of wind erosion

Pest habitat

Abundance of perceived local pests in relation to the numbers of local predators

Soil resource quality

Soil suitability index (or main classes index) includes erosion retention index, including riparian cover (especially gully cover)

Carbon sequestration

Total above-ground plus below-ground carbon (tonnes/ha) reflects societies requirement for CO_2 reduction through sequestration; this will have little effect on the local environment

Water quality

Composite index of water quality variables, e.g. BOD, turbidity, nutrient load, temperature

Salinity control

Area (ha) of actual affected areas plus possible affected areas

Biodiversity

Species diversity and connectivity index

Social criteria

Aesthetic amenity

Value of the aesthetic quality of locality as assessed by the residents of the area

Change management requirements (including re-skilling)

Educating affected persons in new land management practises,

Consistency with government regulation/policy

Including Local, State and Federal Government legislation, regulation and policy. Compliance with *Integrated Planning Act*, *Vegetation Management Act*, Local Area Plans, and current National Action Plans (e.g. Salinity NAP).

Equity

Distribution of costs and benefits geographically, demographically, not disadvantaging any population sub-groups

Community benefits

Net employment

Net change in full-time equivalent positions; full-time permanent positions are valued higher than part time, seasonal or casual positions

Maintaining services

Net change number of services, including shops, schools, medical services, banking services, Government services, libraries

Community capacity

Skills availability in local community

Community impacts

Community cohesion

Sense of community identity including shared values and visions for local area

Community acceptance

Wider community acceptance or opposition to farm forestry scheme and landscape changes

Population turnover

Net change and rate of change of population including changes in demographic profile, assuming current profile is more desirable.

14.7 Options and Criteria for MODSS with Experts and Stakeholders in Hodgson Creek

This section provides details of the options and criteria considered in the Hodgson Creek MODSS.

The forestry options

Eight forestry options were defined for the Hodgson Creek area. To expand on the written descriptions of the options, a hypothetical map detailing the possible spatial extent of the options was produced.

1. An approximation of current land-use

It was beyond the capacity of the research project to produce an inventory of all current land-uses, given the variations at the individual property level. Therefore, this option is based on some assumptions about 'typical' uses. The study area has little irrigation, and is not suitable for cotton. The land ranges from fertile flood plain to low-fertility uplands.

Major land-use categories include:

- Continuous cropping agriculture on fertile soils. The assumed crop rotation is based on one that combines reasonable sustainability with profitability. The rotation is five crops in four years including wheat, sorghum, chick peas and mung beans. In reality, the rotation would be varied according to rainfall deficits.
- Intensive livestock production, including pigs and poultry.
- Ley cropping agriculture on medium fertility soils. The rotation could consist of longer fallow periods between crops or a pasture or fodder crop phase.
- 'Boutique' or new industry farming, including grapes and specialist horticulture.
- Grazing with feed crops and pasture on medium fertility soils.
- Low intensity grazing on native pastures, and often these pastures are degraded.
- Rural residential blocks with a few domestic stock.

Locations where these activities are conducted vary with soil type. These activities could be undertaken by full-time farmers or by recreational farmers or investors. However, it is most likely that the full-time farmers would undertake some combination of the first five activities, especially the first three. Conversely, recreational or part-time farmers are more likely to be engaged in the last three forms of land-use, with a few undertaking some boutique activity and some cropping.

Limitations of this option include:

- economic under-utilisation of some areas
- land degradation
- water degradation
- little contribution to conservation value
- low returns from some activities, especially grazing.

2. High-priority salinity prevention

There are identified saline and at-risk areas in the catchment. These are almost invariably associated with particular geological formations where two hills surround the low-lying area and the result is a high watertable. The proposal is to revegetate the hillsides, which are the recharge areas for the watertable. This would mostly affect the uplands areas of the region. Most of these plantings would be of spotted gum.

The characteristics of these sites include:
- little or no vegetation
- little linkage to remnant vegetation
- generally low productivity grazing country
- low fertility, shallow soils with some erosion
- moderate slopes
- the sites belong to small numbers of landholders.

The potential advantages are:
- lower watertable and consequent reduction in the most pressing salinity threat (eventually)
- low opportunity cost, because existing high activity agriculture is not displaced
- some small conservation benefits
- some small additional water quality benefits
- likely perceived improved amenity (revegetation of bare degraded slopes)
- highly targeted use of government resources
- would enjoy high community support.

Possible limitations of this option include:
- establishment costs might be relatively high in some cases
- costs borne by a few landholders
- landholders selected by ownership of a site, not by willingness to grow trees
- growth rates may be comparatively low, especially initially
- limited regional economic impact because of relatively small areas
- limited contribution to development of regional forest industry.

3. Medium-priority salinity plantings

As above, but with a greater proportion of the recharge area planted. This would increase the long-term effect, but would also reduce the short-term income from conventional agricultural production.

4. Additional under-used areas plantings

As above, being planted, especially if adjacent to the priority areas but with additional areas recognised as having little conventional production.

The potential advantages are:
- low opportunity cost, as existing high activity agriculture is not displaced
- possible corridor linkages to native vegetation
- possible perceived improved landscape amenity (does not threaten farm land)

Possible limitations of this option include:
- small area of forestry development could reduce interest from marketing and processing
- some potential for later landholder disinterest
- some higher cost planting in small areas.

5. Commercial plantations (with corporate land ownership)

This option is based on a medium-scale corporate investment in forestry in the east of the region where rainfall is slightly higher. At this stage there is no immediate prospect of such investment. However, there are some similar plantations in the Kingaroy region that serve as a ‘model’ for what might occur.

The potential advantages are:
- likely develop of supporting infrastructure and skill base that would support small-scale forestry activity
- high likelihood of plantation maintenance
- efficiencies in planting and harvesting
- capacity for large volume sales
- some small conservation benefits (no necessary linkage to native vegetation)
- some water quality benefits
- some salinity benefits, if suitable sites coincide with recharge areas.

Possible limitations of this option include:
- high to medium opportunity cost in terms of lost agricultural production
- some reduction in water flows available for downstream use
- possible high to medium degree of community concern about changing landscapes, if aggregate forestry area is large.

6. Commercial plantations (with leased land)

This option is the same as the previous option, except that the corporation leases land from landholders.

The additional potential additional advantages of this are:
- income for traditional landholders who wish to reduce activity but retain land
- based on the range of suggested lease payments, this would be more profitable for some landholders than engaging in any agricultural activity
- may be less threatening than corporate purchase.

However, there would be costs in returning the land to agriculture at the end of the forestry cycle.

7. Private medium-sized plantations

There may be some landholders who wish to reduce their agricultural activity in order to enjoy semi-retirement or to increase their commitment to off-farm work. However, they may wish to undertake the forestry work themselves, either because of the desire to have the activity, or because of the perception of retaining more of the potential income.

The advantages of this option are:
- less threatening than corporate ownership
- maintenance of existing social linkages

Possible disadvantages include:
- reduced likelihood and quality of plantation maintenance.

8. Agroforestry (plantations and grazing)

This would involve the establishing of wide-spaced plantations, in conjunction with improved or native pasture or even fodder crop strips in more fertile areas. This would be established on the medium-fertility lands, especially those used now for improved pasture or high-quality native pasture. While there is limited activity of this type in the northern cropping areas of Hodgson creek, it may be of future interest where the desire amongst some landholders to maintain pastoral activities. This planting regime is again most likely to appeal to those not dependent on conventional farm enterprises. There might also be some argument that this model is to some extent like some of the open woodlands of the pre-European era. The landholder survey suggests that this model is likely to be most attractive to part-time farmers who can set aside areas while the trees are established.

The potential advantages are:

- low opportunity cost, as existing high activity agriculture is not displaced
- potential for moderate increase in forestry area and a moderate increase in regional industry
- some linkages to native vegetation
- lower watertable and reduced salinity threat
- some water quality benefits, though not as great as would arise if there were no stock
- some conservation benefits
- possible perceived improved amenity (maintains something of the agricultural landscape).

Possible limitations of this option include:

- loss of grazing in the start-up phase
- some potential for later landholder disinterest and later poor maintenance
- substantial reduction in water flows available for downstream use, especially irrigation.

Performance criteria for evaluating the forestry options

In this initial iteration of the analysis, the options were all scored according to opinion of the members of the technical reference group only.

Economic criteria

Forestry revenue - growth
The percentage change in (usually real) gross farm productivity from one year to the next
Forestry revenue - royalty
A share of the product or profit, reserved by the owner for permitting another to use the property, e.g. annuity from joint venture forestry
Infrastructure costs (community)
Cost of improving or building infrastructure, e.g. increasing or upgrading road network
Regional impact
Change in regional structure, employment, services, and infrastructure
Regional output
Change in regional agricultural output, this also includes the effects on regional output of new capital injections based on establishing a forestry industry
Profit (in transitional or steady state period)
Change in farm profit with change in cropping regime
Property value
Change in average improved property value
Rating treatment
Beneficial rating for forestry (this criterion was dropped by the technical reference panel, because there is currently no differential rating applied to forestry)
Risk profile
Economic risk with regards to failure gain economic returns, including crop failure due to poor management or natural disaster (e.g. drought, fire, storm, insects)
Risk of policy change
Change in Local, State and Federal policy that may affect forestry outputs
Equity of financial returns
Especially in joint venture projects
Cash flow – upfront costs
Initial cost including planting costs, and all associated establishment costs
Cash flow – debt servicing
Ongoing costs of debt repayment
Critical mass
Production level to maintain the services, processing infrastructure, and market access

Flexibility of land-use
Ease of change of land-use
Liquidity of assets
Ease of sale of products

Environmental criteria

Shelter effects
Does the option provide protection to other crops and livestock, including shade and windbreaks, also prevention or soil erosion due to wind?
Soil resource quality
Erosion prevention and change in soil quality and that effect on agricultural productivity
Carbon sequestration
Amount of carbon uptake, possibly looking at future carbon credits
Water quality
Water quality including the quality of groundwater, overland flows and creeks
Salinity control
Prevention of actual or potential salinity problems, may include future salt credits
Biodiversity (local native)
Change in abundance of local native species
Water quantity
Impact on available water for on farm use and use by down stream farmers
Cumulative impacts
Highly or critically adverse impacts on local environment due to widespread (and perhaps rapid) uptake of this option
Displacement of existing native bio-systems
This recognises the importance of native grasslands in this areas and their rarity
Habitat quality
Production of habitats favourable to local native species
Pest habitat
Potential for pest invasion, production of habitats favourable to pest species
Air quality (adverse effects of spraying of agricultural chemicals)
Requirements of agricultural chemicals (the less the better), also includes application techniques.

Social criteria

Aesthetic amenity
Countryside attractiveness and farm beautification, especially for tourists
Change management requirements (incl reskilling)
Ease of change of management practices and retraining for these new skills
Consistency with local state fed government regulation and policy
Current and future policy directions
Net employment
Change in number of full-time equivalent positions, full-time permanent positions are preferable to seasonal casual
Maintaining services
Change in number and variety of community services including, banks, schools, medical facilities, shops and libraries
Community capacity
The ability of a community's members to work together over a sustained period to shape a collective future
Community cohesion
A community's shared vision for the future or lack thereof

Community acceptance
Is the future direction the community acceptable to its members
Population turnover
Change in demographics, this indicates a desire to maintain the status quo, the current demographic or one from the past that is no longer present
Increased equity
The costs and the benefits of any option are equally distributed amongst the community and the option does disadvantage any population sub-group especially vulnerable population sub groups
Community health
A measure of the community's medical and social wellbeing
Health effects on family
A measure of the farm family's medical (and social) wellbeing

14.8 Concluding Comments

The MODSS process was applied to farm forestry in both south-east Queensland and the Hodgson Creek catchment. This process differed from that initially proposed (Chapter 13), because of the limited stakeholder involvement and the desire to maximise the input from the stakeholders. The options and criteria identified in Section 14.5 form the basis of the effects table for the south-east Queensland MODSS analysis. These options were analysed and the results and discussions appear in Chapter 15. The options and criteria identified in Section 14.6 form the basis of the effects table for the Hodgson Creek MODSS analysis. These options were analysed and the results and discussions appear in Chapter 16.

15. A Multi-objective Decision-Support System (MODSS) with Input from Experts in South-east Queensland

I. Jeffreys

This chapter reports the MODSS analysis in south-east Queensland (SEQ). This analysis was conduced as an initial analysis of options for farm forestry in the region, presenting current expert opinion on feasible farm forestry practices and there relative merits. The results of the analysis were intended for presentation to other stakeholders to be involved later in the study. This chapter includes a summary of the process of including stakeholder and technical input in the analysis. This included seeking persons with technical expertise in farm forestry, and inviting them to form a technical reference group. This group provided the technical input in the study. This chapter also reports brief descriptions of the options and criteria, the effects tables developed for this initial analysis, the results of the multi-criteria analysis and a discussion of the results.

15.1 The Process of Developing a MODSS for Farm Forestry in South-east Queensland

The initial farm forestry MODSS was constructed from consultations with technical experts only. Input from experts was sought in a one-day workshop followed by a series of interviews with individual experts.

The process is summarised below:

1. Initial options were developed from the preferences of stakeholders inferred from the survey, discussed in Chapters 5 and 6.
2. Options and criteria were further discussed and developed by the technical reference group.
3. Each member of the technical reference group was individually interviewed and the options and criteria as well as the scores were developed. At this stage no importance orders were sought.
4. Combined analyses including input from all the members of the technical reference group were produced. Where there was agreement between the technical reference group members, the separate scores were aggregated. Agreement was assessed using Pearson's correlation coefficient. If the correlation coefficient for two sets of scores for the same criterion was greater than 0.7, the two score sets were aggregated. This level was chosen as it indicates a similar general trend in the scores.
5. The effects table was analysed using the MCA tool Definite. The analyses used no rankings; the criteria were however placed into a hierarchy so at each level all the criteria were considered equally important and weighted the same.
6. Two aggregation methods were used, these being:
    a. The weighed summation technique, used for its transparency and acceptability with stakeholder groups.
    b. The Electre II technique, used to highlight any poor performance in an individual criterion. An explanation of these techniques can be found in Chapter 13, Appendix 13.2.
7. These results were than presented at the stakeholder workshop and became the starting point for the second round of analyses.

15.2 The Farm Forestry Options

This section provides a brief description of the options considered in this analysis. (More detailed descriptions have been reported in Chapter 14).

1. An approximation of current land-use

This option is based on assumptions about 'typical' agricultural and pastoral land-uses and includes various possible and likely land-uses. This option provides a baseline against which the other options will be assessed. For an alternative land-use to be preferred, it must perform better or at least as well as the current land-use.

2. Better use of existing vegetation

This option assumes existing vegetation has some economic value. It would involve identifying suitable species and improving the value of stands through improved management practices. This option may also include some supplementary plantings.

3. High-priority salinity prevention

This option involves identifying saline and at risk areas in the catchment, i.e. the discharge zones. Associated with these discharge zones are recharge zones, higher in the catchment. This option involves revegetation of the recharge zones with forestry.

4. Riparian vegetation enhancement

This option would involve plantings in the riparian zones, an area of 20-30 m adjacent to watercourses. This option involves a low density planting because it is considered desirable to promote an understorey in the riparian zones.

5. Shadeline plantings

This option involves planting belts, four to five trees wide, in current grazing areas. It should provide shelter for the stock and a harvestable timber crop.

6. Agroforestry (plantations and grazing)

This would involve establishing wide-spaced plantations, with room left for some native pasture regrowth, or for pasture or fodder crop production in the alleyways in more fertile areas.

7. Conversion of non-cropping areas to plantations

This option would include forestry plantings on areas that are currently under-used or un-used. It would displace low-intensity grazing, or involve low-fertility areas that are not regularly cultivated.

8. Private medium-scale plantations

This option assumes more of a project approach to forestry, with larger (200-500ha) blocks planted on medium to high fertility country. This work might be undertaken by the landholder or by an organisation leasing the land.

9. Landscape-scale plantations

This option is based on a large-scale corporate investment, and would include large-scale plantations, covering much of a sub-catchment. While this option is not really small-scale or farm forestry, as defined in Chapter 2, it was included to elicit comment on a more dramatic change in land use.

15.3 Criteria for Evaluating the Farm Forestry Options

This section includes a brief description of the criteria used to evaluate the farm forestry options at a sub-catchment level in the SEQ region. (Further detail is provided in Chapter 14.) The criteria are split into three groups, representing the economic, environmental and social aspects of the analysis. The social group is split further into general social criteria and those relevant to community benefits and community impacts. The criteria have been scored on a scale of one to five, five being the best possible score, one the worst. The options were all scored according to the considered opinion of the members of the technical reference group.

Economic Criteria

Net farm production / income / enterprise diversity
Forestry revenue
Return on investment / discounted cash flow
Average improved property value
Establishment cost
Opportunity cost of land-use
Maintenance costs (including debt servicing)
Harvest and transport costs
Infrastructure costs
Regional impact
Market opportunities and processing infrastructure

Environmental Criteria

Shelter effects
Pest habitat
Soil resource quality
Carbon sequestration
Water quality
Salinity control
Biodiversity

Social Criteria

Aesthetic amenity
Change management requirements (including re-skilling)
Consistency with government regulation and policy
Equity
Community benefits
    Net employment
    Maintaining services
    Community capacity
Community impacts
    Community cohesion
    Community acceptance
    Population turnover

15.4 The Effects Table

Table 15.1 is the effects table for the SEQ study. The values that appear in this table indicate the performance of the options against the criteria. The technical reference group evaluated these levels of performance. High scores in this table indicate high levels of performance for the given option against a given criterion. The score range is one to five, one indicating poor performance and five indicating high performance. The shading applied to the table also indicates performance levels. An unshaded cell indicates performance in the top 30% of the score range, a dark shaded cell indicates performance in the lowest 30% of the score range, and the light shaded cell indicate performance in the middle 40% of the score range. The scores in this table were than evaluated using MCA techniques (described in Chapter 13).

Table 15.1 The effects table for the south-east Queensland study

The performance criteria	Approximation of current land-use	Better use of existing vegetation	High-priority salinity prevention	Riparian vegetation enhancement	Shadeline plantings	Agroforestry (plantations and grazing)	Conversion non-cropping areas to plantations	Private medium-scale plantations	Landscape-scale plantation
Economic									
Net farm production /income /enterprise diversity	5.0	3.0	1.0	1.0	3.3	3.3	5.0	4.0	4.0
Forestry revenue	1.0	4.0	1.0	1.0	2.7	2.7	3.0	4.0	5.0
Return on investment / Discounted cash flow	4.0	2.0	1.0	1.0	3.0	2.9	3.0	4.0	5.0
Average improved property value	5.0	2.0	4.0	4.0	5.0	3.8	3.5	4.0	3.0
Establishment cost	5.0	5.0	1.0	1.0	4.0	3.1	2.0	3.0	4.0
Opportunity cost of land-use	4.0	4.0	3.0	2.0	2.0	3.8	5.0	5.0	5.0
Maintenance costs (incl. debt servicing)	4.0	2.0	2.0	1.0	3.0	3.0	3.0	4.0	5.0
Harvest / transport costs	4.0	1.0	5.0	5.0	4.0	3.9	3.0	4.0	5.0
Infrastructure costs	4.0	4.0	2.0	2.0	4.0	3.4	3.0	3.0	5.0
Regional impact	4.0	3.0	3.0	4.0	2.0	3.6	4.0	4.0	5.0
Market opportunities / processing infrastructure	4.0	1.0	4.0	4.0	1.0	2.9	2.0	3.0	4.0
Environmental									
Shelter effects	1.0	2.0	2.0	3.0	4.0	5.0	4.0	5.0	5.0
Pest habitat	1.0	5.0	4.0	4.0	3.0	3.0	3.0	2.0	1.0
Soil resource quality	1.0	1.9	3.6	3.6	2.1	3.9	3.9	5.0	5.0
Carbon sequestration	1.0	2.5	2.5	3.0	2.3	3.5	3.3	4.0	5.0
Water quality	1.0	1.3	3.3	5.0	1.9	3.9	3.3	4.4	5.0
Salinity control	1.0	2.7	4.4	2.1	2.7	5.0	4.4	5.0	5.0
Biodiversity	1.0	2.1	3.3	5.0	2.7	3.9	3.9	4.4	2.1
Social									
Aesthetic amenity	2.0	2.5	3.5	5.0	3.5	3.5	3.5	2.0	1.0
Change management requirements (incl reskilling)	5.0	3.0	3.0	3.0	4.0	1.0	2.0	1.0	2.0
Consistency with government regulation/policy	5.0	3.0	5.0	5.0	2.0	3.0	3.0	3.0	4.0
Equity	3.0	4.0	1.0	3.5	4.5	5.0	5.0	5.0	2.5
Community benefits									
Net employment	1.0	2.0	3.0	3.0	2.0	3.0	4.0	5.0	4.0
Maintaining services	1.0	2.0	2.0	3.0	2.0	4.0	4.0	5.0	3.0
Community capacity	1.0	3.0	3.0	5.0	3.0	5.0	5.0	5.0	3.0
Community impacts									
Community cohesion	3.0	4.0	5.0	5.0	4.0	3.0	3.0	2.5	1.0
Community acceptance	4.0	4.5	5.0	5.0	4.5	3.0	3.0	2.0	1.0
Population turnover	4.0	5.0	5.0	4.0	4.0	3.0	3.0	2.0	1.0

Note: The unshaded areas indicate higher performance; the dark shaded areas indicate poor performance and light shaded areas intermediate performance.

15.5 The Aggregated Performance of the Farm Forestry Options

Figure 15.1 presents the results of the analysis involving farm forestry experts in south-east Queensland.

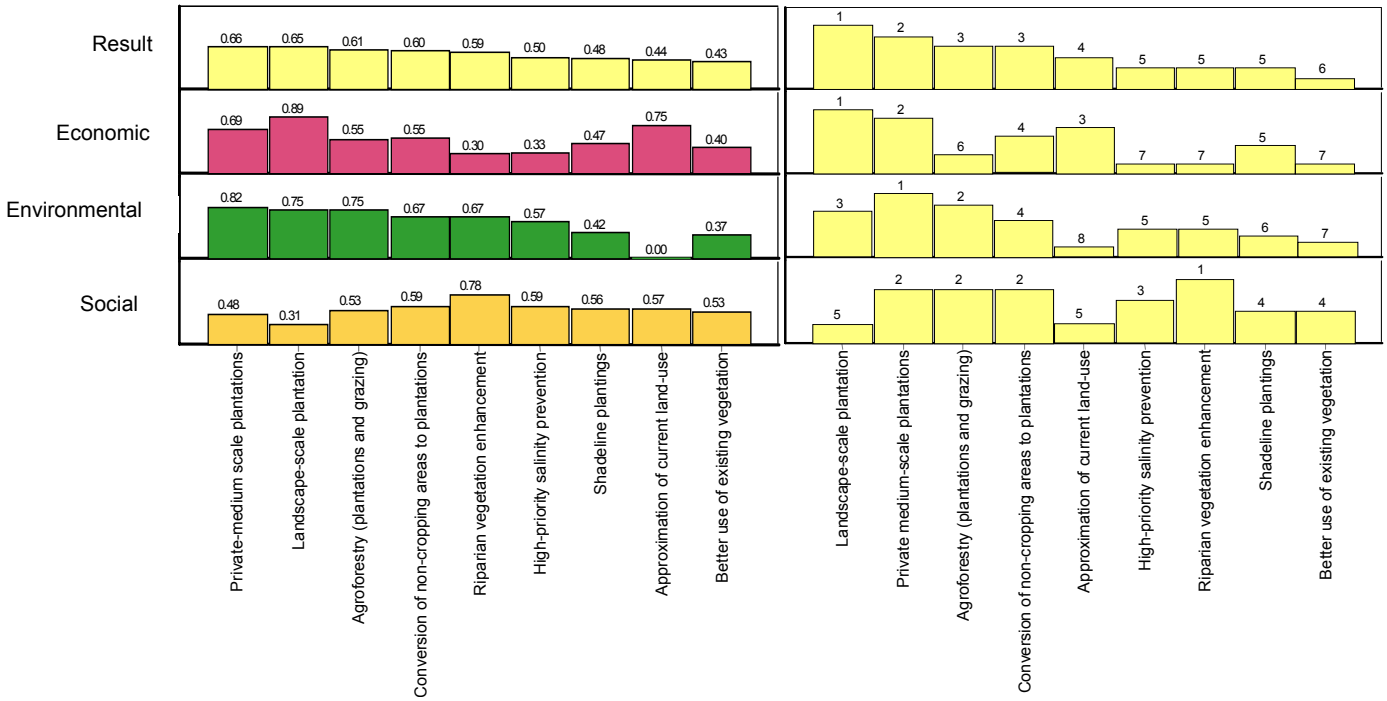


Figure 15.1 The results of the MCA with Experts in South-east Queensland

The panel on the left of Figure 15.1 depicts the aggregated performance of the farm forestry options using the weighted summation aggregation technique, and the panel on the right, the ratios obtained using the Electre II aggregation technique (as outlined in Chapter 13). In each panel, the top histogram is the combined performance of the environmental, economic and social analyses. The second histogram indicates only the economic analyses, third the environmental and forth the social.

The panel on the left of Figure 15.1 presents the results obtained from using the weighted summation aggregation, and should be considered first. The size of the bar represents the performance of the option; larger bars indicate higher performance, smaller bars – poorer performance. The number that appears on top of each bar is the aggregated score for that option, i.e. the weighted sum of the individual scores against all the criteria. For example, the weighted score over economic issues for the option *Private medium-sized plantations* under the weighted summation technique is 0.69, out of a possible maximum score of 1.0.

Considering the four histograms in this panel, an option would be considered to have high overall performance if it had average or high scores and no low scores in each histogram, i.e. for all perspectives (economic, environmental or social).

The panel on the right of Figure 15.1 presents the results using the Electre II aggregation, and should be considered second. As explained in Chapter 13, the Electre II technique is a non-compensatory technique, i.e. poor performance in an individual criterion is reflected by

poor performance in the aggregate performance of the option. These histograms display the ordinal ranking of the options; the numbers that appear in these histograms reflect these rankings. The highest performing option is ranked 1, second highest 2, and so on. If the rank achieved by a given option does not reflect the score it receives using the weighted summation, further investigation is required. For example, if an option receives a high score in the weighted summation results and a low rank in the Electre II results, is likely that option receives poor scores for a number of criteria and high scores for the others. The criteria against which the option performs poorly should be identified from the effects table (Table 15.1). The graphical representations of the effects table that appear in Appendix 15.1 are used for identifying poor performance in individual criterion. The decision-maker should then consider whether these poor performances represent fatal flaws in the option or if they are compensated for high performance in the other criteria. Poor performance in criteria that are deemed as highly important by the stakeholders are the most likely to fatally flaw an option.

15.6 Discussion and Conclusions from Initial Results

The options *Conversion of non-cropping areas to plantations* and *Private medium-scale plantations* are the better performing options in this analysis. The option *Conversion of non-cropping areas to plantations* has high overall performance in the weighted summation analysis and high to average performance from the economic, environmental and social perspectives. Performance improves when the Electre II analysis is considered, because this option has no low scores; it receives a score of 2 or above for every criterion. Taking a precautionary approach, this option has the lowest negative impact, regrading the decision criteria.

The option *Private medium-scale plantations* performs best overall in the weighted summation analysis. It also performs best from the environmental perspective and performs well from the economic perspective. Performance drops for the social perspective in the weighted summation analysis but remains high in the Electre analysis. This high performance is largely because this option has only one low score, a score of 1 in *change management*. Amelioration in the form of education and extension support may be required for wide-scale acceptance of this option.

Two other options worthy of further consideration are *Landscape-scale plantation* and *Riparian vegetation enhancement*. The former of these has the best performance for the economic perspective and high performance for the environmental perspective using the weighted summation technique. Using the Electre II technique the economic performance remains high but environmental performance falls somewhat. This option has a low score in the environmental criterion *pest habitat*, hence specific management practices to prevent pest invasion would need to be considered. This option also has poor social performance using both techniques and specifically in many social criteria, namely the *aesthetic amenity* and all the criteria in the community impact group. This poor performance may fatally flaw this option because amelioration may not be possible in these large plantations.

The option *Riparian vegetation enhancement* has high performance from the social perspective and fair performance from the environmental perspective. This option has poor economic performance, and is not a commercially viable activity. However, it is worthy of further consideration but other non-commercial drivers would be required.

Appendix 15.1: Graphical representations of the effects tables

Figures 15.A1, 15.A2 and 15.A3, display a graphical representation of the effects table (Table 15.1). Each histogram represents the relative performance of the options against a given criterion. The height of the bar is indicative of the performance of an option against the given criterion.

Figure 15.A1 Graphical representation of the effects table, for environmental criteria

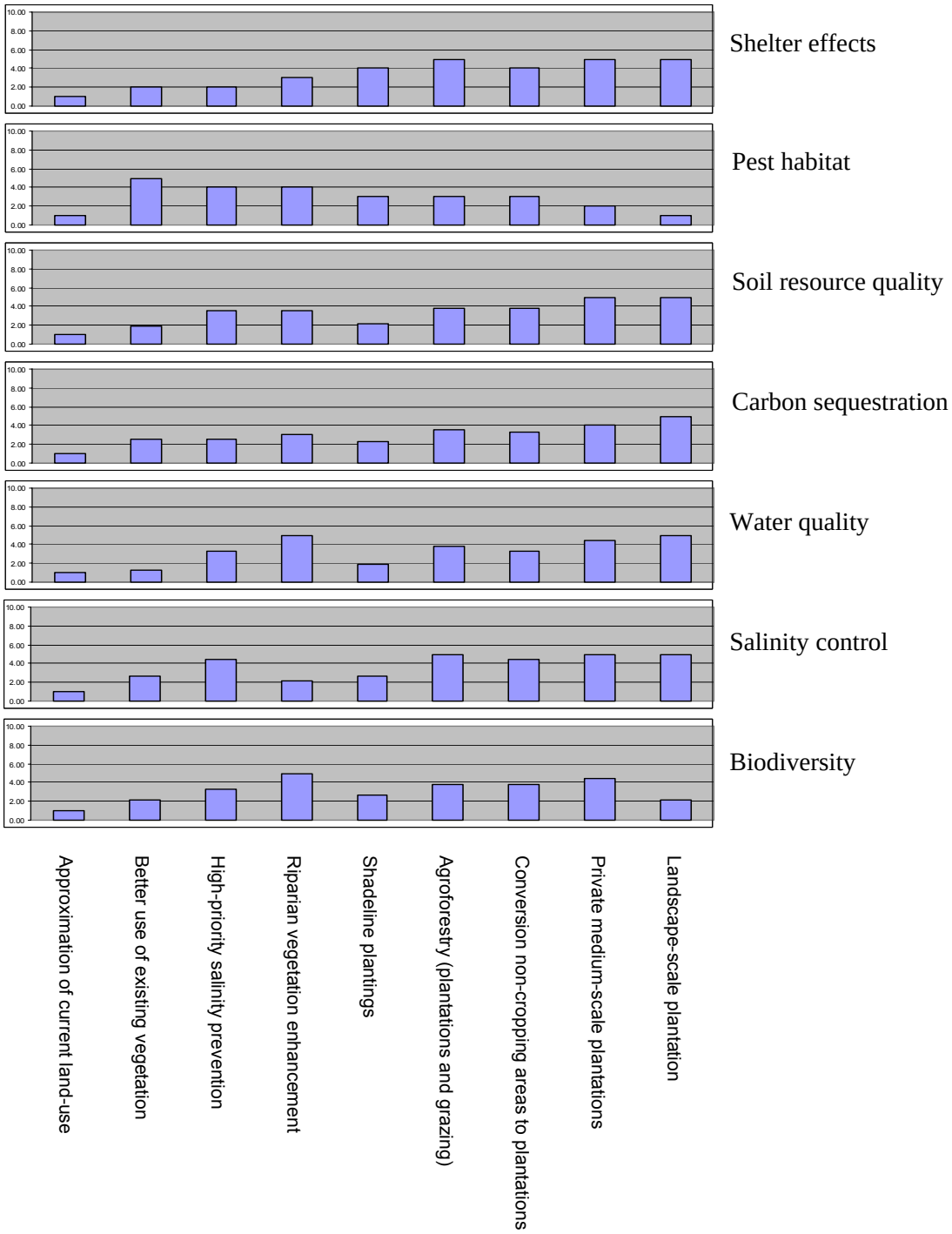


Figure 15.A2 Graphical representation of the effects table, for economic criteria

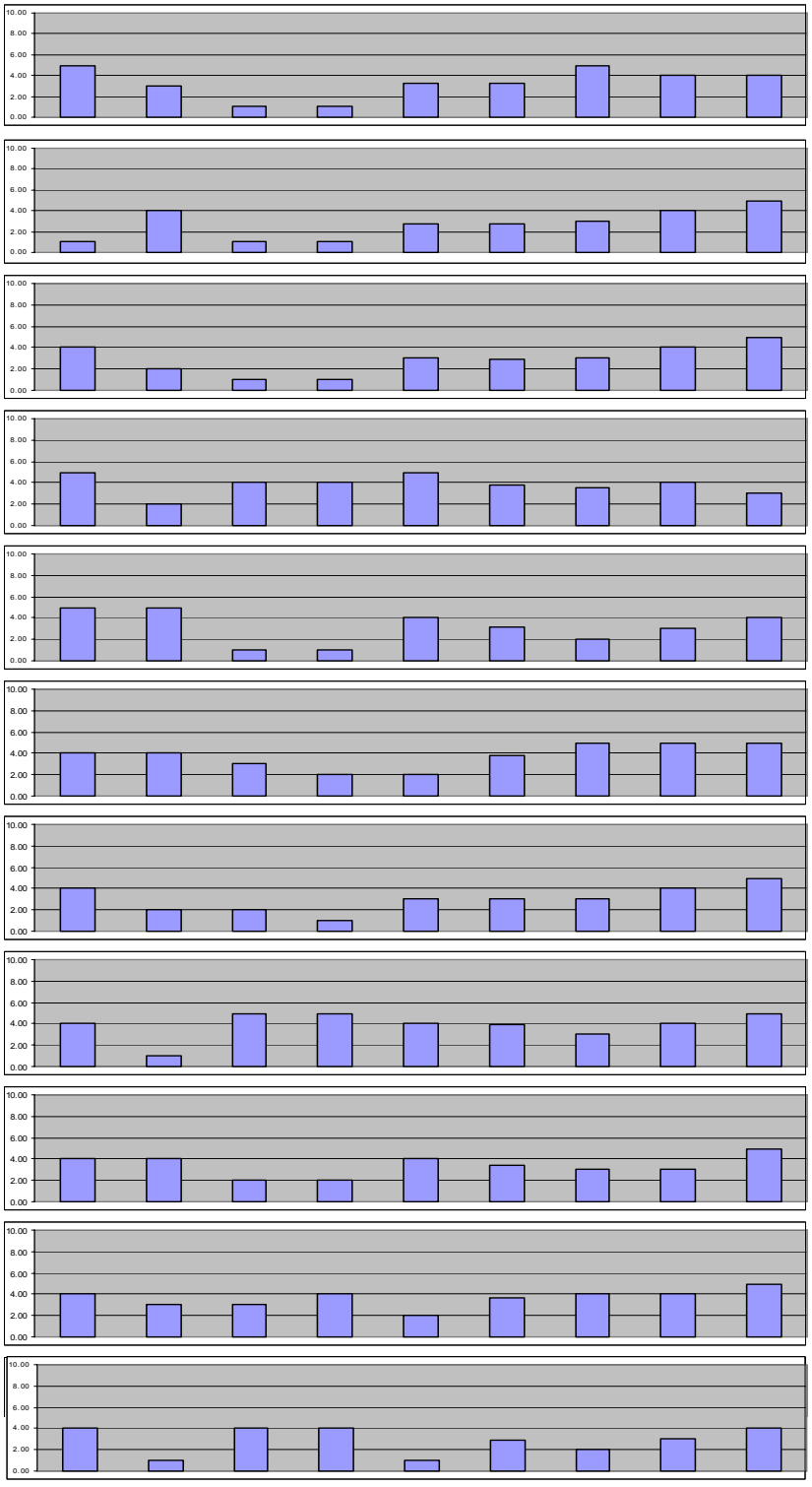
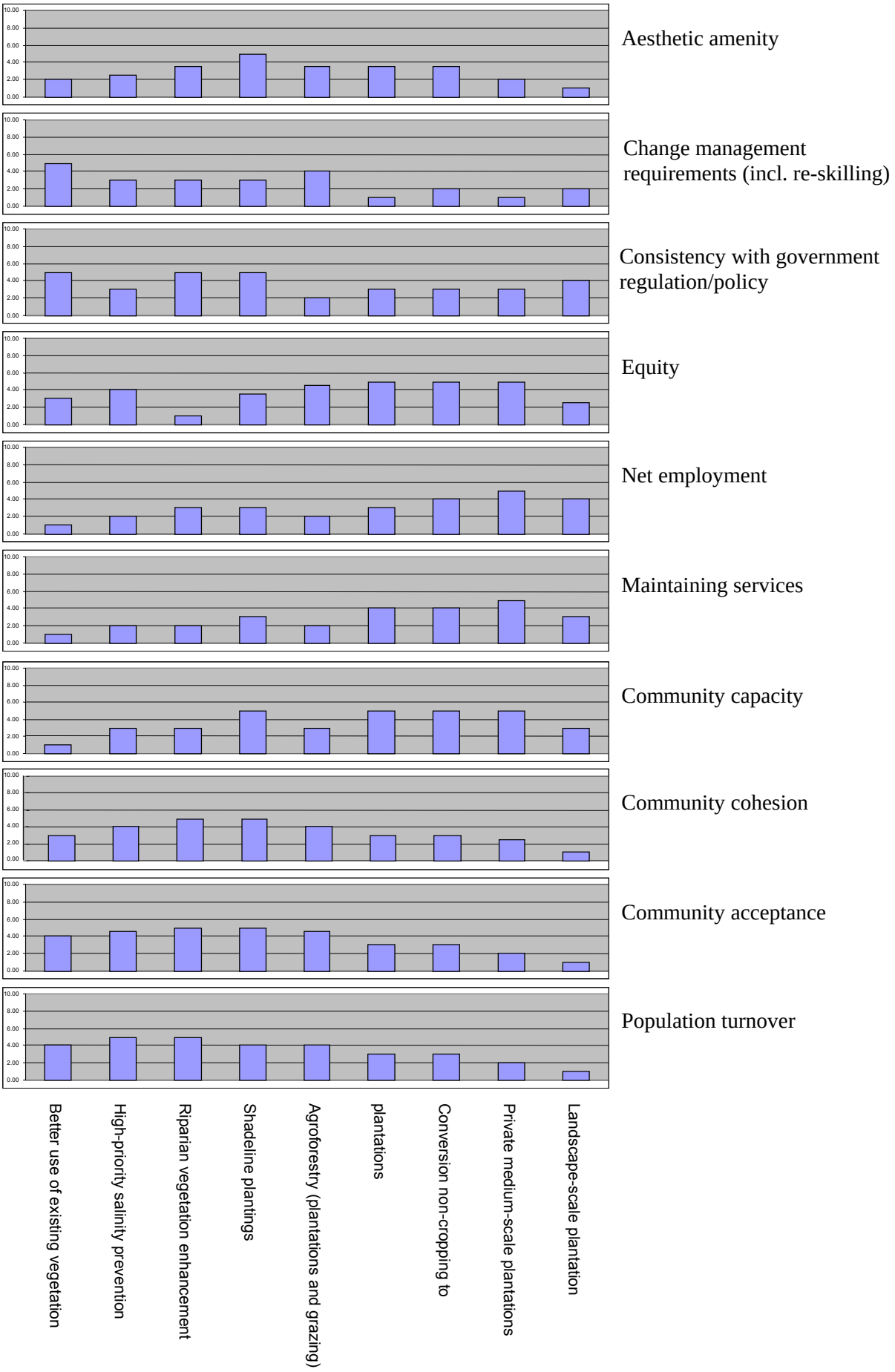


Figure 15.A3 Graphical representation of the effects table, for social criteria



16. A Multi-Objective Decision-Support System (MODSS) with Stakeholders and Experts in the Hodgson Creek Catchment

I. Jeffreys

This chapter reports the MODSS analysis conducted in the Hodgson Creek catchment on the Darling Downs. It summarises the process used to gain stakeholder and technical input into the analysis. Options and criteria developed for the Hodgson Creek analysis are also described briefly, as is the effects table. The results of the multi-criteria analysis are presented and discussed.

16.1 The Process of Developing a MODSS for Farm Forestry in Hodgson Creek

The MODSS for Farm Forestry in Hodgson's Creek was developed through an extended process including consultation with stakeholders and technical experts. Input from stakeholders was sought in a one-day workshop at Felton, in the Hodgson Creek catchment. Input from experts was sought in two one-day workshops. The MODSS development process is summarised below:

Phase 1 – Development of options, criteria, and importance orders

1. An initial MODSS workshop to identify a preliminary list of options and criteria was conducted involving only technical experts (without the assistance of spatial information). The results from the initial MODSS workshop were the starting point of the second analysis (involving both stakeholders and technical experts).
2. The first round results were presented to the stakeholder reference group, along with detailed descriptions of the options including maps of the possible spatial extent of the options.
3. Options and criteria were further discussed in the stakeholder workshop.
4. A final set of options was defined from the preferences of the stakeholder group. Options were removed or substantially changed to reflect the views of this group.
5. A similar process occurred with the criteria, which were evaluated with regards to their relevance and importance to the stakeholder group. During this process, some criteria were added, removed or modified. Three stakeholder factions were present at this meeting, and each faction produced separate importance orders. These factions were landholders, state government extension officers (from the Queensland Department of Primary Industries and the Queensland Department of Natural Resources and Mines) and local government officers (of the Pittsworth Shire Council).
6. This new set of options, criteria and importance orders formed the basis of the second round analysis.

Phase 2 – Development of effects table

1. Persons with local farm forestry knowledge were invited to form the Technical Reference Group (TRG) for the final analysis.
2. The options were scored against the criteria during two focus group sessions. The options were assessed using the considered opinions of those experts present.
3. The options were considered at two time scales, initially defined as the short term and long term. The TRG further defined these periods. Final definitions were (1) the *Transitional period*, that time during which the new forestry industry is being established in the catchment, also defined as the *Cost period*, of the first five to 10 years, and (2) the *Steady-state period* or the *Equilibrium*

period, the time when a forestry industry has been established in the catchment, at about year 30 to 40.

Phase 3 – Resolution of effects table and ranking of options

1. The effects table was analysed using the MCA tool Definite. The analyses used three rankings representing the views of the three factions. The criteria were also placed into a hierarchy and separated into economic, environmental and social criteria.
2. Two aggregation methods were used, these being: the weighed summation technique, used for its transparency and acceptability with stakeholder groups; and the Electré II technique, used to highlight any poor performance in an individual criterion.
3. The results of this analysis from the perspective of the landholder faction are presented in the body of this chapter; those of the other two factions are provided in Appendices 16.3 and 16.4. Differences in the results are discussed in the Section 16.9.

16.2 The Farm Forestry Options

The forestry options considered in the Hodgson creek MODSS are as follows:

Option 1: An approximation of current land-use

This scenario is based on assumptions about ‘typical’ land-uses and includes various possible and likely land-uses. This option provides a baseline against which the others are measured. For an alternative land-use to be viable it must perform better or at least as well as the current land-use.

Option 2: High-priority salinity prevention

This option involves identifying saline and at-risk areas in the catchment, especially the discharge zones. This option involves farm forestry on the associated recharge zones, higher in the catchment.

Option 3: Medium-priority salinity plantings

This option is the same as Option 2, but with a greater proportion of the recharge area planted.

Option 4: Additional under-used areas

This option is the same as Options 2 and 3, but with additional areas recognized as having limited value for conventional agricultural production, being planted with trees, especially if adjacent to the priority salinity areas.

Option 5: Commercial plantations (with corporate land ownership)

This option is based on a medium-scale corporate investment in purchase of land and establishment of forestry in the higher rainfall areas of the region.

Option 6: Commercial plantations (with leased land)

This option is the same as Option 5, except land is leased by the corporation from landholders (potentially increasing the availability and decreasing the cost of land).

Option 7: Private medium-sized plantations

This option is based on a medium-scale forestry planting, undertaken by landholders.

Option 8: Agroforestry (plantations and grazing)

This option involves the establishing of wide-spaced plantations, in conjunction with improved or native pasture or even fodder crop strips in more fertile areas.

16.3 The Criteria for Evaluating the Farm Forestry Options

The performance criteria used to evaluate the forestry options considered in the Hodgson creek MODSS are listed below (and described more fully in Chapter 14).

Economic criteria

Forestry revenue – growth
Forestry revenue – royalty
Infrastructure costs (community)
Regional impact
Regional output
Profit – farm (in transitional or steady-state period)
Profit – regional (in transitional or steady-state period)
Property value
Rating treatment
Risk profile
Risk of policy change
Equity of financial returns
Cash flow – upfront costs
Cash flow – debt servicing
Critical mass
Flexibility of land-use
Liquidity of assets

Environmental criteria

Shelter effects
Soil resource quality
Carbon sequestration
Water quality
Salinity control
Biodiversity (local native)
Water quantity
Cumulative impacts
Displacement of existing native bio systems
Habitat quality
Pest habitat
Air quality (spraying of agricultural chemicals)

Social criteria

Aesthetic amenity
Change management requirements (including res-killing)
Consistency with local state fed government regulation/policy
Net employment
Maintaining services
Community capacity
Community cohesion
Community acceptance
Population turnover
Equity
Community health
Health effects on family

16.4 Importance Orders Applied to the Decision Criteria

Importance orders were elicited from three separate stakeholder groups, namely local landholders, officers from the local shire council and extension staff from state government agencies. It should be noted that the importance orders were personal preference of those questioned, and were not necessarily a reflection of the policy or practice of the agency that employed them. Table 16.1 presents the importance order defined by the local landholders. The importance orders defined by officers from the local shire council and extension staff from state government agencies can be found in Appendices 16.3 and 16.4 respectively.

Table 16.1 Relative importance of the criteria as defined by landholders

Performance criterion	Relative importance
Economic	
Forestry revenue – growth	5 (Not significant)[3]
Forestry revenue – royalty	5 (Not significant)
Infrastructure costs (community)	4
Regional impact	4
Regional output ($)	4
Profit (regional)	1
Profit (farm)	1
Property value	3
Rating treatment	4
Risk profile	2
Risk of policy change	4
Equity of financial returns	4
Cash flow – upfront costs	2
Cash flow – debt servicing	2
Critical mass	4
Flexibility of land-use	3
Liquidity of assets	3

[3] The landholder stakeholder group considered these criteria as insignificant to their decision-making; subsequently, these criteria were placed as the least important in the rank order, a rank of 5.

Performance criterion	Relative importance
Environmental	
Shelter effects	2
Soil resource quality	1
Carbon sequestration	4
Water quality	1
Salinity control	1
Biodiversity (local native)	2
Water quantity	2
Cumulative impacts	2
Displacement of existing native bio-systems	3
Habitat quality	3
Pest habitat	1
Air quality (spraying of agricultural chemicals)	1
Social	
Aesthetic amenity	1
Change management requirements (including reskilling)	4
Consistency with local state federal government regulation/policy	2
Net employment	3
Maintaining services	3
Community capacity	3
Community cohesion	2
Community acceptance	2
Population turnover	2
Equity	2
Community health	2
Health effects on family	1

16.5 The Effects Tables for the Hodgson Creek Study

All the criteria were scored on scale of one to 10, 10 being the best possible score. As this was the initial iteration of the analysis, the options were all scored according to the opinions of the members of the technical reference group. Tables 16.2 and 16.3 display the effects table for the transitional period and the steady-state period in the Hodgson Creek analysis. The tables are also shaded; the darkest shaded cells indicate a score in the lower 30% of the score range, the un-shaded cells the top 30% of the score range, and the light shaded cells show the intermediate scores

Table 16.2 Effects table for the transitional period (years 5-10)

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Economic								
Forestry revenue – growth	1	1	1	1	1	5	1	1
Forestry revenue – royalty	1	1	1	1	1	5	1	1
Infrastructure costs	10	10	10	10	10	10	10	10
Regional impact	1	3	4	9	10	10	9	4
Regional output ($)	9	9	9	8	7	7	7	10
Profit (regional)	10	6	5	3	3	3	3	4
Profit (farm)	10	6	5	3	1	1	1	2
Property value	8	8	8	8	8	8	8	8
Risk profile	9	5	5	5	7	7	7	4
Risk of policy change	8	10	9	9	9	7	7	7
Equity of financial returns	10	9	9	8	7	7	7	9
Cash flow – upfront costs	8	7	6	4	3	10	3	3
Cash flow – debt servicing	8	7	6	4	3	10	3	3
Critical mass	1	2	2	3	4	4	4	3
Flexibility of land-use	10	2	2	2	2	2	2	3
Liquidity of assets	10	1	1	1	1	1	1	1
Environmental								
Shelter effects	1	2	3	4	4	4	4	6
Soil resource quality	1	4	4	4	4	4	4	4
Carbon sequestration	1	6	7	9	10	10	10	9
Water quality	1	3	4	6	7	7	7	6
Salinity control	1	3	4	5	6	6	6	5
BioD (local native)	1	2	3	4	4	4	4	5
Water quantity	10	8	7	6	6	6	6	7
Cumulative impacts	10	10	10	10	10	10	10	10
Displacement of existing	10	9	8	7	7	7	7	7
Habitat quality	1	2	3	3	4	4	4	3
Pest habitat	8	8	7	6	6	6	6	7
Air quality (spraying of	7	6	5	4	3	3	3	3
Social								
Aesthetic amenity	9	10	10	8	8	8	9	9
Change management	10	4	4	8	10	10	8	4
Consistency with	9	10	10	9	9	9	9	9
Net employment	1	5	7	9	9	9	10	5
Maintaining services	1	5	7	9	9	9	10	5
Community capacity	1	4	5	6	7	7	7	6
Community cohesion	5	7	7	7	5	5	5	6
Community acceptance	5	7	7	7	5	5	5	6
Population turnover	7	7	7	7	5	5	5	5
Equity	5	6	6	6	5	5	5	5
Community health	5	5	5	5	5	5	5	5
Health effects on family	5	5	5	5	4	4	4	5

Table 16.3 Effects table for the steady-state or equilibrium period (years 30-40)

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Economic								
Forestry revenue – growth	1	6	7	9	10	10	9	6
Forestry revenue – royalty	1	6	7	9	10	7	9	6
Infrastructure costs	10	10	10	10	9	9	10	10
Regional impact	1	2	2	8	9	9	8	4
Regional output ($)	1	2	2	3	4	4	4	3
Profit (regional)	2	5	6	8	10	10	10	8
Profit (farm)	2	10	10	7	5	5	5	4
Property value	2	10	9	9	9	9	9	7
Risk profile	9	8	8	7	7	7	7	8
Risk of policy change	6	8	8	4	2	2	3	4
Equity of financial returns	10	9	9	8	7	7	7	9
Cash flow – upfront costs	10	10	10	10	10	10	10	10
Cash flow – debt servicing	10	10	10	10	10	10	10	10
Critical mass	1	6	6	8	10	10	10	8
Flexibility of land-use	10	1	1	1	1	1	1	2
Liquidity of assets	7	8	8	8	10	10	10	4
Environmental								
Shelter effects	1	3	4	5	6	6	6	8
Soil resource quality	4	6	5	4	4	4	4	5
Carbon sequestration	1	4	5	7	8	8	8	7
Water quality	1	6	7	8	10	10	10	8
Salinity control	1	7	8	8	8	8	8	8
BioD (local native)	1	4	5	6	6	6	6	7
Water quantity	10	9	8	7	7	7	7	8
Cumulative impacts	9	10	10	10	10	10	10	10
Displacement of existing native bio systems	10	9	8	7	7	7	7	7
Habitat quality	1	4	5	6	6	6	6	6
Pest habitat	8	7	6	5	5	5	5	5
Air quality (spraying of agrichemicals)	7	7	6	5	4	4	4	4
Social								
Aesthetic amenity	9	10	10	8	7	7	8	9
Change management	10	10	10	10	10	10	10	10
Consistency with government regulation/policy	9	10	10	9	9	9	9	9
Net employment	1	2	4	4	3	3	4	2
Maintaining services	1	2	4	4	3	3	4	2
Community capacity	3	5	5	5	6	6	6	6
Community cohesion	5	6	6	6	4	4	4	4
Community acceptance	5	6	6	6	4	4	4	4
Population turnover	7	8	8	8	8	8	8	8
Equity	5	7	7	7	7	7	7	7
Community health	5	5	6	7	7	7	7	7
Health effects on family	5	6	6	6	6	6	6	6

16.6 Results of Analysis from the Landholder Perspective

Some of the results from the MODSS analysis are now presented. The results discussed here are primarily from the local landholder perspective. The results from the perspective of officers from the local shire council and extension staff from state government agencies are reported in Appendices 16.3 and 16.4 respectively.

Figure 16.1 presents in graphical form the aggregated performance of the farm forestry options in the transitional period, and Figure 16.2 in the steady-state period. The panels on the left in Figure 16.1 and 16.2 show the performance using the weighted summation aggregation technique, and the panel on the right, the Electré II aggregation technique. In each panel, the top histogram is the aggregate result of the environmental, economic and social criteria. The second histogram depicts only the economic criteria, third the environmental and fourth the social.

The panels on the left of Figure 16.1 and 16.2 should be considered first. The height of the bar represents the performance of the option – the higher the bars the better the performance. The numbers that appear on top of each bar is the aggregate score for that option, i.e. the weighted sum of the individual scores against all the criteria. Considering the four histograms in this panel, an option will only be considered to have high overall performance if it achieves average or high scores and no low scores in each histogram, i.e. no poor performance in any of the perspectives (economic, environmental or social).

The panels on the right of Figure 16.1 and 16.2 present the aggregated score using the Electré II aggregation and should be considered second. A guide to interpreting these figures can be found in Chapter 15. These histograms display the ordinal ranking of the options; the numbers that appear in these histograms reflect these rankings. The highest performing option is ranked 1, second highest 2, and so on. If the rank achieved by a particular option does not reflect the score it receives using the weighted summation, further investigation is required. For example, if an option receives a high score in the weighted summation results and a low rank in the Electré II results, then that option probably receives poor scores for a number of criteria and high scores for the others. The criteria against which the option performs poorly should be identified from the effects table (Tables 16.2 and 16.3). The graphical representations of the effects table that appear in Appendix 16.1 may be useful in identifying poor performance in individual criteria. The decision-maker should then consider whether these poor performances represent a fatal flaw in this option or if they are compensated for high performance in the other criteria. Poor performance in criteria that were deemed as highly important by the stakeholders are most likely to fatally flaw an option.

Figure 16.3 depicts the change in relative performance of the options across the two time scales. The lines represent the options, while the arrows attached to the lines indicate the passage of time from the transitional period to the steady-state period. In each plot the ideal point (with high performance in both perspectives) is the top right corner of the graph. Options with a general trend towards this area are improving over time. There are three plots in this figure, representing economic versus environmental performance, environmental versus social performance and social versus economic performance.

The interpretation of Figures 16.1 to 16.3 is provided in sections 16.7 and 16.8. Firstly, an overall analysis of the options will be presented in section 16.7; secondly, section 16.8 will present a detailed analysis of each of the individual options.

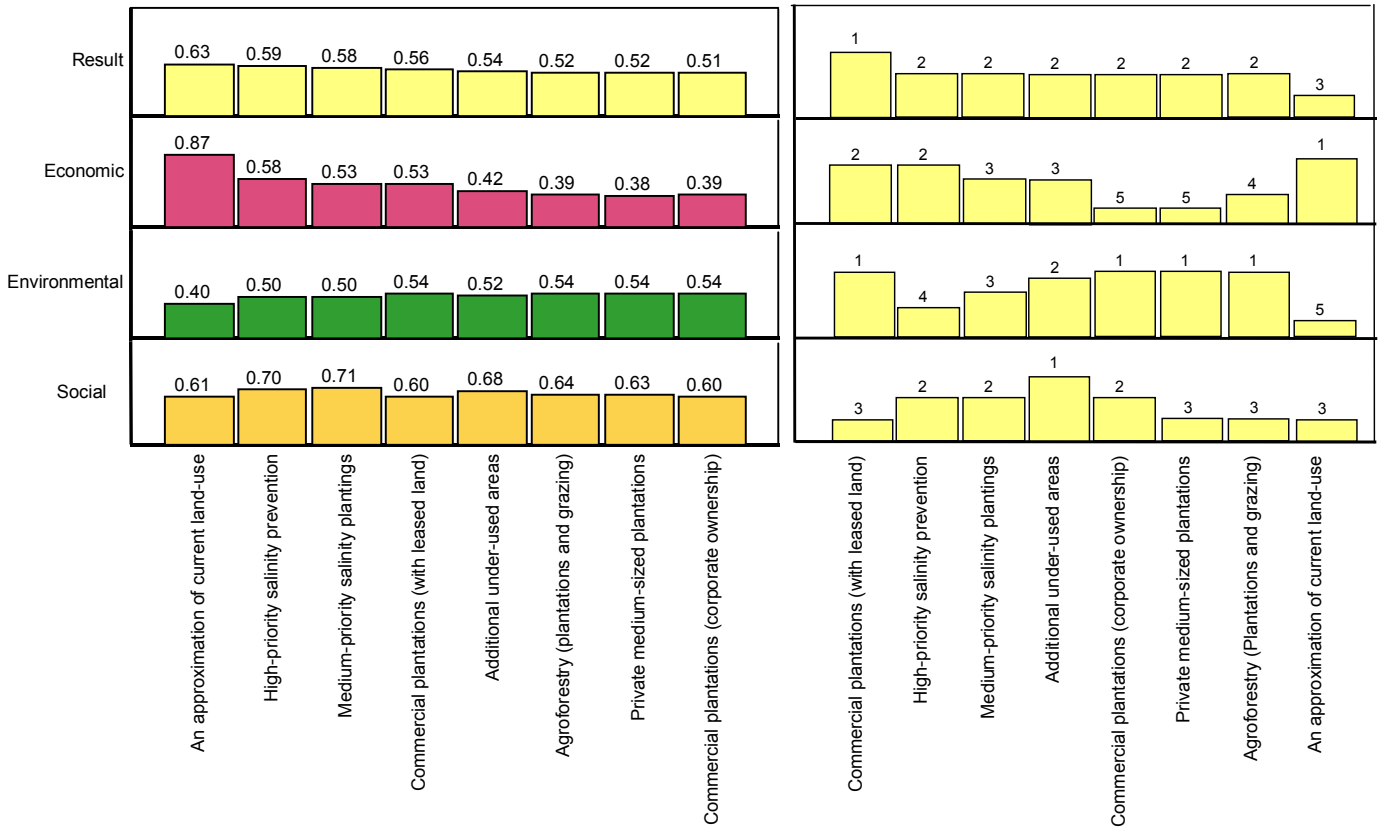


Figure 16.1 Results of the MCA in the transitional period

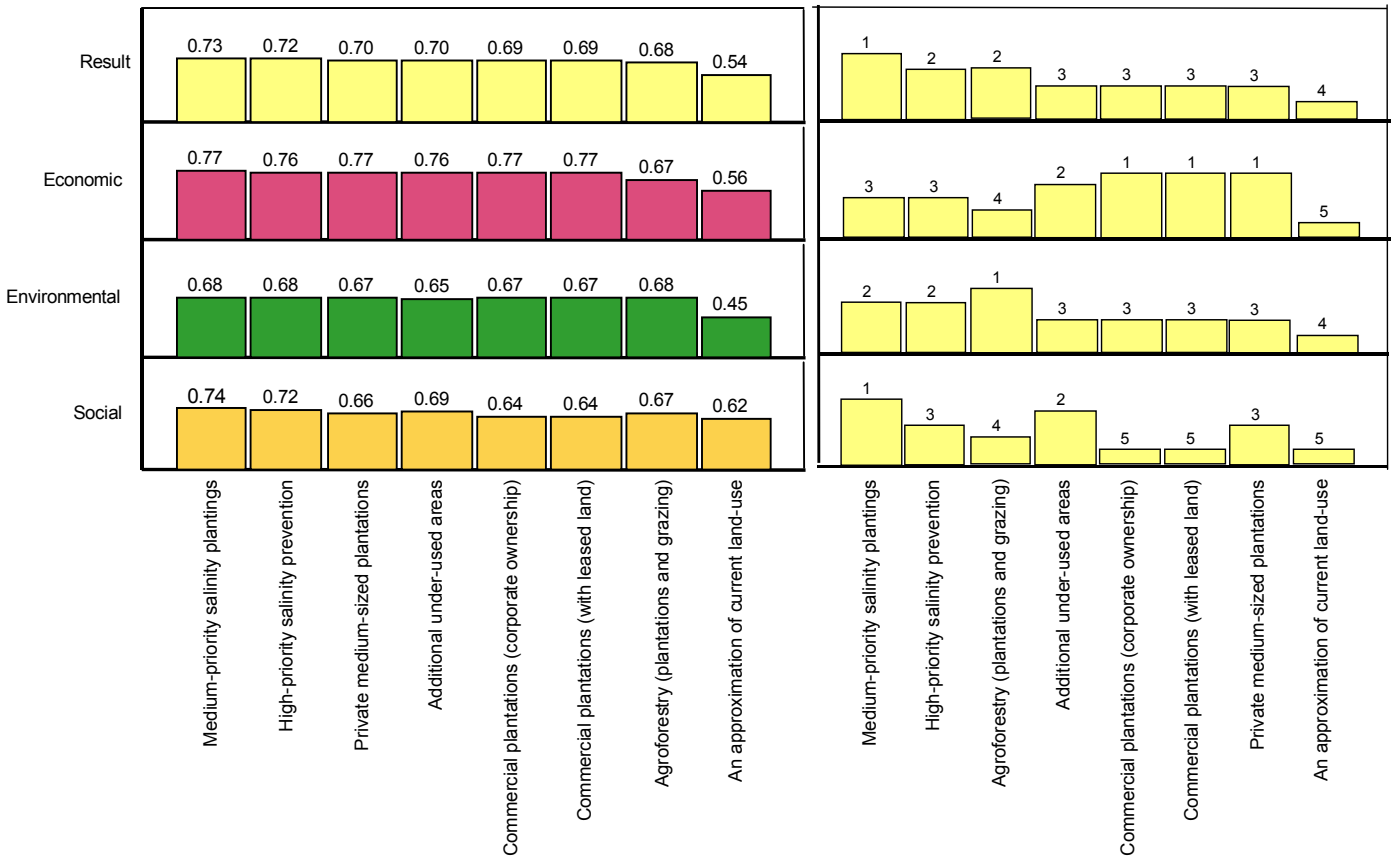
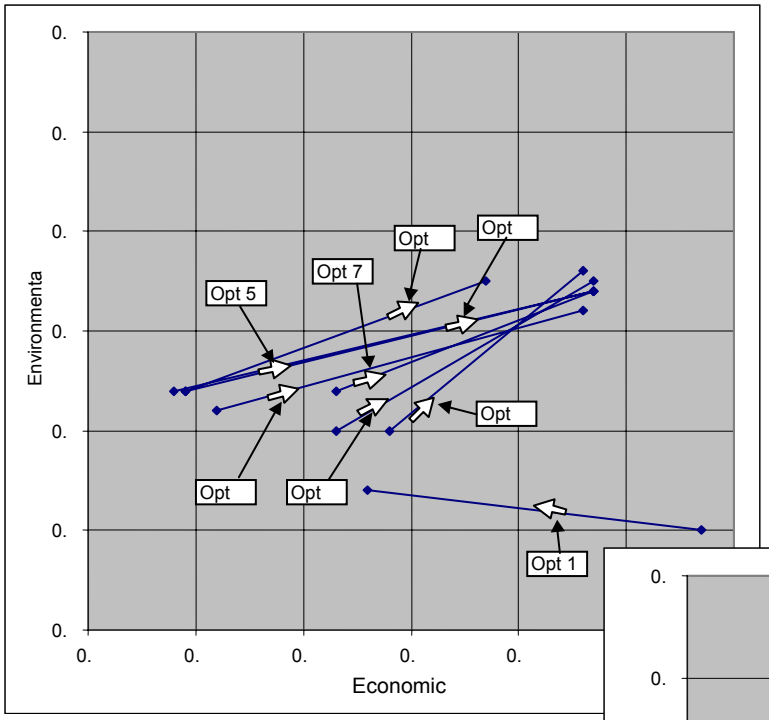
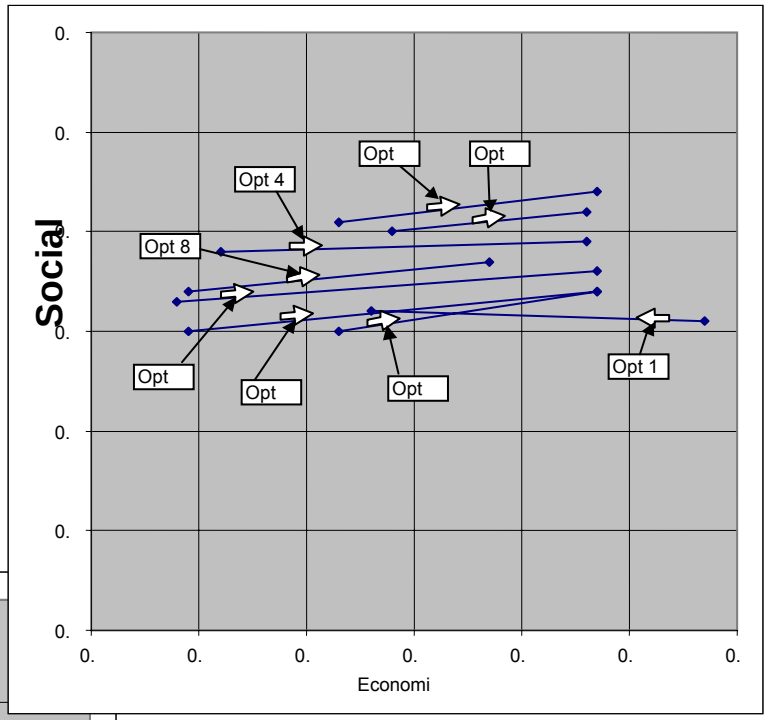


Figure 16.2 Results of the MCA in the steady-state period





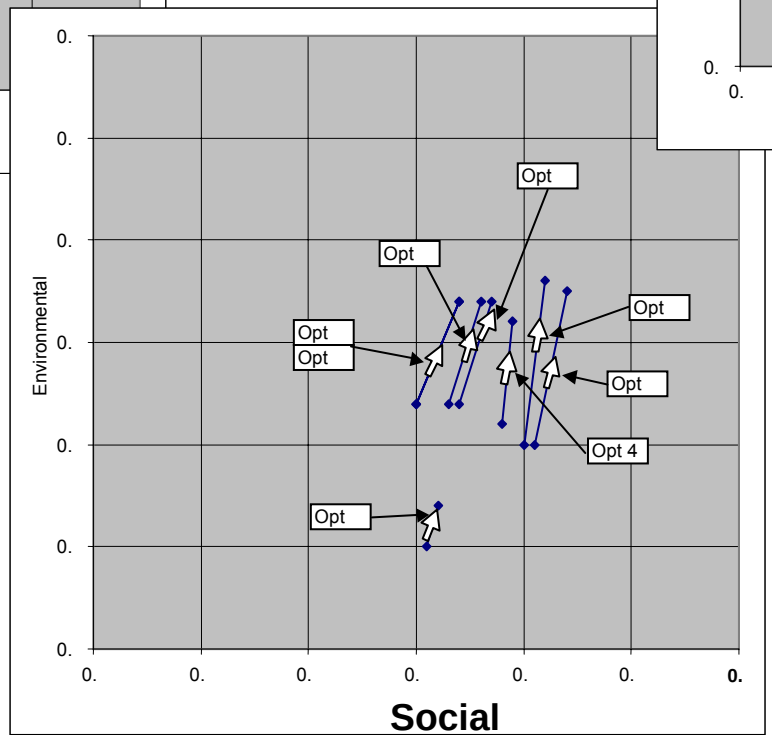


Figure 16.3 Change in relative performance of the options, from the transitional period to the steady-state period

The lines in the panels show the performance of the options, the arrows attached to the lines indicate the passing of time from the transitional period to the steady-state period.

Opt. 1 An approximation of current land use
Opt. 2 High priority salinity prevention
Opt. 3 Medium priority salinity plantings
Opt. 4 Additional under-used areas
Opt. 5 Commercial plantations (with corporate land ownership)
Opt. 6 Commercial plantations (with leased land)
Opt. 7 Private Medium-sized Plantations
Opt. 8 Agroforestry (Plantations and grazing)

16.7 Analysis of the Relative Performance of the Options from the Landholder Perspective

The analysis of the farm forestry in the Hodgson Creek sub-catchment comprised several components. The options were analysed over the transitional and steady-state time periods, and considered from economic, environmental or social perspectives individually, and then from an aggregated perspective in which the economic, environmental and social considerations are integrated and given equal weight. The analysis uses the weighted summation method and the Electré II MCA techniques for aggregating the impacts over the various criteria. The two methods are complementary and aid decision-making. This section will compare the relative performance of the options from the perspective of the economic, environmental and social criteria, and the relative performance of the options across the two time periods considered in the analysis.

Comparison of results using economic, environmental and social criteria, individually and in combination

Using economic criteria alone, in the transitional period 'current practice' is the best option, with high overall performance and no critically poor performance. Other options that perform well are the 'high-priority salinity plantings' and 'commercial plantations (leased land)'. The salinity plantings are small in area and in generally under productive areas so do not displace other land-uses and 'commercial plantations (leased land)' pays annuities. In the steady-state period all the forestry options outperform 'current practice', the large-area forestry options performing best.

Using environmental criteria alone, in both the transitional period and the steady-state period the forestry options outperform 'current practice'. In the transitional period the large-area forestry options, including the 'agroforestry' option, perform better than the small-area forestry options. However in the steady-state period the small-area options outperform the large-area options. The exception to this is the 'agroforestry' option that performs best in the steady-state time period and equal best in the transitional period.

Using social criteria alone in both time periods the small area forestry options perform well, and in the transitional period the 'commercial plantations with leased land' performs well. In the weighted summation analysis 'agroforestry' performs well but not in the Electré II analysis; this may be due to poor performance in a number of criteria.

Using all three major perspectives (economic, environmental and social) aggregated, placing equal weight on each perspective the following observations are noted:

- In the transitional period using the weighted summation analysis all the options fall into a tight range (0.63 to 0.51 on a scale of 1 to 0, 1 being good performance, 0 bad), there is little difference between the options. Within this range, current practice performs best, 'high-priority salinity plantings' and 'medium-priority salinity plantings' perform very similarly to each other and second best, next 'commercial plantations (leased land)' and then the other options. There is a general trend that performance drops as the area planted by trees increases. Considering the Electré II analysis, the results are quite different. The 'commercial plantations (leased land)' option is ranked first, all the other forestry options second and 'current practice' third and last. 'Commercial plantations (leased land)' perform well overall as the scores for the individual criteria are general high and it has few exceptionally poor performing criteria. It scores poorly in the economic criterion of *liquidity of assets* (as do all the forest options) but no others. The drop in performance of 'current practice' is due to critically poor performance in a number of environmental and social criteria.

- In the steady-state period using the weighted summation analysis there is more definition between the options (a range of 0.73 to 0.54). All the forestry options perform similarly within the range of 0.73 to 0.68, and all outperform current practice. Using the Electré II method 'medium-priority salinity plantings' performs best with high-priority second then 'agroforestry', followed by all the other forestry options and current practice with the worst performance. The poorer performance of the large-area forestry options is largely due to poor performance in the social group of criteria.

Relative performance of options over time using economic, environmental, social criteria (or all combined)

The time plots (Figure 16.3) show the changes in scores for the options with the passage of time. The arrows indicate the passage of time and point from the transitional score to the steady-state score. The three plots show the environmental scores plotted against the economic, the social against the environmental and the economic against the social.

Apart from option 1, 'current practice', the options exhibit a general trend towards the top right of the panels indicating an improvement in this area. 'Current practice' shows a large decrease in performance in the economic group of criteria, dropping from a score of 0.87 to 0.56. No other option has a drop in performance. 'Current practice' does, however, show a marginal improvement in both the environmental group (0.40 to 0.45) and the social group (0.60 to 0.61).

Whilst it is not possible to analyse the options in detail using these plots (this will be for each option in the next section) general trends can be identified.

In this analysis all the forestry options exhibit high improvements from all perspectives, the performance of 'current practice' decreases or only improves marginally. Therefore any forestry in this catchment would improve the economy, environment and social wellbeing.

16.8 Performance of Individual Options from the Landholder Perspective

In this section the performance of each option will be discussed in detail. These discussions will draw on the results of the overall analysis and the performance of each option against specific criteria.

Option 1: An approximation of current land-use

Table 16.4 lists the high and low-performing criteria, defined as the criteria with values in the top 30% and lowest 30% of the score range respectively. The evaluation of each option against the set of criteria can be found in Tables 16.2 and 16.3. A criterion against which an option receives a high score relates to the unshaded cells in Tables 16.2 and 16.3, a low score relates to the dark shaded cells. The criteria are listed in no particular order.

This option 'Approximation to current land-use' has variable overall performance in the transitional period. It performs well under the weighted summation analysis and poorly under the Electré II analysis. This indicates sound overall performance but with critically poor performance in some criteria. This is highlighted when the perspectives are considered separately. This option easily outperforms the options in the economic perspective but has poor performance in a number of criteria, especially the key criteria of *regional impact*, and the change in regional structure, employment, services and infrastructure. This is however ranked of low importance by the landholders' perspective.

'Current practice' has the poorest performance in the environmental perspective, with poor performance in many criteria, many of which are ranked of high importance.

Table 16.4 High and low scores for an approximation of current land-use

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional output ($) Profit (regional) Profit (farm) Property value Risk profile Risk of policy change Equity of financial returns Cash flow – upfront costs Cash flow – debt servicing Flexibility of land-use Liquidity of assets	Forestry revenue – growth Forestry revenue – royalty Regional impact Critical mass	Infrastructure costs (community) Risk profile Equity of financial returns Cash flow – upfront costs Cash flow – debt servicing Flexibility of land-use Liquidity of assets	Forestry revenue – growth Forestry revenue – Royalty Regional impact Regional output ($) Profit (regional) Profit (farm) Critical mass
		Environmental criteria	
Water quantity Cumulative impacts Displacement of existing native bio systems Pest habitat	Shelter effects Soil resource quality Carbon sequestration Water quality Salinity control BioD (local native) Habitat quality	Water quantity Cumulative impacts Displacement of existing native bio systems Pest habitat Habitat quality	Carbon sequestration Water quality Salinity control Biodiversity. (local native)
		Social criteria	
Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy	Maintaining services Community capacity	Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy	Maintaining services Community capacity

From the social perspective this option is amongst a group of lower performing options. With poor performance in *maintaining services* and *community capacity*, the stakeholders rank these criteria as third highest importance in a four-point importance order, as presented in Table 16.1.

In the transitional period, this option has high economic performance, poor environmental performance and average social performance. This option has particular poor performance in maintaining employment, local services and infrastructure as well as environmental issues.

In the steady-state period, the overall performance of this option worsens considerably. It has the worst performance overall and in the economic and environmental perspective, although the environmental performance improves slightly. It has average to poor performance in the social perspective, again a slight improvement for the transitional period. It has poor or very poor performance in many important economic criteria.

This option is unlikely to sustain economic viability and environment protection or maintain employment, local services and local infrastructure.

Option 2: High-priority salinity prevention

Table 16.5 lists the high and low-performing criteria, these being the criteria with scores in the top 30% and the lowest 30% of the score range respectively.

Table 16.5 High and low scores for high-priority salinity prevention

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional output ($) Property value Risk of policy change Equity of financial returns	Forestry revenue – growth Forestry revenue – royalty Regional impact Critical mass Flexibility of land-use Liquidity of assets	Infrastructure costs (community) Profit (farm) Property value Risk profile Risk of policy change Equity of financial returns Cash flow – upfront costs Cash flow – debt servicing	Regional impact Regional output ($) Flexibility of land-use
		Environmental criteria	
Water quantity Cumulative impacts Displacement of existing native bio systems Pest habitat	Shelter effects Water quality Salinity control Biodiversity (local native) Habitat quality	Water quantity Cumulative impacts Displacement of existing native bio systems	Shelter effects
		Social criteria	
Aesthetic amenity Consistency with local state fed government regulation/policy		Aesthetic amenity Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Population turnover	Net employment Maintaining services

In the transitional period, ‘High priority salinity plantings’ performs well overall. In the weighted summation results, it comes second after ‘Current practice’, and in the Electré II results it is ranked second on a three point ranking (see Figure 16.1) together with ‘Medium priority salinity plantings’, ‘Additional under-used areas’, ‘Commercial plantations (with corporate land ownership)’, and ‘Agroforestry (plantations and grazing)’. Considering only the economic criteria, it is one of the higher-ranking forestry options. It does however have poor performance in some criteria, notably *critical mass*, because the total area forested will be small, and may be insufficient to support a forest industry in the catchment. From an environmental perspective this is one of poorer performing options; performance level of an option and aggregate area planted to forestry appeared to be positively correlated. Socially, it is one of best performing options and has no low scores.

In the steady state this option performs well overall, being the second highest scoring option in the weighted summation and ranked second in a four-point ranking (see Figure 16.2) in the Electré II results. From the economic perspective its performance remains high, although low scores for the criteria *regional impact* and *regional output* cause a drop in performance using the Electré II technique. Performance is also high from the environmental perspective, though falling under the Electré II technique due to the low score for *shelter effects*. Socially, it performs well (second highest

score) but drops back to third on a five-point scale in the Electré II analysis due to poor performance in the criteria *net employment* and *maintaining services*.

This option performs well overall but there are concerns that the aggregate area which will be planted is not large enough for a viable forestry industry, signified in a low score for the *critical mass* criterion, and there are only marginal improvements from the environmental and social perspective. There is also a limited potential to maintain employment, local services and infrastructure

Option 3: Medium-priority salinity plantings

Table 16.6 lists the high and low performing criteria for this option. The overall performance in the transitional period is marginally lower than that for 'high priority salinity plantings'. The individual perspectives reflect this trend, with the exception of the environment aspects, in which this option performs better and has fewer critically low scores.

Table 16.6 High and low scores for medium-priority salinity plantings

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional output ($) Property value Risk of policy change Equity of financial returns	Forestry revenue – growth Forestry revenue – royalty Critical mass Flexibility of land-use Liquidity of assets	Infrastructure costs (community) Profit (farm) Property value Risk profile Risk of policy change Equity of financial returns Cash flow – upfront costs Cash flow – debt servicing Liquidity of assets	Regional impact Regional output ($) Flexibility of land-use
		Environmental criteria	
Cumulative impacts Displacement of existing native bio systems	Shelter effects Biodiversity (local native) Habitat quality	Salinity control Water quantity Cumulative impacts Displacement of existing native bio systems	
		Social criteria	
Aesthetic amenity Consistency with local state fed government regulation/policy		Aesthetic amenity Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Population turnover	

In the steady-state analysis this options performs similarly to 'high priority salinity plantings'. It has similar economic issues but displays a relative increase in performance from the environmental and social perspectives.

Concerns remain about long-term performance due to the size of plantings. These have increased to a level that may provide some water quality and salinity benefit. The viability of this option would depend on the value of the ecosystem services it supplies rather than economic returns.

Option 4: Additional under-used areas

Table 16.7 lists the high and low performing criteria for this option. In the transitional period this option has average performance. It scores at the lower end of the range in the weighted summation analysis and second in a three-point rank, using Electré II (as do all of the options except 'current practice'). It has similar performance from the economic perspective, with poor financial returns (low scores in *profit -farm and regional*, and *forestry revenue growth and royalty*). From the environmental perspective it has high performance, its increase performance is relative to its size, it only has poor performing environmental criteria. It has high performance from the social perspective with a high score using the weighted summation and is ranked first using Electré II.

Table 16.7 High and low scores for additional under-used areas

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional impact Regional output ($) Property value Risk of policy change Equity of financial returns	Forestry revenue – growth Forestry revenue – royalty Profit (regional) Profit (farm) Critical mass Flexibility of land-use Liquidity of assets	Forestry revenue – growth Forestry revenue – royalty Infrastructure costs (community) Regional impact	Regional output ($) Flexibility of land-use
		Environmental criteria	
Carbon sequestration Cumulative impacts	Habitat quality	Water quality Salinity control Cumulative impacts	
		Social criteria	
Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Net employment Maintaining services		Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Population turnover	

In the steady-state period it maintains a high performance ranking. From the economic perspective it ranks second on a five-point rank. There are some concerns with low scores in *regional output* and *flexibility of land-use*. All the options except 'current practice' score poorly in flexibility of land-use. The establishment time is lengthy relative to other agricultural land-uses. The landholder stakeholder faction places a low rank on this criterion. Environmentally it scores well, with no low ranking criteria. From a social perspective it is one of the higher ranking options, with no poor performing criteria.

The forestry operation in this option is reaching a size that may prove viable in the catchment, although it is still sufficiently small to remain acceptable from a social perspective.

Option 5: Commercial plantations (with corporate land ownership)

Table 16.8 lists the high and low performing criteria for this option. In the transitional period this option has poor overall performance, being ranked second (with the all the other options except

'current practice') using Electré II. From the economic perspective it scores low and is ranked last, having poor performance in *profit – regional and farm, cash flow upfront costs and debt servicing*. This reflects the high cost of establishing such an industry, and with corporate ownership profit will return to the parent corporation, not to persons within the catchment. From the environmental perspective it has high overall performance and is ranked joint first with the other large forestry options. It does however have critically low performance in the important environmental criterion of *air quality* due to the requirements for spraying of agricultural chemicals. Socially, it has poor performance generally over all the criteria with no critically poor performance. This option would require corporations to purchase land in the catchment, the effects of which is not currently reflected in the criteria.

Table 16.8. High and low scores for commercial plantations (with corporate land ownership)

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional impact Property value Risk of policy change	Forestry revenue – growth Forestry revenue – royalty Profit (regional) Profit (farm) Cash flow – upfront costs Cash flow – debt servicing Flexibility of land-use Liquidity of assets	Forestry revenue – growth Forestry revenue – royalty Infrastructure costs (community) Regional impact Profit (regional) Property value Cash flow – upfront costs Cash flow – debt servicing Critical mass Liquidity of assets	Risk of policy change Flexibility of land-use
		Environmental criteria	
Carbon sequestration Cumulative impacts	Air quality (spraying of agri. chemicals)	Carbon sequestration Water quality Salinity control Cumulative impacts	
		Social criteria	
Aesthetic amenity Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Net employment Maintaining services		Change management requirements (incl. re-skilling) Consistency with local state fed government regulation/policy Population turnover	Net employment Maintaining services

The overall performance in the steady-state period is high, though marginally lower than the other forestry options. This option is ranked third in a four-point scale using Electré II. From the economic perspective it scores well and is ranked joint first; it does however have poor performance in *risk of policy change* and *flexibility of land-use*. Environmentally, it performs well on the weighted summation analysis but is ranked third in a four-point scale using Electré II, having a low score for *air quality* due to the need for application of agricultural chemicals. Socially it performs poorly, with a low overall score, and is ranked equal last. There are continuing problems with maintaining employment, local services and infrastructure.

In summary, this option has sound long-term economic prospects, but this comes at a cost to local agriculture and the local community.

Option 6: Commercial plantations (with leased land)

Table 16.9 lists the high and low performing criteria for this option. In the transitional period, this option is ranked first in the Electré II analysis, being one of the highest scoring forestry options in terms of overall score. From the economic perspective it is ranked second in the Electré II analysis. Environmentally, it performs well at this time scale in both analyses, but does have a possibly critically low performance in the important criterion of *air quality* due to the requirements for spraying of agricultural chemicals. Socially, it has overall poor performance but has no critically poor performing criteria.

Table 16.9 High and low scores for commercial plantations (with leased land)

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional impact Property value Cash flow – upfront costs Cash flow – debt servicing	Profit (regional) Profit (farm) Flexibility of land-use Liquidity of assets	Forestry revenue – growth Infrastructure costs (community) Regional impact Infrastructure costs (community) Regional impact Property value Cash flow – upfront costs Cash flow – debt servicing Critical mass Liquidity of assets	Risk of policy change
		Environmental criteria	
Carbon sequestration Cumulative impacts	Air quality (spraying of agri chemicals)	Carbon sequestration Water quality Salinity control Cumulative impacts	
		Social criteria	
Aesthetic amenity Change management requirements (including re-skilling) Consistency with local state and federal government regulation/policy Net employment Maintaining services		Change management requirements (including Re-skilling) Consistency with local regulation/policy state and federal government	Net employment Maintaining services

The overall performance is high in the steady-state period, though marginally lower than the other forestry options. This option is ranked third in a four-point rank. From the economic perspective it scores well and is ranked joint first, though the performance in *risk of policy change* and *flexibility of land-use* is poor. Environmentally, it performs well on the weighted summation analysis but is ranked third in a four-point scale using Electré II, having a low score for *air quality* due to the

continuing need for agricultural chemicals. Socially it performs poorly (equal last), with a low overall score. There are continuing problems with maintaining employment, local services and infrastructure.

In summary, this option has sound long-term economic prospects, but this comes at a cost to local agriculture and the local community, although less of a cost than corporately-owned plantations.

Option 7: Private medium-sized plantations

Table 16.10 lists the high and low performing criteria (top 30% and lowest 30% of the performance score range respectively). In the transitional period this option has poor overall performance and is ranked second (with the all the other options except 'current practice') using Electré II. From the economic perspective it has the lowest overall score, and has many critically poor performing criteria. From the environmental perspective it performs well, except for the need for spraying agricultural chemicals and hence adverse effect on *air quality*. Socially, it has average performance, with no critically low performing criteria.

Table 16.10 High and low scores for private medium-sized plantations

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
	Economic criteria		
Infrastructure costs (community) Regional impact Property value	Forestry revenue – growth Forestry revenue – royalty Infrastructure costs (community) Regional impact Cash flow – upfront costs Cash flow – debt servicing Flexibility of land-use Liquidity of assets	Forestry revenue – growth Forestry revenue – royalty Infrastructure costs (community) Regional impact Infrastructure costs (community) Property value Cash flow – upfront costs Cash flow – debt servicing Critical mass Liquidity of assets	Risk of policy change Flexibility of land-use
	Environmental criteria		
Carbon sequestration Cumulative impacts	Air quality (spraying of agri chemicals)	Carbon sequestration Water quality Salinity control Cumulative impacts	

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Social criteria	
Change management requirements (incl reskilling) Consistency with local state fed government regulation/policy Net employment Maintaining services		Change management requirements (incl reskilling) Consistency with local state fed government regulation/policy Population turnover	

In the steady-state period the overall performance is sound, though marginally lower than the other forestry options (all the options 'except current practice'), being ranked third in a four-point scale. From the economic perspective it is ranked joint first, but does however have poor performance in *risk of policy change* and *flexibility of land-use*. Environmentally, it performs well on the weighted summation analysis but is ranked third in a four-point scale using Electré II, having a low score for *air quality* due to the continuing need for agricultural chemicals. Socially, it has average performance but has no critically low performing criteria, and outperforms the other large-area forestry options.

In summary, this option has potentially high economic returns in the long term, but has adverse features concerning cash flow and debt servicing in the transitional period. There are also continuing issues with spraying of agricultural chemicals and the perceived health effects.

Option 8: Agroforestry (plantations and grazing)

Table 16.11 lists the high and low performing criteria for this option. In the transitional period this option has poor overall performance and is ranked second (with most of the forestry options). From the economic perspective is has poor overall performance and is ranked fourth on a five-point scale. Environmentally, it has overall high performance and is ranked joint first. The scores are low for *habitat quality* and *air quality* (agricultural chemical spraying). From the social perspective overall performance is average using the weighted summation aggregation but ranked joint last using Electré II. It is ranked highly by landholders on the social criteria of *aesthetic amenity*, which is one of the joint most important social criteria.

Table 16.11. High and low scores for agroforestry (plantations and grazing)

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Economic criteria	
Infrastructure costs (community) Regional output ($) Property value Equity of financial returns	Forestry revenue – growth Forestry revenue – royalty Regional impact Cash flow – upfront costs Cash flow – debt servicing Critical mass Flexibility of land-use Liquidity of assets	Infrastructure costs (community) Risk profile Equity of financial returns Cash flow – upfront costs Cash flow – debt servicing Critical mass	Regional output ($) Flexibility of land-use

Transitional period high scores	Transitional period low scores	Steady-state period high scores	Steady-state period low scores
		Environmental criteria	
Carbon sequestration Cumulative impacts	Habitat quality Air quality (spraying of agri chemicals)	Water quality Salinity control Water quantity Cumulative impacts Cumulative impacts Shelter effects	
		Social criteria	
Aesthetic amenity Consistency with local state fed government regulation/policy		Change management requirements (incl reskilling) Consistency with local state fed government regulation/policy Population turnover Aesthetic amenity	Net employment Maintaining services

In the steady-state period in the overall analysis this option has the second lowest score, being superior to 'current practice' only. It is however ranked second on a four-point scale using the Electré II technique. From the economic perspective it again ranks ahead of 'current practice' only. It has critically poor performances in *regional output* and *flexibility of land-use*, and also has low scores in *profit* and *forestry revenue*. This reflects doubt about the quality and value of forestry products from this planting regime. Environmentally, in the steady-state period this option outperforms all the others, with no poor performing criteria. The social performance is average using the weighted summation and is ranked four on a five-point scale using Electré II. It has low scores in *net employment* and *maintaining services*, but scores well in the important criterion of *aesthetic amenity*.

In summary, this option offers marginal economic benefits but extensive environmental benefits. There is a perception that this planting regime is similar to the pre-cleared appearance of the landscape.

16.9 Comparison Between Analysis from a Landholder Perspective and that Using Importance Orders of Other Stakeholder Groups

The analysis so far has only been concerned with the results using the importance order from the landholders' perspective. The other two stakeholder groups were officers from the local Shire council and extension staff from State government agencies. The differing importance attached to the criteria recognizes that each group has differing goals and objectives regarding farm forestry. The analysis was repeated using the importance orders supplied by these factions. The rankings obtained are reported in Appendices 16.3 and 16.4 respectively. The discussion of the results from the landholder perspective is not repeated, but differences between the results will be highlighted and discussed for the other factions.

Considering the importance order supplied by officers from the local Shire council, the following differences are noted.

1. In the transitional period, there is no change in outcomes relative to those of the analysis using the landholder preferences. There is some difference between the options using the weighted summation, but the Electré II results remain unchanged, relative to the analysis using the landholder preferences. The commercial plantation with leased land has improved performance from the economic perspective. Environmentally, the smaller-area forestry options and especially

the high-priority salinity plantings show improved performance, with the large-area forestry options having a decrease in performance. Socially, the option of current practice exhibits a drop in absolute performance but maintains its relative position.
2. In the steady-state period there is little or no difference in the relative performance of the other options. Exceptions are the commercial plantation options that improve their relative performance in the social perspective.
3. Finally, considering the time plots, the economic and environmental considerations remain unchanged – the trends present in the analysis for the landholder stakeholder faction are still present. For the social perspective, all the forestry options exhibit a decline in performance in the steady state from the transitional state.

Considering the importance order supplied by extension staff from State government agencies, the following differences are noted relative to the analysis using the landholder preferences.
1. In the transitional period in the overall analysis the option commercial plantation with leased land has higher performance, equaling current practice under the weighted summation, and is ranked first using Electré II. High and medium salinity prevention plantings also have higher performance, and are first using Electré II. This higher performance for all three options is largely due to their superior economic performance. Environmentally, the 'agroforestry (plantings and grazing)' option outperforms all the other options. Performance is similar to that using the landholder preferences from a social perspective.
2. In the steady-state period there is less definition between the options, but the relative performance remains the same.
3. In the time plots, the larger forestry options have marginally better economic performance in and marginally lower social performance. Performance is similar to that using the landholder preferences from the environmental perspective.

16.10 Conclusions and Recommendations

All the forestry options outperform 'current practice' from most perspectives at both time periods. The major exception is the transitional time period, from an economic perspective, where current practice outperforms all of the forestry options. For forestry to be a viable option in this catchment, measures need to be taken to ameliorate this poor economic performance. Possible measures could include direct government assistance through subsidies, changes in rates systems for forestry, payments for ecosystem services, or other financing structures such as timber co-operatives.

The option of 'commercial plantations (with leased land)' is the best performing forestry option from the economic perspective in the transitional period. This is largely due to the payment of annuities to the landholder by the organisation leasing their land. This option has high overall economic and environmental performance at both time scales. *Air quality* was a major environmental consideration for landholders present at the stakeholder meeting; large-scale forestry requires aerial spraying of agricultural chemicals. Alternative methods of applying these chemicals would need to be considered, for this option to be acceptable in this catchment. This option has average performance in the social perspective under the weighted summation analysis and poor performance in the Electré II analysis, in the steady-state period. This is largely due to poor performance in the criteria *net employment* and *maintaining services;* every option has a low score in these criteria. 'Commercial plantations on leased land' score 3 out of 10, and the best options ('medium-priority salinity plantings', 'additional under-used areas' and 'private medium-sized plantations') score 4 out of 10 in the steady-state period. This suggests that the root of these problems lays elsewhere and is not going to be solved in the long term by introducing a forestry industry in the catchment. This option does however score well against these criteria in the transitional period. In both time periods, 'current practice' scores poorly (1 out of 10) in these criteria.

The options 'additional under-used areas' is also worthy of further consideration, especially if the areas are also those identified where forests may aid salinity prevention. This option has high

performance from the environmental and social perspectives at both time scales. Environmentally, it does not perform as high as the larger area forestry options because the forested area is considerably smaller. The steady-state economics are sound, but the effect on the regional economy would be small because the planted areas are small. The small area planted under this option leads to problems in the transitional period, the option having low scores in *critical mass* and farm and *regional profitability*. This poor performance could be ameliorated by large-scale forestry being established in neighbouring areas. This small-scale industry could piggyback on a nearby large-scale plantation forestry industry, and therefore is worth considering in combination with the previous option.

The ‘agroforestry’ option, whilst it has major concerns due to poor performance in key economic criteria, is worthy of further consideration for its high performance from both the environmental and social perspectives. Low scores in the important economic criterion of *farm profit* in both time periods may however be insurmountable.

Depending on the goals and objectives of the individual landholders any of the options considered may be planted. This analysis has identified the strengths and weaknesses of all the options. This informs the landholder as to benefits and costs that may be incurred when considering any of the farm forestry options and promotes informed decision-making.

Appendix 16.1: Effects table for the Hodgson Creek MODSS

This appendix presents the effects table for the Hodgson Creek MODSS, including the score rationales. The score rationales are the stated reason why the technical reference group assigned a specific value. Rationales were not assigned for every score.

Table 16.A1 Effects table for the final analysis with score rationales in the transitional period (year 5-10)

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Economic								
Forestry revenue – growth	1	1	1	1	1	5 - pays yearly annuity	1	1
Forestry revenue – royalty	1	1	1	1	1	5 - pays yearly annuity	1	1
Infrastructure costs (community)	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present
Regional impact	1	3	4	9	10	10	9	4
Regional output ($)	9	9 - poor quality land little increase to output, no lose in good quality country	9	8	7 - removes good quality agricultural land from conventional production	7 - removes good quality agricultural land from conventional production	7 - removes good quality agricultural land from conventional production	10
Profit (regional)	10	6	5	3	3	3	3	4
Profit (farm)	10	6	5	3	1	1	1	2
Property value	8	8	8	8	8	8	8	8
Rating treatment								
Risk profile	9	5	5	5	7	7	7	4
Risk of policy change	8	10	9	9	9	7	7	7
Equity of financial returns	10	9	9	8	7	7	7	9
Cash flow – upfront costs	8	7	6	4	3	10	3	3
Cash flow – debt servicing	8	7	6	4	3	10	3	3
Critical mass	1	2	2	3	4	4	4	3
Flexibility of land-use	10	2	2	2	2	2	2	3
Liquidity of assets	10	1	1	1	1	1	1	1

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Environmental								
Shelter effects	1	2	3	4	4	4	4	6
Soil resource quality	1	4	4	4	4	4	4	4
Carbon sequestration	1	6	7	9	10	10	10	9
Water quality	1	3	4	6	7	7	7	6
Salinity control	1	3	4	5	6	6	6	5
BioD (local native)	1	2	3	4	4	4	4	5
Water quantity	10	8	7	6	6	6	6	7
Cumulative impacts	10	10	10	10	10	10	10	10
Displacement of existing native bio systems	10	9	8	7	7	7	7	7
Habitat quality	1	2	3	3	4	4	4	3
Pest habitat	8	8	7	6	6	6	6	7
Air quality (spraying of agri chemicals)	7	6	5	4	3	3	3	3

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Social								
Aesthetic amenity	9	10	10	8	8	8	9	9
Change management requirements (incl reskilling)	10 - no new skills required	4 - smaller fragmented areas hard to manage	4 - smaller fragmented areas hard to manage	8 - larger consolidated areas easier to manage	10 - imported labour and imported skills	10 - imported labour and imported skills	8 - larger consolidated areas easier to manage	4 - there are difficulties in managing stock in the plantation, when do you first allow stock in, when does the canopy cover prevent grazing.
Consistency with local state fed government regulation/policy	9 - no conflict with government regs	10 due to current High-priority given to salinity issues	10 due to current High-priority given to salinity issues	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs
Net employment	1	5	7	9	9	9	10	5
Maintaining services	1	5	7	9	9	9	10	5
Community capacity	1	4	5	6	7	7	7	6
Community cohesion	5	7	7	7	5	5	5	6
Community acceptance	5	7	7	7	5	5	5	6
Population turnover	7	7	7	7	5	5	5	5
Equity	5	6	6	6	5	5	5	5
Community health	5	5	5	5	5	5	5	5
Health effects on family	5	5	5	5	4	4	4	5

Table 16.A2 Effects table for the final analysis with score rationales in the steady-state, equilibrium period (year 30-40)

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Economic								
Forestry revenue – growth	1	6 - small areas	7-moderate areas	9 - large areas	10 - largest areas note not a lot larger then Opt. 4	10 - as Opt. 5	9 - similar to Opt. 4	6 - large area, low volumes, lower value products
Forestry revenue – royalty	1	6 - reflect areas as described above	7	9	10	7 - lower as annuity payments do not vary	9	6
Infrastructure costs (community)	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	10 - required infrastructure present	9 - some increased road maintenance required heavy loads being carried	9 - some increased road maintenance required heavy loads being carried	10 - required infrastructure present	10 - required infrastructure present
Regional impact	1	2	2	8	9	9	8	4
Regional output ($)	1	2	2	3	4	4	4	3
Profit (regional)	2	5	6	8	10	10	10	8
Profit (farm)	2	10	10	7	5	5	5	4
Property value	2	10	9	9	9	9	9	7
Rating treatment								
Risk profile	9	8	8	7	7	7	7	8
Risk of policy change	6	8	8	4	2	2	3	4
Equity of financial returns	10	9	9	8	7	7	7	9
Cash flow – upfront costs	10	10	10	10	10	10	10	10
Cash flow – debt servicing	10	10	10	10	10	10	10	10
Critical mass	1	6	6	8	10	10	10	8
Flexibility of land-use	10	1	1	1	1	1	1	2
Liquidity of assets	7	8	8	8	10	10	10	4
Environmental								
Shelter effects	1	3	4	5	6	6	6	8
Soil resource quality	4	6	5	4	4	4	4	5
Carbon sequestration	1	4	5	7	8	8	8	7

Performance criterion	An approximation of current land-use	High-priority salinity prevention	Medium-priority salinity plantings	Additional under-used areas	Commercial plantations (with corporate land ownership)	Commercial plantations (with leased land)	Private Medium-sized Plantations	Agroforestry (Plantations and grazing)
Water quality	1	6	7	8	10	10	10	8
Salinity control	1	7	8	8	8	8	8	8
BioD (local native)	1	4	5	6	6	6	6	7
Water quantity	10	9	8	7	7	7	7	8
Cumulative impacts	9	10	10	10	10	10	10	10
Displacement of existing native bio systems	10	9	8	7	7	7	7	7
Habitat quality	1	4	5	6	6	6	6	6
Pest habitat	8	7	6	5	5	5	5	5
Air quality (spraying of agri chemicals)	7	7	6	5	4	4	4	4
Social								
Aesthetic amenity	9	10	10	8	7	7	8	9
Change management requirements (incl reskilling)	10 - no new skills required	10 - new skills have already been acquired	10 - new skills have already been acquired	10 - new skills have already been acquired	10 - new skills have already been acquired	10 - new skills have already been acquired	10 - new skills have already been acquired	10 - new skills have already been acquired
Consistency with local state fed government regulation/policy	9 - no conflict with government regs	10 due to current High-priority given to salinity issues	10 due to current High-priority given to salinity issues	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs	9 - no conflict with government regs
Net employment	1	2	4	4	3	3	4	2
Maintaining services	1	2	4	4	3	3	4	2
Community capacity	3	5	5	5	6	6	6	6
Community cohesion	5	6	6	6	4	4	4	4
Community acceptance	5	6	6	6	4	4	4	4
Population turnover	7	8	8	8	8	8	8	8
Equity	5	7	7	7	7	7	7	7
Community health	5	5	6	7	7	7	7	7
Health effects on family	5	6	6	6	6	6	6	6

Appendix 16.2: Graphical representations of the effects tables

Figures 16.A1, 16.A2 and 16.A3 display graphical representations of Tables 16.2 and 16.3, the effects tables. Each histogram represents the relative performance of the options against a given criterion. The left-hand side of the histogram represents the transitional period and the right-hand side the steady-state period. The height of the bar is indicative of the performance of an option against the given criterion. Large bars indicate high performance.

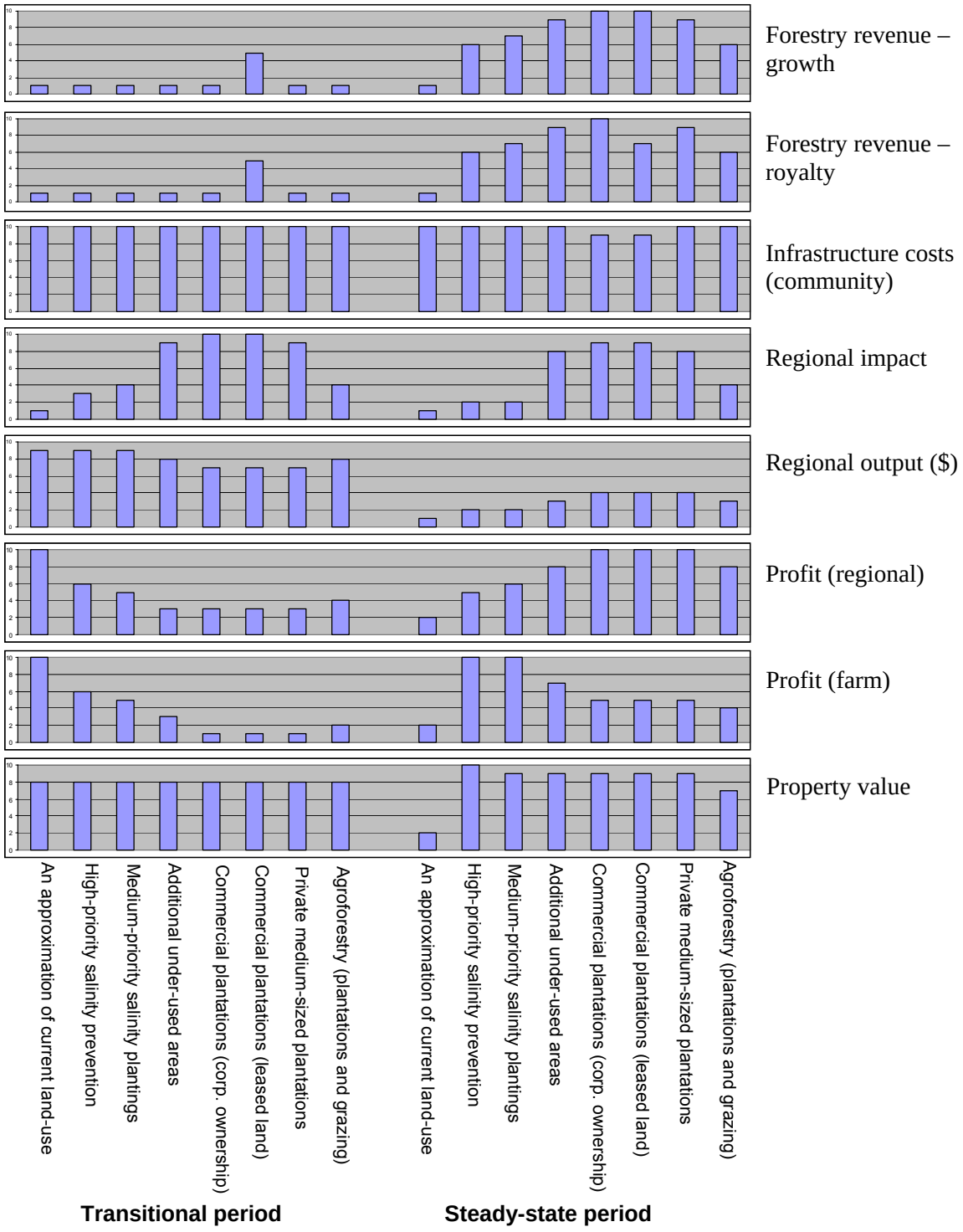


Figure 16.A1 Graphical representations of the effects tables, economic criteria

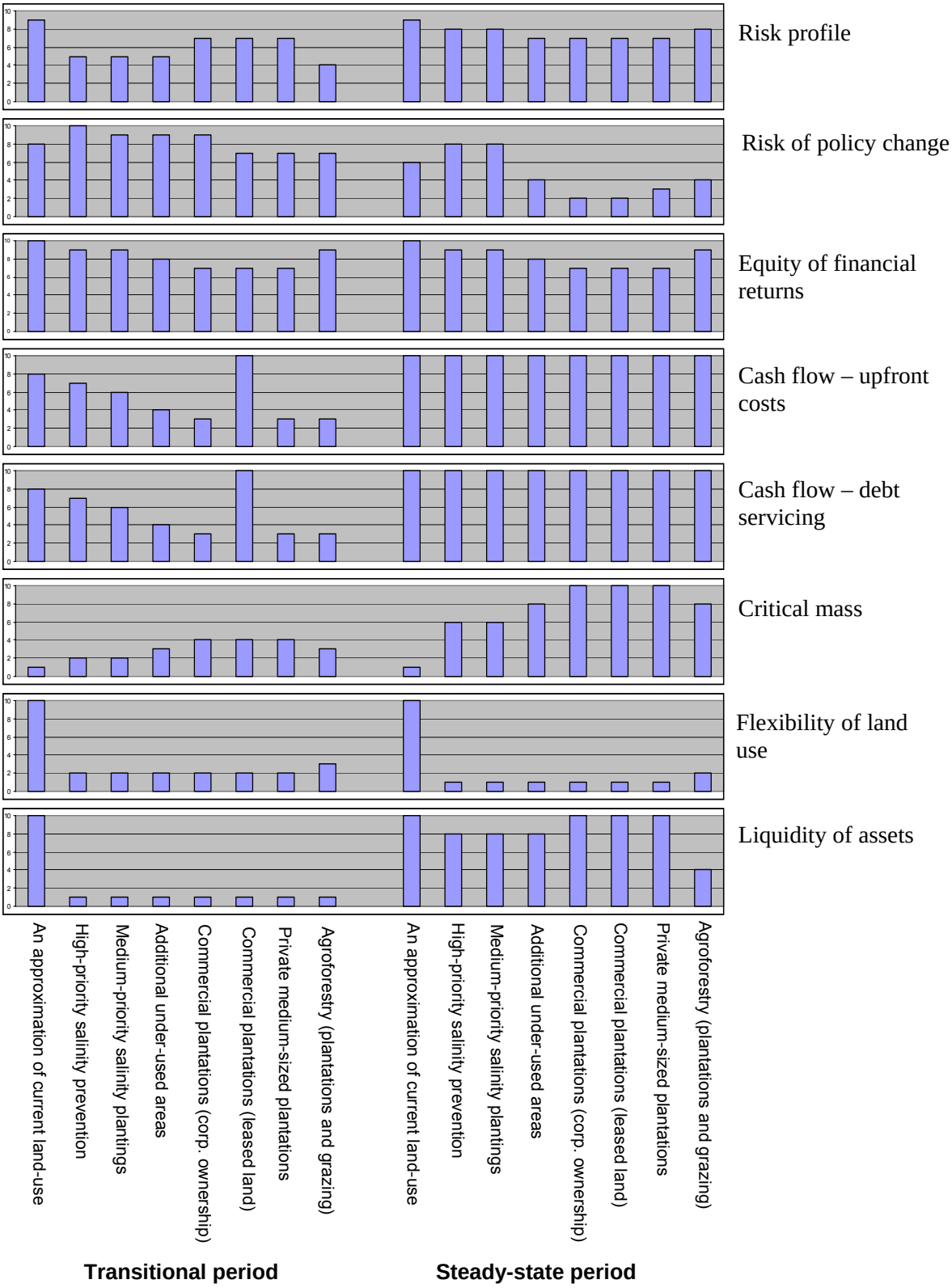


Figure 16.A1 Graphical representations of the effects tables, economic criteria (continued)

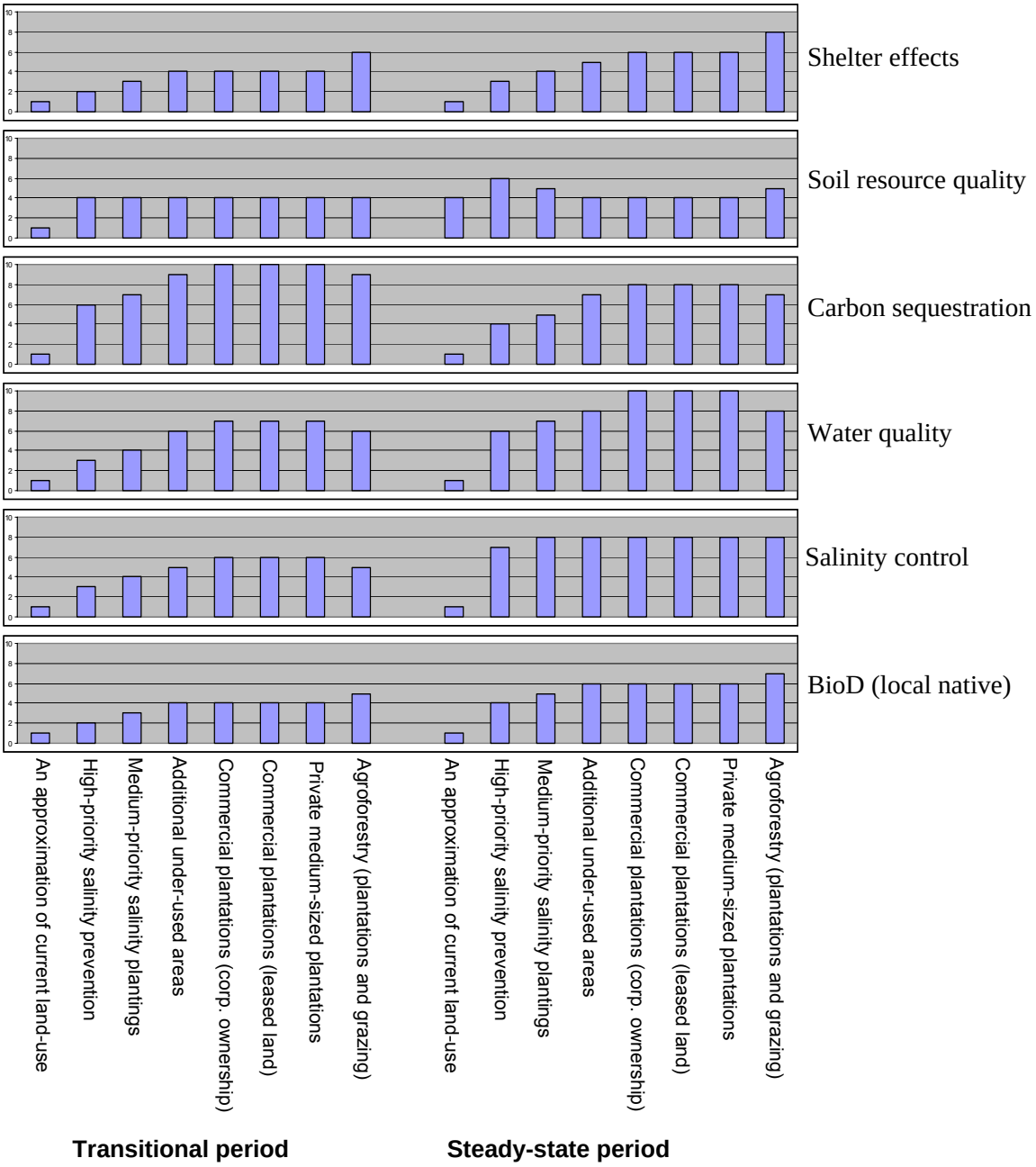


Figure 16.A2 Graphical representations of the effects tables – environmental criteria

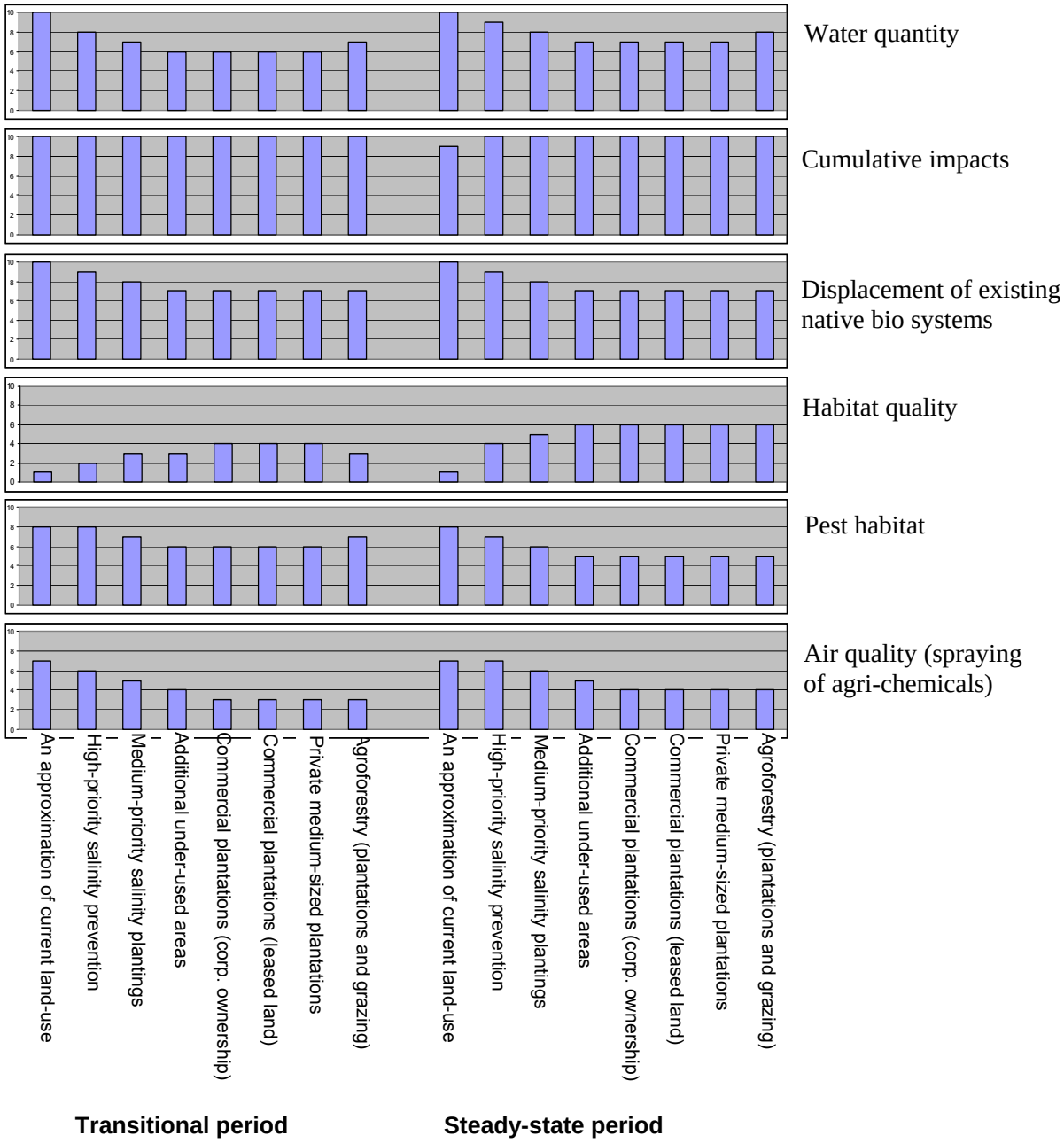


Figure 16.A2 Graphical representations of the effects tables – environmental criteria (contd.)

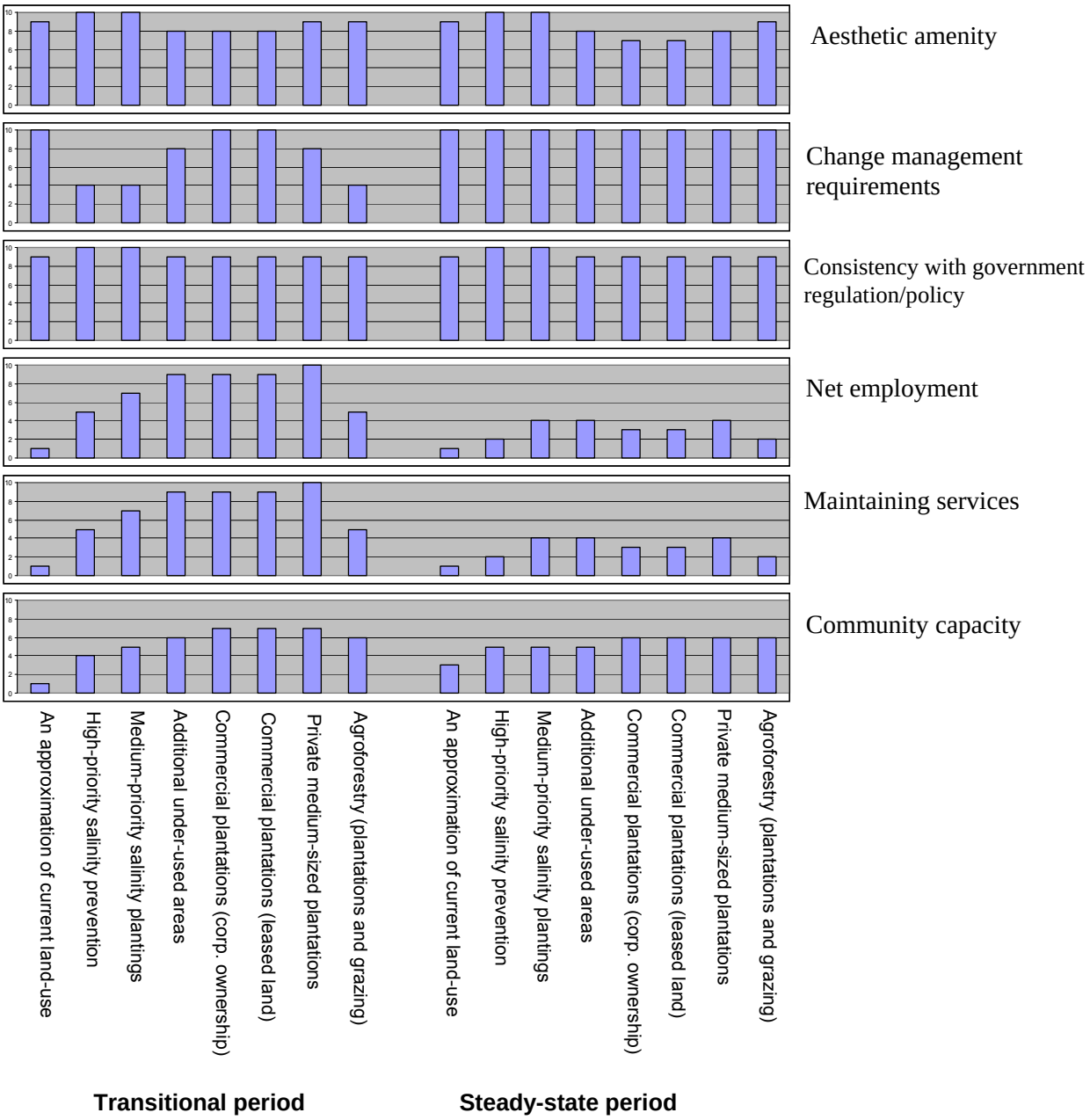


Figure 16.A3 Graphical representations of the effects tables – social criteria

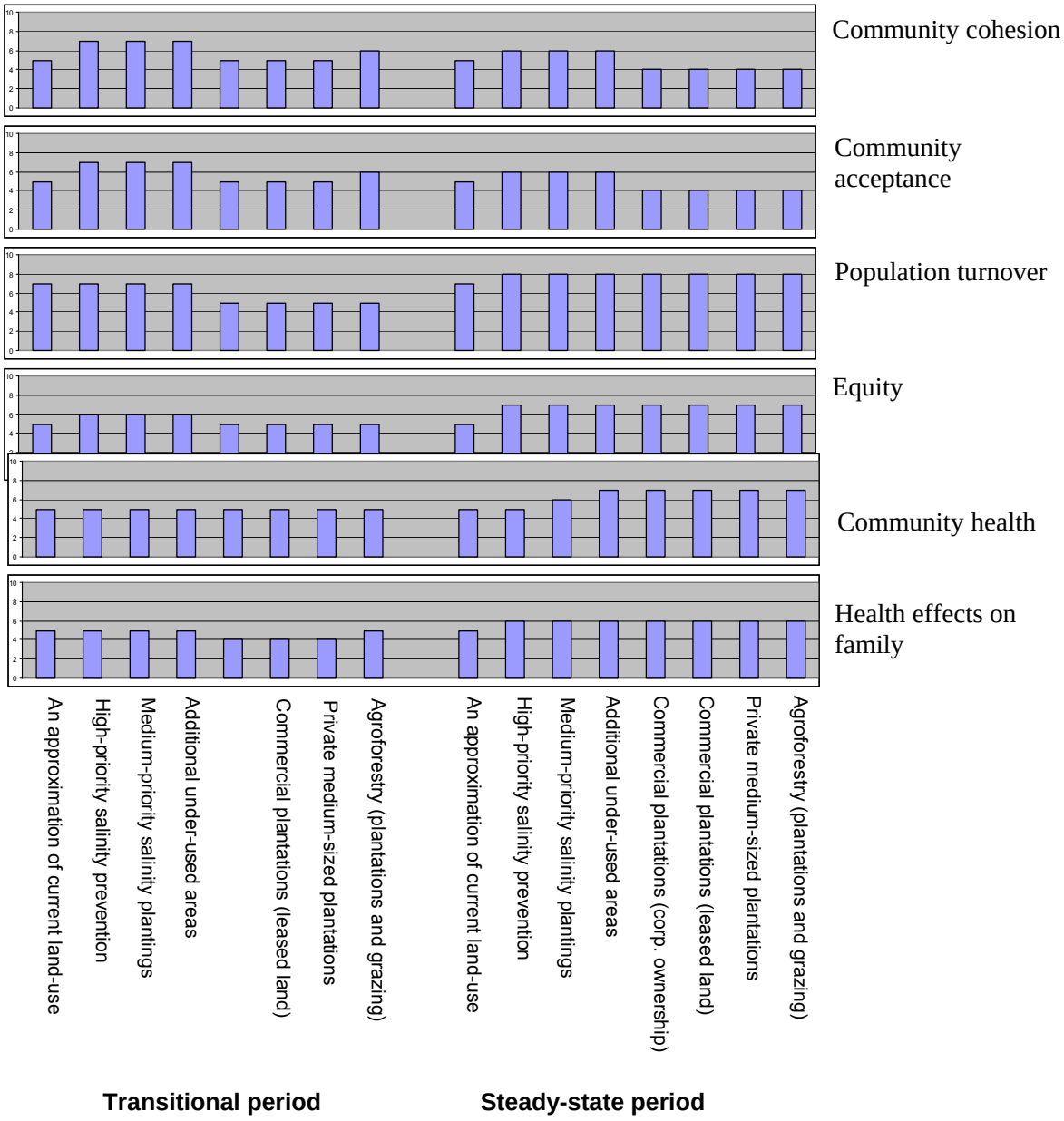


Figure 16.A3 Graphical representations of the effects tables – social criteria (contd.)

Appendix 16.3: Analysis from the perspective of Local Government officers

This appendix presents the results of the MODSS analysis using an alternative importance order, namely the relative importance placed on the criteria by officers of the local shire council, Pittsworth Shire Council. The results in this appendix have been derived using the same analysis methods as used in the analysis from the perspective of the landholders, presented in sections 16.4 to 16.8. These results are not analysed or discussed in this appendix. Section 16.9 provides a discussion of these results relative to the results from the landholder perspective.

Table 16.A3 displays the relative importance order defined by Local Government officers. Figures 16.A4 and 16.A5 display the performance of the farm forestry option in the transitional and steady-state time periods. Figure 16.A6 displays the variation in performance of the farm forestry option with the passage of time.

Table 16.A3 The relative importance of the criteria as defined by Local Government officers

Criterion	Relative Importance
Economic	
Forestry revenue – growth	3
Forestry revenue – royalty	4
Infrastructure costs (community)	1
Regional impact	2
Regional output year X ($)	2
Profit (regional)	1
Profit (farm)	1
Property value	3
Rating treatment	3
Risk profile	2
Risk of policy change	4
Equity of financial returns	3
Cash flow – upfront costs	3
Cash flow – debt servicing	3
Critical mass	3
Flexibility of land-use	2
Liquidity of assets	2
Environmental	
Shelter effects	3
Soil resource quality	1
Carbon sequestration	3
Water quality	2
Salinity control	1
Biodiversity (local native)	2
Water quantity	2
Cumulative impacts	1
Displacement of existing native bio-systems	1
Habitat quality	2
Pest habitat	2
Air quality (spraying of agricultural chemicals)	1
Social	
Aesthetic amenity	3
Change management requirements (including reskilling)	3
Consistency with local state fed government regulation/policy	2
Net employment	1
Maintaining services	1
Community capacity	2
Community cohesion	2
Community acceptance	2
Population turnover	3
Equity	2
Community health	1
Health effects on family	2

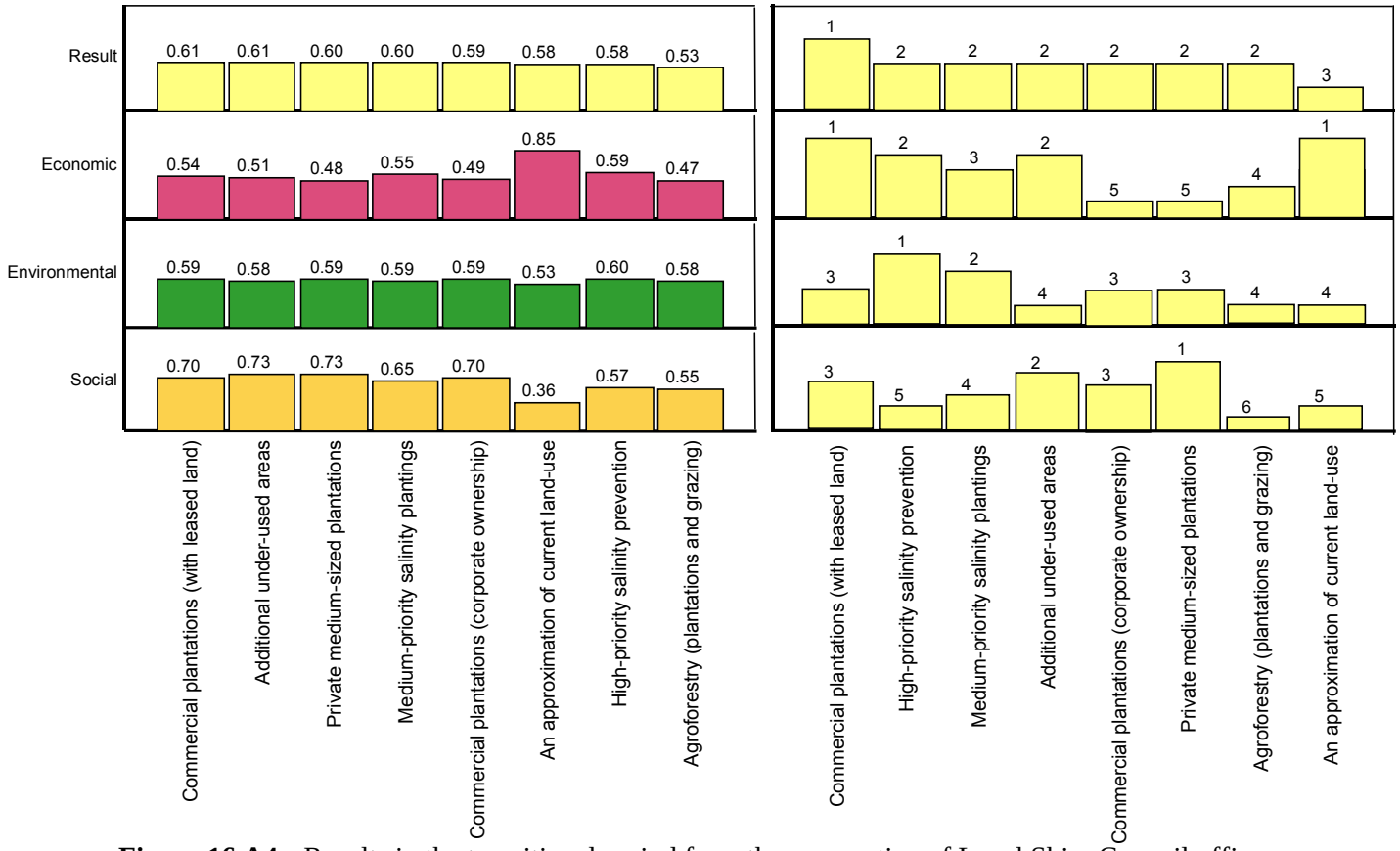


Figure 16.A4 Results in the transitional period from the perspective of Local Shire Council officers

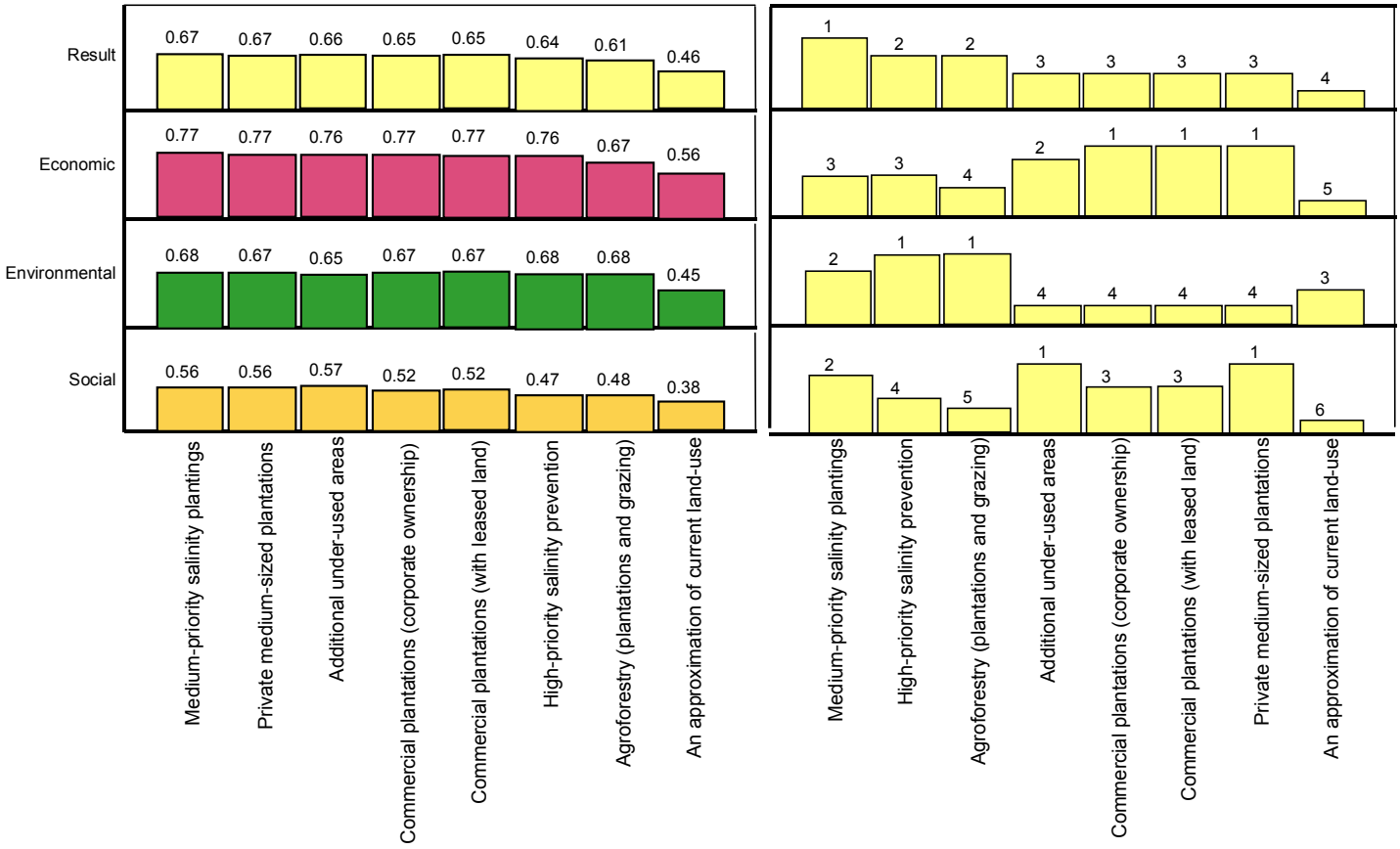
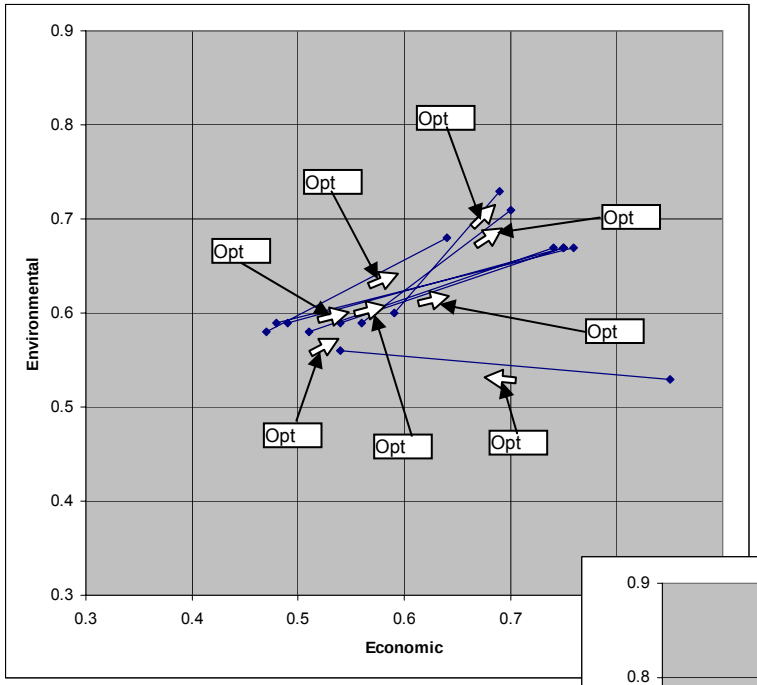
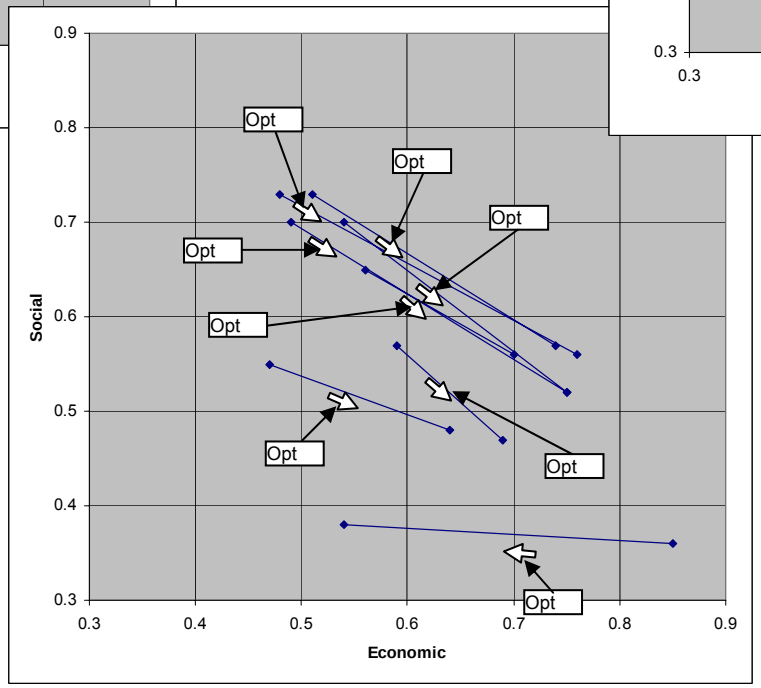


Figure 16.A5 Results in the steady state period from the perspective of Local Shire Council officers





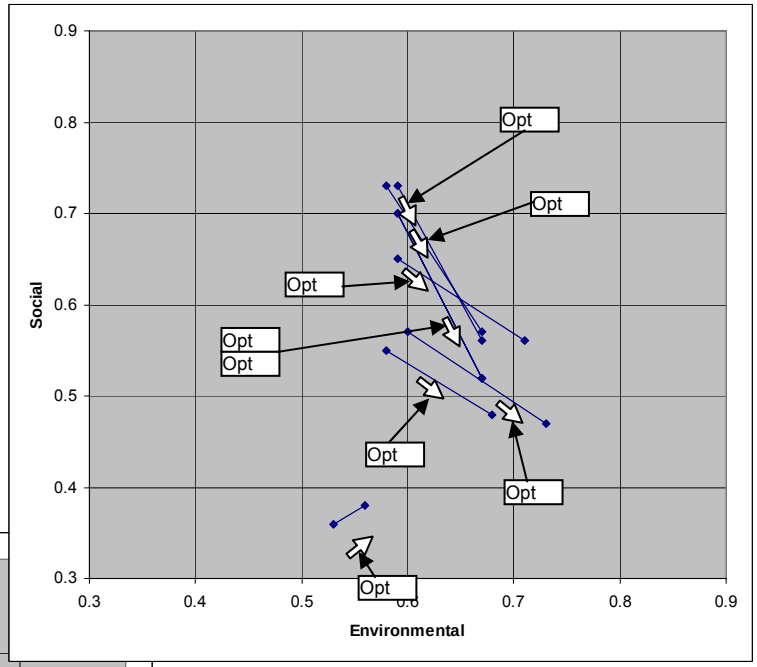


Figure 16.A6 Change in relative performance of the options, from the transitional period to the steady-state period

The lines in the panels show the performance of the options, the arrows attached to the lines indicate the passing of time from the transitional period to the steady-state period.

Opt. 1 An approximation of current land use
Opt. 2 High priority salinity prevention
Opt. 3 Medium priority salinity plantings
Opt. 4 Additional under-used areas
Opt. 5 Commercial plantations (with corporate land ownership)
Opt. 6 Commercial plantations (with leased land)
Opt. 7 Private Medium-sized Plantations
Opt. 8 Agroforestry (Plantations and grazing)

Appendix 16.4: Analysis from the perspective of State Government extension officers

This appendix presents the results of the MODSS analysis using an alternative importance order, namely the relative importance placed on the criteria by State Government extension officers. The results in this appendix have been derived using the same analysis methods as used in the analysis from the perspective of the landholders, presented in sections 16.4 to 16.8. These results are not analysed or discussed in this appendix. Section 16.9 provides a discussion of these results relative to the results from the landholder perspective. Table 16.A4 displays the relative importance order defined by State Government extension officers. Figures 16.A7 and 16.A8 displays the performance of the farm forestry option in the transitional and steady-state time periods. Figure 16.A9 displays the variation in performance of the farm forestry option with the passage of time.

Table 16.A4 The relative importance of the criteria as defined by State Government extension officers

Criterion	Relative importance
Economic	
Forestry revenue – growth	2
Forestry revenue – royalty	1
Infrastructure costs (community)	4
Regional impact	4
Regional output year X ($)	3
Profit (regional)	2 in the transitional period
Profit (state)	2 in the transitional period
Property value	2
Rating treatment	2
Risk profile	2
Risk of policy change	3
Equity of financial returns	3
Cash flow – upfront costs	2
Cash flow – debt servicing	2
Critical mass	2
Flexibility of land-use	3
Liquidity of assets	2
Environmental	
Shelter effects	1
Soil resource quality	2
Carbon sequestration	4
Water quality	2
Salinity control	1
BioD (local native)	2
Water quantity	1
Cumulative impacts	3
Displacement of existing native bio-systems	2
Habitat quality	3
Pest habitat	4
Air quality (spraying of agricultural chemicals)	4
Social	
Aesthetic amenity	2
Change management requirements (including reskilling)	1
Consistency with local state fed government regulation/policy	2
Net employment	3
Maintaining services	3
Community capacity	2
Community cohesion	2
Community acceptance	2
Population turnover	3
Equity	3
Community health	3
Health effects on family	1

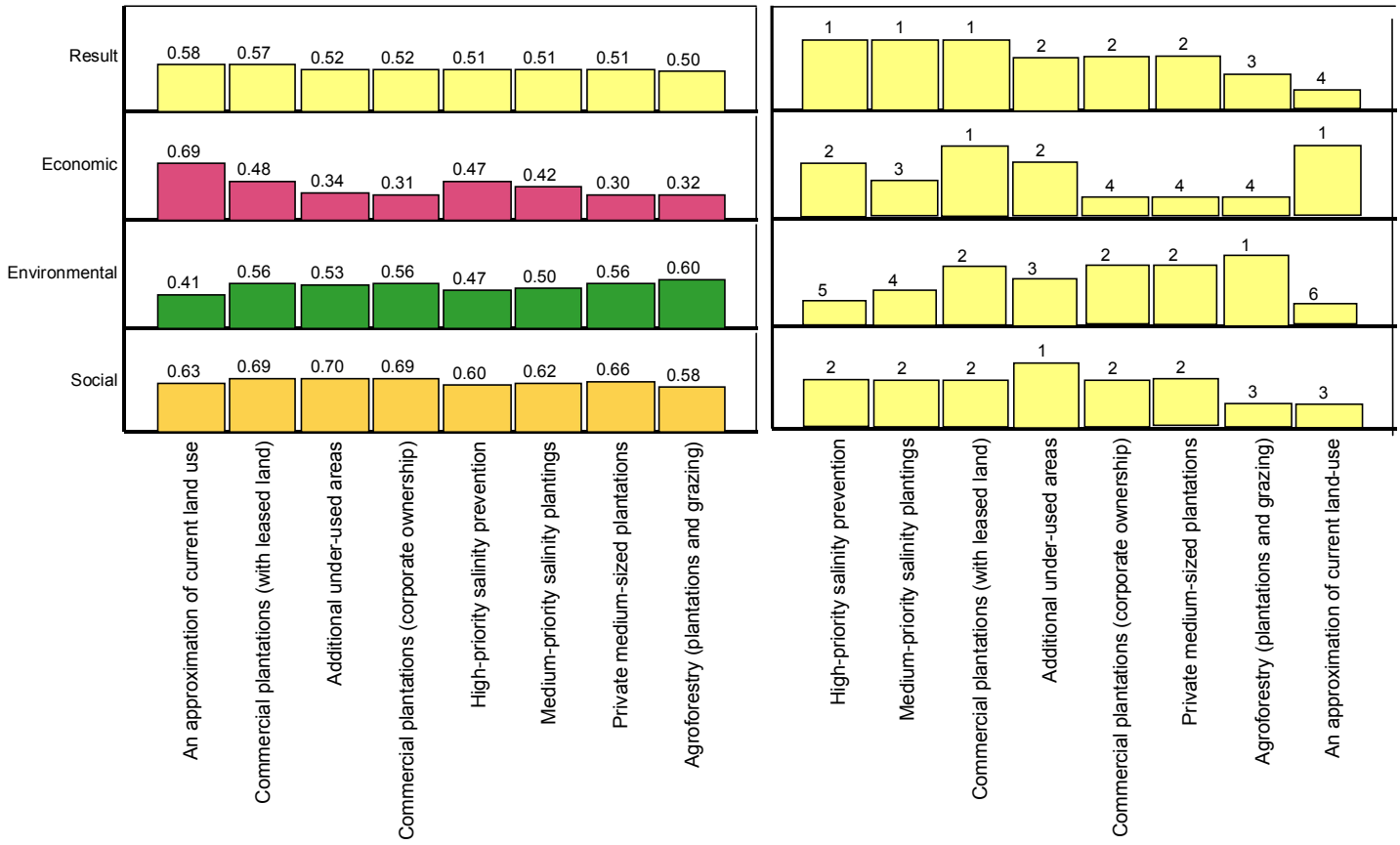


Figure 16.A7 Results in the transitional period from the perspective of State Government extension officers

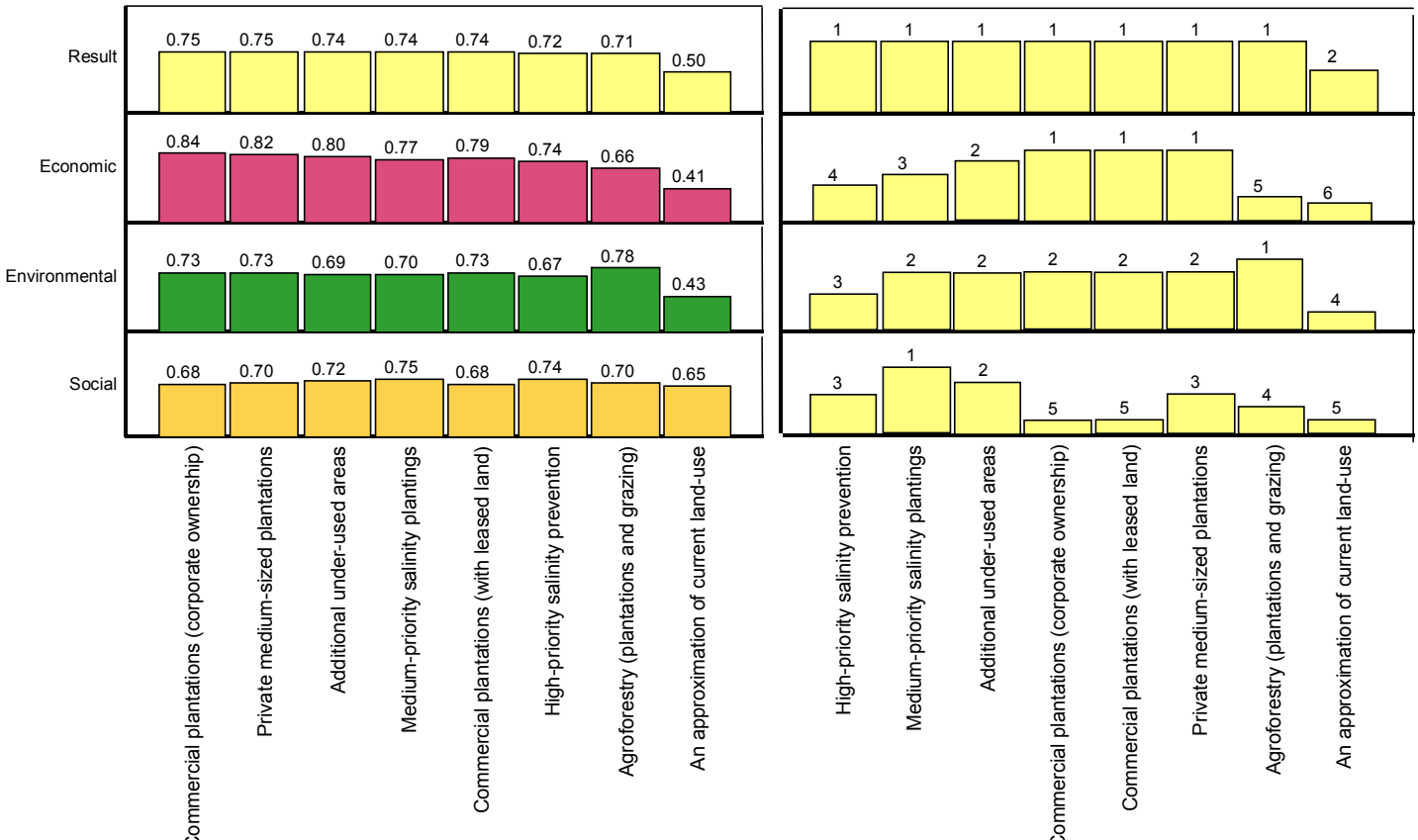
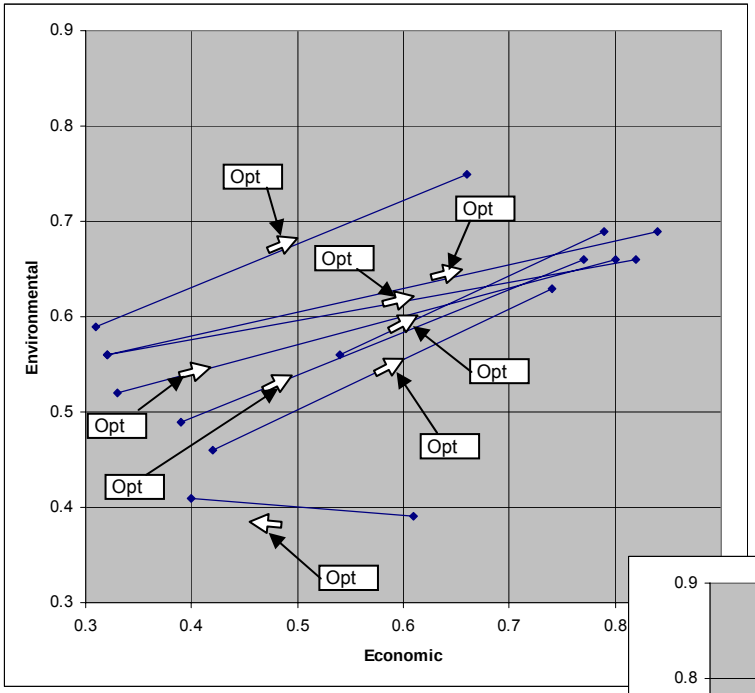
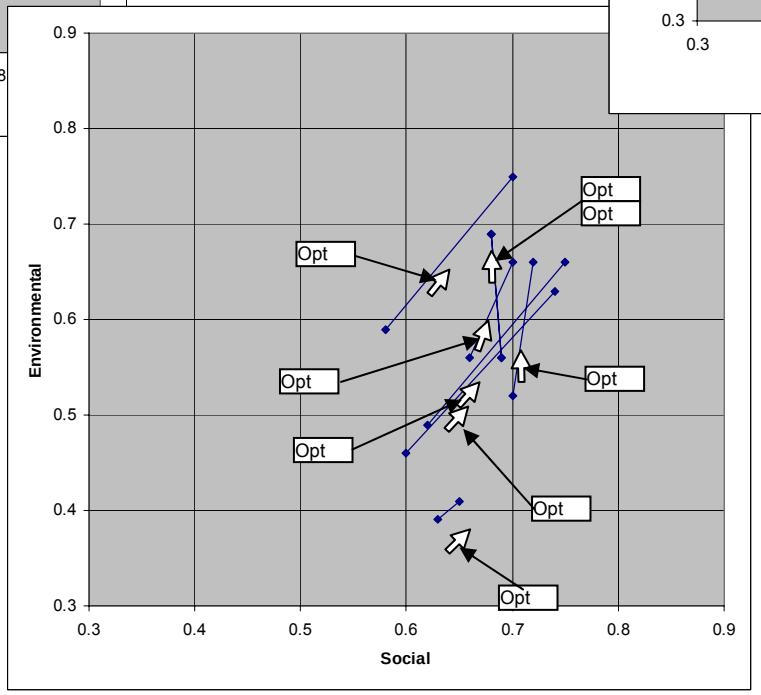


Figure 16.A8 Results in the steady-state period from the perspective of State Government extension officers





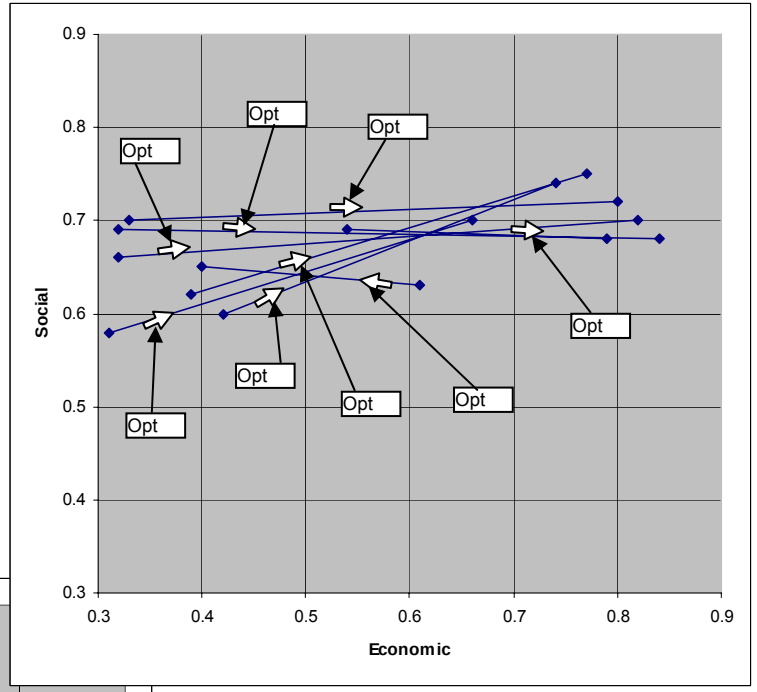


Figure 16.A9 Change in relative performance of the options, from the transitional period to the steady-state period

The lines in the panels show the performance of the options, the arrows attached to the lines indicate the passing of time from the transitional period to the steady-state period.

Opt. 1 An approximation of current land use
Opt. 2 High priority salinity prevention
Opt. 3 Medium priority salinity plantings
Opt. 4 Additional under-used areas
Opt. 5 Commercial plantations (with corporate land ownership)
Opt. 6 Commercial plantations (with leased land)
Opt. 7 Private Medium-sized Plantations
Opt. 8 Agroforestry (Plantations and grazing)

17. A Critical Appraisal of the MODSS Process as Applied to Forestry in South-east Queensland and the Hodgson Creek Catchment

I. Jeffreys and P. Lawrence

This chapter provides a critical appraisal of the MODSS methodology. The application of MODSS for forestry applications is reviewed in general terms, drawing on the experience of this study. A critical appraisal of the success of MODSS in this study, and suggestions as to how the methodology could have been improved, are then provided. The chapter also defines the related techniques MODSS and MCA. The chapter also discusses their relative strengths and weaknesses of MODSS and MCA compared to other analysis techniques, such as cost benefit analysis.

17.1 A Critical Appraisal of MODSS for Forestry Applications in General

MODSS and MCA have been variously defined in overlapping terms to include a broad collection of techniques to support decision-making. For the purposes of this study, MODSS is defined as a process comprising the whole systems approach of integrating stakeholder and expert inputs while satisfying the economic, environmental and social objectives of the various stakeholder groups. MCA, on the other hand, has been defined in the limited view taken by RAC (1992) and Janssen *et al.* (2001), as the analysis techniques of aggregating the effects table, and including weighting and aggregation techniques – essentially a subset of MODSS. This distinction between MODSS and MCA may appear to be somewhat subtle to the casual observer; however, the difference is important in terms of application and communication of outcomes. The differences between MODSS and MCA are explored further in the following section to highlight their respective strengths, weaknesses and future possibilities.

The strengths of the MODSS process as applied to farm forestry decision support

The MODSS process is currently one of very few available methods for integrated analysis of economic, environmental and social considerations. Other commonly used analysis techniques are mono-criteria techniques that prioritise a range of options according to the extent to which they meet a maximum (or minimum) score. Economic analyses, such as cost-benefit analysis, are predominately based on the achievement of economic maximisation with possible costs and benefits largely reduced to dollar terms. Whilst maximizing ‘net present value’ may maximize aggregate benefits to the community, some individuals may become better off and some worse off. The Kaldor-Hicks criterion for a project to be beneficial is that those who gain are potentially able to compensate those who lose and still be better off, although the compensation may not actually take place. In other words, such mono-criteria approaches fail to take account of distributional effects on incomes. Whilst some MODSS techniques maximise aggregate utility and do not explicitly consider the equity of benefit distribution, distributional impacts can be considered as one of many criteria.

Choosing between farm forestry options is inherently a multi-objective problem and hence lends itself to the application of MODSS and MCA. The type of trees and style of planting and management are infinitely variable, as are the combination of forestry purposes desired, e.g. native mixed species and extensive management for conservation or exotic single species and intensive

management for production. Many of the benefits (and costs) are not easily expressed in economic terms.

The MODSS process and the MCA technique assume a complex and multi-faceted system and allow multiple factors to be aggregated. Normalising all data to single dimensionless utilities allows aggregation of multiple factors[4]. In this way, the integration provides a platform to apply a 'triple bottom line' to decision-making. Issues often treated as 'externalities' can be reflected in terms of decision criteria and incorporated into the decision-support process.

A MODSS provides a transparent process to decision-support. Increasingly, community and industry groups are requiring greater accountability and participation of process and the incorporation of science for realistic and defensible alternatives. The MODSS process achieves these requirements through an inclusive, participatory and responsive process. For example, participants are able to suggest decision criteria that are used in the evaluation of the options within an *effects table* (a matrix of options, decision criteria and values). Using a process involving facilitated workshops, the stakeholders can suggest an importance order of the *decision criteria* that reflects their preferences and concerns. The results of these analyses can be displayed almost instantly for further discussion and greater stakeholder ownership of the outcomes. This approach was used extensively throughout this project. The findings of the MODSS process are consistent with those using the AFFFM and the findings of the landholder attitudes to forestry survey.

Weaknesses of the MODSS process as applied to farm forestry decision support

Perhaps one of the most contentious issues associated with MODSS is the assignment of weights to decision criteria in association with the effects table (as summarised in Chapter 4). This issue arises for two reasons. First, it is assumed that stakeholders can articulate their concerns and requirements in the form of performance criteria and an importance ordering of the criteria. Within the MODSS approaches, the most important criteria are allocated the highest weighting. Stakeholders who are not familiar with this approach to decision-support may have difficulty in identifying and ranking performance criteria. Second, scenarios describing the perceptions of various stakeholder groups are generated through their distinct sets of importance orders of the criteria. These importance orders or rank orders, and the subsequent weightings of the criteria, are a subset of all possible rank orders of the criteria set. It is important for the representative stakeholders to consider the relative value of economic impacts, environmental impacts and social impacts within the problem being addressed. If the MODSS process is to be used and supported by the wider community, then some consensus with the community needs to be secured so that the relative weights reflect the longer-term community aspirations.

A problem common to all integrated analyses approaches, particularly when using economic evaluation methods (for example, cost-benefit analysis, choice modelling, benefit transfer methodology) is the extent to which social and environmental effects are artificially forced to be measured as a single dimensionless unit, usually dollars. Both single dimensionless utilities and dollars are constructions of their social environment and have no intrinsic significance. They only obtain meaning when placed in a specific context, i.e. a dollar coin has no intrinsic value (other than that of the metal from which it is constructed); it gains a perceived value when it is offered in exchange for goods or services. A single dimensionless utility has no value until a stakeholder choses to trade it for other utilities, e.g. an increase in environmental utilities for a reduction in economic utilities. Therefore, relative value of economic, environmental and social utilities depends on the perspective of the decision-maker at the particular moment in time. For the analyses applied to farm forestry, economic, environmental and social perspectives are combined, allowing each to be non-dominating. In addition, the outcomes from each analysis are presented from an economic,

[4] The theoretical justification of this process has been provided by Keeney and Raffia (1976).

environmental and social perspective, allowing the stakeholders to attach their own value to these perspectives. This is illustrated in Figure 16.1, in the form of four histograms. The first presents the combined analysis, the second the economic analysis only, the third the environmental only and the fourth the social only.

The perception that the MODSS process and MCA techniques are a subjective methodology is another issue to be considered. The MODSS process is as subjective as the scores in the effects table. In the Burnett water infrastructure development study (Eisner *et al.* 2000) the effects table was evaluated using a mix of subjective and measured data. Alternative analyses are also subjective however, and carry an undefined uncertainty into the analysis. For example, the assigning of discount rates in the AFFFM and other financial models is highly subjective. The discount rate may be regarded as the required rate of return of the investor, which depends – among other things – on their judgment of the performance of alternative investments and their attitude to risk. Changing the discount rate greatly affects the outcome of the analysis. This is the reason why several discount rates are usually included in a sensitivity analysis. In practice, the discount rate is another method of weighting criteria, although it is not explicitly recognized as such. High discount rates weigh current benefits to be more important than future benefits. Hanley and Spash (1993, pp. 144-145) asserted that the discount rate assigned reflects the decision-maker's view on intergenerational equity and is a political choice and therefore open to subjectivity. Similar subjectivity exists in the choice of criteria and their relative weights in MODSS. It must be recognised that all techniques for evaluation of natural resource use options, including MODSS, are highly subjective and are an abstraction of a perceived reality.

A further consideration in the use of MODSS is the validity of using the opinions of experts to quantify the impacts of the alternatives on the decision criteria. The effects table in this study were scored using the considered expert opinion of the members of the Technical Reference Group. This approach was adopted for expediency within the constraints of time and budget. These opinions could have been supported by dynamic, spatial modelling and confirmation of the expert opinions using an alternative advisory group. With more available resources and a longer timeframe, access to more science would have provided greater rigour in identification of the impacts of the alternatives.

Opportunities for future development and application of the MODSS process

A distinguishing feature of the MODSS process is that it is a participatory approach. When well facilitated, MODSS becomes an action-learning process that allows users to learn through their involvement, creating an opportunity for the process of 'learning by doing' (Janssen 1991, p. 10). This is particularly useful when dealing with emotive and polarised stakeholder perspectives. The process of action learning allows users to better appreciate the concerns of other stakeholders.

Multi-criteria analysis (MCA) as applied using the MODSS process can provide a transparent framework for integrating economic, environmental, social and other considerations. This allows a broader perspective to be incorporated into the analysis (Lawrence *et al*. 2001). For these reasons, the MODSS tool can be used for the process of 'triple bottom line' accounting, as supported by the principles of *ecological sustainable development*. In Europe and Canada, MCA is widely used for providing decision-support in relation to the allocation of resources and environmental planning (Janssen 1991; Gambardella *et al*. 2000; Gameda *et al*. 2001).

17.2 A Critical Appraisal of the MODSS Process as Applied in this Study

This section provides a critical appraisal of the MODSS and MCA application to farm forestry in south east Queensland and specifically in the Hodgson Creek catchment on the eastern Darling Downs. Possible shortcomings of this application of MODSS and MCA are examined, on the basis of experience gained in the study. Measures by which the process could be refined and improved are discussed. The study provides insights into the applicability and usefulness of these techniques for evaluating farm forestry practices in other locations.

Identifying the decision issue

In this study the issue was rigidly defined before approaching stakeholders. The issue statement itself was initially quite broad; *to address the uncertainty regarding the suitability, sustainability and profitability of alternative forestry options in relation to regional agricultural systems.* However, it was progressively narrowed by incorporation of expert defined options, criteria and subsequent analysis. Maintaining a broader or fuzzy issue definition would have allowed the stakeholders to develop this in a direction that more closely suited their needs. Increased landholder involvement in the definition of the issue and formation of options and criteria would aid ownership by landowners of the whole process. This would in turn increase the possibility of uptake of some of the options, if only within the landholder groups represented at the meeting.

Identifying the performance criteria

A number of observations may be made concerning identification and definition of decision criteria.

Limiting the number of criteria

It has been observed (in this study and elsewhere) that, when stakeholders are asked to identify criteria by which they may judge the performance of an option, they often produce a long list of items. The number of items may be too great for modelling purposes; this is known as ‘criteria blow-out’. The number of criteria identified rapidly increases as criteria representing increasingly specific goals and issues are identified. These criteria are often interdependent and are judged by the stakeholders as individually having low relative importance. Criteria of low importance create a dilemma for the analyst; a trade-off has to be made as to whether the increased in robustness of the analysis is justified by the increase in time required to evaluate low importance criteria. In the stakeholders meeting for the Hodgson Creek study, 41 criteria were defined. The technical reference group then scored these criteria, which was a time consuming and laborious process, with 656 individual scores being defined. The analysis in southern Queensland defined a more manageable 28 criteria. An ideal number of criteria would be 15 to 21, or 5 to 7 for each broad category (economic, social and environmental).

Highly correlated criteria were investigated further applying a correlation analysis technique to the resulting effects table (details of which are provided in the appendices to Chapter 17). This revealed that criteria were in many cases measuring similar effects, and criteria which were essentially duplicates were removed from the analysis or combined and re-evaluated. For example, the economic criteria of *forestry revenue – growth*, *forestry revenue – royalty*, and *critical mass* are highly correlated (pairwise r-values of 0.98 to 0.91) and they are all concerned with the viability of a forestry industry. These criteria should be combined to form a new criterion, *Industry viability*. The removal of criteria will affect the results generated by the MODSS analysis, and therefore should only be undertaken in consultation with the stakeholder group and the technical reference group. The information regarding correlations and the possible interdependences can be used to define an improved set of criteria. This set would be presented initially to the stakeholder group and

subsequently to the technical reference group. Changes accepted by the stakeholders would require re-evaluation and would create a further iteration of the process.

Criteria can also be judged according to their relative position in the importance order. Criteria at the lower end of the importance order receive low weights and therefore have little impact on the overall performance of the options. For example, in the economic group of criteria using the landholder defined importance order, the joint lowest ranking criteria *forestry revenue – growth* received a weight of 0.6% in the economic analysis and 0.2% in the overall analysis. In contrast, one of the most important criteria (joint first), *profit – farm*, received 18.0% weight in the economic analysis and 6.0% overall. That is not to say that the lower ranking criteria should be arbitrarily removed, but the analyst should inform the stakeholder and technical reference groups that one criterion has many times (30 times, in this example) the influence of the other on the result, and it may be expedient to remove the one with a trivial weight.

Criteria definition and relevance of specific criteria to this application

The performance criteria should be generally applicable to all the options, i.e. it should be possible to evaluate each option against each criterion. For example, the economic criteria *forestry revenue – growth* and *forestry revenue – royalty* are not applicable to all the options. These criteria are dependent on the establishment of a forestry industry; therefore current land-use where there is no forestry cannot be evaluated against these criteria. The option *current land-use* always received the lowest possible score, for these criteria. These criteria should be replaced or included in a general revenue criterion that encompasses all farm revenue. These criteria were also ranked as least important from the landholder and local government perspective, and on these grounds they may warrant removal. However, state government extension officers ranked both relatively highly and therefore redefined versions of these criteria have been retained in the analysis. Other criteria appeared to be placed in the wrong group. For example, *shelter effects* was classed as an environmental criterion, but was defined as only having an impact on productivity and therefore was in effect an economic and not environmental criterion. This criterion has been transferred from the environmental to economic group of criteria in the construction of an improved set of criteria (see below).

An improved set of criteria – initial version

In light of these discussions, two new possible sets of criteria are proposed in this section. Before any changes to the analysis could be made, the proposed changes should be presented to the stakeholder group for feedback. Unfortunately, stakeholder contact was limited to a single one-day workshop, so it has not been possible to carry out such reappraisal in this case. The first alternative criteria set would be constructed by combining correlated criteria and removing unimportant criteria (as defined by the stakeholders). The second would be constructed by combining correlated criteria and keeping only the highly important criteria (as defined by the stakeholders). In both cases, criteria would only be assessed relative to the other criteria in the same group, i.e. within the economic, environmental and social groups. The two revised lists are presented below.

An improved set of criteria – first version

Combining correlated criteria and removing criteria regarded by stakeholders as unimportant leads to the following list:

Economic criteria

Industry viability	Currently, this criterion is *forestry revenue – growth, forestry revenue – royalty*, and *critical mass*. These were highly correlated and all were related to the economic viability of an option. Therefore, they have been combined. The definition of the criterion has been broadened to include any agricultural industry and not only the forestry industry, thus making the criterion applicable to all the options.
Cash flow	Previously this criterion was *cash flow – upfront costs* and cash flow – debt servicing, both were highly correlated and therefore combined.
Property value	Unchanged
Infrastructure costs (community)	Unchanged
Regional impact	Unchanged
Regional output	Unchanged
Profit (farm)	Unchanged
Risk profile	Unchanged
Flexibility of land use	Unchanged
Liquidity of assets	Unchanged

Environmental criteria

Soil resource quality	Unchanged
Water quality and salinity control	This arises from combining two of the current criteria, namely 'water quality' and 'salinity control'. These were highly correlated and both related to water quality and water movement through the catchment.
Biodiversity (local native) and habitat quality	Currently this criterion comprises two criteria, namely *'habitat quality'* and *'biodiversity'*. These were highly correlated and both related to abundance of local native species and conduciveness of the habitat for these species.
Water quantity	Unchanged
Cumulative impacts	Unchanged
Pest habitat	Unchanged
Displacement of existing native bio-systems	Unchanged
Air quality (spraying of agricultural chemicals)	Unchanged. This criterion is highly correlated with displacement of existing native bio-systems, but is clearly measuring a different effect. Both are included in this list, and are likely to be independent[5]. The high correlation appears to be accidental.

[5] It is possible to check for independence using the test outlined in Chapter 13, Section 13.2, proposed by Keeney and Raffia (1976, pp. 299-301).

Social criteria

Aesthetic amenity	Unchanged
Change management requirements (including re-skilling)	Unchanged
Consistency with local state fed government regulation/policy	Unchanged
Maintaining services and employment	This criterion was previously two criteria, namely *maintaining services* and *net employment*. These criteria were highly correlated and equally important.
Community capacity	Unchanged
Community cohesion and acceptance	This criterion was previously two criteria, namely *community cohesion* and *community acceptance*. These criteria were highly correlated and equally important, and are likely to be interdependent.
Population turnover	Unchanged
Equity	Unchanged
Community health	Unchanged
Health effects on family	Unchanged

An improved set of criteria – second version

Combining highly correlated criteria and culling all but the most important criteria leads to the following list:

Economic group

Industry viability
Infrastructure costs (community)
Profit (farm)
Cash flow
Risk profile
Liquidity of assets

Environmental group

Soil resource quality
Water quality and salinity control
Water quantity
Cumulative impacts
Pest habitat
Displacement of existing native bio-systems
Air quality (spraying of agricultural chemicals)

Social group

Aesthetic amenity
Change management requirements (incl. re-skilling)
Consistency with local state fed government regulation/policy
Maintaining services and
Community health
Health effects on family

In the economic criteria the cull was relaxed slightly to include the six highest-ranking criteria because only a few criteria received the absolute highest ranking. These criteria could be used as the basis for building a future MODSS for evaluating farm forestry in another catchment.

The limitation of defining only discrete forestry options

Most evaluation techniques including MODSS, MCA, cost-benefit analysis and environmental impact assessment require discrete and mutually exclusive options. All the decision-support techniques proposed in this report including the AFFFM require discrete options. MODSS and MCA are less flexible in this example compared to the financial modelling in the AFFFM because the value for each criterion is obtained by expert opinion rather than calculated using an equation. In the Burnett water infrastructure study (Eisner *et al.* 2000), many criteria were evaluated using objective value functions with the score for the individual criterion determined according to other attributes of the options. For the current study, determining such objective value functions would have been a time-consuming task and potentially would have added little to the analysis, because of the lack of data suitable for deriving objective estimates. Objective value functions do not currently exist for a large number of the criteria identified in this study. In the interest of expedience, analyses using objective value functions can sometimes exclude factors that cannot be quantified. In fact, one of the major strengths of MODSS is that it is inclusive and integrates all factors that influence a decision – whether objective functions exist for them or not. In the absence of defined objective value functions, options evaluated using expert opinion have to be defined within discrete limits. Whilst in an ideal situation a MODSS would include continuously variable options, it is currently not possible to include all the relevant factors in such an analysis. In the place of continuous options, discrete categorical options placed at logical intervals on this continuum must suffice.

Evaluation of options against criteria

The technical experts described the two workshops in which they evaluated the options for the Hodgson Creek study as highly stressful, rushed and laborious. Experts noted that there was too much work for the two days allowed. Whether this was a result of the options and criteria lacking adequate definition or the demanding nature of the scoring process was unclear. The experience of the technical reference group in the southern Queensland study, for which members of the technical reference group had been instrumental in developing options and criteria, and in development of the definitions, boundaries and baselines, was however quite different. It is hypothesised that the

additional stress was a consequence of the technical reference group having no input prior to the evaluation workshops for the Hodgsons Creek study.

In future MODSS applications, this type of problem would be alleviated somewhat by inviting the technical reference group to observe the stakeholder meeting, although care must be taken not to overwhelm the stakeholder group with technical experts and government officers. Another possible solution would be to remove the evaluation process from the workshop environment. The first workshop would take the form of a general discussion of the options and criteria, clarifying any points of information and adding to and refining the descriptions of the options and criteria. The technical reference group members would then complete the evaluation of the options against the criteria in their own time. The analyst could then combine the data and highlight differences of opinion. The analyst should only highlight differences and not try to resolve them. The second meeting would then discuss any differences in opinion as to the scores for individual criteria and seek consensus on these scores. In this way the areas where there is broad consensus need not be discussed.

A number of additional aids may be useful in the workshop process, including maps and other visualisation tools. In the Hodgson Creek study, maps detailing the hypothetical position and extent of the forestry options within the catchment were produced, although these were not available to the technical reference group until the first workshop. These maps could have proven a useful aid to the technical reference group, if the group were given sufficient time to study the maps. Other visualisation tools may include photographs of similar farm forestry options in other catchments, or composite photographs or an artist's impression of the change in visual appearance of the landscape after implementing a forestry option. The latter of these may prove prohibitively expensive. With the development of advanced computer visualisation tools, it will become increasing possible and affordable to recreate a 'virtual' catchment from GIS data, as a visualisation device by which the stakeholders and experts can explore and view possible land-use changes.

The two-stage iterative process

The MODSS process is an iterative process, whereby options and criteria are developed and refined progressively. This study was limited by the amount of contact possible with stakeholders. Stakeholders were introduced to the process after experts had completed the first round of analysis. On reflection, consulting the stakeholders and producing a quick and simple analysis may have proved a more productive use of the stakeholders' time. The inclusion of the stakeholders at this stage of the process allows them to gain insights into the issues surrounding farm forestry, by 'playing with the problem' (Janssen 1991, p. 10). By presenting the south-east Queensland study to the stakeholder group at the workshop, the workshop was limited to assessing and making changes to these options.

By removing the initial analysis, the technical reference group can build directly from the stakeholder defined options and criteria. Because the technical reference group is defining and scoring one study only, more of the group's time and energy can be placed in to the iterative development of this study. In this report; the south-east Queensland study is superseded by the Hodgson Creek study.

Defining the time periods for the analysis

Any forestry option is a very long-term investment. The impact, of the farm forestry options on the performance criteria is likely to change dramatically over the lifetime of the option. To reflect this, the Hodgson Creek MODSS was analysed at two timescales, namely the *transitional period* and the *steady-state period*. The transitional period – defined as the period during which a farm forestry industry is being developed in the catchment – is also defined as the cost period, and extends from years 0 to 10. The second time period – is defined as the steady-state or equilibrium period – is the

period when a forestry industry has been developed in the catchment, plantings have matured and a rotation of felling and replanting has been established, typically from year 30 or 40 onwards.

This appears to exclude the period from year 10 to year 30 from the analysis. This apparent gap could be filled in two ways. First, the transitional period could be redefined to include the complete interval from the first plantings to the first harvest, i.e. year 0 to approximately year 30. Second, a third time period could be defined. This would involve separating the current transitional period into an establishment period and a new transitional period. The establishment period would be the period when the forest industry is being established, including the cost period during which trees are planted and farm infrastructure is upgraded. Then the redefined transitional period would be the period during which the trees mature. Little silvicultural activity would continue in this latter period.

This is unlikely to reflect the way a forestry industry and individual plantations would be established, since plantings are likely to occur incrementally over the first 30 to 40 years. Both methods would require some re-evaluation of options. In the first method, the scores would need to be revisited to check their applicability to this redefined timescale. In the second method, the two new timescales would require a complete re-evaluation. The first method of redefining and clarifying the extent of the transitional period is preferable because it is more likely to reflect the nature of forest industry development.

Choice of MODSS software packages

The MCA completed in this study used the software package Definite (Janssen *et al.* 2001). This is high-level MODSS package and includes MCA using various weighting and aggregation techniques, CBA, and sensitivity analyses of the MCA and CBA. It has a high degree of functionality, a consequence of which is that the user interface is relatively complicated, and the tool is not suited to inexperienced users. Definite is also commercial licensed software and has to be purchased from the developer. The result of this is that this study could not be easily reproduced in any other catchment without a reasonable amount of funding and persons with technical expertise in the use of this MODSS tool.

One of the other tools considered in this study was the MODSS tool Facilitator (DNR *et al.* 1999). Facilitator is a considerably simpler tool in both the analysis and the user interface. It is available without charge and can be downloaded from the Internet. This tool was developed specifically for use by catchment management and Landcare groups. This study could have been undertaken using Facilitator but would then have lost depth of analysis due to the simpler functionality of Facilitator.

The Definite package is suited for an in-depth analysis of farm forestry options. It is suited to groups that require a detailed and robust analysis, and is especially suited for policy analysis. The Facilitator package is more appropriate for small-scale and local use applications. Because Facilitator is simple to use, problems can be developed and analysed with greater ease and more quickly, and it is therefore more suitable in a workshop situation. The output of Facilitator is a simplified version of that produced by Definite. However, the effects table for both systems can be imported from spreadsheets and data can be transferred between the packages.

17.3 Conclusions

The use of a simple MCA tool (such as Facilitator), to develop options, criteria and importance orders in a participatory group setting, can be useful for action-learning. This would allow stakeholders to ‘play’ or experiment with the decision problem, identifying relationships between the various components of the problem and the outcomes. The MODSS process provides a useful framework for workshops to discuss issues surrounding farm forestry.

The MODSS study into farm forestry on the Darling Downs identified a number of options that are worthy of further consideration and excluded options that would not be feasible in this area. The options identified for further consideration are the same as those identified from the landholder survey (Chapter 6). The MODSS analysis, the case studies using the AFFFM and the survey results support and complement each other, providing validation of the conclusions of each study.

The MODSS process is one tool in a kit for evaluating natural resource and land-use management issues, including farm forestry. MODSS is highly useful in combining data and knowledge in a clear and transparent framework. Currently, MODSS suffer from the 'black box' problem. The processes applied although relatively simple are unseen, being hidden in software packages. This has aroused suspicions as to the nature of the analysis, although acceptance of these methods will increase with greater exposure to them.

Currently the MODSS process using stakeholder and technical input combined with MCA tools, is the best available method for integrating economic, environmental and social analyses, to produce a holistic analysis of natural resource and land-use management issues, including farm forestry issues. Its utility will be further increased with additional work to generate quantitative means to score options, improved means of visualizing options and simpler and more robust means of determining and assessing decision criteria.

17.4 References

Department of Natural Resources (DNR), Agricultural Research Service, USDA and Netstorm Pty Ltd. (1999), *Facilitator 1.2.17 Beta, A Multi-Objective Decision Support System*, presented at the 2nd International Conference for Multiple Objective Decision Support Systems for Land, Water and Environmental Management (MODSS'99), Brisbane.

Eisner R., Lawrence P. and. Jeffreys I. (2000), *Use of MODSS (Multi-Objective Decision Support System) in the Burnett River Catchment Study*, Project report, Department of Natural Resources, Brisbane.

Gambardella L.M., Rizzoli A.E., Fornara N., Alessandrini A., Epifani C. (2000), *The use of simulation in the socio-economical evaluation of the management of an intermodal terminal*, HMS2000, Maritime and Industrial Logistics Modelling and Simulation, 5-7th October, Portofino, Italy.

Gameda, S., Huffman, T., Yang, J., Junkins, B. and Gill, R. (2001), 'Integration of economic and biophysical models for assessing agricultural policy impacts on water quality at a regional scale', *MODSIM 2001 Proceedings of the International Congress on Modelling and Simulation*, The Australian National University, 10-13 December, pp. 1189-1194.

Hanley N. and Spash C. (1993), *Cost-Benefit Analysis and the Environment*, Edward Elgar, Aldershot.

Janssen R. (1991), *Multiobjective Decision Support for Environmental Management*, Kluwer Academic Publishers, Dordrecht.

Janssen R., van Herwijnen M. and Beinat E. (2001), *DEFINITE (version 2) DEcision support system for a FINITE set of alternatives*, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.

Keeney R. and Raffia H. (1976), *Decisions with Multiple Objectives*, Cambridge University Press, Cambridge.

Lawrence, P.A., Robinson, J. and Eisner, R. (2001), A Decision Environment: going beyond a decision framework to improve the effectiveness of decision making in natural resource management. MODSIM 2001 Proceedings of the International Congress on Modelling and Simulation, 10-13 December, The Australian National University, Canberra, pp. 1613-1618.

Resource Assessment Commission (RAC) (1992), *A Multi-criteria Analysis as a Resource Assessment Tool*, Research Paper No. 6, Resource Assessment Commission, Canberra.

Appendix 17.1: Correlation analysis of effects table

Figure 17.A1 to 17.A3 and Tables 17.A1 to 17.A3 present the correlation analysis for the economic, environmental and the social groups of criteria, respectively. Figures 17.A1 to 17.A3 are graphical representations of a Pearson's correlation analysis. In these figures correlated criteria are grouped using extended square brackets. A Pearson's correlation coefficient of 1 indicates perfect positive correlation, 0 no correlation and –1 perfect negative correlation. The degree to which the square brackets are extended represents the value of the correlation co-efficient. These highly correlated groups are subsequently grouped with diminishing levels of positive correlation. The correlation coefficient all the pairwise comparisons of criteria are displayed in Tables 17.A1 to 17.A3. Highly correlated criteria have similar scores and often the same scores for same options. Highly correlated criteria may be measuring the same effect using two different names. For example the social criteria of *maintaining services* and *net employment* are perfectly correlated; this pairwise comparison has a correlation coefficient of 1. These criteria were combined to form the new criterion of *maintaining services and employment*. A second example is the economic criteria of *forestry revenue – growth, forestry revenue - royalty* and *critical mass*, these are highly correlated; the pairwise comparison of these criteria have correlation coefficients of 0.9806, 0.9384 and 0.9123 respectively. These criteria were combined to form the new criterion of *industry viability.*

Figure 17.1 Correlation analysis of the economic group of criteria

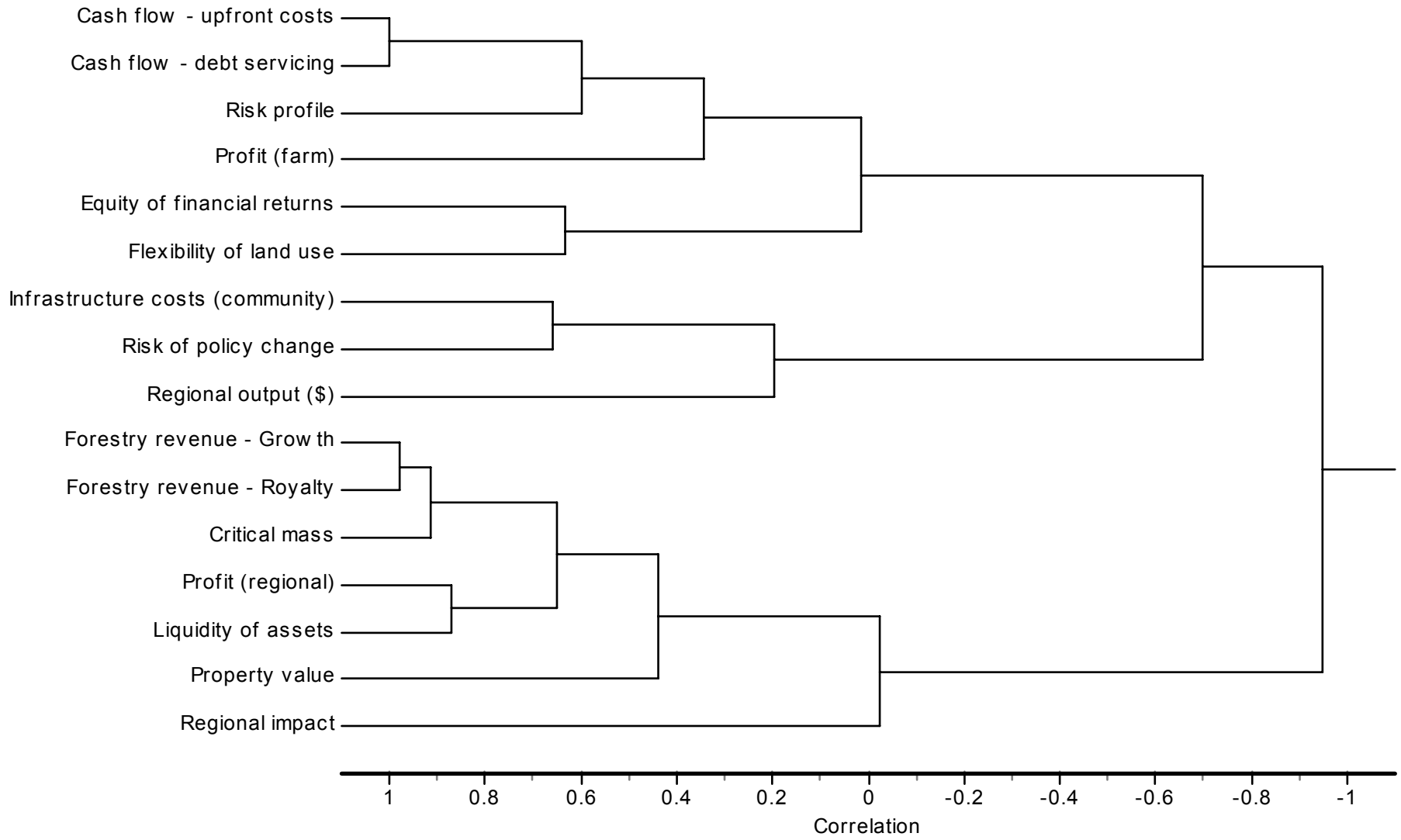


Table 17.1 Pearson's correlation co-efficient for the economic group

Economic criterion	Forestry revenue – royalty	Infrastruct-ure costs (communit y)	Regional impact	Regional output ($)	Profit (regional)	Profit (farm)	Property value	Risk profile	Risk of policy change	Equity of financial returns	Cash flow – upfront costs	Cash flow – debt servicing	Critical mass	Flexibility of land use	Liquidity of assets
Forestry revenue – growth	0.9806	-0.5872	0.3004	-0.6344	0.6843	0.3385	0.4581	0.2788	-0.8102	-0.4356	0.733	0.733	0.9364	-0.5023	0.778
Forestry revenue – royalty		-0.4801	0.2677	-0.6476	0.6523	0.3576	0.4500	0.2924	-0.7678	-0.4012	0.7382	0.7382	0.9123	-0.5027	0.7573
Infrastructure costs (community)			-0.3608	0.1984	-0.5304	-0.0231	-0.2229	-0.0335	0.6581	0.4336	-0.2972	-0.2972	-0.5906	0.226	-0.4948
Regional impact				0.1525	0	-0.5589	0.3311	-0.2707	-0.3428	-0.9489	-0.2142	-0.2142	0.4461	-0.5434	-0.0228
Regional output ($)					-0.1762	-0.2508	0.1616	-0.6178	0.5547	-0.0367	-0.6961	-0.6961	-0.5551	0.0743	-0.4209
Profit (regional)						0.5506	0.4397	0.2335	-0.6452	-0.1006	0.5364	0.5364	0.6536	-0.1165	0.87
Profit (farm)							0.4328	0.3418	0.0345	0.4442	0.4933	0.4933	0.1592	0.0221	0.7036
Property value								-0.2617	-0.0723	-0.4397	0	0	0.4962	-0.7183	0.5269
Risk profile									-0.2807	0.1832	0.597	0.597	0.16	0.4461	0.4415
Risk of policy change										0.4107	-0.5592	-0.5592	-0.8321	0.1841	-0.5972
Equity of financial returns											0.1002	0.1002	-0.5791	0.6351	-0.1237
Cash flow – upfront costs												1	0.5146	0.0135	0.6177
Cash flow – debt servicing													0.5146	0.0135	0.6177
Critical mass														-0.6202	0.6893
Flexibility of land use															-0.1341

Figure 17.2 Correlation analysis of the environmental group of criteria

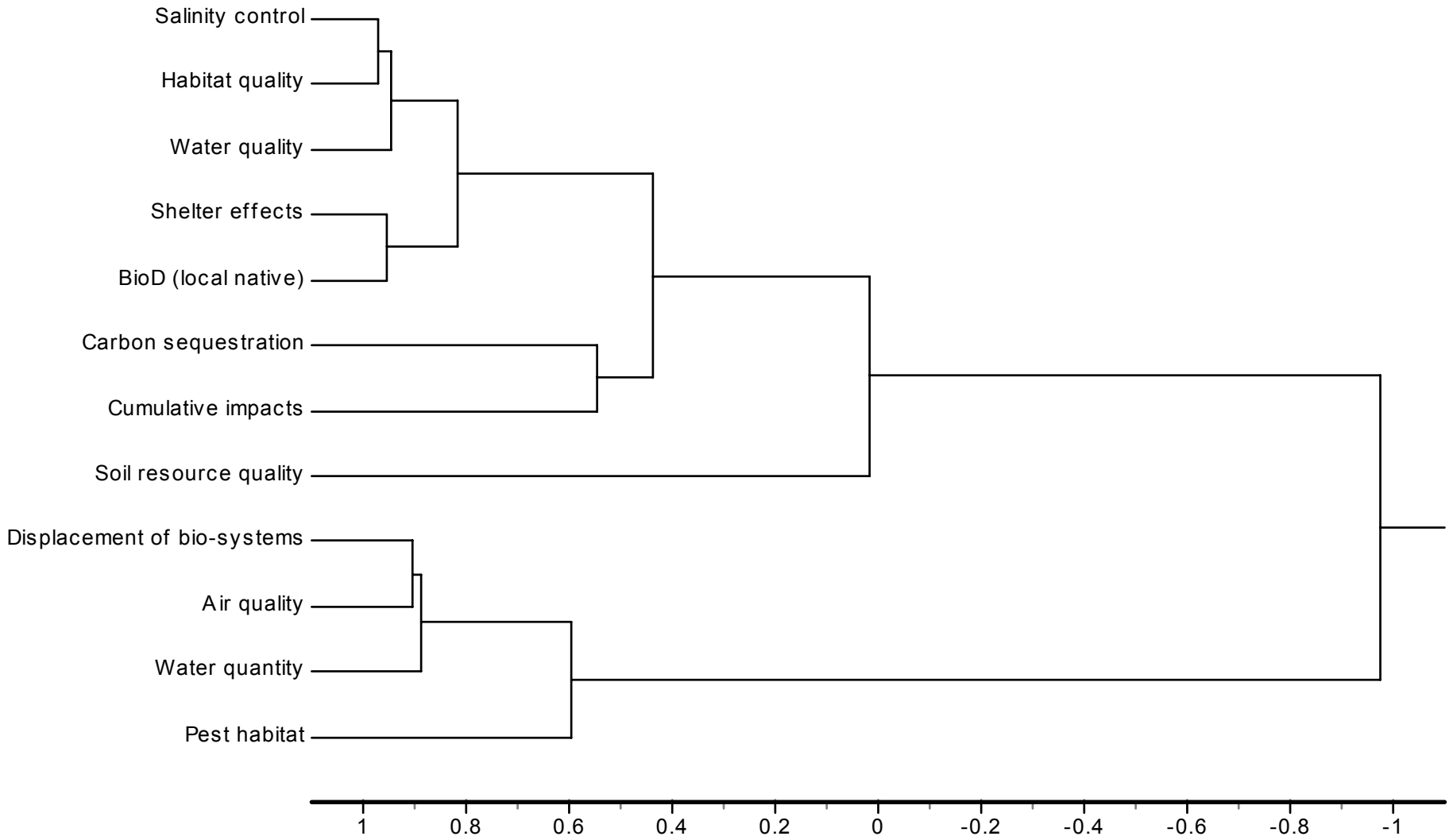


Table 17.2 Pearson's correlation co-efficient for the environmental group

Environmental criterion	Soil resource quality	Carbon sequestration	Water quality	Salinity control	BioD (local native)	Water quantity	Cumulative impacts	Displacement of bio-systems	Habitat quality	Pest habitat	Air quality
Shelter effects	0.3724	0.6147	0.8584	0.8148	0.9556	-0.5048	0.4382	-0.8322	0.8439	-0.8474	-0.669
Soil resource quality		0.2355	0.4153	0.5828	0.4713	-0.1746	0.0167	-0.282	0.4578	-0.3116	-0.0755
Carbon sequestration			0.674	0.5479	0.5715	-0.973	0.5454	-0.9177	0.5037	-0.6084	-0.9425
Water quality				0.9451	0.9301	-0.627	0.4979	-0.8483	0.95	-0.942	-0.6346
Salinity control					0.9389	-0.5047	0.52	-0.7539	0.969	-0.8998	-0.4629
BioD (local native)						-0.4979	0.4795	-0.8193	0.9478	-0.9177	-0.562
Water quantity							-0.5197	0.8897	-0.4632	0.5969	0.8892
Cumulative impacts								-0.5331	0.4568	-0.4146	-0.413
Displacement of bio-systems									-0.7442	0.8421	0.9026
Habitat quality										-0.9471	-0.459
Pest habitat											0.605

Figure 17.3 Correlation analysis of the social group of criteria

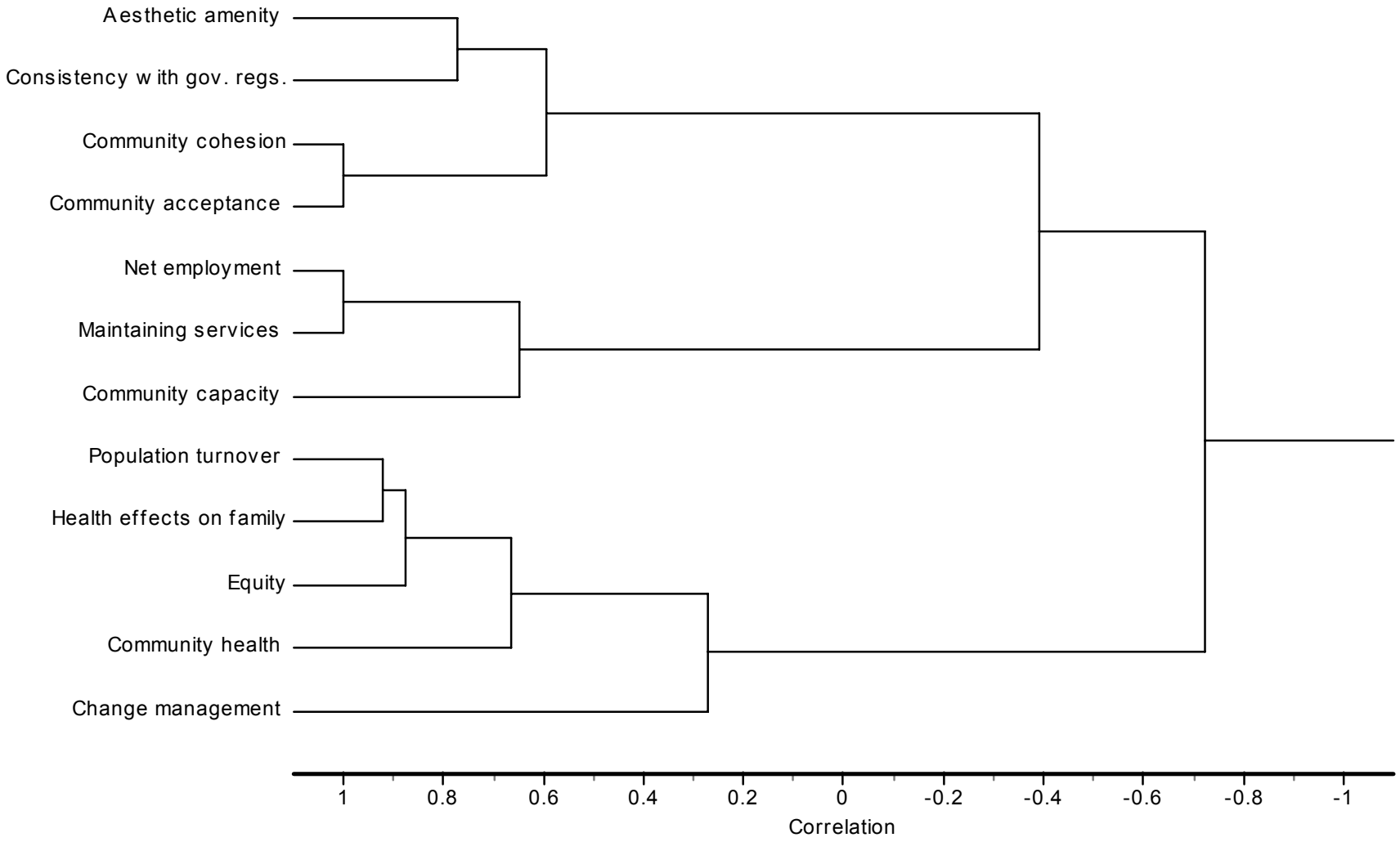


Table 17.3 Pearson's correlation co-efficient for the social group

Social criterion	Aesthetic amenity	Change management	Consistency with government policy and regulations.	Net employment	Maintaining services	Community capacity	Community cohesion	Community acceptance	Population turnover	Equity	Community health	Health effects on family
Aesthetic amenity		-0.4638	0.7715	-0.1003	-0.1003	-0.3926	0.5966	0.5966	-0.0166	-0.1194	-0.5251	-0.0636
Change management			-0.4053	-0.3013	-0.3013	0.0154	-0.66	-0.66	0.3298	0.2815	0.4456	0.27
Consistency with gov. policy and regs.				-0.0738	-0.0738	-0.2123	0.6167	0.6167	0.2712	0.2809	-0.2756	0.1925
Net employment					1	0.6493	0.3185	0.3185	-0.696	-0.4234	-0.4097	-0.7242
Maintaining services						0.6493	0.3185	0.3185	-0.696	-0.4234	-0.4097	-0.7242
Community capacity							-0.1891	-0.1891	-0.3306	0.1221	0.2034	-0.1771
Community cohesion								1	-0.1301	-0.1567	-0.5908	-0.1978
Community acceptance									-0.1301	-0.1567	-0.5908	-0.1978
Population turnover										0.8744	0.6657	0.9222
Equity											0.7821	0.9036
Community health												0.7502
Health effects on family												

18. Recommended Procedure for Future MODSS in Farm Forestry

I. Jeffreys, P. Norman and P. Lawrence

This chapter proposes a procedure for future MODSS in farm forestry. It assumes similar limitations as those which applied in the South-east Queensland and the Hodgson Creek study. The most critical constraint was that contact with the stakeholders, especially landholders, was limited to a half-day workshop. A recommended procedure is described, which aims to support and facilitate the decision-making process and maximise community input to support implementation. The proposed procedure is aimed to provide decision support a sub-catchment scale.

18.1 The Recommended MODSS Procedure

The MODSS process is defined as an iterative construction of a multi-objective decision-support system (MODSS). This process will use a multi-criteria analysis (MCA) tool to evaluate an effects table defined by the stakeholders and technical experts. The first stage involves developing a simple analysis in a workshop environment with local stakeholders and some experts. This initial analysis developed by the stakeholders can then be expanded and re-evaluated by technical experts, with feedback from stakeholders when possible. It is expected that the analysis will undergo a number of iterations before the final outcomes are produced, reported and presented to the wider community.

These recommendations for the MODSS process have been developed drawing on the experience of applying a MODSS to assess farm forestry in South-east Queensland and the Hodgson Creek catchment. This process has also been informed by the literature review presented in Chapter 4 and the processes discussed and developed in Chapters 13 and 14. The proposed procedure contains 11 critical steps to achieve this goal. Each of these steps is discussed in the following section.

Step 1: Identify an issue or planning opportunity

This should be an issue of direct relevance to stakeholders, one that does or will affect their lifestyle. Issues should be identified from areas of pressing need, not just vocal advocacy. Issues should be relevant and of concern to the stakeholders. The process is unlikely to achieve a satisfactory outcome if it is seen as representing a government’s agenda.

Step 2: Identify stakeholders

Stakeholders are those members of the community that will be affected by the outcome either negatively or positively and also include those persons who can affect the outcome. Those affected by the outcome by a decision should include those financially affected, those affected by the change in utility of a resource they previously used, this includes biophysical and social resources. The analyst should be aware that the poor and marginalised are often stakeholders directly affected by an activity. The process of identifying stakeholders should allow persons to self-identify as stakeholders. An initial list of stakeholders in farm forestry would include landholders, Landcare and forestry industry officers, as well as local and state government officers. Other stakeholders may include members of the local indigenous community, local clerics and teachers, all members of landholder families, and representatives of local environment advocacy groups. It is vital that when a broader section of the stakeholders are present, all members have input in to the process. As part of the process, each stakeholder should articulate their position on the issue and their interest in the outcome.

Step 3: Conduct stakeholder workshop

A stakeholder workshop should be convened, which includes a small number of farm forestry experts the role of whom is restricted to advising the meeting on technical issues as they arise. An independent, professional facilitator should conduct the workshop. Their role should be to ensure all opinions are allowed to be expressed without constraint, and to ensure no single group or the proponents of an action dominate the workshop. The stakeholder workshop should also include some selected farm forestry experts.

Step 4: Commence to develop a MODSS on farm forestry

The following is a guide to the process of developing a simple MODSS analysis of farm forestry options. Using a workshop setting, the suggested sequence of activities should be:

a. The facilitator introduces the MODSS process and explains the proposed plan for developing the MODSS.
b. The purpose of MCA tools is introduced using a simple example that is both illustrative of the basic principles of decision-support as well as appropriate given the experience of the stakeholders. An example about purchasing various types of new and second-hand cars may have widespread recognition.
c. The broad range of issues that affect farm forestry, and ways in which farm forestry can affect their catchment, are introduced. A brainstorming approach should aim to identify as many issues as possible, ranging from impacts, benefits, environmental, economic and social barriers and considerations, impediments, anecdotal experiences, actors, reasons for planting trees and reasons for not planting trees. The facilitator may elect to categorise these issues under broad headings as a means of consolidating the discussions. In a later step, these aggregated issues can be used to develop the decision criteria to evaluate the options. Once this is completed, the facilitator should try to focus on goals and objectives, as well as the desirable outcomes, from an individual landholder perspective and a whole-of-catchment viewpoint. The discussion should focus on the benefits and limitations of farm forestry in the catchment and to landholders. These discussions could include the experience in this catchment and other catchments, but with the intention of developing possible farm forestry options for the catchment.
d. The next activity is to review and refine the feasible farm forestry options in the catchment. Involving experienced farm advisors and government staff would assist this stage of the process. In developing these options, consideration must be given to physical constraints within the catchment (for example, soil type and depth, aspect, rainfall) as well as cultural issues that affect the implementation of farm forestry practices. This discussion may challenge the landholder's ideas and views, and requires careful facilitation and access to objective information and advice.
e. Drawing on the goals and values of the stakeholders, next develop the decision criteria that will be used to evaluate the options. It is important that only a minimal set of criteria is defined, perhaps restricting the list to two or three criteria for each of the major perspectives in natural resource management, namely social, economic and environmental perspectives. Each option will be evaluated against these criteria, and experience has demonstrated that this can prove to be a highly time-consuming process.
f. The relative importance of the criteria should be defined preferably from the landholder perspective. That is, which criteria are of the greater and lesser importance when the landholders are considering farm forestry options? The criteria should then be given an ordinal ranking consistent with the preferences of the landholder.
g. The *effects table* is now defined using the options and criteria as the basis. In evaluating the options, a scoring range of 1 to 3 or 1 to 5 is feasible in these situations. Against each criterion, the best option should be assigned the highest score, and the worst assigned the lowest score. The remaining options should be scored relative to the best and worst options. As the scores are assigned, the analyst can progressively enter the data into the MODSS software package.

h. This initial effects table should then be analysed. The software package *Facilitator* (Lawrence and Shaw, in process) is suited for this type of simple application, although there is often confusion with regards to the clarity of the results. *Facilitator* reports a maximum and minimum possible aggregated score for a given effects table and importance order, and there is often a high degree of overlap between the minimum score of one option and the maximum of another option. This is a result of the aggregation technique used in *Facilitator*. As an alternative, *Definite* (Janssen *et al*. 2001) has greater clarity of results, but use of this package can prove unwieldy in a workshop setting. It may be useful to employ *Facilitator* in the initial stages of a project, especially in workshop situations, and then move to *Definite* in the later stages, because *Definite* has greater analytical functionality.
i. The results should be evaluated in the workshop and feedback on the outcomes immediately provided to the stakeholders. The stakeholders should refect on the completeness of the analysis, and identify missing factors. These should include factors not reflected in the decision criteria or additional options which need to be considered. Any other comments on the analysis should be noted and included in the next iteration of the analysis, if time permits.
j. The options, criteria and importance orders should be re-visited and re-evaluated. It may be useful to conduct further iterations of the analyses to examine different scenarios and importance orders of the criteria. In this way, as many iterations as possible should be completed. It is vital that the discussions and comments are recorded, because these data will inform the next stages of the process.

The above process is designed to facilitate and promote discussion of the issues, factors and drivers relevant to the study of farm forestry. It can be described as a ‘quick and dirty’ MODSS. The analysis, while indicative of the possible performance of the options, is secondary to the discussion of the options. It is also desirable that the workshop facilitator encourage the stakeholders to use the MODSS tool so that they can self-investigate other options and practice action-learning principles. This is possible using the *Facilitator* software; however, experience has shown that *Definite* may not be as conducive to workshop use because it requires considerable training and familiarity.

k. The final stage of the workshop is to formulate a consolidated set of criteria developed from previous studies (see Chapter 17, Section 2 for a set of possible criteria). From the MODSS developed in the workshop, criteria should be added where gaps exist, and should be removed where redundancy exists between overlapping criteria. The overall number of criteria should however not significantly change, having regard for up to 7 criteria for each environmental, economic and social perspective. Because the number of criteria can increase rapidly, the workshop facilitator must exercise caution and control to manage the number of criteria. In many cases, a large number of criteria adds little information to the analysis but considerably increases the effort required to evaluate the effects table. A detailed description of all the criteria should be defined in this workshop, including what is to be assessed and the scale at which the criteria applies.
l. Weights that are applied to the criteria should now be defined. The relative importance of the criteria can be elicited from the stakeholders in accordance with their concerns and preferences. This can take a number of forms. It is suggested that a rank order of importance be used. These rank importance orders are used by the MODSS tool to assign weights to the criteria when aggregating the criteria scores into a combined measure of performance.

Step 5: The proposed list of criteria

For future MODSS for farm forestry, it is recommended that the number of criteria should be limited to approximately 21 in all. This number of criteria balances the desire to include all perspectives and considerations, with the need to create an effects table that can be evaluated in a reasonable timeframe. On the basis of the experience in this study, the following list of criteria are recommended for the evaluation of farm forestry options:

Economic group of criteria

Forestry viability
Infrastructure costs (community)
Profit (in transitional or steady state period)
Cash flow
Risk profile
Liquidity of assets

Environmental group of criteria

Soil resource quality
Water quality and salinity control
Water quantity
Cumulative impacts
Pest habitat
Displacement of existing native bio-systems
Air quality (spraying of agricultural chemicals)

Social group of criteria

Aesthetic amenity
Change management requirements (including reskilling)
Consistency with local, state and federal government regulations and policies
Maintaining services
Community health
Health effects on family

Step 6: Eliciting criteria importance orders

While eliciting the importance orders of this refined set of criteria from the stakeholders, it is important to focus efforts on the landholding stakeholders. The particular attention placed on the landholder group is because it is likely that the stakeholder meeting will be the only contact the analyst will have with these people, and the landholders will be the group most responsible for implementation of the farm forestry options. The other stakeholder groups can be contacted later in the analysis. It may be useful at this stage to split the stakeholders into two groups, namely (1) landholders and Landcare members, and possibly a farm forestry expert known to the stakeholders, and (2) extension officers, local government officers, state government officers and industry representatives. Each group can then consider the importance orders of the criteria and bring these preferences to the discussions as part of the scenario analysis.

Step 7: Documenting the process

The discussions with stakeholders and experts and analyses developed in the stakeholder workshops should be recorded and preserved for later discussions. Each iteration should be documented, with rationales behind changes to the analysis included, as well as descriptions of the options and criteria and any subsequent changes in definitions. This documentation should be returned to the stakeholders shortly after the workshop and feedback requested.

Step 8: Convene a technical reference group

Identify and convene a technical reference group to review the outcomes from the MODSS conducted by the stakeholder group. This meeting will also consider the options and criteria – in particular the spatial extent and temporal variability of the options.

Step 9: Spatial representations of the options

The possible spatial extent of the options should be developed using a geographical information system (GIS). A GIS can assist in formulating feasible options by superimposing areas of forestry plantings on an image of the catchment or farm location. This work would be undertaken in consultation with the technical reference group

Step 10: Evaluate the options against the criteria

The technical reference group then evaluates the options against all the criteria for the defined timescales. Currently, it is proposed that the evaluation will be the considered opinion of the technical reference group members. Two methods of evaluation may be considered. In the first, the highest score is assigned to the best option and the lowest to the worst, and all other options are assigned the intermediate values. In the second method, the technical reference group identifies a best and worst possible option for each criterion. These would be hypothetical options and would need to be evaluated. The best and worst possible options would then be assigned the highest and lowest scores respectively. The other options again would be assigned intermediate values. It may be advantageous for the technical reference group to score the criteria in their own time prior to the second technical reference group meeting. The analyst can then combine the data and highlight differences of opinion. The analyst should only highlight and not try to resolve differences. In the second technical reference group meeting these differences in scores are highlighted and discussed. Consensus should be sought with regard to all scores – those where there is agreement and those where there is a difference of opinion. Thus an effects table is produced. If time allows, the effects table should be analysed and presented to the technical reference group in the second meeting. However, if time is scarce, the results should be presented to the expert group as soon as possible. Results should be discussed and feedback sought. Options, criteria, scores and importance orders should be re-evaluated and the analysis repeated. This process should be continued until the technical reference group is satisfied that the outcomes of the analysis are consistent and defensible. The analysis should be appraised and the results fed back to all the stakeholders and experts.

Step 11: Report the findings to the stakeholder and technical reference group

Convene a final meeting that is open to all interested parties including stakeholders, the technical reference group, and other government and industry bodies. It might also be beneficial to invite persons from other catchments who may be interested in applying a MODSS approach. At this meeting, the outcomes of the analyses developed in the stakeholder workshops and the final analysis produced by the technical reference group should be presented. Notes and comments on the final results should be incorporated into the analysis. The process and outcomes should be included in the final project report. This would include possible changes for future applications and an implementation and monitoring strategy of the preferred option.

18.2 Discussion

It is difficult to visualise individual farmers sitting at the kitchen table using decision-support software such as *Facilitator* in planning tree planting. Possibly large-scale commercial farms and corporate entities may use such an approach to inform decisions about a range of farm issues. However, individual farmers are generally suspicious of such ‘black box’ approaches. The processes applied, although relatively simple, are unseen, being hidden in software packages. This has aroused

suspicions as to the nature of the analysis, although acceptance of these methods by stakeholders will increase as stakeholders receive greater exposure to them. However, a simple cut-down manual version could be appropriate.

Contemporary extension thought emphasises the need for farmer groups to undertake self-supported decision-making in natural resource and land-use management. It is in these types of forums where MODSS and the software package *Facilitator* are ideal. Facilitator has already demonstrated utility in catchment planning where supported with group facilitation leadership.

Given the increasing push toward multi-dimensional and integrated approaches to natural resources and land-use management and the push for decisions to be moved downward from central administrators towards local landholders, the relevance of MODSS is likely if anything to increase. There needs to be investment to build rapidly the capacity in catchment groups to make the types of multi-objective decisions that are now being expected of them. MODSS and the *Facilitator* software package may be well suited to this task.

18.3 References

Janssen, R., van Herwijnen, M. and Beinat, E. (2001), *DEFINITE (version 2) DEcision support system for a FINITE set of alternatives*, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.

Lawrence, P. A. and Shaw, R.J. (in process), 'A framework for evaluating options for improved irrigation management', in Proceedings MODSS'99 2nd International Conference on Multiple Objective Decision Support Systems for Land, Water and Environmental Management, Brisbane 1-6 July, 1999.

19. The Farm Forestry Decision-Support System: Research Outcomes in Relation to Farm Surveys, the AFFFM and the MODSS

S. Harrison, J. Herbohn, G. Cockfield, N. Emtage and I. Jeffreys

This chapter reviews the outcomes of the various components of the project 'A Whole-Farm and Regional Agroforestry Decision-Support System', including the landholder surveys and spatial modelling, and development and application of the decision-support systems (DSSs), and development and testing of the Australian Farm Forestry Financial Model. Achievements of the research and its relevance to decision-making at the farm and regional level are examined. Comments are also made on the viability of the approach of combining a number of separate research groups into a single team.

19.1 Findings on Landholder Attitudes to Forestry

An important component of the research was a survey of attitudes of Darling Downs and New England landholders to management of native forests and to establishment of plantation forestry or woodlots on their land. Past studies of landholder attitudes to forestry were also reviewed to provide background to the results of this survey. The survey was designed both to provide information for development of the MODSS and to anticipate any likely changes in land-use by identifying factors and associations that might influence-policies related to farm forestry.

The survey findings, as reported in Chapters 5 and 6, added to the body of knowledge relating to attitudes to farm forestry of landholders in general, and in particular, considerably advanced knowledge of landholder attitudes in broadacre farming areas. Interpretation of these findings points to a number of key influences over possible developments in the management of plantations and native forests and help paint a picture of the probable future of farm forestry in the area:

1. There is unlikely to be any large-scale increase in the rate of plantation establishment by existing landholders in broadacre agricultural landscapes. Nor is there likely to be a major increase in the area of native forests that is managed for timber production.
2. Any expansion in the number of plantation growers will primarily be based on smallholder activity, especially those with higher incomes, professional backgrounds and off-farm income and with some pre-existing interest in, or experience with, trees. These same types of landholders are more likely to be interested in the commercial management of native forests, but whether or not they will provide a reliable source of native timbers needs to be further considered.
3. Plantations are seen by landholders as having the potential to provide soil protection benefits, although this purpose is most strongly supported by the low-production landholders. This is less interest in forestry by high-production commercial landholders, who are not so likely to see plantation or native forests as having a land protection role, nor having a significant role in providing habitat.
4. Both plantation and native timber production are seen by landholders, especially those with a commercial focus, as something that is best placed on poor soils. This thinking is likely to contribute to poor perceptions of the commercial potential of farm forestry because landholders assess forest potential on the basis of plots that are established in inappropriate areas.
5. It appears that landholder attitudes vary with the extent of their experience with trees, irrespective of whether that experience was gained through having native forest areas on their farms or through undertaking conservation plantings. Those who have experience with harvesting native timber believe there are economic reasons for managing native forests for

timber production, although they are most supportive of the particular reason of providing timber for on-farm use. This suggests that attitudes may change over time as an increasing number of landholders gain some experience with trees, though the cause and effect relationship needs further investigation.

6. Landholders who have a native timber resource, or at least believe they have it, see some reasons, including both conservation and economic reasons, for managing the resource. These landholders are also more likely to believe they are capable of managing forestry (the management barrier). However, they still seem to be concerned about the economic barriers.
7. Landholders, particularly those with relatively low levels of education and a high dependency on agriculture for their income, are concerned about the perceived threat of government regulations restricting future harvesting opportunities. Those who recognise that they have native timber resource on their properties are more concerned about regulation than those who do not. It is notable that those who believe they have the tenure that allows them to harvest native timber are the most likely to consider native timber production.

The likely future scenario for farm forestry region-wide

Across the landscape, plantations will most likely be established nearest the Great Dividing Range, where smallholders are most numerous, with little farm forestry activity in the pastoral zone. Plantations will be small, most likely scattered, and in some cases productivity will probably be quite low. This is because landholders, including the low-production groups, see plantations as primarily serving functions that tend to be associated with ‘mosaic’ plantings. Assuming that landholders see most land degradation as being at particular and limited sites within a property and given that minimising land degradation is viewed as one of the most important reasons for establishing plantations, those who act to minimise such degradation will at least initially plant small and perhaps irregularly shaped plots. Shelter-belts will only be strips on the landscape, and in some cases farms have only patches of low-fertility soil which they will be inclined to plant. Therefore, if landholders act according to the apparent priorities revealed by this analysis, then the result will be a mosaic of forestry pieces, rather than any orderly aggregation. These results suggest that landholders are likely to favour plantation options that fit around cropping and grazing activities, even where those activities are conducted at a sub-commercial level. In particular, most landholder types tend to see plantations as having a conservation function. Some commercial landholders may consider native timber production if it can be shown that combined grazing and timber production result in a net increase in income, although some landholders may still be reluctant to consider managing trees because of a lack of interest in the activity, and in some cases hostility to trees in crop and pasture landscapes.

Farm forestry options for MODSS development

On the basis of the landholder survey and discussion with forestry experts, eight farm forestry options were identified for further investigation in the Hodgson Creek catchment, briefly described as: an approximation of current land-use; high-priority salinity prevention; medium-priority salinity plantings; forestry on additional under-used areas; commercial plantations (with corporate land ownership); commercial plantations (with leased land); private medium-sized plantations; and agroforestry (plantations and grazing).

These land-use scenarios were developed from information about landholder attitudes, government policy documents and expert and local knowledge. An initial set of nine scenarios was developed, and scenarios were modified or eliminated through a MODSS process and by the re-examination of the initial criteria, to arrive at the final eight scenarios. The feedback from that exercise was used to refine and simplify the scenarios to the above set which are the ones considered in the spatial analysis.

Spatial analysis in relation to forestry options

A spatial analysis was undertaken to model the changes in the value of agricultural output that would result from the conversion of land to forestry use. This was designed to provide further information to policy makers as to whether there are sound economic reasons for pursuing the goal of increasing the area devoted to farm forestry. Achievement of this task was constrained by the lack of relevant biophysical data relating to forestry production in the study region. By necessity the analysis is based on estimates of what could be produced through conventional crop and livestock production from the region. A closer integration of the spatial component with the actual production would require a detailed on-ground survey, and given rotational land-use, would involve a highly complex model. An additional problem is that an infinite number of combinations of land-use activities in various locations across the region are possible. Therefore, the analysis compares the spatial distribution and value of broadacre, dryland crops with scenarios in which some of the land is used for forestry plantations.

This comparison was done by selecting a study site, the Hodgson Creek catchment, south-west of Toowoomba on the eastern Darling Downs, creating a representation of current land-use based on existing spatial data sets and some interpretation of satellite imagery, and then adding possible farm forestry scenarios to create new land-use combinations for the catchment. The farm forestry scenarios were initially as deduced from the landholder survey findings outlined in Chapter 5, from advice from local forestry extension personnel, and from Queensland State and Federal Government policy goals in relation to farm forestry.

The spatial analysis provided useful indications of the changes in output that could result from various changes in land-use and provided an indication of the spatial distribution of a new form of land-use, based on particular criteria. The results of the economic analysis for this case study suggest it would be difficult to argue that plantations result in a clear economic advantage, especially in the short to medium term. This is largely because of the opportunity cost of displacing existing production. However, the spatial analysis reveals that there is a considerable area of land within the catchment that is not being used for agricultural or pastoral purposes, and for which there is little opportunity cost associated with conversion to farm woodlots. A possible strategy to increase the area of plantations is therefore the development of a mosaic of plantations across the landscape on underutilised sites. This will mean a low opportunity cost in terms of agricultural production foregone, but it may also mean there is a limited contribution to conservation and land protection benefits.

There is, however, a need for further research work before such a conclusion forms the basis of a policy decision. In comparing forestry scenarios, the ‘Commercial plantations’ option would displace a greater area of existing agricultural production, but is more likely to support local forestry processing. On the other hand, the ‘Private medium-sized plantations’ option allows for the maintenance of existing agricultural output and still produces a long-run net gain in terms of stakeholder multiple objectives.

19.2 Research Outcomes in Relation to the Australian Farm Forestry Financial Model

This study has lead to the refinement and extension of the Australian Rainforest Cabinet Timbers Financial Model to the Australian Farm Forestry Financial Model. Notable developments of the AFFFM include:

1. *Reprogramming in Visual Basic*. The model is now independent of proprietary software such as Microsoft Excel. This overcomes previous problems with software compatibility and improves ease of access for a range of users.
2. *Inclusion of biological performance data for species selected by experts as appropriate for planting in the study sites*. This was achieved mainly through the use of suitability indices compiled using the PlantGro software package. This greatly improves the usefulness of the model to users who do not have specialist knowledge of tree performance.
3. *Inclusion of native forest as well as plantations management into the model.* Native forests form an important part of many farms in the South-east Queensland and the inclusion of the native forests greatly increases the usefulness of the model to landholders and extension staff in this area.
4. *Inclusion of the ability to consider interactions with other elements of the farm enterprise*. Many farmers wish to consider forestry in the context of 'whole-farm' activities. Elements of the CARE Pty Ltd whole-farm model have been adapted to allow users to model the impact that farm forestry will have on other farm activities and overall profitability and cashflows. This provides a powerful tool for exploring a variety of combinations of traditional farm activities together with forestry (e.g. reduced grazing land due to tree planting or increased carrying capacity due to shelter).
5. *Extensive testing and demonstrations* (followed by further refinement to address issues arising from the tests).
6. *Packaging for distribution.* This included the development of the facility to download across the Web and production of a user manual.

Development of default data

The usability of the AFFFM has been greatly enhanced by generation of data files through use of PlantGro and the collection of harvest age and MAI data through Delphi surveys. Default data are available for initial runs of the model where the user does not have access to data specific to the planting sites.

Testing of the AFFFM

Testing of the financial model proved to be a major challenge, particularly in terms of ensuring that the package operated well for users not involved in its development and not fully conversant with its purposes, features and limitations. A wide variety of people experimented superficially with the model, but in general did not provide extensive feedback. The most effective testing was when students of the School of Natural and Rural Systems Management at the Gatton Campus of The University of Queensland undertook an assessable project using the model. The exercise identified a range of problems when people unfamiliar with the model attempt to use it in a practical setting, and resulted in extensive refinement of the model in terms of operational (as distinct from analysis) features to improve user-friendliness.

Case studies with the AFFFM

A further test of the model, and assessment carried out of the financial viability of farm forestry, by applying the model in two case studies, namely native forest management in the New England region and plantation establishment on the Darling Downs. The model proved sufficiently flexible to

accommodate both of these case studies. Bringing native forest under management in the New England region is attractive in that the initial outlays are relatively small and revenue is generated quickly. The business cash position is at no time worse than without native forest management, and the net revenue per hectare for the whole farm is substantially increased. Timber milling on-farm greatly increases the financial payoff from the native forest. In contrast, conversion of 50 ha of grazing land to a forestry plantation on a Darling Downs farm appears to be financially unattractive, due to the high establishment cost of plantations, long wait for returns and reduction in revenue from livestock.

Potential uses of the AFFFM

A number of uses of AFFFM have become apparent as this project has proceeded. The major use of the model is envisaged to be by individual landholders and their advisors to investigate the potential for farm forestry development on private landholdings. A number of additional uses have also been identified.

Business applications. Some of the variety of potential business applications identified include:

- Evaluation of the economic payoff from forestry investment for individual landholders. The model allows this type of analysis to be carried out, within the context of the overall farm business and cashflow situation. It may be that initially landholders will require the assistance of an extension worker or consultant to assemble input data, operate the model and interpret the output.
- Providing evidence of forestry business status for taxation purposes. Changes have recently been made in Australian taxation legislation with respect to the deductibility from taxable income of expenses incurred in the undertaking farm forestry operations. An important component of being eligible to claim these deductions is for the farm forester to be able to demonstrate that they are carrying on a business with the reasonable expectation of profit. In this context, the AFFFM is potentially a powerful tool for demonstrating the likely profitability of farm forestry.
- Estimating the land value impacts of forestry. It would appear that land valuers typically disregard the value of native forest and plantations when valuing rural holdings, the reason being at least in part that they do not have a reliable source of the likely future timber revenue. The AFFFM can provide estimates with improved credibility relative to guesstimates based on broad rules of thumb.

Research applications. A number of applications are feasible including:

- identifying key variables and issues that affect the profitability of individual forestry investments – this could be provided as case studies across various regions and farming systems
- predicting the financial performance of timber production using non-traditional species, mixtures, and production and harvest regimes
- investigating the potential economic payoff from forestry in areas where this has not been a traditional land-use
- as a support tool for the development of regional forestry industry through case studies for business groups or policy makers
- providing economic data which is input to the spatial modelling approaches described in this study or for the MODSS approach
- with further development, for demonstrating the differences between do-it-yourself and joint venture options;

Perhaps the most important use of the AFFFM will be in further research into the profitability of farm forestry in northern Australia. It has already been used to undertake some preliminary investigations for the Far North Queensland Regional Plantation Committee (known as Private Forests North Queensland) and this group plans to undertake further investigations utilising the model. Greening Australia has also expressed an interest in using the AFFFM to perform case studies on farms. Financial support has been approved from RIRDC to carry out further case studies of the financial returns from farm forestry at a variety of locations in Queensland.

Educational applications. Much of the education relating to farm forestry concentrates on the technical side of the investment decision. There are few tools which allow potential investors to explore the financial implications for their own businesses. The AFFFM provides this capacity and is amenable to use in workshop situations for people interested in forestry investment, and in teaching situations in forestry and related training programs.

19.3 Research Outcomes in Relation to the Multi-Objective Decision-Support System

The MODSS process, using stakeholder and technical input, is a powerful method for integrating economic, environmental and social analyses, to produce a holistic analysis of natural management issues. This project has demonstrated its applicability to farm forestry. The MODSS approach is particularly useful for combining data and knowledge in a clear and transparent framework. The application of a simple MODSS development tool (such as Facilitator) and the process of developing options, criteria and importance orders provide a useful action-learning tool. This allows stakeholders to 'play' or experiment with the decision problem, identifying relationships between the various components of the problem and the outcomes. The MODSS process provides a useful framework for workshops to discuss issues surrounding farm forestry.

MODSS were developed in relation to farm forestry, for both south-east Queensland and for the Hodgson Creek catchment on the eastern Darling Downs. Forestry options investigated in these analyses were those developed from the landholder survey. Input for the MODSS effects tables were provided by both a technical advisory group and a meeting of landholders. A large number of economic, environmental and social decision criteria for farm forestry were identified. Some deletions and amalgamations of criteria were made, on the basis of practical logic and correlation analysis of scores provided by the informants. Two time periods were considered in the analysis, viz. plantation establishment and steady-state forestry.

Two solution methods of the MODSS were employed, viz. weighted summation and the Electre II method. The former is a compensatory aggregation method (meaning that poor performance on one criteria can be compensated by high performance on another) while the latter is a non-compensatory aggregation method (and hence can identify options which are 'fatally flawed' with regard to essential performance criteria). Aggregate performance measures have been derived for forestry options overall and for economic, environmental and social performance. Aggregate scores, using weighted summation, fall in the range zero (extremely poor) to one (outstandingly good). The Electre II method produces an ordinal ranking of the options.

In the Hodgson Creek analysis, for the *transition period* and under the weighted summation method, all the options fall into a tight range (0.51 to 0.63), i.e. there is little difference between the desirability of the options. Within this range, 'current practice' performs best, 'high-priority salinity plantings' and 'medium-priority salinity plantings' perform next best, then 'commercial plantations (leased land)' and then the other options. There is a general trend that performance drops as the area planted by trees increases. Considering the Electre II analysis, the results are quite different. The 'commercial plantations (leased land)' option is ranked first, followed by all the other forestry options and with 'current practice' ranked last. 'Commercial plantations (leased land)' performs well overall, with scores for the individual criteria general high and with few exceptionally poor performing criteria. It scores poorly in the economic criterion of *liquidity of assets* (as do all the forest options) but no others. The drop in performance of 'current practice' is due to critically poor performance in a number of environmental and social criteria.

In the *steady-state period* and using the weighted summation analysis, there is more definition between the options (a range of 0.54 to 0.73). All the forestry options perform similarly within the range of 0.68 to 0.73, and all outperform 'current practice'. Using the Electre II method 'medium-priority salinity plantings' performs best with 'high-priority salinity prevention' second then

‘agroforestry’, followed by all the other forestry options and with ‘current practice’ having the worst performance. The poorer performance of the large-area forestry options is largely due to poor performance in the social group of criteria.

Some difficulties in development of the MODSS

The literature review indicated various definitions have been adopted for multi-objective decision-support system (MODSS) and multi-criteria analysis (MCA). For some, MCA is an umbrella term to encompass a large number of quantitative techniques which allow the comparison of management policies where more than a single goal is recognized. For others, MCA is approximately a synonym with MODSS, and is concerned with a specific decision-support technique for comparing a number of management options on the basis of a hierarchy of decision criteria, in which importance weights of the criteria are summarised in an *effects table*. This latter definition has been adopted in this project.

Development of the MODSS proved to be perhaps the most difficult and challenging component of the project. Some of the particular issues faced related to dependence on outputs of the other components of the project as input for the MODSS, the time horizon of forestry activities, choice of software package, limited access to stakeholders, the large number of performance criteria identified and need to eliminate closely related criteria.

The forestry scenarios for the MODSS analysis as listed above were generated in the landholder study and related research. The forestry case studies providing estimates of the financial returns from plantations and management of native forests were not available at the time of MODSS development.

Forestry takes the form of a very-long-term investment, with long-term impacts. Decisions needed to be examined for the short, intermediate and long term. Previous NRM applications of MODSS have been concerned with situations where a decisions needed to be made as soon as possible, on the basis of current information, though the impacts could be long term. Forestry presented a somewhat more difficult application area, because of the large number of potential applications and the need to consider performance in at least two time periods. It was found that the software package intended for use in this study (Facilitator), which was used in previous MODSS applications of NRM and in initial work in this project, was rather limited in terms of meeting the project needs. The decision was therefore taken to switch to the commercial package Definite.

It was difficult to capture and hold the attention of landholders to obtain detailed information about the nature of their decision criteria and the relative importance of the various criteria. This proved to be a difficult and tiring task for participants, and hence limited the landholder workshop time to a single session.

The technical and stakeholder groups were able to suggest a large number of decision criteria by which alternative forestry options could be evaluated. The scoring of the criteria became a challenging task. Further, sometimes these criteria were closely related. Hence it became necessary to examine the levels of correlation between scores for the criteria and to delete or amalgamate highly correlated criteria to arrive at a workable set.

Critique of the applicability of the MODSS approach

The experience of this study suggests that while MODSS are somewhat more difficult to develop for forestry than for shorter-term land management and irrigation projects, this approach is nevertheless feasible for assisting forestry decisions. MODSS would appear to be a particularly useful tool for extension officers concerned with regional or catchment planning or policy. It may be more limited as a decision-support tool at a farm level, although the strength of MODSS as an ‘action-learning’ tool is equally valid with individuals as it is in groups. If MODSS were to be used at the farm scale,

the development of any analyses would require facilitation from extension staff or other farm advisors.

MODSS is sometimes criticised as a ‘soft’ analysis technique, which relies heavily on subjective data, particularly in regard to estimates of importance of decision criteria. However, it should be noted that all business planning and control techniques have a substantial degree of subjectivity. Reliance on an apparently ‘objective’ analysis of observations of past data – generally from a limited number of sites and under limited treatments and environmental conditions – to make management prescriptions for the future, is fraught with difficulty. Real-world situations faced by decision-makers are simply not repeatable events; there is no hard science of decision-making.

To some extent, cost-benefit analysis (CBA) constitutes an alternative to MODSS for the evaluation of alternative forestry scenarios. However, CBA also requires that a number of subjective decisions be made. For example, net present values (NPVs) of forestry investments are found to depend strongly on the discount rate adopted, because of the long time horizon of forestry. However, choice of discount rate is to some extent a subjective decision, there being no precise method to determine the social rate of time preference at present, let alone for many years into the future. In effect, the discount rate is another method of weighting criteria, although it is not explicitly recognized as such. High discount rates weight current benefits to be strongly more important than future benefits. Another subjective decision in CBA is the extent to which non-wood costs and benefits are to be included in the analysis. While much progress has been made in non-market valuation techniques, often benefit transfer methodology is adopted, requiring subjective choices to be made about which sources of value estimates to choose and what adjustments to make to transfer these estimates to the target site.

MODSS incorporates economic, environmental and social considerations. Both quantitative and qualitative criteria can be included. By evaluating these perspectives in terms of *single dimensionless utilities*, MODSS enables the stakeholders to place their own values on these perspectives. Value judgments are elicited which are highly individual, highly divergent within the community, and not easily summarised. This also removes the need for laborious non-market valuation techniques or benefit transfers of uncertain reliability.

MODSS can provide an integrating framework for information from a variety of sources. If a high weight is placed by stakeholders on the financial payoff from farm forestry, then a financial model such as the AFFFM can provide estimates of performance of forestry scenarios in terms of this criterion, using farmers’ estimates of forestry physical and financial parameters.

In summary, if a MODSS is developed and applied with care, it can provide a highly powerful tool for decision-support in natural resource management, where multiple stakeholders are present, a variety of policy options exist and a large number of economic, environmental and social criteria need to be taken into account. This has been the situation faced in comparing farm forestry or agroforestry options in marginal forestry areas in this project.

19.4 Team Dynamics in the Project

As noted in Chapter 4, four research teams which had proposed broadly similar research projects were brought together by the Joint Venture Agroforestry Program into a single integrated project. This was presumably motivated by a desire to gain synergies from the four groups working together, avoid duplication of effort, and achieve cost-effectiveness with respect to budgets. Initial reactions of the participants were both positive and negative. On the one hand, an integrated project presented an excellent opportunity to bridge the gap between university and government departmental research into natural resource management and to broaden professional contacts. A convenient structure was established for the exchange of information and ideas, and for synergy between researchers from differing backgrounds,

On the other hand, the requirement that the groups work together for a common objective raised issues of loss of independence, reliance on others to perform their part of the project, coordination issues in meeting deadlines, possible delays in disbursement of funding, and other difficulties which have been noted elsewhere when project groups which are not natural partners have been forced together. For example, Harrison and Tisdell (1997) noted difficulties in relation to four research projects funded by the Land and Water Resources Research and Development Corporation (LWRRDC), for which coordination had been imposed in relation to development of a technology transfer package. They noted that 'the coordination role has not functioned as intended, with no recent combined meetings of the joint partners for all four projects' (p. 53). The failure to collaborate effectively appears to have been due to both differences in specific research objectives of the four researchers (who all had individual research grants), differing research cultures (participants involved in basic research and in government regulatory activities were involved), and lack of travel funds to support meetings and workshops.

The experience of this project was that while the groups at times worked relatively independently, the coordination worked relatively well, due to the goodwill of the team members and coordination efforts early in the project by the Department of Natural Resources and Mines. The experience was a rewarding one. The extent to which various components of the study integrated with each other was variable. Some constraints naturally arose with respect to integration. For example, the attitude survey and MODSS work proceeded to some extent in parallel, such that there was limited opportunity to use the findings about landholder attitudes in one to reinforce the other. On the positive side, the CARE and UQ groups worked closely in the financial modelling. Various members of the team provided input design for the questionnaire used in the farm survey. The NRM and USQ worked closely in facilitating the development of the MODSS analysis, including facilitating the stakeholder and technical reference group workshops. The CARE and USQ members assisted in the workshops to elicit decision criteria from landholders.

19.5 References

Harrison, S.R. and Tisdell, J.G. (1997), *Evaluating the Impacts of Research Projects Relating to Australia's Natural Resources*, Land and Water Resources Research and Development Corporation, Impacts of Research Series, Canberra.

20. Decision-Support Systems in Farm Forestry: Implications of Research Findings and Future Directions

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This chapter draws together the findings of the various components of the research reported in this collection of papers, to review achievements, draw implications from the research, and present some judgments about future directions in the development of decision-support systems (DSS) for farm forestry and agroforestry in north-eastern Australia. Some speculation is carried out, on the basis of findings from this study and judgment of the researchers.

20.1 General Role of DSS in Decision-Support

The research reported here has consisted of a number of separate components but with a common theme of developing decision-support systems (DSS, including MODSS) for farm forestry. These DSS are designed to augment the knowledge and judgment of decision-makers by providing systematic and quantitative information about the desirability of alternative management policies. DSS potentially have a role at both the farm level and the district or regional level, to guide both private decisions and extension and regulatory decisions. They also have a research role in regard to natural resource management.

This project has brought home to the researchers the dichotomy of objectives between providing decision-support information for individual landholders and providing support for policy in relation to natural resource management at the district and regional level, by resource management agencies in government. DSS are relevant in both cases, but the analysis can be quite different. From the social or governance perspective, social and environmental externalities become much more important.

The use of DSS can be controversial, partly due to a misunderstanding of their role. DSS are not meant to *make* decisions, and are no substitute for practical experience, sound judgment and (when dealing with policy issues) consultation with stakeholders. However, they do allow information from a variety of sources to be compiled, structured and analysed, and presented in an organised manner to enhance understanding of the system to be managed. MODSS in particular perform an integrating function, in evaluating a variety of management options, providing a common framework and language and taking into account the performance criteria regarded as important by the variety of stakeholders who will be affected by or will affect resource management decisions. In addition, the effects table bounds the decision-support process and provides a relatively transparent means by which to assess the relative impact of various factors and to focus discussion on those issues that are directly relevant and those values that have the greatest impact on decisions. When used in conjunction with decision-support software, stakeholders can explore a range of ‘what-if’ scenarios in order to achieve their goals and articulated aspirations.

20.2 Implications of Findings on Landholder Attitudes to Farm Forestry

Whereas most landholder surveys concerning farm forestry in north-eastern Australia have been carried out in the higher rainfall coastal areas, the survey work on the Darling Downs and New England district provides new insights into the role of farm forestry. The question facing the researchers was whether in lower rainfall regions characterized by more broadacre agriculture it can be expected that the patterns of attitudes, intentions and practices with respect to farm forestry will be

similar to those in the more traditional farm-forestry areas. Another question of interest was whether clear typologies of landholders with respect to forestry apply in these more marginal areas, such that extension and other intervention measures to promote tree planting can be targeted for greater effectiveness.

The findings of the landholder survey to some extent confirm other findings reported in the literature about which landholders are likely to be interested in farm forestry and motives for tree planting on farms. For example, it is clear that landholders on the larger and more commercially successful properties have relatively low interest in farm trees. Farmers involved in Landcare activities are also more likely to invest in farm forestry for reasons associated with soil and water conservation. Those on smaller holdings, with less prime cropping land, and considerable off-farm income, are more likely to be interested in a forestry enterprise. Also, in general landholders plant trees for multiple goals, with a strong emphasis on land and catchment protection. The perception of sovereign risk – relating for example to harvest rights and changes in taxation policy – again appears to be a serious impediment to tree planting.

It is notable, however, that some major differences exist relative to the more traditional farm forestry areas. The species choice is much narrower, and more difficult sites are encountered. Property sizes are larger, and it is likely that forestry will remain a relatively minor activity, particularly where profitable cropping options are available. Interest in managing native forests is relatively strong.

It is often the case that farm forestry is of marginal profitability, but generates considerable on-farm and off-farm environmental benefits, and for this reason there is a case for taxpayer support to encourage tree planting, or at least for government to take steps to remove unnecessary impediments. It would appear that commercial forestry will develop only slowly, and that extension effort probably will be most successful if focused on more environmental plantings. Since these are likely to have the greater externality benefits, this would appear to be consistent with maximizing the community benefits of taxpayer expenditure to promote forestry.

It is possible that large-scale planting will take place at some sites, probably in upper catchments where rainfall is relatively high and cropping options limited by land slope and soil depth. This could have adverse social impacts, as have been experienced in industrial forestry on farms in southern Australia. While a number of forestry options exist for the region, the evidence is that the uptake will be slow and that these adverse social impacts are unlikely to be severe. Over time, the landscape of the fringes of the Darling Downs and New England Tableland may move towards that before European settlement, in terms of forestry on the sloping lands adjacent the major agricultural areas.

Spatial analysis in relation to forestry options

The spatial analysis as applied to the Hodgson Creek catchment is a useful means of assisting landholders and other stakeholder groups assess land-use change and shows considerable potential as a means of assessing other production versus conservation trade-off situations, such as habitat plantings, and replacing crops with deep-rooted plant species. Spatial analysis is highly dependent on data availability and resolution, and requires some technical expertise in the development of geographical information systems (GIS). The process of constructing forestry scenarios is straightforward provided there is some means of deriving some initial criteria for preferred land-use. This may be more difficult than the technical analysis.

The spatial analysis of this study has provided useful indications of the changes in output that could result from various changes in land-use and in providing an idea of the spatial distribution of a new form of land-use, based on particular criteria. It has also revealed that there is a considerable area of land within the case-study catchment that is not being used for agricultural or pastoral purposes. This analysis may have even underestimated the area of land that supports little or no production. If this line of thinking is pursued it means the focus remains on developing a mosaic of small plantations

across the landscape. This will mean a low opportunity cost in terms of production, but it may also mean there is a limited contribution to conservation and land protection benefits depending on area, orientation and shape of the plantation.

This type of analysis, when based on sound resource inventory data and on economic and social analysis in relation to farm forestry, has considerable scope for shedding light on what future rural landscapes will look like if current trends continue. It also provides a basis for designing polices to influence future landscapes towards what is most desirable socially. New tools in visualization can support property management planning. Although not utilized in this study, other work has shown the utility of visualization to assist catchment and property scale planning. There may be justification for influencing forestry development towards an orderly landscape of tree planting rather than a mosaic of forestry pieces on land with little opportunity cost. The mosaic scenario presents particular potential difficulties for commercial timber production from farm forestry (in terms of consistency of supply flow and quality required by large scale timber processors). This scenario also presents potential difficulties for individual growers eg in marketing such small quantities of timber or in gaining economies of scale in management and harvesting.

This is an area where further research clearly could be useful for supporting land-use policy. Some commercial landholders may engage in native timber production if it can be shown that combined grazing and timber production results in a net increase in income. The commercial potential of small-scale fragments of forest may be improved by their being clustered around a large consolidated core of established commercial native forest or plantation. Timber markets (particularly for hardwood species) are overwhelmingly dominated by the public sector in Australia and Governments need to consider the impact decisions they make about the management of their own estates on the viability or otherwise of forestry activities in the private sector. Increased silvicultural management of native forests would have minimal landscape impact and generate greater returns from a currently underutilized resource. This would appear to have been a neglected extension area.

20.3 Lessons Learnt from Development of the Financial Model

A major lesson arising from development of the AFFFM is that development of the user interface and testing of the user-friendliness and operational reliability of the model is a greater and more time-consuming challenge than programming of the analysis capabilities. If the objective were simply to develop a research tool, to be applied by a small group of people closely familiar with the model, much of the recent refinement effort would not have been essential. However, the objective has been to develop a tool that can be used widely to evaluate farm forestry scenarios. Even though it has not been the intention to develop a commercial software package, for the AFFFM to be useful it must be suitable for operation by a wide variety of people in the farm forestry industry. This has implications for the menu system, output and displays, the on-line help system, stability of the package during computer runs, training and future maintenance of the software to support previous versions and data tables.

The combination of features – such as ability to include mixed species plantings, facility for whole-of-farm-business analysis, and default stand growth data – make this a highly versatile and useful generic financial analysis package for evaluation of plantation and native forest management projects. A large amount of effort and expenditure has now been sunk into development of this model, which is now in a suitable form for widespread application, and it is to be hoped that payoff from development efforts will now be realized.

Potential further developments of the AFFFM

The experience of the financial modelling group is that a model is not simply built and tested as a one-hit operation, but rather evolves over time as new uses are realized and new features incorporated, and as confidence is gained in the use of the model. In this sense, the developers have

identified a variety of useful extensions which could be made to the AFFFM should opportunities arise.

The AFFFM could be modified to include modules that allow assessment of the financial impact of: (1) joint venture financing arrangements; (2) annuity payments to growers for joint venture participation; (3) annuity payments to growers or for environmental services (e.g. carbon and salinity credits); and (4) taxation benefits and liabilities of forestry activities for the farm business. Each of these areas of refinement relates to an issue in which there is currently considerable interest by landholders and forestry extension officers. Such additional modules would considerably enhance the usefulness of the AFFFM as a decision-support and extension tool for agroforestry including farm forestry. This would make the AFFFM an even more powerful and versatile tool that individual landholders can use to assess the potential financial performance of forestry projects in their particular circumstances in a whole-farm context.

Another potentially useful extension of the AFFFM is to evaluate the financial performance of management of native forests. The model currently has limited ability to deal with periodic harvesting of native forests, e.g. where an initial harvest may be used to cover the costs of introducing silvicultural management and subsequent harvests may be at non-uniform intervals. Given the high current level of interest in managing native forests for timber production in South-east Queensland, there would be considerable scope for using the model to evaluate native forest management proposals. In that many landholders may wish to manage native forest for a variety of objectives, a further step towards providing management advice develop a MODSS for native forest management, of which financial performance is one of the information inputs.

A further potential extension of the AFFFM is the inclusion of non-wood forest benefits, in relation to both native forests and plantations. A great deal of research has recently been undertaken into the recreation and environmental benefits of forestry (e.g. Harrison *et al*., 2002). Such information could be included in the model as default data, which could be readily modified by the user to represent the specific qualities of a chosen forestry site. In this way, the model could be extended from a *financial* to an *economic* model. Depending on whether the non-wood benefits were those accruing to the landholder or to the community at large, the model could be used for private or social economic evaluation of forestry projects.

Such extensions to the model would of course have resource requirements. The researchers intend to seek funding for at least some of these extensions. It is also possible that postgraduate students could be found who would be prepared to work on development of particular features for the model as part of their dissertations, and this could be a cost-effective approach.

The usefulness of farm forestry financial models in general

As discussed in Chapter 3, there are a number of issues which affect the usefulness of decision-support systems such as the AFFFM. These are issues which require careful consideration by agencies who fund research into models such as those developed in this study. In particular, there is the issue of the need for continuing support for decision-support systems which do fill a worthwhile niche in the decision-making process for farm forestry.

This support may be directed at a number of activities including continuing improvement and debugging of the software, the addition of new features as requested by users, training in the use of the software and the generation of case studies based upon analysis using the software for customers who want the model output without having to use the model themselves.

Investment in such activities will be tempered in part by the fact that of the numerous computerised decision-support systems built for both agriculture and forestry, few see large-scale mainstream use, particularly by farmers. The majority remain in the domain of extension staff (whose ranks are

decreasing in most government agencies), researchers and the model developers. The AFFFM will be freely available but there are issues of user support that may need to be addressed, despite the fact that an extensive on-line help menu has been included in the model.

As outlined in Chapter 3, future funding support for models such as AFFFM should also be directed by a clear understanding of the target audience involved, and the expressed needs of this audience. The AFFFM was largely aimed at farm and forestry advisors and one of the core outcomes of this was a progressive simplification of the model structure and capability as it became clear that initial versions were too complex for the target audience.

20.4 Lessons Learnt from Development of the MODSS

MODSS can be applied to a variety of forestry options. In the case of the Darling Downs, the current level of tree planting for timber and other uses is relatively small. A number of forestry options are available, in terms of the locations of farmland where trees may be planted. A variety of impacts can be recognized from increased planting. The MODSS analysis for Hodgson Creek catchment suggests that all the forestry options outperform 'current practice' from most perspectives. The major exception is the transitional time period in the economic considerations, where current practice outperforms all of the forestry options. For forestry to be a viable option in this catchment, measures need to be taken to ameliorate this poor short-term economic performance. More specifically options worthy of further consideration are 'commercial plantations (with leased land)', and 'forestry on additional under-used areas'.

Some further lessons arise: forestry presents a difficult application area for MODSS, partly because it is a very long-term investment. This problem can be addressed to some extent by developing several effects tables to match the performance of the forestry options at various time-scales. This is the first study of its kind to employ this technique, and represents a major innovation in the use of MODSS.

This project has also demonstrated the benefits of engaging farmers and catchment stakeholders in a structured process of decision-making. The participation of landholders challenged some of the preconceived notions and approaches to community involvement. When a simple decision-support tool is used and training provided, the capacity of the stakeholders is increased by them being better informed when making decisions that affect their livelihoods. By being multi-objective the process used in this study helped landholders to understand better the relative importance they place on the full suite of economic, environmental and social factors and impediments when making decisions about farm forestry at a farm and catchment level. In future research activities, it may be possible to increase the integration between farmer response surveys that define incentives and impediments to forestry investment and the use of multiple objective decision-support systems.

Focus area for the MODSS

Regional versus farm-level MODSS. The development of a MODSS is an iterative process. As these iterations pass, the focus of the MODSS changes. In the initial stages, the strength of the MODSS is as an 'action-learning' tool. These initial stages have been described as a 'quick and dirty' MODSS. In these stages, possible options and criteria are explored from the very simplest, and those involved may start to gain further insights into the nature and interactions between the options the criteria and the outcomes. This was described by Janssen (1991) as 'playing' with the problem. At this stage the MODSS is equally applicable at the regional or farm scale (although at the latter scale there would be a one-to-one relationship between the modeller and farmer, and therefore no need for a workshop). This process needs to be facilitated, in particular when used with individual farmers, by an extension officer or a farm or forestry advisor. As the analysis gains in complexity, the focus shifts. A technical reference group or similar group will be required to critically evaluate the options and criteria (and counter the inclination to 'criteria blow-out). The findings of the analysis gain

greater importance, and become the focus for the study. These later iterations are likely to not be feasible at the farm scale, and are more suited to regional decision-support.

The dilemma of who the MODSS is for (farmers or extension officers). The MODSS process provides a framework to tailor the decision-support system for a particular region. This process is likely to be a facilitated process, lead by extension officers or farm or forestry advisors. While experience in this project suggests that MODSS are rather constrained in terms of usefulness at the individual farm level, engagement in the process will benefit farmers and extension staff, provided the process is well facilitated. The outcomes and especially information about the relative strengths and weaknesses of the forestry options will be useful to farmers. While it is recognised that a farmer may not elect to implement the highest performing option, through the processes recommended in this study they will be aware of the potential problems that may arise from their chosen forestry option. The exercise can be as much about making transparent (and hence understanding) the relative importance placed on criteria in a decision already made as it can be about providing a rational basis upon which future decisions will be made.

Scope for further development of the MODSS approach to farm forestry

The MODSS process as described in this study is essentially a generic process that could be applied to any natural resource and land-use management issue. The software tools are generic in the sense that it is possible to apply the tools to any issue that can be formulated in terms of options and decision criteria. There is scope for a simple MODSS software tool specific to forestry. This tool could include suggested criteria lists specific to the different stages of the analysis, or geographically specific options including various species and planting regimes. It has been suggested that a non-computer based tool would also be useful. Such a tool in the current climate would indeed be useful, however computer literacy is rapidly increasing in all sectors of community, as is availability of computer hardware. It is likely that computer-based decision-support systems are going to become increasingly widespread and increasingly accepted.

The techniques and models developed and used in this study have a wider application in natural resource policy. Although focused on farm forestry issues, the approaches demonstrated by this project to engage stakeholders and technical experts and improve the consideration of environmental, economic and social requirements are equally applicable to best practice planning. In this regard, the farming industry could implement a code of practice that is recognised and acknowledged by government agencies. Furthermore, these practices can be integrated with national approaches to reverse salinity and water quality degradation. Such actions would be a proactive response to some of the larger political discussions on vegetation management and the preservation of native forests.

Spatial MODSS. It had been hoped to use this project as a platform to develop an interactive spatial modelling platform linked to the MODSS to dynamically map ‘what if scenarios’. The Hodgson’s Creek study demonstrated the value of mapping (even at a very schematic hypothetical level) to aid stakeholders in evaluating options. This study used a relatively static approach of generating maps based on scenarios ‘best guessed’ by experts before the event. Clearly it would be even more useful to be able to generate such maps (and accompanying tables of comparative statistics) ‘on the run’ in response to stakeholder suggestions. This is technically feasible but difficult due to the almost unlimited possible options (and general limitations in the amount and quality of spatial data). Work to develop ‘spatial MODSS’ is ongoing in various projects.

The future role of MODSS in farm forestry

Chapter 18 provides suggestions on how MODSS could be applied efficiently in future applications to farm forestry. The future role envisaged for MODSS is two fold. The first role is to provide an ‘action-learning’ tool or framework, a process for stakeholders to gain further insights in to the strengths and weaknesses of farm forestry practices across the tenets of economic, social and

environmental considerations. The second role is to provide an integrated, structured and transparent framework for assessing farm forestry practices, including the input of farmers and other stakeholder with that of technical experts.

Recommended procedure for development of forestry MODSS

On the basis of this study, recommendations have been developed for a procedure for developing MODSS for farm forestry situations. The key elements of this procedure are:

1. Undertake a simple MODSS analysis that allows the stakeholders to become familiar with the process and to experiment with issues and options. This initial evaluation and discovery should be completed under the guidance of an extension staff or trained facilitator.
2. Develop a more detailed MODSS analysis, expanding upon the options and criteria developed in the initial step and drawing on the findings of previous studies. Input from technical experts would allow greater insights to the benefits and opportunities to farm forestry options, and establish an informed position to make decisions. This stage would produce an integrated and transparent analysis of the farm forestry options, while balancing economic, environmental and social considerations.
3. Feedback and re-evaluation of the options. The MODSS process should be a stakeholder-driven process, flexible and the stakeholders should be given opportunities to change the analysis at any point.

20.5 Concluding Comments

A number of directions for future research into decision-support systems for farm forestry or agroforestry can be identified. The MODSS framework provides a powerful approach to integrate and direct this research.

Although the AFFFM has evolved through a number of versions, and been broadened to be a whole-farm financial model, various areas can be recognized where extensions to the model would increase the versatility and range of applications of the model.

One area of interest identified by both the AFFFM and MODSS is scoring or valuation of goods and services with no market values. Approaches to value and incorporate these in decision-support tools are still in need of improvement.

20.6 References

Harrison, S., Bennett, J. and Tisdell, C. (2002), 'The role of non-market valuation in forest management and recreation policy', *Economic Analysis and Policy*, 32(2): 1-10.

Janssen R. (1991), *Multiobjective Decision Support for Environmental Management*, Kluwer Academic Publishers, Dordrecht.