



Agroforestry R&D Priorities for Northern Australia

**A report for the RIRDC/Land & Water
Australia/FWPRDC**

Joint Venture Agroforestry Program

by Nigel Turvey and Peter Larsen

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Foreword

Northern Australia has been identified as a key priority area for future R&D support in the JVAP's Five Year Strategic Plan. This report details the findings of a study to define research priorities for agroforestry and farm forestry for northern Australia to better target R&D funding and effort for this vast region.

To date, much of the R&D into agroforestry systems has been concentrated in temperate and high rainfall areas of Australia. There is a need to transfer some of this effort to northern Australia with adaptation to the range of agro-ecosystems present there.

The review of R&D priorities in this report covers bioregions of northern Australia which were grouped into five regions to assist in interpretation of the study results: south east Queensland and central Mackay coast, wet tropics, dry tropics, savannas, and Ord-Bonaparte region. The review addresses the views and needs of both client stakeholders (farmers and land owners) and research stakeholders, and provides R&D priorities based on regional requirements for the improved integration of sustainable and productive agroforestry within Australian vegetation and farming systems in northern Australia.

The R&D priorities which have been distilled from a review of completed and current research, interviews, and questionnaires received from researcher and client stakeholders, are listed in tabular form with links to JVAP's Five Year Strategic Plan. This presentation of R&D priorities for agroforestry research in northern Australia will greatly help researchers to focus efforts on key target areas, and will help provide synergies between research organisations with similar goals.

Implications for implementation of the findings from the study are:

- Realisation of multiple benefits for the management of planted and native vegetation in rural landscapes and rural enterprises in northern Australia through better targeted R&D.
- Improved efficiency of expenditure on agroforestry R&D for northern Australia.
- R&D targeted better to specific issues in bioregions of northern Australia, and
- R&D synergies through improved collaboration between research groups operating in northern Australia.

This project was funded by the Joint Venture Agroforestry Program (JVAP). The JVAP is supported by three R&D Corporations — Rural Industries, Land & Water Australia and Forest and Wood Products. These Corporations are funded principally by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 700 research publications, forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems.

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Peter Core

Managing Director
Rural Industries Research and Development Corporation

Abbreviations

ACIAR	Australian Centre for International Agricultural Research
CALM	Conservation and Land Management (WA)
CPQ	Commercial Plantations Queensland
CRRP	Community Rainforest Reforestation Program
DNRM	Department of Natural Resources and Mines (Queensland)
DPI	Department of Primary Industries (Queensland)
DPIF	Department of Primary Industries and Fisheries (NT)
DPI-F	Department of Primary Industries – Forestry (Queensland)
DPLE	Department of Lands Planning & Environment (NT)
FPC	Forest Products Commission (WA)
GRO	Greenfield Resource Options Pty Ltd
GA	Greening Australia
ITC	Integrated Tree Cropping Pty Ltd
JVAP	Joint Venture Agroforestry Program
JCU	James Cook University
MLA	Meat and Livestock Australia
NAP	Northern Australia Program of MLA
NHT	National Heritage Trust
NQA	North Queensland Afforestation Inc
NQTC	North Queensland Timber Cooperative
NTFTPC	Northern Territory Forestry and Timber Products Network
ORIA	Ord River Irrigation Area
PFNQ	Private Forestry North Queensland
QFRI	Queensland Forest Research Institute
RIRDC	Rural Industries Research and Development Corporation
RPC	Regional Plantation Committee
SQFFA	South Queensland Farm Forestry Association
TREM	Cooperative Research Centre for Tropical Rainforest Ecology and Management
TSCRC	Tropical Savannas Cooperative Research Centre
UQ	University of Queensland

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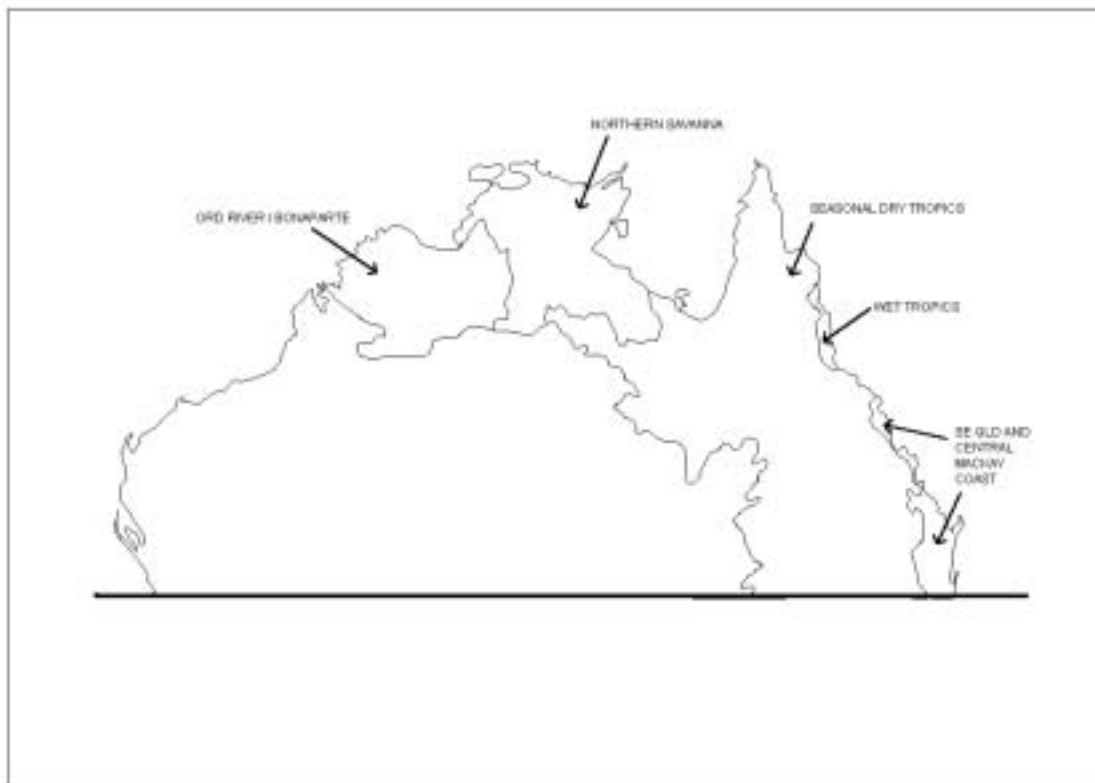
Executive Summary

This report is the findings of a study to define research priorities for agroforestry and farm forestry for northern Australia, and has been conducted in three parts:

- Review of completed and current research
- Field and telephone interviews with research stakeholders and client stakeholders
- Analysis of a questionnaire sent to client and researcher stakeholders.

Research priorities were gathered from growers and researchers in centres across northern Australia which was defined as Australia north of 29°S (westwards from the Queensland/New South Wales border). To assist in interpretation of the study results, the area was divided into five main regions: south east Queensland and central Mackay coast, wet tropics, dry tropics, northern savannas, and Ord-Bonaparte region, as shown in Figure E-1 below.

Figure E-1 Five main study regions for agroforestry for northern Australia



Respondents to questionnaires and interviews stated that constraints to agroforestry development in northern Australia were based on both a lack of confidence in investment in agroforestry, and a lack of information in key areas to support the investment. The lack of confidence in investment in agroforestry was based on issues of:

- Security of harvest on freehold land
- Status of ownership of trees on leasehold land

- Uncertainty of land use and investment caused by native title.

These issues can be alleviated by clarification and enactment of existing legislation, and implementation of new legislation which ensures the realisation by owners of their investment in planted trees, or their ability to sustainably manage native vegetation on a commercial basis.

The canvassing of some forty researchers involved in some aspects of agroforestry research across in northern Australia illustrates the relatively small research effort which is applied to the region. This is supported by the relatively sparse published research base of some 70 papers reviewed for this project. The existence and the scarcity of both research and publications reveals gaps in the R&D effort for northern Australia. This also shows that the development of agroforestry in northern Australia is in its infancy, and will consequently require a substantial R&D input in order to stimulate agroforestry development.

In general the five highest R&D priorities identified for agroforestry and farm forestry across all of northern Australia were:

- Requirements to better understand the financial viability of agroforestry projects, including innovative economic treatment of the value of trees as ecosystem goods and services
- Availability of domestic and international marketing information for agroforestry products and how eco-labelling or certification will affect these markets
- Issues surrounding the cultural, legal and policy constraints to development of agroforestry projects
- Wood and milling properties of native and introduced species used in agroforestry plantings
- Increased linkages between research and extension activities via demonstration of key research findings and coordinated research activities across northern Australia.

Within each of the five regions specific research priorities were identified. The most important R&D requirements identified by respondents for each region are listed below:

South east Queensland and central Mackay coast

- Economic analysis of silvicultural treatments that add value to logs
- Identification and analysis of uses for small diameter timbers

Wet tropics

- Write up and widely publish results from the decade of CRRP planting
- Identify cost effective weed control measures to aid plantation establishment in high rainfall environments

Dry tropics

- Evaluate and demonstrate the economic value to grazing enterprises of the interaction between tree density and grass production across pastoral landscapes
- Develop establishment and silvicultural practices for production of agroforestry, including appropriate management of supplementary water in dry environments

Northern Savannas

- Recommendations as for the dry tropics

- Rescue research trial data from 30 years of forestry trials in the Northern Territory from which to develop a base for future work, conduct milling studies and capture genetic selection

Ord-Bonaparte

- Coordinate research into establishment, management and wood properties of high value tree crops using irrigation

The JVAP focus on trees on managed land does not translate readily into the use of woody vegetation on aboriginal land. In order to resolve this issue, a well structured study needs to be carried out concentrating on the specific requirements of aboriginal communities, the potential for commercial management of native timber resources, and the potential for other woody perennial crops. There was a very clear message from a range of stakeholders that ‘bush tucker’ was a subject worthy of further research for the benefit of aboriginal communities. The potential may well be in conjunction with other enterprises such as tourism.

Agroforestry in northern Australia is in its infancy. There are very large gaps in basic information required to underpin agroforestry development, and there is a lack of coordination of information which does exist. Those wishing to invest in farm forestry activities on their properties are faced with shortages of information on all aspects of the enterprise ranging from products and markets, to what species to grow, how to grow them, and quantification of yields and economic and environmental benefits.

Within this diffuse and patchy information base there are two clear frameworks on which to create a prioritisation of research for northern Australia: these include maximising the economic and environmental return from planted trees, and maximising the economic and environmental value derived from improved management of native vegetation on farms.

Research priorities to maximise the economic and environmental returns from planted trees are centred on ensuring the provision of an economic return to the grower. These areas include markets for species grown, and how to grow target species for markets. There is strong, although isolated and anecdotal, evidence of excellent financial returns from tropical timbers by processors who have addressed markets and supplied them highly targeted products; some instances are shown in this report. Defining and understanding markets is a fundamental prerequisite to a commercial forestry enterprise.

Treatment of planted trees for their value, in a non-traditional market sense, as an ecosystem good or service is an innovative development in valuing a rural enterprise, and a great deal of research is required to develop methodologies to establish transactional values for trees in a variety of guises.

Much of northern Australia’s agricultural environment is comprised of pastures in woodland ecosystems, i.e., savannas. This is markedly different from southern Australia where much of the agricultural landscape has been cleared of trees. Moreover, in many of the savanna woodlands of northern Australia, clearing of trees is a temporary ecosystem perturbation, and trees regenerate readily in the landscape unless energy is expended by the farmer or grazier to suppress them.

Against this background, a clear priority is research to provide mechanisms to encourage farmers and graziers to retain trees in the landscape. In order to do this, farmers and graziers need to have an understanding for their particular woodland ecosystem, often in a low and variable rainfall environment. Graziers need to be provided with information which allows them to manage the requisite balance of trees in the landscape and to provide sufficient pasture to sustain grazing, whilst providing shade and shelter for stock and protecting water and salt movement in the landscape.

Retention of native vegetation on farmland can also be treated as an ecosystem good or service when it increases landscape aesthetic values, conserves biodiversity, protects catchments, conserves water in the landscape and protects the region from salinity. If these benefits extend outside the confines of the managed property, then there is a clear case for a transactional value to be placed on such retention. Some models currently exist for the creation of ‘credits’ for beneficial action such as carbon credits or salt credits. This is the focus of much innovative research into quantifying values and creating transaction mechanisms which benefit the farmer or grazier.

The R&D priorities which have been distilled from the review of completed and current research, the interviews, and questionnaires received from researcher and client stakeholders, are listed below in tabular form with links to the RIRDC/JVAP R&D Plan 1999-2004 (1999).

Table E-1 R&D priorities for agroforestry and farm forestry for northern Australia

Rank	R&D Subject & Topic	JVAP Strategy	Rationale for ranking
1	Financial viability of agroforestry projects.	5.3, 5.4	Primary need is to demonstrate a commercial return for the investment in agroforestry.
2	Additional market information for agroforestry products.	1.1, 1.2	Must identify a market for the crop.
3	Addressing cultural, legal and policy constraints to agroforestry.	1.3	Facilitate investment by landholders.
4	Increased links with research and extension activities.	6.1, 6.2	Get the best value for R&D already done.
5	Sustainable management of savanna woodland for commercial timber production.	5.2	Work with existing systems and landscapes
6	Define mechanisms by which trees in the landscape can be recognised and valued, and transacted between the community and the landholder.	2.2	Broaden the economic potential of agroforestry.
7	Spacing and species mix for multiple benefits.	5.1	Broaden the economic potential of agroforestry.
8	Agroforestry for protection of stock and crops.	3.1, 3.2	Broaden the economic potential of agroforestry.
9	Research into wood quality of the tropical timber species grown, and wood and milling properties of plantation grown hardwood species.	4.3	Ensure that the crop can meet market requirements.
10	Species and provenances for planting, and availability of seed and seedlings. • Write up and widely publish the results of more than a decade of CRRP activities. • The rescue of growth yield and wood quality information from trials established more than 30 years ago in the Northern Territory. • Coordinated research into Sandalwood and other exotics as crop species.	4.1, 4.2	Plant the right species in the right way.
11	Silvicultural information on spacing and harvesting. • Cost benefit analysis of silvicultural treatments such as pruning on log values and the use of small diameter timber from a wide range of species. • Effective use of water in irrigation for establishment of tree woodlots in low rainfall areas across northern Australia.	4.4	Ensure the crop is grown to market specification.
12	Environmentally friendly termiticides in conjunction with cultural methods for use by growers in a range of environments.	4.5	Protect investment in the crop
13	Community participation and cost sharing for agroforestry projects.	1.5	Reduce cost inputs, broaden social benefits and have fun.

1 The study context

1.1 Terms of Reference

The TOR for this project are premised by the statement from JVAP that:

“Farm forestry has the potential to contribute to the national economy, through timber production and processing, increase and diversify farm income, community benefits such as reduction in salinity of rivers and land, reduction of greenhouse gases, and conservation of biodiversity.”¹

The guiding objective of the Joint Venture Agroforestry R&D Program is:

“To integrate sustainable and productive agroforestry within Australian farming systems.” (RIRDC 1999).

Within this context, the objective of this project is to identify R&D priorities for agroforestry in northern Australia. The specific TOR for this study are:

1. To review completed and current research into agroforestry and farm forestry systems relevant to northern Australia by agro-ecological zone. The review will include, but not be limited to, summary and analysis of:
 - 1.1. R&D related to farm forestry systems within pasture production systems.
 - 1.2. R&D resulting from the Community Rainforest Reforestation Program, and other Farm Forestry Programs.
 - 1.3. R&D that evaluates the benefits of alternate spacing systems.
 - 1.4. R&D investigating potential species and products for northern Australia.
2. To determine key agroforestry and farm forestry R&D gaps for the range of agricultural systems in northern Australia.
3. To provide a list of recommended R&D priorities, arising from gap analysis in (2), based on potential achievement of economic, social and environmental benefits.
 - 3.1. Specific consideration should be given to whether JVAP has a role in determining appropriate tree density and spacing in woodland/pasture systems (generally a role for the MLA Northern Australia Program).

1.2 The study

The study to fulfil the TOR was conducted in three parts:

1. Review of completed and current research,
2. Field and telephone interviews with client and researcher stakeholders, and
3. Analysis of questionnaires sent to both client and researcher stakeholders.

¹ RIRDC Terms of Reference: “Identification of R&D priorities for northern Australia”.

1.3 Need for information

Information is required at all levels of rural industry development. In northern Australia farm forestry can be seen as a developing industry requiring information about almost all levels of growing and commercialising woody perennials on managed land. Farm forestry in all its forms is in such an early state of development in most regions of northern Australia, that all levels and qualities of information are required. This information may be considered fundamental research to some and a matter of extension by others: to the client or agroforestry practitioner it is a fundamental gap in information necessary to underpin an investment.

During the conduct of this study it became quite clear that there was consensus about the need to bring together current knowledge in particular areas, and to make that information readily available to clients. It also became clear that within the scope of this study, some information is available but not in a form that is suitable for clients to obtain: in this case there is a need for extension services to make this information more accessible and useable by the client base.

In preparing this report we have not drawn a strong line between research and extension requirements. We have included both requirements in the list of priorities. This has been done in order to demonstrate the relative effectiveness of past research, and to stress that the delivery of research results to the client is as important as the conduct of the research itself. The question of the appropriate role of JVAP in funding both research and extension has not been entered into.

In some cases there is a clear opportunity for research gaps to be filled through better organisation of the delivery of research funds to obtain effective outcomes. Where pertinent we have documented such opportunities.

2 A sketch of Northern Australia

2.1 Biogeography and climate

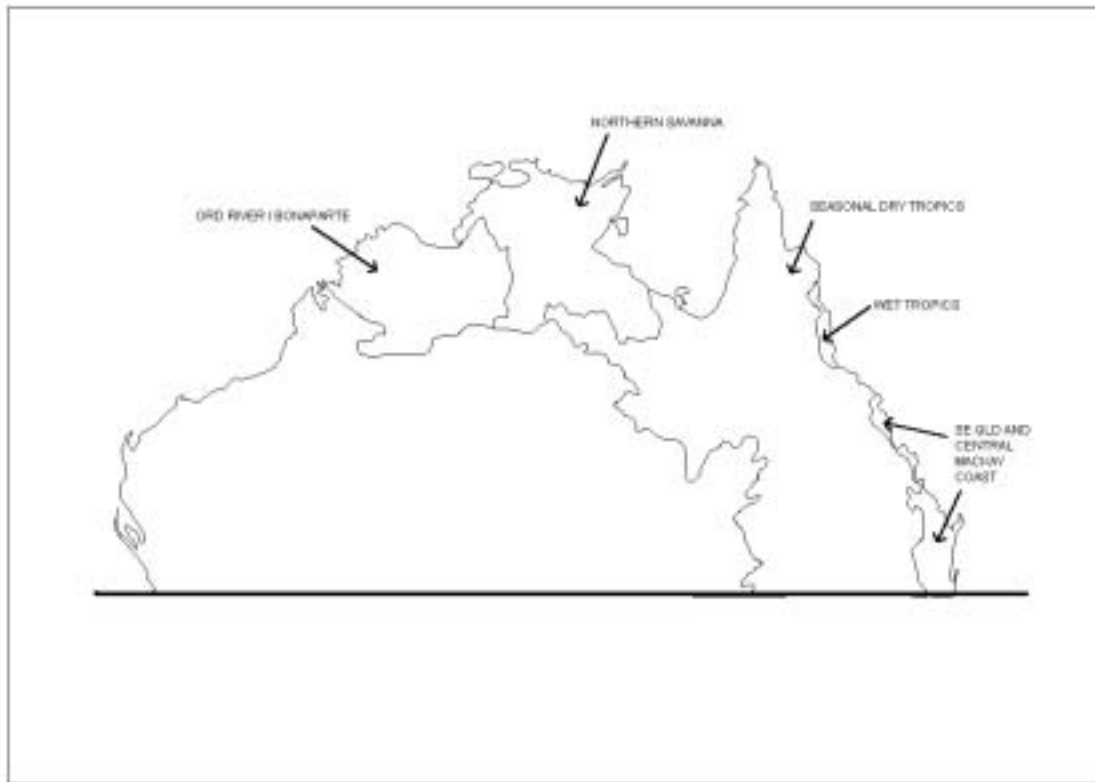
Northern Australia has been defined for the purposes of this study as the area north of 29°S. The bioregions within this area have been defined according to the IBRA regions (Interim Biogeographical Regionalisation of Australia: Thackway, R. and I.D. Cresswell, I.D., (1992)). IBRA is a flexible, dynamic and pragmatic approach to developing an ecologically meaningful regionalisation of Australia. It seeks to define, map and describe the major ecosystems in Australia. While the primary purpose for developing the IBRA has been in the context of developing a national reserves system it will be of value for a range of other conservation planning and management applications such as the current study.

The area covered and the characteristics of the region are shown in Appendix A. For ease of interpretation of results, northern Australia has been divided into five regions:

1. South east Queensland and Central Mackay Coast
2. Wet Tropics
3. Season Dry Tropics
4. Northern Savanna
5. Ord River/Bonaparte Region.

These regions are shown in Figure 1 below.

Figure 1 Five main study regions for agroforestry for northern Australia



Southern and northern Australia contrast significantly in their climate. Southern Australia is dominated by a temperate climatic pattern that is characterised by high winter rainfall with corresponding low evaporation, while summer rainfall is generally low and evaporation high (Figure 3). Conversely northern Australia is dominated by a tropical climate that has a high summer rainfall and high evaporation and little or no winter rainfall (Figure 4). The location of the sites identified in Figure 3 and Figure 4 are illustrated in the Figure 2 below; the line across the map is the boundary between northern and southern Australia as defined for this study.

In southern Australia low evaporation rates during the winter wet season results in high effective rainfall for this period which replenishes subsoil moisture; effective rainfall in the summer period is negligible due to the high evaporation rates. Conversely, although rainfall in northern Australia is high in the summer months due to the influence of monsoonal systems, effective rainfall is low due to high evaporation rates and high rainfall intensities resulting in considerable runoff. Northern Australia is also characterised by distinct winter dry seasons where rainfall is very low to absent, and evaporation rates are still reasonably high. These differences in climatic patterns between southern and northern Australia affect management strategies used by tree growers in these two areas and will consequently effect R&D strategies for growing trees in these areas.

Figure 2 Location of weather stations used to illustrate the range of climatic influences across southern and northern Australia.

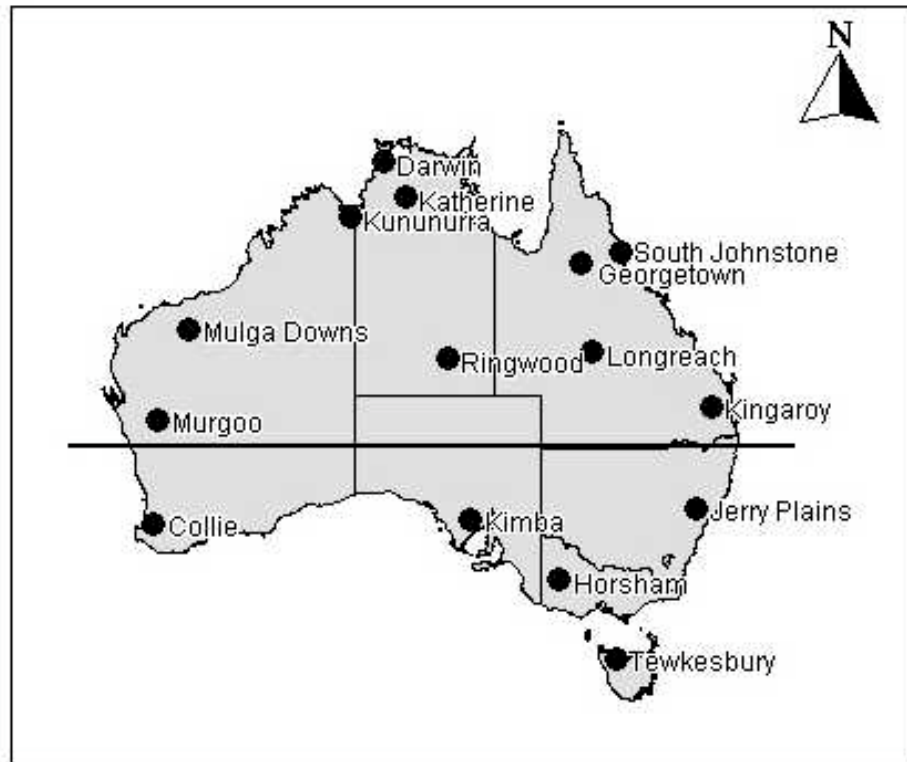


Figure 3 Median rainfall and pan evaporation for sites in southern Australia. (Australian Rainman 1999)

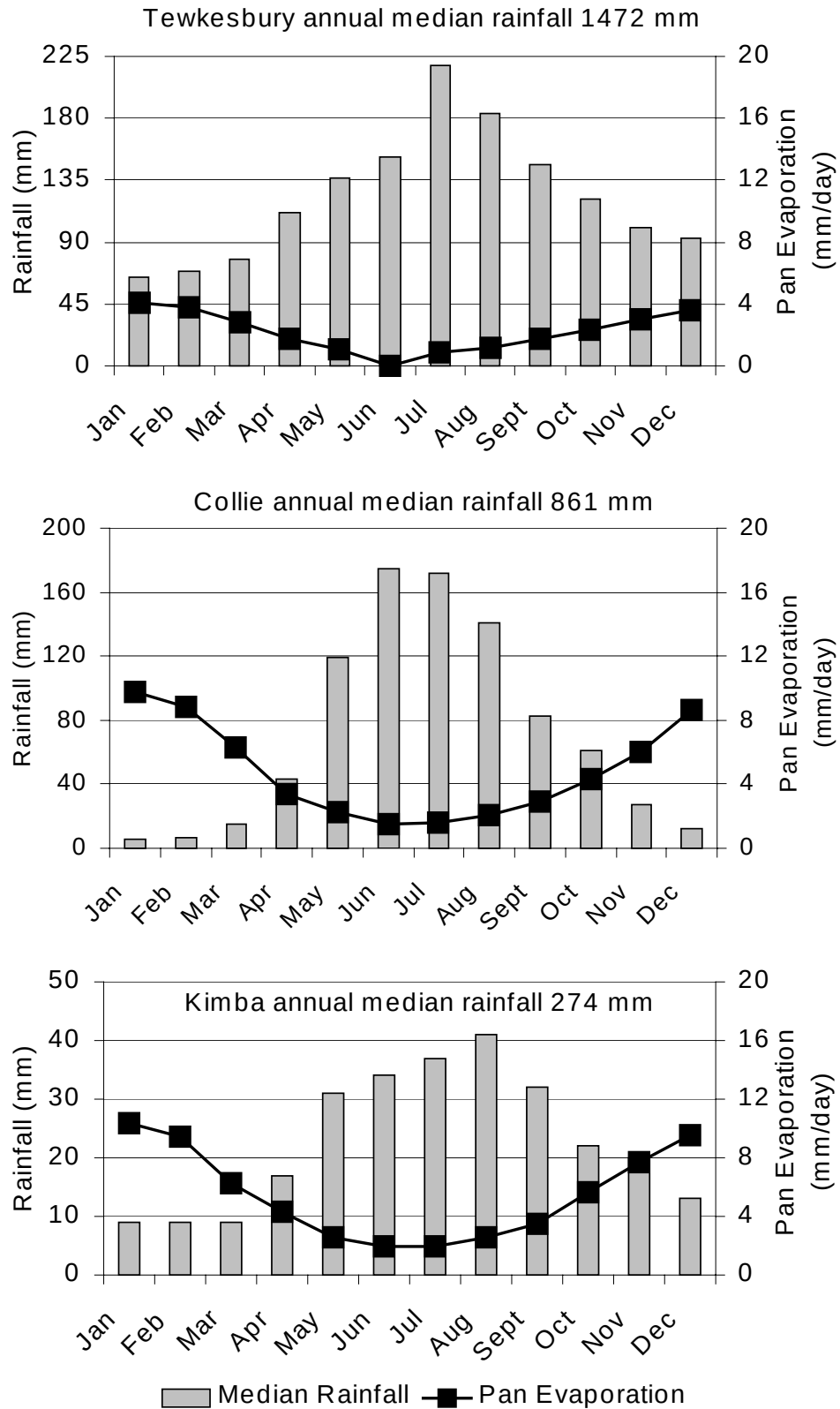
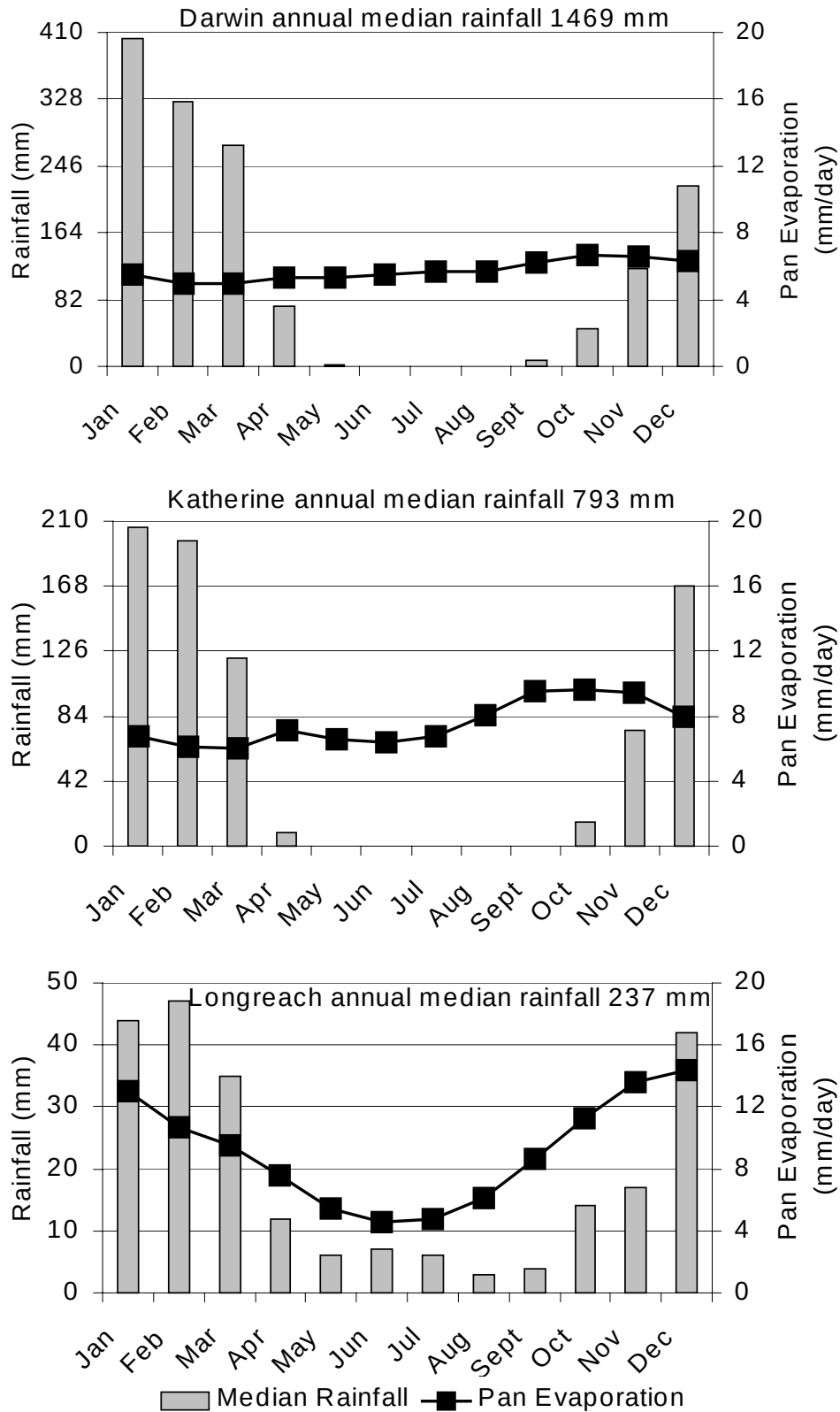


Figure 4 Median rainfall and pan evaporation for sites in northern Australia. (Australian Rainman 1999)



2.2 R&D encompassing agroforestry across the northern Australia region

Apart from JVAP, the Meat and Livestock Australia (MLA) North Australia Program (NAP) covers much of the region defined for this current study (MLA 1999). This program has sponsored research programs based on resource and environmental management, pasture and animal production, and whole-of-enterprise management strategies. The program has strong producer involvement and is committed to broad communication of research activity and outputs. 2001 is the final year of the current phase of the NAP, and the program is currently under review. There are obvious and strong potential synergies between the objectives and the research efforts of both MLA NAP and JVAP with respects to stimulating agroforestry. In particular there is a common target in northern Australia to provide useable outcomes for graziers and land holders to value trees in pasture production systems. This requires detailed research into tree and pasture interactions to define optimum vegetation mixes which stimulate livestock production. Some of this research is reported in Section 4.4.3.

The Tropical Savanna CRC (TSCRC) has been active in establishing the biophysical and social parameters and basic frameworks to the vast region of northern Australia (excluding the wet tropics) in which they operate. The greatest R&D initiative of the group has been the completion of a vegetation map for the whole region which can be used to target regions of importance for addressing landscape, ecosystem and community health.

The Land and Water Resources Research and Development Corporation funded a study of Sustainable Development of Tropical Australia: R&D for Management of Land, Water and Marine Resources (L&WRRDC 1999). The study region extended westwards from the Cape York Peninsula to the Broome region in Western Australia. The study was conducted over a six month period from May 1998.

The study involved interviews of 85 stakeholders from 61 organisations and a review of the literature from the terrestrial through to the marine environment. The study concluded that, to date (1998), there had been a comparatively small investment of R&D in the study region. The consequence was that, relative to the rest of Australia, R&D effort in the study region was slight.

The 1998 study found there was a growing R&D capacity within the study region, particularly with the emergence of organisations such as the CRC for the Sustainable Development of Tropical Savannas and the Centre for Indigenous Natural and Cultural Resource Management. Potential R&D capacity was also found to exist within agencies such as CSIRO, the Queensland Department of Natural Resources, the Australian Institute of Marine Science, James Cook University, the Australian National University, the University of Western Australia, the CRC for Sustainable Sugar Production and the CRC for Sustainable Development of the Great Barrier Reef.

From the perspective of the current study (2001), to this list can be added the CRC for Tropical Rainforest Ecology and Management, the University of Queensland, and the Queensland Department of Primary Industry through the Queensland Forestry Research Institute.

Northern Australia covers a vast area that is sparsely populated but has some regions where the population is growing very rapidly. It has a higher proportion of indigenous peoples in the population than most regions of Australia. The 1998 study concluded that indigenous peoples had been marginalised in economic and natural resource planning, management and decision-making, despite the demographic reality of tropical Australia. The authors found that there was a lack of effective recognition of indigenous aspirations and rights in resource management in the region, particularly the lack of incorporation of Native Title into broad land use objectives. There

had also been poor integration of indigenous peoples knowledge in resource planning and management practice, in part due to a lack of appropriate mechanisms to do so.

From the 1998 study, seven key priorities with broad relevance to the study area were identified:

1. Resource inventory: there was a clear need to improve baseline technical information at a relevant scale if sustainable development of the region was to occur.
2. Process understanding: the capacity to assess the ecological impacts of resource development in the region was constrained by the lack of process understanding at a relevant scale within and between terrestrial, aquatic and marine ecosystems.
3. Social, cultural and economic data/understanding: while some technical information was available, very little was formally known about the key economic, social and cultural processes driving natural resource use in the region.
4. Integration: mechanisms and tools to integrate and make accessible data, knowledge and understanding within the region were required to support planning and management activities.
5. Participation: research into best practice for participatory planning in rural regions was seen as essential in ensuring more effective planning and management processes in the future.
6. Institutions: institutional failure was uniformly viewed as a key impediment to effective and equitable natural resource planning and management in the region. Stakeholders saw a key R&D opportunity in developing and evaluating alternative institutional arrangements.
7. Capacity: lack of human and financial capacity was seen as a fundamental constraint to effectively delivering R&D for sustainable natural resource management in the region.

The geographical focus of highest priority for implementation of the above conclusions was focused on the Kimberley, with special emphasis on the Ord-Bonaparte region.

Many aspects of the above conclusions were echoed in the findings of this present study, and they provide the context of the natural resources R&D environment for northern Australia. .

The context of farm forestry in northern Australia can be seen in results of a recent ABARE study of Australia-wide farm forestry activities within the Landcare movement (Alexander et al. 2000). This study revealed that the proportion of farms with a Landcare member in 1998-9 was highest in the Northern Territory (62%) and Western Australia (57%) compared to 26-42% for the other states. Moreover, Landcare membership increased by 7% in the period between 1992-3 and 1995-6 which masked a decrease in Landcare membership in NSW over this period. Landcare activity was closely linked to tree planting activities on farms, with the proportion of farms with planted trees Australia-wide rising from 48% in 1993-4 to 68% in 1998-9. The reported benefits of trees on farms most often related to indirect benefits of shade and shelter. This is consistent with one of the greatest constraint to farm forestry investment being the lack of perceived financial returns.

3 Agroforestry research on the record

This Section comprises a review of the available literature which has been published, or is in draft in some form, covering research into agroforestry systems in northern Australia. The scope of the review is broad in subject matter, but is limited to research that has been done in the region. The objective has been to highlight the agroforestry research that has been done within northern Australia in order to identify gaps in research.

There is a substantial body of valuable research into agroforestry in the tropics that has been carried out under the auspices of ACIAR. This research has generally focused on developing agroforestry systems for small landholders in tropical countries of Asia. Most of this research has been conducted off-shore, but results are often directly transferable to many situations and areas of northern Australia, making these reports valuable sources of information that need to be considered in the development of research, development and extension programs for agroforestry in northern Australia. Key reports that were identified as being particularly relevant to this review include Boland (1989), Booth (1996), Doran and Turnbull (1997) and Shelton *et al.* (1998).

3.1 Agroforestry development

Keenan and Lamb (In press) reviewed and listed a range of alternative agroforestry options for the wet tropical region of north Queensland to meet both economic and biological goals of growers. They concluded that a timber industry in the wet tropics will be difficult to develop due to a lack of understanding of the potential levels of production a site might achieve, and limited information of the silvicultural practices required to maximise returns. Vize and Creighton (In press) concluded that the major technical impediments to agroforestry development included:

- A lack of knowledge of growing requirements of high value species (spacing, species mix, silvicultural regimes)
- A lack of knowledge on how to control disease and pests such as tip moth in red cedar
- Poor seedling quality and low availability of seedlings
- A need to develop plantation establishment and maintenance techniques for high temperature and rainfall areas, where there is high weed competition
- A lack of knowledge of species growth rates for use in financial models to assess the potential viability of agroforestry venture.

Other issues identified by Vize and Creighton as limiting the development of agroforestry/farm forestry in northern Australia included:

- Educational issues such as lack of a farm forestry culture,
- Land tenure and planning issues,
- Economic and marketing issues including the supply of logs from public sector forests creating a monopoly situation that effectively sets market price below production costs (AACM 1996) and the lack of alternative or clearly defined markets, and,
- Risk associated with the long payback periods of forestry.

Although these findings relate particularly to the wet tropics of north east Queensland, the constraints identified as restricting agroforestry development in this region can be readily applied across all of northern Australian.

3.2 Agroforestry research

3.2.1 Multiple use of trees

A valuable resource from which strategies can be developed to overcome the constraints identified in Section 3.1 as limiting agroforestry development in the wet tropics are the plantings of the Community Rainforest Reforestation Program (CRRP) (Keenan and Annandale 1999).

The CRRP plantings were established in 1992 and provide a framework of demonstration sites to encourage future growers into developing a hardwood 'cabinet timber' industry in the wet tropics. Some 2,000 ha of small plantings have been established on private land under the auspices of CRRP. This programme has successfully established mixed plantings of rainforest species across a wide range of sites and management strategies. Toward the end of the programme, 80% of the participants who joined the programme did so with the explicit intent of growing trees for timber production (Herbohn *et al.* 1999). Despite the obvious importance of the CRRP plantings, and the research undertaken in them, the development of an agroforestry industry in the wet tropics has stalled. A lack of definitive information on hardwood plantation development and a failure to use the CRRP plantings as an effective extension tool has resulted in a low level of interest in developing agroforestry plantings.

The stimulation of a hardwood timber industry in the wet tropics based on agroforestry plantings is constrained by a lack of information on species growth rates and expected rotation lengths or time to harvest. QFRI has established 99 permanent measurement plots over 51 different CRRP sites (Keenan and Annandale 1999). These plots were measured in May-July 1998 and reported in 1999. Further measurements were taken by QFRI staff at the end of November 2000, however no results have been released from these measurements.

Hardwood cabinet timbers have been planted in a limited extent to control weed infestation in headlands and waterways of sugarcane fields with the view of controlling rat populations. Brodie and Webster (1997) examined some CRRP plantings and reported that rat populations in sugarcane crops were reduced by planting trees at spacings ranging from 3 m x 5 m to 1.5 m x 1.5 m in rat harborage areas; in addition the biomass of weeds in these areas was also reduced. The report lists the cost of establishing the tree planting and provides advice on the appropriate species to plant and the procedures to follow for establishing the trees. Unfortunately there has been no evaluation of the effectiveness of these research findings in stimulating tree planting on sugarcane farms for control of rats.

A range of tree species have been trialed across a range of environments in northern Australia for potential timber production including native species such as eucalypts, acacias, grevillea and casuarinas (Harwood *et al.* 1993, Sun *et al.* 1995, Harwood *et al.* 1997, Pinyopusarerk and Williams 2000) and introduced species such as *Khaya senegalensis*, *Swietenia spp.*, *Tectona grandis* (D Reilly DPIF pers comm.).

Agroforestry trials across northern Australia vary considerably in age with some trials being recently established (NHT plantings in the Darwin to Katherine area that are less than 3 years old) and other trials being older than 20 years old (DPIF are custodians of trial plantings of introduced species). More than 900 forestry trials have been established in the Northern Territory over the past 30 years, but many plot records have been lost in changes in ownership by administering bodies (D Reilly DPIF pers comm). Few of these trials have been written up to communicate information on the establishment of trees in the dry arid tropics. Moreover, these trials provide a valuable resource of mature timber for milling studies as well growth and yield information and material for genetic selection. These issues are addressed further in Section 4.5.3.2

Eucalyptus pellita provenances were trialed in a range of tropical environments and compared to *E. grandis*, *E. urophylla* and *Acacia mangium* (Harwood *et al.* 1997). Generally the New Guinea provenances outperformed the Queensland provenances in survival, growth and form. *E. pellita* out performed other eucalypts on some sites and was less susceptible to stem borer. It was recommended that a tree breeding program be established to provide seed from the following hybrids:

E. pellita (New Guinea) x *E. urophylla*

E. pellita (New Guinea) x *E. grandis*

E. pellita (New Guinea) x *E. deglupta*

The potential for developing irrigated forestry industries in north Western Australia was reviewed by Radomiljac *et al.* (1998). In their review they identified the use of high valued timber species such as *Santalum album* as potential species for the Ord River Irrigation Area (ORIA). Trees can play a role in the ORIA especially on some soil types where intensive agriculture has not been fully developed. They reviewed a trial established on the sandy soils of the ORIA where 8 species were planted in July 1996. The trial was drip irrigated and termiticide (Lorsban) and fertiliser applied with the irrigation water. The trial results for 7 months age were reported. There appears to be no further information published on the trials although we were advised that further measurements of the trees had been completed.

Soil salinity is an issue across large areas of Australia that are irrigated for agricultural production. The Burdekin Irrigation Area (BIA) in north-east Queensland has soils that have high sodicity and/or salinity levels. A range of tree species were screened for their suitability to grow in both non-saline and saline soils in the dry tropical environment of the BIA in northern Queensland (Sun and Dickinson 1995c, Sun and Dickinson 1997a). Tree height and DBH was measured at 24 months and *E. camaldulensis* was identified as one of the most important species for use on saline sites when salinity levels are low to moderate (Sun and Dickinson 1995b).

Alley cropping is a system of agroforestry where crops and pastures are cultivated in alleys between spaced rows of trees and shrubs (Kang *et al.* 1990). Stirzaker and Lefroy (1997) reviewed alley cropping research in Australian and to a lesser extent internationally. The review concentrated on the research that has been done in southern Australia in terms of alley cropping, since this was where the research had been focused. The review included a list of challenges for research from the strategic to local level. The main issue was in planting the most profitable trees in the right proportion of the landscape in the optimal places with the least disruption to annual based farming systems. Consequently, at the farm scale information must be able to demonstrate how to maximise the complementarity between trees and crops while considering the driving factor to the success of alley cropping systems which is the availability of water.

The use of trees as windbreaks in the Australian landscape has been extensively researched under the auspices of the National Windbreaks Program. Snell and Brooks (1999) reported on the use of trees as windbreaks for cropping on the Atherton tablelands. The research found that trees used as a windbreak increased potato and peanut yield but had no effect on maize yields. The increased yield was associated with reduced leaf damage and a decrease in water stress on the plants. Bole length to lowest branch height was determined as an important parameter for selecting tree species suitable for use in windbreaks (Sun and Dickinson 1996). Tree species that kept their lower branches at maturity, such as *E. microcorys*, were more suitable for use in windbreaks than species that did not keep their low branches such as *E. grandis*. Consequently, to maximise the windbreak effect of trees it is important that combinations of species be planted to ensure intermeshing of different canopy configurations to increase the effectiveness of the windbreak (Sun and Dickinson 1996). A cost:benefit analysis of a potato/maize rotation suggested that financial benefits provided by windbreaks were considerable, even allowing for the loss in cropping area. Further analysis suggested establishment of additional windbreaks in the landscape will lead to large returns to the growers. There has been no analysis of the effect this research has had on farmers attitudes to establishing windbreaks in the Atherton tablelands or the development of windbreak in the area. Moreover, there is vocal opposition by some landholders to the establishment of trees on farmland in the region (Harrison and Herbohn In press).

The use of trees as fodder crops has important implications for the development of the pastoral industry in northern Australia. In particular, the role of tree legumes in the region has been reviewed extensively (Bray *et al.* 1997, Mannetje 1997, Gutteridge *et al.* 1999). Considerable research effort has been directed at developing pastoral systems that utilise tree legumes to maximise beef cattle production. The prospects for adoption of woody legumes in the semi arid tropical areas is good, providing that the trees are properly established and grazing managed carefully (Bray *et al.* 1997, Mannetje 1997). Trees that have been identified as being suitable for development in hedgerows for fodder include *Leucaena* (Bray 1986, Shelton *et al.* 1998), *Gliricidia* and *Calliandra*. Irrigated *Leucaena leucocephala* / *Digitaria eriantha* pastures in NW Australia produced some of the highest cattle liveweight gains per hectare recorded (Petty *et al.* 1998). The management of the irrigation system is detailed in Petty *et al.* (1998). *Gliricidia sepium* has been extensively trialed as a potential fodder crop in northern Australia, with the yield, digestibility, N content and mineral composition of 28 accessions being assessed (Bray *et al.* 1993). *Tipuana tipu* was trialed under a cutting regime to determine if it was suitable for use as a fodder crop (Gutteridge 1997). Preliminary results suggested that *Tipuana* could be used as a fodder source for cattle.

3.2.2 Managing native woody vegetation

The definition of agroforestry encompasses the management of native forests. Parsons (1999) provided an overview of the state of native forests in Australia and includes a list of the areas, volumes etc., but the review provides limited forest statistics or forest management strategies for northern Australia.

Much of the managed land of northern Australia is savannah systems consisting of scattered native trees and native or improved pasture. Native trees scattered in pastoral systems have been reported to have varying effects on grass yield and cattle production. Jackson and Ash (1998) reported that trees play an important role in soil nutrient dynamics and do not impact on grass water relations since they access deeper soil layers than the grass. Conversely Wilson (1998) concluded that trees competed with grass for water in the 0.1-0.5 m zones during dry years, thereby reducing grass yields. Although trees in a pasture increased the pasture quality and yield under them (Ash and McIvor 1998, Jackson and Ash 1998) due to higher N content (Ash and McIvor 1998, Wilson 1998) it is debatable as to whether this effect may be outweighed by the competition for water in drier years reducing grass biomass production (Wilson 1998). The effect of killing trees on grass yields near Katherine in NW Australia was reported by Winter *et al.* (1989). They found grass dry matter yields increased in the first three years after killing the trees, however there was no advantage in killing trees on grass dry matter yields by the fourth year. The Decision Support System GRASSMAN was designed to estimate the impacts of changing tree density on grass and animal production (Scanlan and McKeon 1990). However, the software was limited in its range of applicability. A tree module was added to GRASP and validated across a range of different environments (Scanlan and McKeon 1993). The role of trees in pastoral systems needs to be clarified further to ascertain the role of different tree densities in the landscape and the effect of these densities on pasture quality and production, as well as the soil water/pasture/tree interactions.

3.2.3 Species research

In a relative sense, species selection and establishment requirements of hardwood species for south eastern Queensland is well understood, with recommendations for species, establishment and subsequent silviculture made available through the QFRI Hardwoods Queensland Project (<http://www.dpi.qld.gov.au/hardwoodsqld/>). Such recommendations are the result of a recently

established R&D effort to support the development of a hardwood plantation industry in south eastern Queensland.

Four species (Table 1) are currently recommended by QFRI for plantation development in south eastern Queensland because they have good wood quality, good market potential and are expected to grow well on a range of sites in the region.

Table 1 Hardwood species recommended for south eastern Queensland

Scientific name	Standard trade name	Common names
<i>Eucalyptus cloeziana</i> F. Muell.	Gympie messmate	Gympie messmate messmate
<i>Eucalyptus pilularis</i> Smith	blackbutt	blackbutt
<i>Eucalyptus argophloia</i> Blakely	western white gum	western white gum Chinchilla white gum Burncluith gum
<i>Corymbia citriodora</i> subsp. <i>variegata</i> (F. Muell.) A.R.Bean & M.W.McDonald (south-east Queensland provenances)	spotted gum	spotted gum

Source: http://www.dpi.qld.gov.au/hardwoods_qld/

Several other hardwood species are being tested by QFRI for their suitability for different site conditions, timber quality and susceptibility to pests and diseases (Table 2).

Table 2 Species being tested for plantation forestry in south eastern Queensland

Scientific name	Standard trade name	Common names
<i>Eucalyptus acmenoides</i> Shauer	white mahogany	white mahogany yellow stringybark stringybark
<i>C. citriodora</i> subsp. <i>citriodora</i> (Hook.) A.R.Bean & M.W.McDonald	spotted gum	lemon-scented gum spotted gum
<i>C. henryi</i> (S.T. Blake) K.D. Hill and L.A.S. Johnson	spotted gum	large-leaved spotted gum
<i>E. camaldulensis</i> Dehnh.	river red gum	river red gum blue gum Murray red gum
<i>E. dunnii</i> Maiden	Dunn's white gum	Dunn's white gum white gum
<i>E. globulus</i> ssp <i>maidenii</i> F. Muell.	southern blue gum	maiden's gum
<i>E. grandis</i> W. Hill ex Maiden	rose gum	rose gum flooded gum
<i>E. grandis</i> x <i>E. camaldulensis</i>		hybrid
<i>E. grandis</i> x <i>E. urophylla</i>		hybrid
<i>E. grandis</i> x <i>E. resinifera</i>		hybrid
<i>E. longirostrata</i> (Blakely) L. Johnson and K. Hill		grey gum
<i>E. microcorys</i> F. Muell.	tallowwood	tallowwood
<i>E. pellita</i> F. Muell.	red mahogany	red mahogany large-fruited red mahogany
<i>E. resinifera</i> Smith	red mahogany	red mahogany
<i>E. robusta</i> Smith	swamp mahogany	swamp mahogany swamp messmate
<i>E. tereticornis</i> Smith	forest red gum	forest red gum blue gum
<i>E. urophylla</i> S.T. Blake		Timor mountain gum

Source: <http://www.dpi.qld.gov.au/hardwoodsqli/>

Spotted gums, *Corymbia citriodora* subsp. *variegata*, *C. citriodora* subsp. *citriodora* and *C. henryi*, are susceptible to *Ramularia* shoot blight (RSB) and research is under way to identify resistant provenances. More resistant provenances of *Corymbia citriodora* subsp. *variegata* have been identified and improved seed should be available from 2002.

Selection of species to be grown in northern Australia will depend on the aim of planting the trees in the first place. Several texts are available that list a range of potential tree species for planting in the tropics (including but not limited to Boland 1989, Cremer 1990, Doran and Turnbull 1997). The review by Doran and Turnbull (1997) includes a list of species that are suitable for planting in wet and dry tropical areas. For each species the following items are described:

- Main attributes of the species
- Name: botanical and common of the species
- Botanical features: a brief word description of the species form
- Occurrence: lists the natural range of the species
- Climate: climate in which the species naturally occurs
- Physiology and soils: describes the main soil types in which the species is found
- Vegetation type: lists the vegetation associations in which the species is found
- Utilisation: lists potential uses including fodder, fuelwood, wood and other uses
- Silvicultural features: describes establishment requirements and potential yields
- Pest and diseases: list main pests and diseases of the species
- Limitations: what limits growth and production of the species
- Related species

Ryan and Bell (1989) report the growth of 148 Australia tree species and provenances in two trials in Queensland. The data set compiled by these authors represents a vast knowledge base of genera and their survival and growth under differing management regimes. The existence of this dataset provides a basis from which species and provenances can be selected for further trial work; the existence of these trials today would be of great use for further work to update the current knowledge on the species trialed.

A range of potential tree species were recommended for further research in their capacity to be used for both wood and animal feed production (dual purpose) in tropical agroforestry situations (Lowry and Seebeck 1997). Research priorities were suggested for providing sufficient evidence to growers to allow them to assess the value in committing resources to tree planting. Research included looking at tree phenology and agroecology and the nutritional evaluation of animals. Some of the species identified are listed in Table 3 below.

Table 3 Tree species identified for their potential multipurpose in agroforestry developments in the tropics (Lowry and Seebeck 1997).

Species	Common name	Purpose
<i>Albizia lebbbeck</i>	The siris tree	Green and dry leaf Leaf and pods for fodder Promotes pasture Timber-good
<i>Albizia procera</i>	Forest siris	Green leaf Promote pasture Rainforest timber
<i>Tipuana tipu</i>	Tipuana	Fallen leaf and pod Promote pasture Timber-workable
<i>Gmelina arborea</i>	Yemane	Fallen leaf Timber-high
<i>Melia azedarach</i>	White cedar	Fallen leaf Timber-very high value
<i>Albizia toona</i>	Mackay Cedar	Nutritive value unknown Timber-high furniture
<i>Albizia saman</i>	Rain tree	Shade Fallen leaf and pods Timber-wood work
<i>Albizia basaltica</i>	Dead finish	Browse Wood turning very dense
<i>Dalbergia sissoo</i>	Rosewood	Browse Timber-rosewood
<i>Khaya senegalensis</i>	African mahogany	Fallen leaf Timber-high
<i>Melia volkensii</i>	Cedar	Browse Fallen leaf Timber-high yield

3.2.4 Establishment of trees

The establishment of trees in northern Australia will probably be confined to those areas of land previously cleared for agricultural purposes and are now considered marginal both in an economic and/or environmental sense. Although the area of cleared land in northern Australia is not known precisely, in a qualitative sense it is very small in extent compared to cleared land for agriculture in southern Australia.

The establishment of trees on cleared lands in northern Australia will require careful strategies to ensure the success of the plantings. Webb *et al.* (1997) identified that deficiencies in major nutrients such as P, N, K and Ca severely limit the establishment and growth of seedlings on most

soils types that have previously been cleared in the wet tropics. It is anticipated that similar findings will extend to the majority of soil types across northern Australia.

The successful establishment of trees in the field is strongly dependent on the delivery of high quality seedlings from the nursery. Dunn *et al.* (1997) reported that coating nursery containers with copper carbonate improved root morphology and tree establishment of five native Australian tree species. The establishment of tropical rainforest species in the wet tropics was enhanced when trees were planted using 'grow tubes' and reduced when trees were planted into a fresh bagasse mulch (Applegate and Robson 1994).

Establishment of trees in the semi-dry tropics of northern Australia is difficult due to the harsh environmental conditions that prevail through most of the year, dry hot winters and very wet hot summers. Establishment of six provenances of *E. camaldulensis* were trialed in this harsh environment (Sun and Dickinson 1997b). Generally, local northern provenances were better suited to surviving in the harsh environment than the southern provenances. Planting seedlings into a mulch bed did not increase tree survival. Trees were planted in 5 m x 3 m spacing and weeds controlled using Glyphosate. After 3 years the best provenance was 2.7 m tall and had a 3.7 cm diameter at breast height. It has been reported that trickle irrigation is needed to assist in the establishment of trees in the dry tropical zones of northern Australia (D. Reilly DPIF, R. Collins NQA pers. comm.).

It was estimated in 1991 that there were 56,000 ha of infertile cleared land on the Atherton Tablelands suitable for *Pinus caribaea* var. *hondurensis* production in silvopastoral systems (Applegate 1991). Silvopastoral trials using *P. caribaea* in this region found trees were successfully established if the site was ploughed to 20 cm in planting lines 8 m apart with trees every 2.5 m along the line (500 stems/ha). The trees were fertilised with 200 g superphosphate and weeds were controlled for 2 years by applying Simazine and Glyphosate in a 1 m radius around the trees. Interrows were slashed regularly to reduce grass growth and weaner cattle introduced 30 months after establishment when the trees were 4 to 5 m tall. The introduction of the cattle had no negative effects on tree growth, whereas the introduction of horses at 35 months resulted in tip grazing. Unfortunately, growers are now clearing many plantings of *P. caribaea* in the region because of the lack of markets for the timber, and the opportunity cost of the land occupied.

In the wet tropics in general, Applegate and Nicholson (1988) reported that landowners will take shortcuts in trying to establish farm forestry plots on their land, which jeopardises the success of establishing the trees. Weed control was identified as of paramount importance and is needed for 18 months after establishment or until trees are 2 m tall in areas where there is aggressive weed growth such as the wet tropics.

Sheltering tree seedlings when they are establishing in windy areas using tall annual crops such as maize as a wind break is a useful technique (Sun and Dickinson 1995a). Trees established without a windbreak were leaning away from the incident wind direction and had reduced height and crown growth compared to trees planted behind a crop used as a wind break.

Sixteen cabinet timber species were trialed to determine their potential for use in mixed species plantings (Lamb and Borschmann 1998). The work considered stocking rates, plant nutrition, establishment and pruning regimes to maximise tree growth and timber production. Several species were identified as being immediately appropriate for use in mixed plantings. In addition, planting of rainforest trees at low densities was found to maintain pasture production thereby allowing the integration of grazing and timber production. This research is continuing.

The production system required for establishing sandalwood (*Santalum album* L.) has been reported by Radomiljac *et al.* (1998a, 1999a&b). Based on this research, commercial plantings of

sandalwood are occurring in the ORIA. However, the research did not consider the host requirement of the parasite as it continues to grow, or the effect of the final hosts on oil production. Additional research is required into the host/parasite interaction to minimise the age at which heartwood develops and maximise oil production, since this is the fundamental entity on which the success of the sandalwood plantings will be measured.

3.2.5 Growth rates and crop management

The QFRI Hardwoods Queensland Project has resulted in recommendations for the silviculture of those hardwoods recommended for planting in south eastern Queensland shown in Table 1. Spacing and pruning recommendations are based on published research such as contained in Dickinson et al. (2000).

Herbohn *et al.* (1999) used Delphic review methodology to determine from experts the likely growth rates and time to harvest of 31 key tropical cabinet timbers planted in the CRRP plantings. Twenty four of the 31 species were identified as being potential candidates for planting programs with the top five species being *Flindersia brayleyana*, *Eucalyptus cloeziana*, *Elaeocarpus angustifolius*, *Araucaria cunninghamii* and *E. pellita*. Concerns have arisen as to how mixed species plantings will affect the yield potential of these plantings, and that mixed species plantings are harder to manage and harvest. For the 21 species identified by the panel of experts, mean annual increment (MAI) was expected to range between 3-21 m³/ha/year and harvest age from 31-156 years (Herbohn *et al.* 1999).

The growth of two eucalypts in silvopastoral regimes on the coastal lowlands of the wet tropics were reported by Sun *et al.* (1996). Procedures for the establishment of the trees were outlined and it was clear that effective weed control was essential to ensure the survival and establishment of the trees. Tree growth was evaluated at 12, 24 and 39 months and pasture growth at 39 months. Silvicultural regimes trialed included two thinnings and the relative performance of the two tree species evaluated. *E. urophylla* had poorer form but superior height and diameter than *E. pellita*. The trial identified that there was potential to develop silvopastoral farm forestry industries in the region since tree growth had no effect on pasture growth at 39 months.

Teak (*Tectona grandis*) when intercropped with *Leucaena* had greater height and diameter than teak grown in pure stands (Kumar *et al.* 1998). This intercropped system had a reduced requirement for nitrogen and had the potential to be adapted into a grazing system which utilises *Leucaena* for cattle fodder.

3.2.6 Harvesting and milling

Constraints to the development of sawmills and the expansion of sawmills in northern Australia were reviewed by Smorfitt *et al.* (1999). Resource security was identified as the largest single factor contributing to the lack of sawmill expansion or development in the area. Currently, sawmills in the wet tropics are primarily supplied from private growers outside the Natural Heritage listed areas, however, concerns were expressed as to the security of this resource and to the security of timber resources established in the near future which may become indistinguishable, in lay-persons eyes, from protected forest areas. In addition, the current supplies of native hardwood cabinet timbers from the private resource is piecemeal and is too small a quantity to warrant development of additional milling capacity in the region. Consequently, the potential for the use of portable sawmills to mill timber from the current private resource and any future resource was investigated with the view of identifying the role these mills may play and the cost of operating these mills.

Portable sawmills have been noted as producing high recovery rates from logs, quoted values are in the vicinity of 60-70% (Smorfitt *et al.* 1999). These recovery figures are double industry standards for fixed mills, and may be artificially inflated by what is classed as a product (ie limited processing of timber into slab products increases apparent recovery). Costs are reported to be comparable to large fixed mills, however the full costs structure of the operation of such mills are not fully understood and further understanding of these costs structures is required before their profitability can be fully assessed. Smorfitt *et al.* (1999) reviewed the factors to consider when purchasing a portable sawmill and conclude that portable sawmills may play a role in the sawmilling sector. However, each case for the use of a portable sawmill will need to be analysed for costs and the role the mill will play. The processing of trees on farms using portable sawmills has been reviewed by Stewart and Hanson (1998). In order for much of the timber grown in northern Australia to be sold it must be treated against insect attack and decay; this is legislated in Queensland. Fixed mills have treatment plants in situ which are under regulatory control, but the cost of transport of products from portable sawmills for treatment at other mills is an impediment to the sale of these products. Treatment of timbers in situ in the field carries environmental concerns over lack of regulation of the process, and containment of the treatment solution in particular.

Preliminary investigation of the milling and wood properties of *Tectona grandis* and *Khaya senegalensis* grown in irrigated trials near Kununurra, Western Australia were reported by Brennan and Radomiljac (1998). A single 22 year old teak and 8 year old African mahogany were milled and wood properties reported, however, the report uses only a limited dataset and, although the results are encouraging, they cannot form the foundation for a timber industry based on these two species.

There is a larger body of information for the milling and wood properties of hardwood species grown in south eastern Queensland based on studies done by QFRI (eg: Leggate *et al.* (1998), Leggate *et al.* (2000), Lewty *et al.* (2000)). However, these studies are expensive to conduct, are relatively few in number, and the body of knowledge is limited.

Recoveries recorded from plantation hardwoods have been lower than that from natural forest hardwood conversion, however, it is expected that recoveries will greatly improve in the future given improvements in genetics, silviculture and processing, which are major challenges in the QFRI Hardwoods Queensland Project.

It is apparent that information on processing tropical timbers is a very large R&D gap, and there needs to be greater emphasis placed on milling and wood properties in the near future if markets are to be convinced of the wood quality that can be produced in northern Australia.

3.2.7 Economics

Growers intending to enter the forestry industry or who are currently in the forestry industry, particularly as farm foresters have a need to place a value on the resource that they intend to grow. There are many manuals and guidelines available to growers that assist them evaluate their resource; eg the Australian Master Tree Growers Program <http://www.mtg.unimelb.edu.au/> which provides documentation and training in the management and assessment of timber stands. There is a widespread need for a well written plain English manual detailing forest measurement techniques that will assist growers in the understanding of how to evaluate and value their resource (Sun *et al.* 1998). This manual could easily be developed by compiling, modifying and expanding existing manuals and guidelines to include new and relevant information to allow growers to assess their stands (Sun *et al.* 1998).

The development of a farm forestry industry in northern Australia is dependent on identifying the economic viability of planting trees. Hardman *et al.* (1985) evaluated the potential for farm

forestry on the Atherton tablelands and concluded that farm forestry could not compete with cash crops and dairying, however it was more profitable than beef. This research now needs to be revisited based on the de-regulation of the dairy industry in Australia and the need for dairy farmers to diversify their incomes and to improve their efficiency of operations. Hardman *et al.* (1985) listed estimates of costs for establishing and maintaining farm forestry in the region, however, these costs are all 1980 values and have little relevance to today's costs and techniques of establishing farm forestry plots in the region. It was concluded that farm forestry will play a role in the region, but the viability of the ventures will depend on where they are located in the landscape. Potentially, farm forestry would play a role on the flat cropping lands as wind breaks and amenity plantings and on hilly sites for land degradation control. However, Hardman *et al.* (1985) identified there was no role for agroforestry in the drier areas of the Atherton Tablelands.

The attitude of growers to the development of plantations varies considerably, however it was generally found that growers principally support tree planting on private land for environmental and personal reasons (Emtage *et al.* In press). There is considerable scepticism about the financial viability of commercial timber production on private lands, and most landholders are concerned about the stability of the regulatory environment for farm forestry, particularly security of harvest. It would appear that the adoption of farm forestry in northern Australia is very much dependent on stable and transparent markets and regulatory environments (Emtage *et al.* In press).

3.3 Gaps in the published agroforestry knowledge base

The opportunity for farm forestry to enhance biodiversity in the landscape is well recognised, however, there is little scientific evidence to illustrate the comparative and relative difference in biodiversity between different types of farm forestry plantings and cleared, disturbed or undisturbed land in northern Australia (Dames and Moore 1999). It is acknowledged that some farm forestry plantings, particularly of exotic species, will not contribute to biodiversity conservation. In southern Australia, considerable effort has been targeted at developing innovative systems to increase biodiversity including using nurse trees and habitat plantings; this type of research has not been undertaken on a useful scale in northern Australia.

Despite the obvious importance of the CRRP plantings and the research undertaken in them, the development of an agroforestry industry in the wet tropics has stalled. The CRRP plantings and others established in the dry tropics are important resources that need to be regularly monitored for tree growth. These results must be disseminated quickly so that maximum potential marketing of the role of trees in the landscape can be presented to growers. In addition the trials need to be used as demonstration sites, where appropriate, to maximise the use of each site.

There appears to be very little published research information on the establishment of agroforestry trees for timber production in the dry tropics. Some trials have recently been established in the Northern Territory (D. Reilly DPIF pers. comm.). However, there is a need to establish high quality research/demonstration trials in key areas in the dry tropics that can be utilised by a range of researchers and extension officers for timber production using introduced and native tree species.

Tree fodder legume research has been well published in a number of international and domestic reports. There is a requirement however to establish a series of trials in key areas of northern Australia to highlight and demonstrate the key research findings to pastoralists. These trials should be linked with timber production trials in these key areas so that pastoralists and wood producers are encouraged to observe both types of agroforestry systems for their region.

The role of existing native trees in the pastoral system needs to be further explored. It is acknowledged that trees play a role in nutrient cycling and improve pasture quality, however, more research is required to allow these effects to be incorporated into existing modelling programs. Consequently, research is required into the effect of varying tree density in the landscape and the effect this has on pasture quality and production, as well as soil water/pasture/tree relationships.

Overall there is a dearth of information on wood quality and wood processing for native and introduced timber species in northern Australia. There are numerous trials in northern Australia that were established in the 1960-1980s that could be utilised to assess wood quality and wood processing factors, thereby providing useful information now on which species will provide better wood qualities (B. Robertson DPIF, M. Bristow QFRI pers. comm.).

The knowledge base and attitudes of growers to agroforestry needs to be understood further to assess the effectiveness of extension and marketing programmes in convincing growers to adopt agroforestry as an alternative production system. Consequently, it is important that the knowledge base and growers' attitudes be assessed in a manner that will allow for the continual sampling of these attributes in time so that extension and research programs in agroforestry can be effectively monitored.

There is a lack of information on the marketing of wood products in both the domestic and international markets, and how the role of eco-labelling or certification will affect these markets in the future. There is a requirement for detailed marketing information to be established for the timber producing species to be grown in northern Australia. Although agroforestry plantings clearly have multiple uses, understanding the market for timber grown in agroforestry systems in northern Australia is fundamental to defining the economic viability of agroforestry plantings.

4 Current agroforestry in northern Australia

4.1 Introduction and methodology

This Section reports on interviews conducted through on-site visits to research stakeholders and client stakeholders across northern Australia, together with telephone interviews, conducted in March and April 2001. Centres where people were interviewed included Townsville, Mackay, Cairns, Atherton, Tully, Darwin, Katherine, Kununurra, Perth and Brisbane. A list of the people interviewed is shown in Appendix B.

The information collected from these interviews is presented below by groups of regions.

4.2 South east Queensland and Central Mackay Coast

4.2.1 The Region

Bio-regions covered: SEQ, CMC

4.2.2 Farming systems and farm forestry

South east Queensland, and its extension north into the Central Mackay Coast region is markedly different from the rest of northern Australia. It contains: a high population density, substantial

transport and port infrastructure, a very small area of leasehold land, relatively small aboriginal population on the land, and a wide range of farming activities including sugar, mangoes, avocados, bananas, dairying and grazing. The region also contains a mature softwood growing and processing industry located mainly in the south.

The exotic softwood plantation estate is currently fully committed to existing processors. The two major softwood sawmilling processors are Hyne and Son Pty Ltd at Tuan with a log intake of around 400,000 m³ per annum, and Weyerhaeuser's mill at Caboolture, with a log intake of around 280,000 m³ per annum. The wood processing facilities are well below world scale size of greater than 750,000 m³ per annum log intake. In addition, there are a number of smaller softwood processors in the region with a log intake of around 30,000 to 50,000 m³ per annum.

Traditionally, there has been little hardwood plantation development in south east Queensland, both in actual terms and when compared with exotic and native softwood. The hardwood industry is dominated by a large number of small sawmills which are prevalent across the region in the large number of small towns.

Existing hardwood processing industries in the region have relied for supply on native forest sawlogs from both State Forest and private property in an approximate ratio 1:2. However, as a result of the Regional Forest Agreement process, stakeholders in south east Queensland have agreed to the cessation of harvesting of native hardwood timber from State Forests by 2025. Remaining native forests on private land are unregulated apart from the provisions under Queensland's Vegetation Management Act.

A number of proposals over the years, including pulp mills and eucalypt-based reconstituted board industries, have investigated the possibility to utilise hardwood residues from the region, however these have not progressed further. In addition, Federal Government legislation has been in place for a number of years requiring approval for the felling of trees as pulpwood for conversion to woodchip for export. In combination with the relatively small volumes of sawmill residues currently utilised by the industry, there is a significant surplus of native forest hardwood residues in the region.

A list of species for immediate planting on highly suitable sites should be constrained to species which are known to have a market for their products, and are known to grow well and without major problems. For sawlog production this list should include *Eucalyptus pilularis* (blackbutt) and *E. cloeziana* (Gympie messmate) in the higher rainfall zone. *Corymbia citriodora* (Spotted gum) is the highest priority species for drier sites, but current plantings in the region show widespread susceptibility of some provenances to *Ramularia* leaf blight. Successful plantings of *Corymbia* species will require adequate supply of seed from *Ramularia* resistant provenances. *E. grandis* grows very well in the region but is susceptible to attack from a wood boring moth which degrades the commercial quality of the timber.

The rationale for these species priorities are:

- Established products and markets,
- Basic demonstration of performance in plantations,
- No major impediments to growth from pests and diseases,
- Growth, form and wood quality in native environments and soils, and
- Overall performance in native range and suitability for coastal soils east of the Dividing Range.

The QFRI has indicated the following problems and solutions required for conversion of plantation grown hardwood timber.

Table 4: Issues to consider in processing young plantation eucalypts

Issue	Problems	Solutions
Growth stresses	Distortion during sawing	Twin edging saws
	Brittle heart	Multiple blade saws
	End splitting	Radial sawing
	Low recovery	Wet storage
	Increased conversion costs	Increase log size through silviculture Reduce growth stresses through silviculture and site selection
Drying	Steep moisture gradients	Pre-drying technology
	Checking collapse	Solar kiln drying
	Long drying times	Radio frequency vacuum drying
		Production of thin wood and reconstituted boards
Defects	Insect borer holes	Remove need for whole board
	Knots	New products such as laminated veneer lumber (LVL)
	Rot	Veneer wrapped products
	Kino veins	Maximise market potential for feature wood highlighting imperfections

The species most likely to be successful in plantations have high standards of timber quality. The two main species selected as suitable for sawlog production have outstanding wood quality and have reliable markets based on these characteristics. This is based on wood samples taken from slowly grown trees from natural stands. It is generally well understood that the quality of timber from plantation grown trees will be different, and generally poorer in some respects. This is due to faster growth rates and growth stresses in the stem. Improvements in wood quality from plantation-grown timber can be achieved through a more uniform-dimensioned product, and fewer defects because of silvicultural management such as pruning and management of fire and insects. Improvements in uniformity and predictability of the wood product are expected to far outweigh small decreases in wood quality and performance during drying.

4.2.3 Research Groups

With respect to research activities, the region is well served by the University of Queensland, Griffith University, Queensland University of Technology, Southern Queensland University, University of the Sunshine Coast and Central Queensland University. The forest industry is also serviced by the Queensland Forest Research Institute centres at Indooroopilly and Gympie. Research on native vegetation is also carried out by Queensland DNRM at Indooroopilly.

Both The University of Queensland and the QFRI are members of the CRC for Sustainable Forest Management based in Hobart. The University of Queensland and Griffith University are members of the CRC for Tropical Rainforest Ecology and Management (TREM).

Research into hardwood plantation silviculture and species development is being done by agencies within DPI, including QFRI, funded by various agencies as shown in the following table.

Table 5 Plantation and agroforestry research programs being undertaken by DPI (DPI 2000).

DPI Project No.	R&D project	Researcher	Funding agency
2765	Developing agroforestry systems for river frontage country in central Queensland	H. G. Bishop, Qld Beef Ind Institute, Mackay.	NHT
2984	Using agroforestry to improve the viability and sustainability of land use systems in the inland Burnett	M. J. Bell, Farming Sytems Institute, J. Bjelke-Petersen R. S.	DPI
2914	Silvicultural research to facilitate the development of large scale commercial farm forestry on farms	M. J. Lewty, QFRI	FWRDC
2921	The demonstration of silvicultural systems for farm forestry	M. J. Lewty, QFRI	NHT
2924	Sustainable native forest management on private lands – Mary River Sunshine Coast Region.	D. W. Taylor, QFRI	NHT
2927	Silviculture of rainforest cabinet timbers	A. P. House	JVAP
2929	Commercial eucalypt hybrid plantings for marginal lands in northern Australia	D. J. Lee, QFRI	JVAP
2930	Sustainable private native forest management – Wet Tropics	A. J. Snell, QFRI	NHT
2932	The silvicultural basis for national farm forestry in Australia	R. H. Lott, QFRI	JVAP

4.2.4 Grower Groups

The establishment of farm forestry hardwood plantations in joint ventures with land owners has been initiated by DPI-F. Several plantation companies are also establishing hardwood plantations in the region or investigating investment opportunities. These include: Greenfield Resource Options, East Coast Tree Farms, Plantations International, Integrated Tree Cropping, Great Southern, Forest Enterprises Australia, and Yates Forests Limited.

Interest in land purchase for the establishment of hardwood plantations by plantation development companies, such as those mentioned above, has extended to the Central Coast of Queensland. Interest in farming land for plantation establishment now extends from south of Brisbane in the Boonah and Beaudesert areas, to north of Rockhampton. However, these projects involve a complete change in land use from farming to forestry, and are considered to be separate to the main purpose of agroforestry which is the integration of trees and farming systems.

There is a strong interest in farm forestry for commercial returns in the region, and a Farm Forestry Directory for south east Queensland has been created (McCarthy 1999). Active grower groups include: Greening Australia, Landcare groups, South Queensland Farm Forestry Association (SQFFA), Cooloola Forest Growers Cooperative, and the Forest Farmers Association Qld Inc (FFAQ) which have strong networks of growers. Regional Plantation Committees have been formed or are in the process of being formed in south east Queensland and Central Queensland. Apart from working with plantation investment in the regions, these organisations should have the capacity and leadership potential to coordinate farm forestry development and to stimulate extension and communication of research results to growers.

There are relatively few constraints to farm forestry development in the region compared to other regions of northern Australia. There is an active and substantial softwood plantation timber industry in the region which also exports wood chip from Gladstone. There is an increasing interest and activity in investment in plantings in the region by plantation development companies. There is also significant research and extension support infrastructure in the region through QFRI and DPI, although there is client dissatisfaction with information availability: this may be simply a function of little information to disseminate.

Constraints to farm forestry are caused by the lack of links between these factors. For example, there is very little privately grown softwood timber grown or delivered to the softwood mills, and there is little integration of farm forestry by companies developing hardwood plantations. Farm forestry groups perceive a lack of assistance from the State Government particularly in the availability of research information and genetic material which the State Government controls for its own priorities and competes with the private sector. There is also a perceived need for governmental assistance in funding effective property management planning and business planning for those wanting to integrate agroforestry into their enterprises. Concerns about security of harvest and the future of native vegetation controls, proliferation of local government planning controls and land taxes are also paramount amongst potential growers concerns in the region.

4.2.5 Research priorities

Research priorities defined by both client and researcher stakeholder responses reflect the maturity of the farming systems and the maturity of the forest industry in the region. Research priorities include:

- Research into the wood properties and milling properties of plantation grown hardwood species.
- Silvicultural research which makes commercial use of small diameter timber from a wide range of species.
- Cost benefit analysis of silvicultural treatments such as pruning on log values.

Privately owned native forests are being harvested at a supposed unsustainable rate. There is a very high priority to define sustainable management criteria for native forests on private land in order to both protect the future of the hardwood milling industry and regional biodiversity values, as well as to allow growers the opportunity of certifying their timber as being grown in sustainably managed forests.

4.3 Wet tropics

4.3.1 The Region

Wet tropics (Rainfall >2,000 mm per annum with no true seasonal pattern, however summer is wetter than winter).

Bio-regions covered: WT

Interviews were conducted in Cairns, Atherton and Tully.

4.3.2 Farming systems and farm forestry

The farming systems in the wet tropics are characterised by small properties used for high value and high intensity agriculture such as dairying, sugar production, bananas, mangoes and avocados.

The sugar industry operates in a climate of fluctuating world prices and adverse seasonal impacts of harvests, the tobacco and dairying industries are in decline, there is an oversupply in markets for mangoes, paw paws and avocados, and the tea tree industry has not been successful. By contrast, there is great interest in the region from tourism. Growers looking for alternative sources of income or moving toward sustainable land management have shown an interest in establishing trees in the landscape.

The farm forestry sector in the region is characterised by:

- A wide range of timber species planted,
- Small volumes of species grown, and
- Small processing capacity in the region.

Constraints to farm forestry include concerns about the right of harvest, and the length of time until a commercial return on investment is achieved. There are also tax disincentives to small scale development since each project needs to show commerciality to gain tax relief on the investment.

The timber industry is characterised by small quantities of resource available for harvesting from freehold land, and economic inertia preventing restarting sawmills which were closed in the region due to the World Heritage Area listing of the tropical rainforests.

There is a strong element of land holder mistrust of the future viability of rainforest plantings. There is a perceived lack of surety that rainforest plantings can be harvested in the future once they have established understoreys and increased biodiversity values. Legislation of the right to harvest may come some way to alleviating this perception. The realisation of receiving additional monetary value from the plantation for its role in improving landscape and water values will also assist growers to move towards planting trees in the landscape in the wet tropics.

Native forest logging still occurs in non-endangered ecosystems on private land, and anecdotal observations suggest that much of this harvesting is not sustainable. In addition, rainforest logs attract only low stumpages² in the region of \$35 /m³. Prior to the establishment of the World Heritage Area, the stumpages paid for rainforest logs was in the region of \$100 /m³. The stumpage rate for native rainforest timbers does not cover the payment of rates by land holders. By contrast, *Acacia* (*A. aulacocarpa* and *A. mangium*) regrowth on private land is harvested and sold at a stumpage of \$70 /m³.

The main reason for the low stumpages paid for rainforest timbers is the low volume of supply and the lack of identified markets for the small volumes. However, experience from the Northern Territory shows that small volumes can supply niche markets and attract high prices if markets are identified and opened (refer to Section 4.5.2.1).

Cyclone activity in the region causes damage to plantings, particularly on the coast, and this will undoubtedly result in reduced log values from damaged trees. Damage from cyclones is fickle

² The term stumpage refers to the price paid by the purchaser for the timber standing in the forest. The purchaser then has to fund harvesting, transport and milling in order to commercialise the timber.

and sporadic and hard to predict. However, the frequency of cyclones does not seem to be a strong disincentive to tree planting in the region.

In the early 1990s the Community Rainforest Reforestation Project (CRRP) was established by the Shires of far north Queensland. The program was funded by federal monies to help establish a planted rainforest timber resource to replace the forests of the World Heritage Area which were no longer available for commercial utilisation. The CRRP had wide ranging objectives including establishing plantations of rainforest species on private land as well as providing employment and training to young people in tree planting activities. The progress of the CRRP is examined in more detail in Section 4.3.3.

There are three main clientele groups for tree planting: commercial farmers who need confidence in markets and silviculture, lifestyle land holders who need information on a wide range of species and their timber and non-timber products, and forestry investment companies who require fundamental information about all facets of establishing and processing plantation timber in the region.

DPI-F encouraged the establishment of softwood (*Pinus caribaea*) by private land holders some 30 years ago and many of these plantings are now at a harvestable size. However, there has been little silvicultural treatment of these stands (thinning and pruning), much of the timber is high in resin and undesirable for processing, there is no local milling interest in the resource, and there is no market close enough to be of interest. The result is that many land owners are clearing and burning former farm forestry plantings of softwood.

Eucalypt plantings, particularly *E. grandis*, in the region have suffered from defoliation by *Cylindrocladium*, and there is little interest from private land holders in growing these species. There is, however, interest from a plantation development company, Yates Forestry Limited, in growing *E. pellita* in plantations to create a peeler log market. The development of such a market may stimulate private land holders growing these species in farm forestry plots if a the project eventuates and a future market develops for the timbers.

There is some interest in establishing commercial plantations of tropical timbers by Perth based Forest Rewards Limited who are in the planning stages of establishing 100 ha of teak plantation near Tully.

Future development of forestry plantations in the region by investment companies may provide incentives to land holders if the provision of annuities for land use for plantations is sufficiently high, and if a processing industry eventuates.

There are very contrasting opinions about tree planting across the shires in north Queensland. Johnstone Shire provides rate relief for tree growers, whereas Atherton Shire strongly opposes tree growing on agricultural land.

There are problems in exporting timber from the region. The harbour at Mourilyan requires tugs to be brought from Townsville to handle ships large enough for timber export.

Success of farm forestry in the wet tropics is dependent upon demonstrated success in selling timber from plantation grown rainforest species at a sustainable market price. This will provide confidence in growers to continue with their investment, and will provide the incentive to achieve scale in both the resource and processing capacity.

The future of farm forestry is also dependent upon a paradigm shift from the value of trees purely for timber value towards definition of a value in providing ecosystem goods and services. This concept involves the land owner receiving financial benefits from planting and managing trees in the landscape. Such benefits include aesthetic value for tourism, protection of landscapes from salinity, and catchment protection to improve water quality values. The concept involves the land

owner receiving financial reward for such activities which benefit the community as a whole. Adoption of such a paradigm also aids communication of the multiple value of trees in the landscape to the wider community. Financial returns from the provision of ecosystem goods and services is some way off, but there are indicators that the value of trees to the community is understood in some areas by the rate relief given to tree planting by the Johnstone Shire Council.

4.3.3 Growers groups

The history of the CRRP is characterised by change. The CRRP originally covered many objectives including a substantial component of employment and training. The CRRP was administered initially by the Joint Board, and for some time by DNRM whilst the program fitted within their Tree Care extension program for land holders. The introduction of the DPI-F Joint Venture plantation developments conflicted with the planting activities of the CRRP, with the result that the CRRP ceased field planting and reduced greatly in size and function from some 40 staff down to three. The CRRP is now run under the auspices of North Queensland Afforestation (NQA); NQA is the former Joint Board of the north Queensland shires. DNRM has ceased its Tree Care program, and DPI-F has reduced in size its Joint Venture program. The effect of all these changes is:

- Some 2,000 ha of planted rainforest species on private land,
- Some 600 private land holders intimately involved in farm forestry using predominantly native rainforest species, however introduced species have been trialed in the region as well,
- A substantial tree establishment and maintenance skill base in the region as a result of the employment program,
- A heightened perception amongst land owners of the potential for farm forestry in the wet tropics through a large number of plantings,
- A following of, and interest in, farm forestry from the community and grower organisations, and
- A reduction in the ability of all organisations in the region to deliver field extension services and advice to potential growers.

The grower base is represented by NQA, PFNQ (the Regional Plantation Committee), and the NQTC which was set up to address the interests of growers in the CRRP. The NQTC has some 30 members.

Queensland State Agencies now have altered priorities: DNRM's emphasis in the region is on implementation of the Vegetation Management Act, and DPI-F's interest is in expanding and managing softwood plantations.

There is a demonstrated potential for growing tropical hardwoods in the wet tropics. This has been demonstrated through the successes and failures of the CRRP on the ground, but there is no recorded or published comprehensive reporting of this work. Without adequate reporting there is great potential to re-invent mistakes and lose more than a decade of research in the wet tropics.

There is a common high prioritisation amongst grower groups and representatives to see the results of the CRRP decade pulled together, written up and published in a form that is suitable for the grower client base.

The next priority amongst growers is information on and access to markets for their small volumes of speciality timbers.

4.3.4 Research groups

TREM based at James Cook University Cairns Campus is the premier forestry research body for the region. Its partnership includes:

- CSIRO Tropical Forest Research Centre
- James Cook University of North Queensland
- The University of Queensland
- Griffith University
- Wet Tropics Management Authority
- Tourism Council of Australia
- Alliance for Sustainable Tourism
- Aboriginal and Torres Strait Islander Commission
- The State of Queensland: Environmental Protection Agency, Queensland Parks and Wildlife Service, Department of Natural Resources and Mines, Department of Primary Industries – Forestry.

In addition to its regional role in providing a centre for research and education, an international Rainforest Centre of Excellence is being planned for the JCU Cairns campus.

In addition to the research effort provided by TREM, research is also provided by CSIRO Tropical Forest Research Centre in Atherton, although much of this effort is directed through TREM.

Research is provided by QFRI, Atherton on a wide range of mainly tree-specific research topics. QFRI has also measured some of the CRRP plantings, and this is reported in QFRI Report 7/99 (Keenan and Annandale 1999).

The Bureau of Sugar Experiment Station (BSES) is conducting research into the integration of trees into sugar plantation areas (headlands). BSES research has found that trees on the periphery of sugar plantations control rat populations by providing shade and hence reducing ground cover in rat harborage areas. This group used the CRRP plantings as their research base for selecting species, spacing and establishment procedures, further highlighting the valuable information that is contained in these plantings.

ACIAR has had a role in sponsoring research which has broad applicability across the Pacific or Asian environments. The audience for this research is not generally the Australian community; rather it is for overseas consumption. However, much of this research is locally applicable and the results can benefit regional farm forestry if packaged appropriately in an extension program for local dissemination.

There is frustration amongst research providers that good research has not been taken up. There is a perceived need to influence policy at local and State Government level to facilitate uptake of R&D and change. There is a need for a stimulus to develop a forest industry outside of the World Heritage Area, with TREM providing the basis for an international centre of excellence for rainforest research.

A substantial piece of research on the economics of farm forestry in the wet tropics has been conducted by Dr John Herbon and Dr Steve Harrison of the Economics Department at The University of Queensland. This work has primarily been funded through TREM, and is linked to ACIAR funded research in the Philippines. Their research has focused on the establishment of

non-industrial forestry in small rural communities such as the wet tropics and in the Philippines. Their research is summarised below:

The markets and marketing of farm grown timber is very weak with growers being mainly price takers in the market. There is very little current primary data on tropical timber markets both domestically and internationally, and no clear understanding of the issues concerning eco-labelling and branding of timbers for premium markets in Europe and America. Some market research for north Queensland timber is currently being conducted by Tyrone Venn (JVAP PhD Scholar) and Mark Annandale (QFRI) for native species timbers, and Michael Cox (PhD student at QUT School of International Business) focusing on domestic markets for Hoop Pine.

There is a lack of a farm forestry culture in NQ; this is compounded by a series of unsuccessful attempts to try and stimulate an industry such as pine plantings on the Atherton Tablelands and the industrial plantings in the Northern Territory.

There is little dissemination of published research information, on the attitudes of land holders to farm forestry, to research providers and extension providers of farm forestry advice.

There is very little information available in a useable format that will assist growers in choosing the farm forestry system suiting their requirements, and there is an absence of support from government agencies in providing advice on farm forestry.

Issues such as resource security (concern over World Heritage listing and the future expansion of this zone), government intervention in the future, timber prices, tax impediments, lack of capital funding options are all serious issues to potential farm forestry growers.

Sawmilling infrastructure is weak with mostly outdated mills, and there is a lack of critical mass in plantings to raise resource availability for milling.

Several researchers are developing methods of applying the concept of ecosystem goods and services to the management of water, vegetation and landscape values. Prof Nigel Stork, the CEO of TREM, Paul Reddell at CSIRO Land and Water as part of TREM, and Dan Walker in CSIRO Sustainable Ecosystems are involved in the research of this concept.

There is general and broad interest in the future of bush tucker as an industry, but there is little understanding about what the term encompasses, and what shape the industry might take.

The research areas considered of prime importance by respondents were:

- Better integration, publication and dissemination of current knowledge so as to avoid re-invention of knowledge.
- Gathering information for and refining and developing the market for timber from the wet tropics, including requirements for certification of sustainable management to supply European and North American markets.
- Defining a maximum of six species for growing commercially in the wet tropics which can be integrated in a wide range of ecosystem goods and services.

4.3.5 R&D Priorities

The CRRP planted some 2,000 ha of predominantly rainforest species on private land in the north Queensland shires. These plantings are a resource of information on successes and failures in species and systems for planting and maintenance. There is currently only one report (Keenan

and Annandale 1999) with measured results from the program. There is an urgent need to define which key species should be concentrated on for a commercial timber return, so that growing and marketing issues can be addressed in a focussed way. There is a very high priority to provide funding to report on the results of the activities of the CRRP in a single and widely accessible publication. This report should include measurements and growth and yield results (both successes and failures) of the CRRP plantings, together with the land DCDB, rainfall, wind and soils information. Most importantly, this should be seen as an extension publication, not a research report.

CRRP plantings represent a substantial demonstration and extension base. There is a pressing and un-resourced need to provide extension services to growers.

CRRP plantings are a valuable resource that needs to be routinely monitored to allow for modelling of tree growth in mixed plantings, so economic assessment of agroforestry systems can be undertaken and ranked.

Current low prices for native timber harvested from private land provides no incentive for planting. There is a very high priority to address the markets for so-called cabinet timbers which can be grown in the region. This includes questions on how to address the markets through demonstration of sustainable management and certification of timber from sustainably managed forests.

In order to address markets, there is a need for wood quality information from the most widely planted and most regionally suitable plantation grown rainforest species.

Once wood quality information is collected and collated there is a high priority to communicate the information on markets, prices, species and silviculture, growth and yield, rainfall and soils. Communication should be in the form of multi-media information including printed materials and web based information.

There is a high priority for a coordinated strategy to address farm forestry and its future. This is based on social needs for trees in the landscape as well as a need for a commercial return to growers. The framework of ecosystem goods and services should be used to formulate such a strategy to define the individual and community benefits from management of trees on farms.

There is a pressing need to define sustainable management parameters for native forest resources on private land in the region. If markets are also addressed, this will allow the development of a sustainable wood supply for a market, and hence the development of better prices for the timber.

There is a priority to define the parameters of a bush tucker industry. The concept is currently too broad and ill defined. This area is considered by proponents as a high priority for aboriginal communities, but there is little good documentation as to the what and how of the development of a bush tucker industry.

Research is required into rural community adjustment and alignment with current land management philosophies and values. This applies to the ability of local government entities to operate the legislative framework that they are being given, particularly in Queensland.

Research is required into how to effectively change policy and generate initiatives from a governmental level. This applies both to the timber industry development as well as the development of ecosystem goods and services as a financial incentive for growers, and as a planning tool for local governments. Research is required on how to remove institutional constraints from the development of farm forestry.

Research is required on effective extension. With the withdrawal of State Agencies from agricultural and forestry extension services, researchers themselves are providing extension support in addition to their research function. If this is to continue, researchers need to be better

equipped for delivery of information in a useable form to interested growers. The Master Tree Growers Course operated by Melbourne University has had a strong and positive effect on elevating the understanding and technical capability of growers in the NT, and this could be replicated elsewhere (Section 4.5.4).

One of the main impediments to establishing tropical timber species successfully in the wet tropics is control of competing weeds. There is a high priority to determine how to improve weed control whilst reducing costs to make planting system more economically viable.

4.4 Seasonal dry tropics

4.4.1 The Region

Bio-regions covered include CYP, GUP, MII, EIU, MGD, DEU, BBN, BBS, ML

Personal and telephone interviews were conducted in Townsville, Mackay, Atherton and Cairns.

4.4.2 Farming Systems and Farm Forestry

The dry tropics are vast by comparison with the wet tropics. The region extends west with rainfall between 900 and 650 mm/yr, and north to Cape York. Generally farming systems are extensive in nature and are based on grazing carried out in modified woodland environments, some of which have been cleared of native trees. There is little land cleared specifically for intensive agriculture primarily due to the requirement for irrigation.

The attitudes of land holders in the dry tropics is markedly different from those in the wet tropics. There is a drive to try new farming systems and crops. Cattle market have fluctuated significantly over the years forcing growers to seek ways to diversify their income. In intensive growing areas there has been a loss of tobacco and tea tree markets, resulting in these growers also seeking alternative income streams.

Leasehold conditions on land is the major issue in adapting extensive farming systems to recognise the value and multiple use of trees. Currently, there is conflict in the ownership and management of the trees on leasehold land. This provides a disincentive for landholders to manage and value trees. On leasehold land, landholders cannot manage trees for carbon sequestration or for timber production for their own benefit. If a leaseholder plants a crop, he has the harvest rights to that crop. If he grazes cattle, he owns the cattle. If he grows trees, he does not own the right to harvest those trees or claim the carbons sequestration rights to the trees.

Native woodlands are harvested for timber on a small scale with mostly *Eucalyptus tereticornis* being harvested from river and creek frontages, and *E. coolibah*, *E. tessellaris*, *E. intermedia*, *E. crebra* and *Acacia rhodoxylon* being harvested from grazed woodland areas. Soils on river frontages are generally deep and fertile with periodic flooding; this results in an under-utilised resource in which it is also difficult to re-establish trees due to prolific weed growth after flooding.

The extensive grazing industry has been well serviced in the past. There has been a large body of research conducted into woody perennial shrub legumes such as *Leucaena* and *Calliandra* as fodder crops in the seasonal dry tropics by CSIRO Davis Laboratory. *Leucaena* has been planted into grazing systems in Banana Shire in Queensland, and is now being introduced to ironbark country on basalt soils. One of the main drawbacks of such plantings is increased soil acidification due to legumes and weed problems associated with escaping trees. Much of this research has been published in Shelton *et al.* (1998).

Smaller land holders in the area make up a large proportion of the potential client base for farm forestry, although they make up a small proportion of the area. These small land holders are generally day workers who have a secure income base and want to grow trees for 'superannuation'. They have discretionary income, and no pressing need to make a return from trees in the short term. Many of these day workers are connected with the mining industry in western Queensland.

Water is the region's major environmental issue. Almost all farm tree plantings require irrigation to establish them. This is both an added cost and an environmental overhead because the ground water resources are not fully known. This is a very important area of research in order to make best use of scarce water resources.

There is potential to maximise the use of water in the seasonal dry tropics through the utilisation of effluent water for irrigation. The potential for effluent irrigation includes, biomass production for remote area power generation, and production of high timber quality tree species including African mahogany and Sandalwood. Concern as with all irrigation is long term viability and soil resilience to irrigation. Trees have been planted in sewage effluent trials at Mt Isa, Yeppoon, Biloela and Atherton; there is a priority to assess the success of these plantings and to deliver results to the community.

There is currently JVAP funded species testing in the Burdekin and Gulf Regions, and bush tucker research in western Queensland. In addition there is some work being done on species selection in drier areas, mainly by QFRI. There are trial plots at Croydon and effluent irrigation trials at Mt Isa.

Native sandalwood has a role in the region: it has a lower oil content than the WA and Indian sandalwoods, but it has a demonstrated niche market. If successful, it will be a small scale operation in Queensland compared to elsewhere.

There is much interest in African mahogany (*Khaya senegalensis*) which has been grown successfully in the seasonal dry tropics. Anecdotal information on growth rates indicates that millable trees may be produced under irrigated conditions in as little as 15 years. There are however concerns about the incidence of tip moth damage on log form and wood quality. There are also environmental concerns about the weed potential of *Khaya* which has a winged seed and disperses readily.

Other perennial woody crops which can be grown in the dry tropics include shrub legumes, biomass crops for fuel, and trees for foliage cropping for the flower market.

There are major issues concerning the management of native forests on Cape York, and the interaction with and needs of the aboriginal communities there. Aboriginal communities are interested in diversification away from cattle in Cape York and towards growing timber and bush tucker for markets. Linked to this is the move by aboriginal groups to go "Back to Country", ie return to their land and traditional values.

Bush tucker attracts interest and is almost always considered, by non aboriginal people, as a suitable enterprise for aboriginal groups. However, bush tucker products are poorly defined, and there is no clear commercial business framework on which to base the concept. Improved scoping and definition of the potential bush tucker industry is required before further research funds are directed towards it.

There is still a major issue of marketing timber from aboriginal lands. There is the potential to provide an aboriginal brand to the market place as attempted by the Body Shop through aboriginal-sourced tea tree oil. Social research is required amongst aboriginal groups to determine how a forestry project should be structured to get off the ground. There is considered

to be great potential for forestry projects in all aboriginal communities, but there are few factual concepts as to how this may be achieved. There is a high research requirement for an independent review of the needs of aboriginal communities to be undertaken across all communities in the region to identify research requirements for these communities.

There is a need for skilling and technical training to address business development by aboriginal groups in the seasonal dry tropics. Training must be backed up with an industry to move into, otherwise training will be for no end and there will be no incentive.

Information is required on the sustainable management of native forests in the dry tropics, and there is a need for a marketing study for native forest timbers on Cape York. This needs to be supported by definitions of sustainable management of these ecosystems, and demonstrations of good management.

4.4.3 Research groups

Groups conducting research in the seasonal dry tropics include: QFRI, CSIRO Sustainable Ecosystems, DPI, DNRM and the TSCRC.

The research carried out by QFRI is mainly in establishing species trial plots across a range of environments. QFRI is also conducting research into native forest management on Cape York.

CSIRO Sustainable Ecosystems at Townsville has established a large body of research into shrub legumes in grazing systems, with successful uptake of *Leucaena* systems at Emerald.

The work of the TSCRC in the seasonal dry tropics is detailed in Section 4.5.

DPI provides some research into agroforestry through land use programs in the Beef Institute.

A research group in DNRM including Greg McKeon, Chris Chilcott, Beverly Herry, Ken Day, Grant Stone, and John Carter, is conducting grazing systems research. The group has roles in providing strategic advice to government in terms of drought alerts, and providing modelling support and services to clients of research, namely growers and extension officers, thereby assisting in the development of property plans. This group does not have the resources to provide links to growers. Their research is focusing on the role of trees in the grazing environment and how to manage trees to maximise grass production and to maximise the benefits of keeping trees in the landscape.

This group and other members have, over the last 20 years, developed a grass growth model (GRASS) that is used to provide strategic advice to government in terms of drought alerts and specific case advice to growers at a property level in terms of management strategies concerning stocking levels for seasonal climate forecasts, burning and sowing of pastures to maximise grass growth. The model uses water balance, nitrogen uptake and mineralisation, and grass growth modules to arrive at grass growth. The model does consider the interaction between grass and trees, however only in terms of the upper soil profiles. The model has been successful in raising regional awareness to the issue of trees in the landscape.

The GRASS model recognises the importance and role of trees in the grazing system. The model is capable of effectively computing how trees and grass compete for resources and the effect of pasture growth, however the model fails to:

- predict individual tree growth,
- predict tree population growth, and
- provide an understanding of how trees access soil moisture below 1m.

There are some data available on trees in the landscape from Bill Burrows (DPI) work looking at woodlands dynamics in TRAPS. Currently the modelling team is trying to integrate this data into GRASS.

The model does not consider the microclimate effects of trees on grass, especially the dynamics of shading on grass growth and protein content. The model does not consider the role of trees in drainage, including surface runoff and deep drainage through the soil profile and hence potential water table and salinity issues.

Further developments of the model are required to provide an understanding of the tree grass balance in terms of carbon balance. Carbon content in extensive grazing areas are predicted using foliage cover to predict basal area and biomass from which C content is calculated. Currently there is no consideration given to soil C dynamics and very little research has been done into soil C and how it changes with land use.

There is a clear opportunity for JVAP and the MLA (Meat and Livestock Australia) to collaborate in funding research into tree and grass interactions. This may be an outcome of the MLA's Northern Australia program which is currently under revision.

4.4.4 Grower groups

Grower groups are not as strong in the seasonal dry tropics as elsewhere. Support for farm forestry in the community is provided by NHT funded groups such as the Fitzroy Basin Association, and Landcare groups.

Aboriginal communities dominate large areas of the dry tropics. There is very little support for farm forestry within these communities, despite a desire to adopt farm forestry as a viable income stream. Considerable time and effort will be required to determine and assess the R&D needs for agroforestry for each individual community if the development of agroforestry is to be successful in these communities.

4.4.5 R&D Priorities

Research issues defined by respondents included:

- Species and growth rates,
- Irrigation requirements and watering strategies,
- Exotic species and weed potential,
- Wood quality at young ages to get a return on investment,
- Local processing and value adding opportunities,
- Transport to markets, and
- Markets for tree products including timbers, food and others.

Research priorities include:

- A very high priority for research into water requirements and effective water use by farm woodlots, since much of farm forestry in the seasonal dry tropics requires irrigation to get established. This should be done in concert with an increased understanding of regional groundwater quality and quantities, and the impact of irrigated farm forestry on ground water resources.

- A strong need for a regional demonstration of dry region farm forestry on a property large enough to be of significance and create interest in the region. This should include demonstrations of shrub fodder legumes as well as woodlots of commercial timber showing irrigation methods and silvicultural management systems in action.
- A high research priority is to increase the understanding in tree and grass interactions in the dry woodlands of the region so that trees in the landscape can be managed to maximise grass and livestock production while maintaining environmental goods and services.
- There is little information on the sustainable management of woodland in the seasonal dry tropics. This information is required, particularly by aboriginal communities with ownership rights who perceive low volume harvesting and milling of native timbers to have a business potential.
- Bush tucker is seen by many researchers and aboriginal groups as a potential business area for aboriginal communities. However, there is little clear definition as to what bush tucker represents, what resources there are to utilise and, most importantly, definition of markets for the products.
- There is great interest in and a perceived shortage of information on the use of trees for a wide range of purposes including control of salinity, soil erosion and greenhouse gases. This can be summarised in a simple requirement for well targeted extension services and information which is effective in getting to the client base.
- The potential for growing exotic timbers such as *Khaya* under irrigation is being taken up by some landholders. This needs to be supported by high quality research into the markets and processing requirements for this timber.
- Irrigation appears to be required in most instances in order to successfully establish and grow trees on farms. There is little understanding of the effects on wood quality of the high growth rates achieved with irrigation. Wood quality research focussed on market entry and acceptance is a high research priority for irrigated farm woodlots.
- A high research priority is to identify the critical factor to getting growing systems established and functioning eg: *Rhizobium* populations on *Leucaena*, and irrigation rates for establishing exotic timbers.

4.5 Northern Savanna

4.5.1 The Region

Bio-regions covered include STU, DAB, PCA, TEC, CA, GFU, GUC.

The region ranges from a wet coastal strip across the northern coastline, down to the arid zone at the edge of the Tanami and Great Sandy Deserts.

Interviews were conducted in Darwin and Katherine.

4.5.2 Farming systems and farm forestry

Farming systems are extensive and are dominated by cattle grazing on very large land holdings. The small amount of cleared farmland is used for intensive horticulture such as mangoes and other tropical fruits. These areas are mainly around Darwin and Katherine, with a move into the Daly river area. Farm forestry is being seen as an alternative to fruit growing in these areas.

The Tiwi aboriginal group based on the Tiwi Islands has leased land to a plantation forest development company Sylvatech, although further development of this project is under question following the collapse of the parent company Australian Plantation Timbers Ltd. This project on aboriginal land is developing *Acacia mangium* plantations for pulpwood for export.

Large scale plantation forestry developments involving the clearing of native vegetation can be regulated under the Federal Government's Environmental Protection Biodiversity and Conservation Act. This Act can halt development of land which will result in removal or damage to native vegetation, and can be enacted in the Northern Territory. In addition, the Northern Territory's Pastoral Lands Act affects the planting of trees on leasehold land. The Federal Government's Native Title legislation affects the development of land subject to native title claim. These pieces of legislation are seen as constraints to commercial tree planting outside the relatively restricted area of freehold land in the Northern Territory.

These constraints on land development has prompted approaches to aboriginal groups to lease their land for forestry enterprises.

Building codes for the Northern Territory specify steel in construction because of cyclone rating and prevention of termite damage, and this does not stimulate a local market for housing timber.

The perceived expensive failure of the Northern Territory Conservation Commission's past activities in forestry plantations is seen as a black cloud hanging over the future development of forestry and a forestry industry in the Northern Territory. The perception is that, despite the investment of some \$30 million in the 1960s to 1980s, there is little to show for it: productivity of what was planted is poor, there is no industry in place, and investors cannot see where future markets are. Despite this, there is some limited processing of the planted *Cupressus intratropica*, the heartwood from which contains an essential oil.

Pessimism over the industry is also underpinned by the damage caused by cyclone Tracey and by subsequent cyclones, and by the frequent occurrence of fire in the savanna landscape. The Northern Territory's termite *Mastotermes darwiniensis* has a fierce reputation much greater than its size, but it can do great damage to planted trees.

The exotic timber tree trials in the Darwin and Katherine regions have been carried out on the premise that high value tropical timbers must be grown successfully in order to offset the high cost of establishing and growing the trees and protecting them from fire, termites, drought and wind.

In the native woodland, the commercial use of trees in dijeridoo manufacture is carried out more by non-aboriginal businesses than by aboriginal groups. The harvesting process is 'hit and miss' with a large number of trees harvested for a few suitable stems with hollow centres. The nature of fire in the savanna landscape has increased in frequency, intensity and size, and this is affecting species mixes in the savanna.

Landholders have the potential to manage trees for carbon sequestration in an extensive process, but impediments to this are slow growth rates, fire, termites, wind and ownership rights issues.

A prime research issue is in determining the value of trees and vegetation communities as ecosystem goods and services.

4.5.2.1 Native forest timber processing

This following section reports an interview with John Hoggard, General Manager of Mary River Sawmill near Pine Creek, NT. This mill represents the potential for utilisation of native timbers given careful harvesting, appropriate technology applied to milling and, most importantly,

identification of markets able to buy timber at prices which makes the enterprise a commercial success.

This mill is located some 170 km south of Darwin. It harvests, mills and processes the following species.

Table 6 Native timber species processed by Mary River Sawmill in the Northern Territory

Common name	Botanical name	Wood density (kg/m ³)
Cooktown ironwood	Erythrophleum chlorostachys	1,300
Long fruited bloodwood	Eucalyptus polycarpus	900
Ghost gum	Eucalyptus papuana	800

Harvesting of Cooktown ironwood

Harvesting is done under licence from the Northern Territory National Parks and Wildlife Service. Ironwood trees of diameter greater than 350 mm are harvested. Trees are cut at about 450 mm above ground height in order to stimulate coppicing. Stumps may also be barked at ground level to stimulate shoot production. The logs are extracted with rubber tyred front end loaders equipped with forks. The soil is protected from erosion.

Trees of harvest size almost always have a pipe in the centre.

Haul distance to the mill is c.10 km.

Milling

Most log sizes taken to the mill are of c. 0.2 m³.

Because of the density of the timber, all blades and saw teeth are tungsten tipped. The log is processed with a large Canadian saw followed by a decking saw and a multi-rip saw. Respirators and masks are required to be worn during processing because of the irritable properties of sapwood sawdust.

Wood is stacked and air dried. Low ambient humidity during the dry season reduces the need for kiln drying.

Products

The mill sells Cooktown ironwood under a brand name “Red Ebony”. Products are listed in Table 7.

Table 7 Products produced from Cooktown ironwood

Product	Property	Selling price
Sawn boards	Stability, density, colour, smooth grain	\$800 /m ³
Tongue & groove flooring 75 x 16 mm	Hard wearing and colour	\$8 – 9 /linear metre
Violin & guitar fingerboards and chin rests etc	Hard wearing, smooth grain and stable	\$10 – 15 /kg
Pool tables	Density and stability	
Snare drums	Resonance properties	

Almost all sales of Cooktown ironwood from Mary River are sold to a dealer in Sydney who supplies the Australian and overseas market places. Components for musical instruments are

made in Australia and assembled together with other timber components in China before reimportation of finished products.

4.5.2.2 Potential for processing logs from agroforestry plantings

The main problem at the moment for establishing farm forestry in the region is understanding of and access to markets for the wide range of tropical timbers that are being grown. It is thought that a 2,000 ha resource would be able to satisfy the economies of scale of milling and marketing.

Most experience in milling and wood properties has come from processing street trees from Darwin. This includes experience in processing African mahogany. Milled mahogany is currently used in the Darwin region for items such as tables, bar tops, and decking for outdoor areas.

Mills need to be well equipped with tungsten cutting edges to be able to cope with the wide range of timber properties potentially able to go through the mill.

Problems found with harvesting and processing mahogany include:

- Trees liable to shatter on felling,
- Logs fracture if dropped,
- Boards tend to split if dried too quickly, and
- Slow curing required for high stability end uses.

4.5.3 Research groups

4.5.3.1 Tropical Savannas CRC

The TSCRC has been active in establishing the biophysical and social parameters and basic frameworks to the vast region of northern Australia (excluding the wet tropics) in which they operate. The greatest R&D initiative of the group has been the completion of a vegetation map for the whole region which can be used to target regions of importance for addressing landscape, ecosystem and community health.

There is work in the TSCRC on structural change in woodland vegetation which has been called vegetation thickening. This work is being carried out using both oblique photos and satellite imagery.

The TSCRC has no research programs concerning the harvesting and commercialisation of bush tucker which is mainly located in the rainforest and vine forest areas of the coast.

4.5.3.2 Department of Primary Industries and Fisheries, Northern Territory

The DPIF works closely in promoting tree planting with GA and the NTFTPN. DPIF is responsible for carrying out a limited range of species trials around Darwin and Katherine. This work is detailed below in Section 4.5.4.

Between 1958 and 1986 the former Northern Territory Conservation Commission (NTCC) established 942 trials in the Northern Territory. The NTCC is now defunct, and the majority of files pertaining to these trials are missing. This represents a lost resource. This leads to three priorities:

1. A task force should be set up to attempt to recover as much growth and yield information as possible on the wide range of trials which were established by the NTCC since this material is of an age which can deliver a great deal of information about growth and yield.
2. The NTCC trials also represent a resource of mature trees which can be used for milling and wood quality studies.
3. The NTCC trials comprise a collection of field tested genetic material which can be selected and propagated further for current trial and demonstration programs. This genetic material is very valuable and select material should be planted in a well designed framework for propagation and in a secure location.

The current range of trials being established needs to be well archived and supported by growth measurements and reporting so as to both maximise the value of the trials and the investment in the trial program.

4.5.4 Grower groups

All farm forestry growers interviewed between Darwin and Katherine were owners of small blocks, or owners of hobby farms who were developing small tree plantings on them. They are characterised by people who are well informed, have a source of income from the property being managed or outside the property, and are not dependent upon income from the trees, although all talked of the trees being their 'superannuation'.

The Katherine region is characterised by fertile deep loamy alluvial soils with high calcium content. The region is underlain by good quality ground water, and shows great potential for the establishment of agroforestry plantings on cleared land. However, cleared land is at a premium in the region, and native woodland would have to be cleared to promote large areas of exotic plantings. There is some potential to replace old fruit tree plantings of non-current varieties with such exotic timber species, but the extent is limited.

Several of the tree growers had undertaken the Master Tree Growers course delivered by The University of Melbourne School of Forestry in conjunction with GA. They spoke very highly of the course, the learning experience, and the education obtained from this short course.

All the growers visited had been supported by DPIF in the Northern Territory through NHT funding. Seedlings and advice were given freely by a DPIF officer; the growers provided land and established and maintained the plantation. The areas established were in the order of 1-2 ha, although some growers had continued to plant larger areas on their own initiative.

All plantings were established with cultivation and fertiliser applied at planting, weed control and drip irrigation. Control of weeds is an important and continuing expenditure.

Expectations are for logs of 60 cm diameter producing at least 5 m of clear log or a total of 20 m³/ha in an average of 12 years. Growth rates seen can support this objective in some areas.

Species being grown are shown in Table 8.

Table 8 Tropical timber species being trialed in the Northern Territory farm forestry plantings

Common name	Botanical name
Exotic species	
African Mahogany	<i>Khaya senegalensis, Khaya nyasica</i>
American Mahogany	<i>Swietenia humilis, Swietenia macrophylla</i>
Indian Mahogany	<i>Chukrasia velutina</i>
Teak	<i>Tectona grandis</i>
West Indian Cedar	<i>Cedrela odorata</i>
Guanacaste	<i>Enterolobium cyclocarpum</i>
Rosewood, Padauk	<i>Pterocarpus indicus, Pterocarpus macrocarpus</i>
Terminalia	<i>Terminalia belerica</i>
Butternut Rose	<i>Blepharocaryo involucrigera</i>
Australian Species	
Red Cedar	<i>Toona ciliata</i>
Red Mahogany	<i>Eucalyptus pellita</i>
Acacia	<i>Acacia mangium</i>
Canarium	<i>Canarium australianum</i>
Cypress pine	<i>Callitris intratropica</i>

4.5.5 R&D Priorities

The Northern Territory contains contrasts in optimism and pessimism about the future of planted forests. Recent work by enthusiastic landholders shows that there is potential for growing high value exotic timbers, and limited milling by a local specially equipped sawmiller has shown that niche markets can be found for specialised timbers. However, farm forestry development in the Northern Territory is beset with many hurdles, and the following research priorities are selected to resolve some of these.

A high priority is the rescue of old trials and information, and the use of these trials for establishment of long term growth and yield predictions, wood quality testing, and the capture of genetic improvement.

There needs to be research to define what is a critical growing and processing resource mass to address potential markets. Once the markets have been defined, silvicultural systems can be developed to deliver timber to the markets.

Wood quality testing is a high research priority in order to define what wood can be harvested at what age and the markets which can be addressed with the product.

Irrigation is an essential component of successful establishment and early growth of tropical timber woodlots. A high research priority is to define water requirements by fast growing tropical timbers, and the most effective use of water resources for tree growing.

Termites are a major pest of all timber plantings in the region. Research into environmentally friendly termiticides is a high priority in order to progress commercially successful tree growing

in the region. In addition cultural methods for controlling termite infestations should be investigated along with methodologies for applying termiticides to trees.

The region is free of tip moth which attacks *Swietenia*, *Khaya*, *Cedrella* and *Toona* species elsewhere. This needs to be maintained through strict plant quarantine.

4.6 Ord River / Bonaparte Region

4.6.1 The Region

Bio-regions covered CK, NK,OVP, VB.

Interviews were conducted in Kununurra and Perth.

4.6.2 Farming systems and farm forestry

The region is characterised by very high temperatures and evaporative demand. Farming systems form a marked contrast between the intensively managed 13,000 ha of the Ord River Irrigation Area (ORIA), and the surrounding savanna woodland used extensively for cattle grazing.

The ORIA is a black soil area which is irrigated from the waters of the artificial Lake Argyle. The land of the ORIA is freehold and competition for the land is intense. Land prices range from \$7,000 to \$12,000/ha.

Crops grown in the ORIA include sugar, bananas, mangoes, and a new attempt at growing cotton. Stage 2 of the ORIA will expand the area to some 60,000 ha, but there are mixed expectations about whether this development will go ahead. A major constraint on the development is the existence of Native Title over much of Stage 2.

The role of trees in the ORIA in lowering rising ground water tables is being recognised, but there is such competition for land that tree growing is not yet considered a priority.

Some tree growing has been carried out following research by CALM which developed from early work on Indian Sandalwood (*Santalum album*) done by CSIRO funded by ACIAR. Sandalwood is a hemi-parasite which requires a host plant in order to grow. There has been much research on host plants, and a local woody legume, is considered one of the best hosts. There is the hope that a commercially viable timber species could be used as the host, and trials are being made with teak and mahogany species.

The work on Sandalwood has resulted in the development of an industry focussed around growing the crop funded by monies raised through public prospectus. There are now some 840 ha of Sandalwood planted in the ORIA.

There is a growing Sandalwood processing industry which is focussed on export to south Asia, south east Asia and China of wood, processed wood, joss sticks and essential oils.

There are contrasting opinions on the relative potential of the Sandalwood species: Indian Sandalwood (*Santalum album*), West Australian Sandalwood (*Santalum spicatum*), and Queensland Sandalwood (*Santalum lanceolatum*). Each has different levels of oil production by the heartwood, and each has different timber properties. Some opinions are that *S. album* has a limited future because Asian cultures are changing, whereas others consider the future to be strong because of the demand and growing populations in the Asian regions.

The growing of Sandalwood has outpaced research, and growers are developing their own cultural management of the crop. The main biological constraint to the development of the Sandalwood industry is the availability of good seed and good genetic material.

Despite the relatively healthy Sandalwood growing industry, the rate of production of Sandalwood is almost a complete unknown. There is little known about oil recovery rates and heartwood production rates, and what the crop will produce and when. There are also common assumptions about the markets for the products that have little factual basis for their market predictions. It is considered by some land owners that the drivers for the Sandalwood industry, namely the Sandalwood prospectuses, are artificial and do not represent a mature market strategy. Small private growers consider themselves to carry very high risk in growing Sandalwood, funded by themselves, under the current climate of unknowns.

There has been limited attempts to grow exotic tropical timber species with limited success. Irrigation is essential to establish and maintain the tree crops in an environment where pan evaporation can reach 10 mm/day. In addition, the region is remote from markets, population and infrastructure. However, there is an understanding amongst growers of the use of trees in keeping water tables down, and in combating salinity from rising ground waters.

Tree growing has not been considered a commercial option on leasehold and aboriginal land in the region. Land tenure arrangements are a disincentive to pastoralists growing trees. In addition, conditions for tree growing are considered harsh with limitations caused by termites, fire, and high evapotranspiration.

Despite the problems of tree growing there is a strong sentiment that semi-arid lands have great potential for growing biomass for fuel production systems.

The region is considered one of the best regions for developing a bush tucker industry on aboriginal lands. This is because the traditional culture is still well practiced, there is a tourism base to provide income, there is some productive land which can be used for the purpose, and the native species are still an abundant resource.

4.6.3 Research Groups

4.6.3.1 *Ord-Bonaparte Program*

The Ord-Bonaparte Program is a collaborative R&D effort planned and implemented by regional stakeholders, industries and communities, WA government and Commonwealth agencies with a legislative responsibility for natural resource management and regional development. The overall objective of the program is to look at how environmental resources, regional economies and communities fit together within the Kimberly area. The program has just commenced and research plans for farm forestry and the role of trees in the environment are still being formulated.

4.6.3.2 *WA state government agencies*

Until recently the majority of research into farm forestry associated with wood production and related products was undertaken by CALM. Within the last two years this organisation has undergone considerable restructuring with CALM remaining in control of forestry and farm forestry research and the Forest Products Commission (FPC) being created. FPC has control of commercial timber production from state resources.

CALM has invested considerable effort and resources into researching aspects of Sandalwood culture both from commercial planting and native sources. Most of this information has been published in scientific journals or internal reports. There is a high priority to make this

information available to grower groups in a format that is more appropriate for their use. Traditionally, CALM has focused its farm forestry efforts in the SW of WA where salinity issues have necessitated the need for trees to be replanted in the landscape. The tropical northern areas of the state are characterised by small areas of freehold land surrounded by large leasehold areas. CALM has tended not to invest many resources into farm forestry in this area due to the perception of distance from markets and hence lack of commerciality and the issues surrounding native title.

4.6.4 Grower Groups

The region is characterised by three main land holders. There are the extensive pastoralists that primarily have large tracts of leasehold land, small intensive agriculturalists on freehold land and aboriginal communities on both pastoral leases and aboriginal lands.

The pastoralist and aboriginal groups manage vast areas of native timbers that potentially could be used for timber production as has been seen in a limited way in the Darwin region. Research is needed into potential markets for the timber that can be extracted from these regions and in the sustainable harvesting of this resource. Cattle production in the area is limited by protein droughts during the dry season, and research into fodder crops in the area has generally identified that trees are best grown in irrigated areas where stands can be maintained during the dry season. There is little need for research in the region for improving irrigated fodder crops, however research into establishment of fodder crops in dry land situations may be necessary.

Small intensive agriculturalists on freehold land growing high value horticultural crops in irrigated areas such as the ORIA have expressed concern about the movement of what they perceive as speculative tree products (Sandalwood prospectuses) into prime agricultural lands. This has resulted in an escalation of land prices. The ORIA is currently facing rising ground water problems and the role of trees in combating this is acknowledged, but there is little immediate incentive to remove scarce land from agricultural production. A high research priority for the ORIA is to determine the role of trees in the overall production system of that area.

4.6.5 R&D priorities

The Sandalwood industry has moved well ahead of the research, and growers are developing their own management systems. The role that research can best play in the Sandalwood growing industry is in sponsoring a collection of germplasm across the natural range of Sandalwood. This intellectual property for this collection should be closely controlled by JVAP with licensing arrangements to facilitate access by all interested parties.

There is also a research priority in coordinating germplasm collections for other target tropical timbers such as Teak, African Mahogany, American Mahogany, Cedar and Rosewood.

There is a need to have a coordinated approach to Sandalwood research across northern Australia. There is a need to set targets and timelines for delivery of collaborative research into sustainable Sandalwood management systems by active researchers across northern Australia. Such a research collaboration should bring together research into the constraints for Sandalwood growing including host plants, stocking densities, irrigation and termites.

If the Sandalwood industry is to be successful and not go the way of the tea tree industry, there is a pressing need to quantify rates of both oil and heartwood production of the range of Sandalwood species under culture, and under different growing conditions. This information is essential to provide stability and a future to the Sandalwood industry.

Pastoral lands have some timber potential, but there is little information on sustainable yields, and markets for the speciality timbers. Improving such information is a research priority, particularly where it may affect the sustainability of aboriginal communities.

Bush tucker is seen by many researchers and aboriginal groups as a potential business area for aboriginal communities. As with other regions, there is a pressing need to define potential bush tucker industries and business models under which such an enterprise might operate, together with industries such as tourism.

4.7 Conclusions from interviews

4.7.1 Overview

4.7.1.1 Current state of development of farm forestry

Farm forestry in northern Australia is in its infancy compared to the temperate farming systems of southern Australia. The areas which most clearly align to the southern Australia concept of farm forestry are south east Queensland and the Wet Tropics. These areas have had some history of land clearing and intensive farming development which makes them suitable for growing trees on farms for multiple benefits.

Much of northern Australia's farming landscape is under leasehold tenure which provides a disincentive to growing and managing trees on farms. Moreover, there is no strong incentive by land owners to establish trees on the limited areas of land which have recently been cleared of savanna woodland for pastoral or horticultural development.

Interest in farm forestry development in the strict sense in much of northern Australia is confined to growing mainly exotic timber trees under irrigation.

The most pressing issue in the management of perennial woody vegetation is sustainable use for and multiple products of savanna woodland.

The paradigm with the greatest potential to stimulate improved management of woody perennials on managed land is the concept of the provision by woody vegetation of ecosystem goods and services. In this concept, the ecological value of trees has a transactional monetary value which provides low level but continuous income to the landholder for the provision of landscape, soil, water and biodiversity values which are of benefit to the broader community.

4.7.1.2 Markets

One of the most pressing needs to ensure a commercial return from investment in growing trees on farms and to sustainably manage native vegetation is knowledge of timber markets, volumes traded and prices. This information, widely disseminated, will do more than any other information to stimulate landholders to plant trees for a profitable return.

The remoteness and small scale of the development of any farm forestry timber growing industry in northern Australia are its greatest constraints. Market information will allow potential growers the confidence to invest in key suitable areas such as Cairns, Katherine and Kununurra.

The reduction in the availability of suitably priced land for development of forestry projects by prospectus based investment companies in southern Australia is driving such companies into northern Australia. The companies are entering the region with little solid growing and market

information on which to develop their projects. This pressure may see greater investment by the private sector in research to ensure the successful establishment of trees by such companies.

4.7.1.3 Research collaboration

The extent of research collaboration across northern Australia is markedly different between regions.

In south east Queensland and the wet tropics there is strong competition between research agencies for funding. TREM has strong and relevant programs and plays a strong role in the region, but it does not provide the expected synergy of research effort in the region. This is a function of the various agencies rather than the efforts of the CRC.

By contrast, in the Northern Territory there is strong collaboration between agencies and it is difficult to differentiate 'ownership' of research and development programs.

In Western Australia the research and development effort for the northern part of the state is very low, and is carried by the main agency CALM with limited input from other researchers in CSIRO and the Universities.

4.7.1.4 Intellectual property

There is a move by all research agencies to realise the intellectual property value of research information. In many cases this is being done with no clear mechanism within the agencies to licence the information to interested parties. There is also some confusion about the availability of research information which was collected previously with the use of public funds. The outcome of heightened protection of research results is a restriction of information released to the public domain and restrictions on the communication of research results to public or commercial inquiries. Researchers questioned in this survey responded that such lack of communication of research results is pushing researchers into duplication of research effort. The inevitable result of this is less communication amongst researchers and with stakeholder parties, and potentially lower quality research which is not widely useable.

4.7.1.5 Role of JVAP

The parties interviewed projected a strong and repeated theme that there is a need for leadership in development of forestry research in all its forms in northern Australia. Perhaps because of the focus of the interviews, JVAP was promoted as the most appropriate lead agency. Growers and researchers alike repeated the need for strong leadership in the region and in the subject area. Leadership is required to ensure a commercial focus of research effort, to ensure group synergies, and to ensure communication of results to the client base.

JVAP has a lead role to ensure that the information collected under its funding is made readily available and widely disseminated to all interested parties.

4.7.2 Aboriginal groups: research priorities

The consultants were told repeatedly by aboriginal groups that this study has neither the resources nor the time allocation to pay adequate service to the needs of aboriginal groups for research into the management of woody perennials on their land. The JVAP focus on trees on managed land does not translate easily into the use of aboriginal land. In order to resolve this issue, a well structured study needs to be carried out concentrating on the specific requirements of aboriginal communities, the potential for commercial management of native timber resources, and the

potential for other woody perennial crops. In developing this study, recognition must be given to the time required to gather information from traditional owners and the need to visit each individual community as the requirements of each will differ greatly.

In spite of the inability of the current study to adequately address research strategies and priorities for aboriginal communities, there is a very clear message from a range of stakeholders that ‘bush tucker’ is a subject worthy of further research. This topic however must be viewed without commercial paternalism. The potential may well be in conjunction with other enterprises such as tourism.

There is a high priority to provide aboriginal training scholarships and traineeships in natural resource management, together with agribusiness skills so as to better equip communities to progress commercial development of natural timber resources.

4.7.3 Cross-regional research priorities

Research priorities which had a common theme across regions include the following:

- Wherever timber is grown in woodlots across northern Australia there is a request for market information to underpin the investment. The provision of market information for tropical timber species is a very high priority. Current market information provided by ITTO (eg ITTO 2001) could be expanded upon and communicated widely to growers through pertinent information channels which are readily available across northern Australia.
- There is a very high priority for research into wood quality of the tropical timber species grown. This relates not only to the exotic timbers such as African and American Mahogany, Teak and Sandalwood, but also to selected native species which have niche markets and which can be commercialised.
- Due to low and variable rainfall, trees cannot be established and grown successfully across much of northern Australia without the use of irrigation. There is a very high priority for research into effective use of water in irrigating tree woodlots in low rainfall areas across northern Australia.
- Termites are a major threat to successful commercial realisation of investment in tree plantings across northern Australia. There is a very high research priority to develop environmentally friendly termiticides in conjunction with cultural methods for wide use by growers in a range of environments.
- There is a high priority to target research focus across agencies into specific common tasks such as multi-agency research into African Mahogany or Sandalwood. The research should be targeted on all aspects of growing, processing and marketing the species. Such concerted research will result in synergies of effort, and a body of high quality information for target species.
- There is a high priority for research into the sustainable management of savanna woodland for commercial timber production in areas such as Cape York where aboriginal communities may benefit, and markets may be within reach.
- The paradigm of environmental goods and services is one which recognises the multiple benefits of trees in the landscape. This concept alone provides the potential to facilitate

the establishment and sustainable management of trees in many parts of northern Australia. This concept is immature in its application to monetary transactions, and a high research priority is to define mechanisms by which trees in the landscape can be recognised and valued, and their value passed over in a transaction between the community and the landholder.

4.7.4 Regional research priorities

4.7.4.1 South east Queensland research priorities

This area is of moderate extent and is characterised by a large population, relatively intensive agricultural activities, a mature softwood plantation and native forest industry, and interest in investment in plantation forestry. The highest research priorities in this region are:

- Research into the wood properties and milling properties of plantation grown hardwood species.
- Silvicultural research which makes commercial use of small diameter timber from a wide range of species.
- Cost benefit analysis of silvicultural treatments such as pruning on log values.

4.7.4.2 Wet Tropics research priorities

This area is geographically focussed and small. Because of the establishment of a World Heritage Area over the native rainforest communities, there has been a history of research and development in the establishment of plantations of rainforest timber species.

The highest priority in this area is to write up and widely publish the results of more than a decade of CRRP planting activities. This must be done by all parties involved including NQA, QFRI, CSIRO, TREM and CRRP growers. The outcomes from the project must be directed towards communication of the results to the client community rather than the research community. To achieve this, the project must involve a group close to the client base such as NQA.

4.7.4.3 Seasonal dry tropics research priorities

This area, together with the northern savanna has by far the greatest extent and the least development in farm forestry. The area is characterised by a small population, extensive land holdings, comparatively little cleared land despite locally intensive land clearing in some areas, and aboriginal community interest in land management.

There are no specific research priorities for this region: the research priorities are those proposed across regions in Section 4.7.2 and 4.7.3.

4.7.4.4 Northern savanna research priorities

This area, together with the seasonal dry tropics has by far the greatest extent and the least development in farm forestry.

The most pressing regional research priority is the rescue of growth yield and wood quality information from trials established more than 20 years ago in the Northern Territory. This information will do more than anything else to underpin the commercial potential of timber species in the region.

4.7.4.5 Ord River /Bonaparte region research priorities

This area is remote and has a high contrast in land use in one small area. The research priorities pertinent to this area are selected from those pertinent across northern Australia, including the need for coordinated research into Sandalwood as a crop, the use of irrigation in growing tree crops and the sustainable management of native timber resources and identification of appropriate markets.

5 Stakeholders' agroforestry priorities

5.1 Introduction and methodology

Client stakeholders (e.g. tree growers and farmers) and researcher stakeholders were sent questionnaires covering the range of issues associated with agroforestry in northern Australia. The objective of the questionnaire was to obtain feedback from a wider group of stakeholders than could be achieved by face to face interviews. Since the result of any research effort is to provide further information on a particular topic, the questionnaire was designed to determine where the recipient perceived that additional information would assist the development of agroforestry systems in their field of influence, activity or interest.

The questionnaires used in the survey are shown in Appendix C.

The questionnaire was designed to obtain quantitative score-based information on the main issues which affect the development of agroforestry systems. These issues are detailed in the R&D Plan for the Agroforestry and Farm Forestry Joint Venture Agroforestry Program 1999-2004 (RIRDC 1999). The context of the questions was drawn from the six objectives of the R&D Plan, and the strategies outlined to achieve the objectives. This resulted in 22 questions related to the content of the R&D Plan. The subject of the questions is shown in the following table; questions 1-7 were concerned with respondent information.

Table 9 Question number and question subject matter

Question number	Question subject	JVAP strategy No.
8	Markets, market information, and their development for agroforestry products.	1.1, 1.2
9	Cultural, legislative, policy or legal constraints to the development of agroforestry systems.	1.3
10	Community participation for sharing costs and resources for agroforestry development.	1.5
11	Water movement in the landscape.	2.1, 2.3
12	Control of salinity.	2.1
13	Biodiversity and nature conservation.	2.2
14	Carbon sequestration capacity.	2.4
15	Soil properties.	2.5
16	Productivity of farming enterprises	3.1
17	Species and provenances.	2.5, 4.1, 4.2
18	Availability of seedlings.	4.1, 4.2
19	Wood processing technologies.	4.3
20	Cultivation, weed control and fertiliser use.	4.4
21	Spacing, pruning, thinning and harvesting systems.	4.4
22	Control of insects and pests.	4.5
23	Management of weeds.	4.4
24	Management of high winds.	3.2
25	Design options with grazing and cropping systems.	5.1
26	Sustainable management of native forests on farmland.	5.2
27	Financial and economic viability of agroforestry options.	5.4
28	Threats to financial and economic viability of agroforestry options.	5.4
29	Contact with research groups and extension activities.	6.1, 6.2

Respondents were asked to rank, on a five point scale, the degree to which further information on the topic would assist development of agroforestry systems in their region. This approach allowed the respondent to give equal or marginally scaled priorities to the topics presented. This approach was considered to be better than a request to provide a simple ranking of topics which would have forced a greater contrast between topics than was perceived by the respondent.

The questionnaire was also designed to obtain background information from the respondents which was pertinent to interpretation of the responses. Such information included the type of organisation represented by the respondent, the geographical scope covered by the respondent, and farming activities and the state of farm forestry in the regions covered.

Respondents were also encouraged to provide a narrative response to the issues and to raise issues not covered by the questionnaire.

5.2 Return of questionnaires

A total of 330 questionnaires were distributed to both client and researcher stakeholders; this includes all clients and researchers interviewed who were also encouraged to complete a questionnaire. A total of 77 responses were received; this is a 23% response rate.

A total of 290 questionnaires were sent out to client stakeholders, and a total of 57 responses received: a 20% response rate. The response rate amongst researchers was much higher with a 50% response rate from a total of 40 questionnaires distributed.

5.2.1 Regional responses

The area of northern Australia covers 43 bioregions. The responses received from both client and researcher stakeholders is shown by the 22 regions from which client responses were received in Table 10. No client responses were received from the 21 regions not shown in Table 10, but four researchers expressed a research interest in all regions of northern Australia. Note that both clients and researchers often noted an interest in more than one region.

Table 10 Client and researcher responses received by region, ranked by client responses.

Region	SEQ	WT	BBN	EIU	BBS	TEC	VB	CMC	GUP	CYP	DAB	DEU	PCA	CK	MGD	DL	GSD	MII	ML	NK	OVP	TAN
Client	11	11	9	8	7	7	7	5	5	4	4	3	3	2	2	1	1	1	1	1	1	1
Researcher	6	10	7	7	5	8	6	4	4	5	7	3	8	3	5	3	3	4	3	3	4	3

The majority of client responses came from south eastern Queensland and an equal number from the wet tropics regions. The wet tropics region also provided the greatest number of researcher responses. The dry tropics west of these regions provided the next largest grouping of respondents. Respondents were concentrated around the eastern and northern rim of northern Australia, with little or no representation from central and western areas.

5.3 Responses to questions

5.3.1 Regional groupings

The large number of bioregions and relatively small number of responses required that like - regions were amalgamated for analytical purposes. The regional groupings included:

- SEQ/CMC (south eastern and central coast Queensland)
- BBS/BBN/DEU/EIU (dry tropics)
- WT (wet tropics)
- CYP/GUP (Cape York and Gulf Plains)
- TEC/PCA/DAB/VB (Top End)

It is acknowledged that there may be some significant differences within these groupings but, on balance, these groupings were considered to provide sufficient similarities and number of respondents with which to interpret priorities for research in the regions.

5.3.2 Characteristics of client respondents

The majority (30%) of all client respondents were land owners, with a further 40% coming from a combination of Landcare or farmer organisations (Table 11). Nineteen percent of responses were

received from client stakeholders in government agencies. Within the regional groupings shown in Table 11, the wet tropics and the Cape York/Gulf Plains were represented most by forest grower groups with relatively small representation from land owners.

No responses were received from aboriginal groups since these groups were not well targeted in this study. Additional time and a separate strategy is required to obtain priorities for agroforestry and vegetation management for land controlled by aboriginal groups.

Table 11 Group membership of client respondents (percent of total in region class).

	Land owner	Landcare/ catchment group	Farmer org.	Forest grower group	Regional Plantation Committee	Aboriginal org.	Govt. agency	Other
All regions	30.4	21.5	3.8	19.0	3.8	0.0	19.0	2.5
SEQ/CMC	21.7	21.7	0.0	26.1	0.0	0.0	26.1	4.3
BBS/BBN/DEU/EIU	13.8	34.5	3.4	20.7	6.9	0.0	20.7	0.0
WT	6.3	18.8	6.3	37.5	12.5	0.0	18.8	0.0
CYP/GUP	9.1	18.2	9.1	27.3	18.2	0.0	18.2	0.0
TEC/PCA/DAB/VB	59.3	3.7	7.4	11.1	3.7	0.0	11.1	3.7

Overall, respondents from northern Australia were from areas dominated by either grazing or horticulture (Table 12). Sugar production was of significance in the wet tropics and the Cape York/Gulf Plains, and horticulture dominated the Top End regions (TEC/PCA/DABN/VB).

Table 12 Farming activities in regions of client respondents (percent of total in region class).

	Grazing	Dairying	Horticulture	Sugar	Other crops
All regions	28.6	14.3	25.2	14.3	17.7
SEQ/CMC	27.1	27.1	18.8	10.4	16.7
BBS/BBN/DEU/EIU	33.3	13.7	17.6	13.7	21.6
WT	23.1	20.5	20.5	23.1	12.8
CYP/GUP	21.7	17.4	21.7	21.7	17.4
TEC/PCA/DAB/VB	25.6	2.3	39.5	14.0	18.6

5.3.3 Characteristics of researcher respondents

Half of the researcher respondents were from State Government Agencies (Table 13), with a further 41% of respondents from a combination of Universities, CSIRO and the three CRCs (Tropical Rainforest Ecology and Management, Tropical Savannas, and Sustainable Production Forestry).

Table 13 Group membership of researcher respondents (percent of total).

University	CSIRO	CRC	State Government Agency	Federal Government Agency	Grower Cooperative	Private sector
13.6	13.6	13.6	50.0	0.0	4.5	4.5

5.3.4 Client responses

The level of agroforestry activities conducted in the regions was very low. Amongst these activities, use of trees on farms for traditional roundwood and sawn wood production dominated

the dry tropics regions. Multiple use of trees on farms for fodder, shade shelter and soil and water protection dominated the wet tropics and the Cape York and Gulf Plains regions. The Top End was dominated by use of trees for craft wood and for fodder, shade and shelter (Table 14).

The opportunities for agroforestry were considered to be fairly widely spread across the categories with little strong discrimination between categories or regions (Table 15).

The priorities for additional information to assist the development of agroforestry are shown in Table 16, together with the top five priorities in each region. The highest overall priority was for information about species and provenances for planting. The top five priorities across regions included:

- Additional market information for agroforestry products,
- Addressing cultural, legal and policy constraints to agroforestry,
- Community participation and cost sharing for agroforestry projects,
- Agroforestry for protection of stock and crops,
- Availability of seed and seedlings,
- Silvicultural information on spacing and harvesting,
- Information on financial viability of agroforestry projects,
- Information on financial threats to agroforestry projects, and
- Increased links with research and extension activities.

Table 14 Current agroforestry activities in regions (percent of total in region class)

	Roundwood	Sawn wood	Craft timber	Fodder shade shelter	Water protection	Soil protection	Soil improvement	Salinity control	Biodiversity conservation	Biofuel	Firewood	Carbon capture & credits	Food	Fruit cropping	Pharmaceuticals	Extractives	Other
All regions	10.4	10.8	9.3	10.8	8.2	8.2	4.9	2.6	8.6	1.1	3.7	1.5	3.7	6.0	2.2	6.0	1.9
SEQ/CMC	11.8	15.1	9.7	10.8	6.5	6.5	5.4	3.2	8.6	0.0	6.5	3.2	2.2	3.2	1.1	4.3	2.2
BBS/BBN/DEU/EIU	10.4	11.3	7.0	11.3	8.7	9.6	6.1	4.3	9.6	1.7	3.5	1.7	2.6	3.5	2.6	3.5	2.6
WT	8.6	10.0	5.7	10.0	12.9	11.4	7.1	1.4	11.4	2.9	2.9	2.9	2.9	2.9	1.4	2.9	2.9
CYP/GUP	6.1	8.2	8.2	10.2	10.2	10.2	6.1	2.0	10.2	4.1	4.1	4.1	2.0	6.1	2.0	6.1	0.0
TEC/PCA/DAB/VB	5.0	6.7	15.0	10.0	6.7	6.7	1.7	1.7	5.0	1.7	1.7	0.0	6.7	16.7	1.7	11.7	1.7

Table 15 Opportunities for agroforestry activities in regions (percent of total in region class)

	Roundwood	Sawn wood	Craft timber	Fodder shade shelter	Water protection	Soil protection	Soil improvement	Salinity control	Biodiversity conservation	Biofuel	Firewood	Carbon capture & credits	Food	Fruit cropping	Pharmaceuticals	Extractives	Other
All regions	6.8	8.7	7.8	7.0	6.0	6.4	6.2	6.2	7.4	4.3	3.5	6.4	5.6	4.7	4.7	6.0	2.3
SEQ/CMC	6.3	8.0	6.8	6.8	5.1	6.3	6.3	6.8	6.8	6.3	5.7	6.8	5.1	5.1	4.5	3.4	4.0
BBS/BBN/DEU/EIU	7.1	8.7	6.1	7.1	6.6	7.1	7.1	6.6	7.1	5.1	2.0	6.1	5.6	3.6	5.1	6.1	2.6
WT	6.9	8.9	5.9	5.9	6.9	5.9	5.0	5.0	6.9	5.9	3.0	6.9	5.9	5.0	5.0	5.9	5.0
CYP/GUP	6.1	6.1	6.1	6.1	7.3	7.3	6.1	4.9	7.3	6.1	3.7	6.1	6.1	4.9	6.1	6.1	3.7
TEC/PCA/DAB/VB	6.8	8.2	9.6	6.2	6.2	6.8	6.2	6.2	6.8	2.7	2.7	6.2	4.8	5.5	5.5	8.9	0.7

Table 16 Client responses to information requirements. Scores between 1 (information will not assist) and 5 (information will greatly assist).

	Market information	Cultural/legal/policy constraints	Community participation	Water movement in landscape	Control of salinity	Biodiversity & nature conservation	Carbon capture and credits	Influence of soil properties	Protection of stock and crops	Species and provenances for planting	Availability of seed and seedlings	Wood processing technologies	Tree establishment techniques & costs	Spacing/pruning/harvesting information	Control of insects & pests	Weed management	High winds	Multiple benefits of agroforestry	Management of native vegetation	Financial & economic viability	Financial & economic threats	Links with research & extension activities
All regions	4.24	4.16	4.21	3.43	3.22	3.35	3.44	3.64	3.65	4.36	4.22	3.67	3.75	3.78	3.65	3.58	3.16	3.80	3.65	4.20	3.87	4.22
Rank	2	7	5	19	21	20	18	16	13	1	3	12	11	10	13	17	22	9	13	6	8	4
SEQ/CMC	4.21	4.45	4.40	4.00	4.00	3.79	3.93	3.79	3.93	4.71	4.00	3.64	3.93	3.64	3.43	3.50	3.21	3.71	4.21	4.29	3.71	4.50
Rank	6	3	4	8	8	14	11	14	11	1	8	18	11	18	21	20	22	16	6	5	16	2
BBS/BBN/DE U/EIU	4.61	4.18	4.13	3.56	3.61	3.44	3.12	3.56	4.22	4.22	4.00	3.78	3.72	3.67	3.44	3.56	3.11	3.94	4.11	4.33	4.17	4.17
Rank	1	5	8	16	15	19	21	16	3	3	10	12	13	14	19	16	22	11	9	2	6	6
WT	3.91	4.33	4.33	3.30	2.91	3.36	3.50	3.36	3.91	4.00	4.17	3.82	3.27	3.27	3.18	3.36	3.55	3.55	3.45	3.91	4.00	3.64
Rank	6	1	1	18	22	15	13	15	6	4	3	9	19	19	21	15	11	11	14	6	4	10
CYP/GUP	4.83	4.50	4.40	3.83	3.50	3.67	3.60	4.00	4.33	4.33	4.33	4.33	4.00	4.00	3.67	3.83	3.83	4.00	4.17	4.83	4.67	4.17
Rank	1	4	5	16	22	19	21	12	6	6	6	6	12	12	19	16	16	12	10	1	3	10
TEC/PCA/DA B/VB	4.10	3.89	3.75	3.14	2.67	3.00	3.48	3.76	2.90	4.29	4.43	3.57	3.81	4.00	3.95	3.52	3.10	3.48	2.76	4.00	3.62	4.10
Rank	3	8	11	17	22	19	15	10	20	2	1	13	9	5	7	14	18	15	21	5	12	4

Table 17 Comparison of client and researcher responses to information requirements. Scores between 1 (information will not assist) and 5 (information will greatly assist).

	Links with research & extension activities	Financial & economic threats	Financial & economic viability	Management of native vegetation	Multiple benefits of agroforestry	High winds	Weed management	Control of insects & pests	Spacing/pruning/harvesting information	Tree establishment techniques & costs	Wood processing technologies	Availability of seed and seedlings	Species and provenances for planting	Protection of stock and crops	Influence of soil properties	Carbon capture and credits	Biodiversity & nature conservation	Control of salinity	Water movement in landscape	Community participation	Cultural/legal/policy constraints	Market information
Clients	4.22	3.87	4.20	3.65	3.80	3.16	3.58	3.65	3.78	3.75	3.67	4.22	4.36	3.65	3.64	3.44	3.35	3.22	3.43	4.21	4.16	4.24
Rank	4	8	6	13	9	22	17	13	10	11	12	3	1	13	16	18	20	21	19	5	7	2
Researchers	4.25	4.30	4.60	4.00	4.30	3.10	3.60	3.63	3.95	4.16	3.78	3.50	4.50	4.20	3.90	3.80	3.10	3.00	3.20	3.79	3.53	4.15
Rank	5	3	1	9	3	20	16	15	10	7	14	18	2	6	11	12	20	22	19	13	17	8

Cultural, legal and policy constraints to agroforestry development were considered important priorities and included three main topics:

- Security of harvest on freehold land,
- Status of ownership of trees on leasehold land, and
- Uncertainty of land use and investment caused by native title.

5.3.5 Researcher responses

The top five researcher priorities for information requirements that would assist the development of agroforestry included:

- Financial and economic viability,
- Species and provenances for planting,
- Financial and economic threats,
- Spacing and species mix for multiple benefits, and,
- Links with research and extension groups.

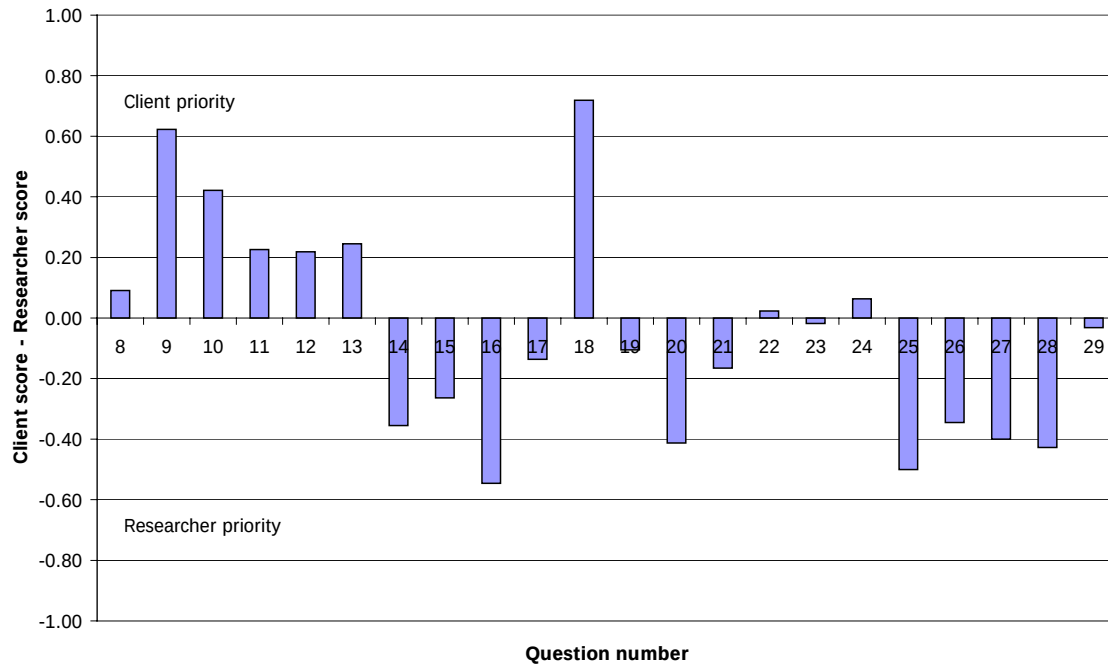
5.3.6 Contrasts between clients and researchers

There were some marked differences between clients and researcher stakeholders in the priorities given to information requirements as shown in Figure 5. The most marked difference was for availability of seed and seedlings (18) which was given a much higher priority by clients than by researchers. Clients tended to give higher priorities than researchers to information on cultural and legal constraints (9), community participation (10), and the effect of trees on water (11), salinity (12) and nature conservation and biodiversity (13).

By contrast, researchers gave higher priorities to information on carbon capture and carbon credits (14), soil properties (15), protection crops and stock (16), tree establishment (20), design for multiple benefits of agroforestry (25), sustainable management of native forests (26), and information on financial and economic viability of (27) and threats to agroforestry systems (28).

These differences between clients and researchers reflect differences brought about by attempting to implement agroforestry systems on the clients' part, and perceptions of where agroforestry should be heading on the researchers part.

Figure 5 Differences between client and researcher priorities. Refer to Table 9 for details of questions.



5.4 Conclusions from questionnaires

Priorities for information for agroforestry which were common to both client and researcher stakeholders included:

- Information on financial viability of agroforestry projects,
- Information on financial threats to agroforestry projects, and
- Increased links with research and extension activities.
- Additional client priorities for information included:
- Additional market information for agroforestry products,
- Addressing cultural, legal and policy constraints to agroforestry,
- Community participation and cost sharing for agroforestry projects,
- Agroforestry for protection of stock and crops,
- Availability of seed and seedlings,
- Silvicultural information on spacing and harvesting,
- Additional researcher priorities for information included:
- Species and provenances for planting, and,
- Spacing and species mix for multiple benefits.
- Cultural, legal and policy constraints were considered important priorities and included three main topics:

- Security of harvest on freehold land,
- Status of ownership of trees on leasehold land, and
- Uncertainty of land use and investment caused by native title.

The conclusion from these prioritised categories is that there is a common concern for information about the financial viability of investment in agroforestry projects, and a common desire to both receive and deliver research and extension information about agroforestry systems. Client priorities extended to include the practical aspects of implementing agroforestry projects which includes the mechanisms of establishing trees, availability of planting material and how to configure it in the landscape. Client priorities also reflected a concern for markets, cultural and legal constraints to implementation, and facilitation of community participation and sharing of costs and equipment.

6 Conclusions and priorities

6.1 Constraints to agroforestry

Constraints to agroforestry development in northern Australia are based on both a lack of confidence in investment in agroforestry, and a lack of information in key areas to support confidence in investment.

From the questionnaire responses it was evident that a lack of confidence in investment in agroforestry is based on issues of:

- Security of harvest on freehold land,
- Status of ownership of trees on leasehold land, and
- Uncertainty of land use and investment caused by native title.

These issues can be alleviated by clarification and enactment of existing legislation, and implementation of new legislation which ensures the realisation by owners of their investment in planted trees, or their ability to sustainably manage native vegetation on a commercial basis.

Encouraging uptake of agroforestry by private landholders or leaseholders is one of encouragement rather than coercion, and is largely dependent on the commercial viability of the agroforestry enterprise. This applies equally to the sustainable management of native vegetation on private land, where landholders need to be convinced of the benefits of sustainable management to the sustainability of their own agricultural enterprise. Moreover, "...if the considerable public benefits offered by agroforestry are to be achieved, we need a growing commercially viable agroforestry sector." (RIRDC 1999).

The above constraints are critical to the uptake of farm forestry and improved management of native vegetation on farmland in northern Australia. The constraints are institutional; they are not issues which are resolvable through research prioritisation or funding. This is not to deny that a research outcome may highlight the constraint as an impediment to implementation of research outcomes.

Agroforestry in northern Australia is in its infancy. There are very large gaps in basic information which is required to underpin agroforestry development, and there is a lack of coordination of information which does exist. Those wishing to invest in farm forestry activities on their properties are faced with shortages of information on all aspects of the enterprise ranging

from products and markets to what species to grow, how to grow them, and quantification of yields and economic and environmental benefits.

Within this diffuse and patchy information base there are two clear frameworks on which to create a prioritisation of research for northern Australia: these include maximising the economic and environmental return from planted trees, and maximising the economic and environmental value derived from improved management of native vegetation on farms.

6.2 Economic and environmental returns from planted trees.

Research priorities to maximise the economic and environmental returns from planted trees are centred on issue of ensuring the provision of an economic return to the grower. These areas include:

- Markets for species grown, including the products produced, their value and marketability, and certification requirements to address export markets.
- Species to be grown and how they are grown in terms of spacing, silviculture and integration into farming systems.
- Treatment of planted trees in a non-traditional market sense for their innate environmental value: treating them as an environmental good or service. This involves establishing a transactional value for the value of the trees in enhancing environmental values for the community.

With the exception of the last point, these research priorities are no different from those which are fundamental to the establishment of a new rural industry. Such information is fundamental for any investor in any new rural industry. For example, if a farmer was evaluating a move into peanut cropping, he or she would identify markets for the crop type and varieties suitable to be grown on the available soil type, and draw up a schedule of yields and a cash flow for costs and returns. With the assembled information a farmer may then make the decision to raise capital and invest. In the case of agroforestry, many of the key fundamental to such an investment decision are unavailable, hence there is reluctance to put scarce capital in high risk, unknown or unsubstantiated markets, costs, yields, and returns.

Treatment of planted trees for their value, in a non-traditional market sense, as an ecosystem good or service is an innovative development in valuing a rural enterprise, and a great deal of research is required to develop methodologies to establish a transactional values for trees in a variety of guises.

6.3 Economic environmental and value of native vegetation.

Much of northern Australia's agricultural environment is comprised of pastures in woodland ecosystems, i.e., savannas. This is markedly different from southern Australia where much of the agricultural landscape has been cleared of trees. Moreover, in many of the savanna woodlands of northern Australia, clearing of trees is a temporary ecosystem perturbation, and trees regenerate readily in the landscape unless energy is expended by the farmer or grazier to suppress them.

Against this background, a clear priority is research to provide mechanisms to encourage farmers and graziers to retain trees in the landscape. In order to do this, farmers and graziers need to have an understanding for their particular woodland ecosystem, often in a low and variable rainfall environment, of the requisite balance of trees in the landscape to provide sufficient pasture to sustain grazing, whilst providing shade and shelter for stock and protecting water and salt movement in the landscape.

Retention of native vegetation on farmland can also be treated as an ecosystem good or service when it increases landscape aesthetic values, conserves biodiversity, protects catchments, conserves water in the landscape and protects the region from salinity. If these benefits extend outside the confines of the managed property, then there is a clear case for a transactional value to be placed on such retention. Some models currently exist for the creation of 'credits' for beneficial action such as carbon credits or salt credits. This is the focus of much innovative research into quantifying values and creating transaction mechanisms which benefit the farmer or grazier.

6.4 Addressing the Terms of Reference

The Terms of Reference are addressed below with attention to the three specific subject areas: a review of completed and current research into agroforestry in northern Australia, the key agroforestry R&D gaps for the range of agricultural systems in northern Australia, and a list of recommended R&D priorities arising from the gap analysis.

6.4.1 Review of completed and current research into agroforestry and farm forestry in northern Australia.

The canvassing of some forty researchers involved in some aspect of agroforestry research in northern Australia illustrates the relatively small research effort which is applied to the region. This is supported by the relatively sparse published research base of some 70 papers reviewed for this project. Both the existence and the sparsity of both research and publications reveals large gaps in the R&D effort for northern Australia.

Pastoral systems are a dominant component of agricultural systems over much of the drier parts of northern Australia. Thus it is important that the role of existing native trees in the pastoral system needs to be further explored. It is acknowledged that trees play a role in nutrient cycling and improve pasture quality, however, more research is required to allow these effects to be incorporated into existing modelling programs. The results of existing modelling efforts have not been disseminated widely, and there is great benefit to be gained in the provision of extension of modelling outcomes to graziers who may be able to use the results to better manage their agricultural systems. Consequently, both research and extension is required to better translate the affects of varying tree density in the landscape on pasture quality and production, to those who may best be able to use it.

Tree fodder legume research has been well published in a number of international and domestic reports. There is a requirement however to establish a series of trials in key areas of northern Australia to highlight and demonstrate the key research findings to pastoralists. These trials should be linked with timber production trials in these key areas so that pastoralists and wood producers are encouraged to observe both types of agroforestry systems for their region.

Despite the obvious importance of the CRRP plantings and the research undertaken in them, the development of an agroforestry industry in the wet tropics has stalled. The CRRP plantings and others established in the dry tropics are important resources that need to be regularly monitored for tree growth. The results must be disseminated quickly so that maximum potential marketing of the role of trees in the landscape can be presented to growers. In addition the trials need to be used as demonstration sites, where appropriate, to maximise the use of each site. Apart from one report prepared within QFRI, there are no useful publications arising out of the CRRP program. A clear priority is to provide the means to remedy this situation and to communicate the results, both good and bad, to potential farm forestry investors in the wet tropics.

There is a lack of information on the marketing of wood products in both the domestic and international markets, and how the role of eco-labelling or certification will effect these markets in the future. There is a requirement for a detailed marketing plan to be established for the timber producing species to be grown in northern Australia.

There appears to be very little published research information on the establishment of agroforestry trees for timber production in the dry tropics. More than 1,000 trials have been established in the Northern Territory over a period of some 30 years, and a clear priority is to step up efforts to recover as much information as possible about this material, much of which will be at an age suitable for commercial timber evaluation. Overall there is a dearth of information on wood quality and wood processing for native or introduced timber species in northern Australia. These trials, if found, could be used to provide millable timber and hence wood quality information, as well as providing a basis for the selection of the best genetic material from the trials for establishing propagation banks.

The paucity of published information, together with requests from landholders, reveals the need to establish high quality research/demonstration trials in key areas in the dry tropics that can be utilised by a range of researchers and extension officers for timber production using introduced and native tree species. Most importantly, these trials need to be established so that they and their results can be perpetuated and communicated.

The opportunity for farm forestry to enhance biodiversity in the landscape is well recognised, however, there is little scientific evidence to illustrate the comparative and relative difference in biodiversity between different types of farm forestry plantings and cleared, disturbed or undisturbed land in northern Australia. It is acknowledged that some farm forestry plantings, particularly of exotic species, will not contribute to biodiversity conservation. In southern Australia, considerable effort has been targeted at developing innovative systems to increase biodiversity including using nurse trees and habitat plantings, but this type of research has not been undertaken on a useful scale in northern Australia.

The knowledge base and attitudes of growers to agroforestry needs to be understood further to assess the effectiveness of extension and marketing programmes in convincing growers to adopt agroforestry as an integrated farm production system. Consequently, it is important that the knowledge base and growers' attitudes be assessed in a manner that will allow for the continual sampling of these attributes in time so that extension and research programs in the agroforestry can be effectively monitored.

6.4.2 Key agroforestry and farm forestry R&D gaps for the range of agricultural systems in northern Australia.

Research gaps which had a common theme across regions include the following:

- Market information for timbers to demonstrate market realities to investors.
- Research into wood quality of the tropical timber species grown.
- Sustainable management of savanna woodland for commercial timber production.
- Define mechanisms by which trees in the landscape can be recognised and valued, and transacted between the community and the landholder.
- Effective use of water in irrigation for establishment of tree woodlots in low rainfall areas across northern Australia.

- Environmentally friendly termiticides in conjunction with cultural methods for use by growers in a range of environments.
- Bush tucker as a research area and priority requires clear definition of its content, scope, geographical and commercial potential.
- Research gaps for south eastern Queensland include:
- Wood and milling properties of plantation grown hardwood species.
- Cost benefit analysis of silvicultural treatments such as pruning on log values and the use of small diameter timber from a wide range of species.
- One specific research gap in the wet tropics is:
- Write up and widely publish the results of more than a decade of CRRP activities.
- There are probably more numerous R&D gaps for the northern savanna areas than for other parts of northern Australia, but the most specific research gaps are:
- The rescue of growth yield and wood quality information from trials established more than 30 years ago in the Northern Territory.
- Coordinated research into Sandalwood and other exotics as crop species.

6.4.3 R&D priorities based on potential achievement of economic, social and environmental benefits.

A specific term of reference in this section concerned whether JVAP has a role in determining appropriate tree density and spacing in woodland/pasture systems (generally a role for the MLA Northern Australia Program). There is a clear research priority in defining appropriate tree density and spacing in woodland pasture systems which occupy much of the grazing systems of northern Australia, and this should build on modelling already done as discussed in Section 4.4.3 and Section 6.4.1. This is a high priority to ensure the retention of native vegetation to protect landscape and water values whilst contributing to commercial sustainability of farming enterprises. This is a priority of the MLA northern Australia program and is likely to gain greater prominence, although more from the graziers' point of view, in the recently restructured MLA Northern Australia program.

The R&D priorities which have been distilled from the research and literature review, the interviews, and questionnaires received from researcher and client stakeholders, are listed below in tabular form with links to the RIRDC/JVAP R&D Plan 1999-2004 (1999).

Table 18 R&D priorities for agroforestry and farm forestry for northern Australia

Rank	R&D Subject & Topic	JVAP Strategy	Rationale for ranking
1	Financial viability of agroforestry projects.	5.3, 5.4	Primary need is to demonstrate a commercial return for the investment in agroforestry.
2	Additional market information for agroforestry products.	1.1, 1.2	Must identify a market for the crop.
3	Addressing cultural, legal and policy constraints to agroforestry.	1.3	Facilitate investment by landholders.
4	Increased links with research and extension activities.	6.1, 6.2	Get the best value for R&D already done.
5	Sustainable management of savanna woodland for commercial timber production.	5.2	Work with existing systems and landscapes
6	Define mechanisms by which trees in the landscape can be recognised and valued, and transacted between the community and the landholder.	2.2	Broaden the economic potential of agroforestry.
7	Spacing and species mix for multiple benefits.	5.1	Broaden the economic potential of agroforestry.
8	Agroforestry for protection of stock and crops.	3.1, 3.2	Broaden the economic potential of agroforestry.
9	Research into wood quality of the tropical timber species grown, and wood and milling properties of plantation grown hardwood species.	4.3	Ensure that the crop can meet market requirements.
10	Species and provenances for planting, and availability of seed and seedlings. Write up and widely publish the results of more than a decade of CRRP activities. The rescue of growth yield and wood quality information from trials established more than 30 years ago in the Northern Territory. Coordinated research into Sandalwood and other exotics as crop species.	4.1, 4.2	Plant the right species in the right way.
11	Silvicultural information on spacing and harvesting. Cost benefit analysis of silvicultural treatments such as pruning on log values and the use of small diameter timber from a wide range of species. Effective use of water in irrigation for establishment of tree woodlots in low rainfall areas across northern Australia.	4.4	Ensure the crop is grown to market specification.
12	Environmentally friendly termiticides in conjunction with cultural methods for use by growers in a range of environments.	4.5	Protect investment in the crop
13	Community participation and cost sharing for agroforestry projects.	1.5	Reduce cost inputs, broaden social benefits and have fun.

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Appendix A IBRA Regions of northern Australia

BBN Brigalow Belt North

Permian volcanics and Permian-Triassic sediments of the Bowen and Galilee Basins, Carboniferous and Devonian sediments and volcanics of the Drummond Basin and coastal blocks, Cambrian and Ordovician rocks of the Anakie inlier and associated Tertiary deposits. Subhumid to semiarid. Woodlands of ironbarks (*E. melanophloia*, *E. crebra*), poplar box and Brown's box (*E. populnea*, *E. brownii*) and brigalow (*Acacia harpophylla*), blackwood (*A. Argyrodendron*) and gidgee (*A. cambagei*). Region reaches the coast in the dry coastal corridor of Proserpine - Townsville.

BBS Brigalow Belt South

Predominantly Jurassic and younger deposits of the Great Artesian Basin and Tertiary deposits with elevated basalt flows. Subhumid. Eucalyptus woodlands and open forests of ironbarks, poplar box, spotted gum (*E. maculata*), cypress pine (*Callitris glaucophylla*), Bloodwoods (eg. *E. trachyphloia*, *E. hendersonii* ms) brigalow-belah forests (*E. harpophylla*, *Casuarina cristata*) and semi-evergreen vine thicket.

BRT Burt Plain

Plains and low rocky ranges of Pre-Cambrian granites with mulga and other acacia woodlands on red earths.

CA Central Arnhem

Gently sloping terrain and low hills on Cretaceous sandstones and siltstones and lateritised Tertiary material; yellow earthy sands and shallow stony sands; Darwin Woollybutt and Darwin Stringybark open forest to woodland with grass understorey.

CAR Carnarvon

Quaternary alluvial, aeolian and marine sediments overlying Cretaceous strata. A mosaic of saline alluvial plains with samphire and saltbush low shrublands, Bowgada low woodland on sandy ridges and plains, Snakewood scrubs on clay flats, and tree to shrub steppe over hummock grasslands on and between red sand dune fields. Limestone strata with *Acacia startii* / *bivenosa* shrublands outcrop in the north, where extensive tidal flats in sheltered embayments support Mangal. Arid

CHC Channel Country

Low hills on Cretaceous sediments; forbfields and Mitchell grass downs, and intervening braided river systems of coolibah *E. coolibah* woodlands and lignum/saltbush *Muehlenbeckia* sp./*Chenopodium* sp. shrublands. (Includes small areas of sand plains.)

CK Central Kimberley

Hilly to mountainous country with parallel siliceous ranges of Proterozoic sedimentary rocks with skeletal sandy soils supporting *Plectrachne pungens* hummock grasses with scattered trees, and with earths on Proterozoic volcanics in valleys supporting Ribbon Grass with scattered trees. Open forests of River Gum and Pandanus occur along drainage lines. Dry hot tropical, sub-humid to semi-arid, summer rainfall.

CMC Central Mackay Coast

Humid tropical coastal ranges and plains. Rainforests (complex evergreen and semi-deciduous notophyll vine forest), *Eucalyptus* open forests and woodlands, *Melaleuca* spp. wetlands.

CR Central Ranges

High proportion of Proterozoic ranges and derived soil plains, interspersed with red Quaternary sandplains. The sandplains support low open woodlands of either Desert Oak or Mulga over *Triodia basedowii* hummock grasslands. Low open woodlands of Ironwood (*Acacia estrophiolata*) and Corkwoods (*Hakea* spp.) over tussock and hummock grasses often fringe ranges. The ranges support mixed wattle scrub or *Callitris glaucophylla* woodlands over hummock and tussock grasslands. Arid, with summer and winter rain.

CYP Cape York Peninsula

Low hills and plains, tropical humid/maritime; *Eucalyptus* and *Melaleuca* woodlands,

DAB Daly Basin

Gently undulating plains and scattered low plateau remnants on Palaeozoic sandstones, siltstones and limestones; neutral loamy and sandy red earths; Darwin Stringybark and Darwin Woollybutt open forest with perennial and annual grass understorey.

DEU Desert Uplands

Ranges and plains on dissected Tertiary surface and Triassic sandstones; woodlands of *E.whitei*, *E.similis* and *E.trachyphloia*.

DL Dampierland

1. Quaternary sandplain overlying Jurassic and Mesozoic sandstones with Pindan. Hummock grasslands on hills.
2. Quaternary marine deposits on coastal plains, with Mangal, samphire - *Sporobolus* grasslands, *Melaleuca acacioides* low forests, and *Spinifex* - *Crotalaria* strand communities.
3. Quaternary alluvial plains associated with the Permian and Mesozoic sediments of Fitzroy Trough support tree savannas of *Crysopogon* - *Dichanthium* grasses with scattered *Eucalyptus microtheca* - *Lysiphyllum cunninghamii*. Riparian forests of River Gum and Cadjeput fringe drainages.
4. Devonian reef limestones in the north and east support sparse tree steppe over *Triodia intermedia* and *T. wiseana* hummock grasses.

Dry hot tropical, semi-arid summer rainfall.

EIU Einasleigh Uplands

High plateau of Palaeozoic sediments, granites, and basalts; dominated by ironbark (*Eucalyptus* spp) woodlands.

FIN Finke

Arid sandplains, dissected uplands and valleys formed from Pre-Cambrian volcanics with spinifex hummock grasslands and acacia shrublands on red earths and shallow sands

GAS Gascoyne

Rugged low Proterozoic sedimentary and granite ranges divided by broad flat valleys. Open mulga woodlands occur on shallow earthy loams over hardpan on the plains, with mulga scrub and *Eremophila* shrublands on the shallow stony loams of the ranges. The Carnegie Salient, in the east, is characterised by extensive salt lake features supporting succulent steppes. Arid.

GD Gibson Desert

Lateritised upland on flat-lying Jurassic and Cretaceous sandstones of Canning Basin. Mulga parkland over *Triodia basedowii* on lateritic "buckshot" plains. Mixed shrub steppe of *Acacia*, *Hakea* and *Grevillea* over *Triodia pungens* on red sand plains and dune fields. Lateritic uplands support shrub steppe in the north and mulga scrub in the south. Quaternary alluvia associated with palaeo-drainage features support Coolabah woodlands over bunch grasses. Arid, mainly summer rainfall.

GFU Gulf Fall Uplands

Undulating terrain with scattered low, steep hills on Proterozoic and Palaeozoic sedimentary rocks, often overlain by lateritised Tertiary material; skeletal soils and shallow sands; Darwin Boxwood and Variable-barked Bloodwood woodland to low open woodland with spinifex understorey.

GS Geraldton Sandplains

Mainly proteaceous scrub-heaths, rich in endemics, on the sandy earths of an extensive, undulating, lateritic sandplain mantling Permian to Cretaceous strata. Extensive York Gum and Jam woodlands occur on outwash plains associated drainage. Semi-arid (Dry) warm Mediterranean.

GSD Great Sandy Desert

Mainly tree steppe grading to shrub steppe in south; comprising open hummock grassland of *Triodia pungens* and *Plectrachne schinzii* with scattered trees of *Owenia reticulata* and Bloodwoods, and shrubs of *Acacia* spp, *Grevillea wickhamii* and *G. refracta*, on Quaternary red longitudinal sand dune fields overlying Jurassic and Cretaceous sandstones of the Canning and Armadeus Basins. *Casuarina decaisneana* (Desert Oak) occurs in the far east of the region. Gently undulating lateritised uplands support shrub steppe such as *Acacia pachycarpa* shrublands over *Triodia pungens* hummock grass. Calcrete and evaporite surfaces are associated with occluded palaeo-drainage systems that traverse the desert; these include extensive salt lake chains with samphire low shrublands, and *Melaleuca glomerata* - *M. lasiandra* shrublands. Monsoonal influences are apparent in the north-western sector of this region. Arid tropical with summer rain.

GUC Gulf Coastal

Gently undulating plains with scattered rugged areas on Proterozoic sandstones and Tertiary sediments; sandy red earths and shallow gravelly, sandy soils; Darwin Stringybark woodland with spinifex understorey.

GUP Gulf Plains

Marine and terrestrial deposits of the Carpentaria and Karumba basins; plains, plateaus and outwash plains; woodlands and grasslands.

GVD Great Victoria Desert

Arid active sand-ridge desert of deep Quaternary aeolian sands overlying Permian and Mesozoic strata of the Officer Basin. Tree steppe of *Eucalyptus gongylocarpa*, Mulga and *E. youngiana* over hummock grassland dominated by *Triodia basedowii*. Arid, with summer and winter rain.

LSD Little Sandy Desert

Red Quaternary dune fields with abrupt Proterozoic sandstone ranges of Bangemall Basin. Shrub steppe of acacias, *Thryptomene* and grevilleas over *Plectrachne schinzii* on sandy surfaces. Sparse shrub-steppe over *Triodia basedowii* on stony hills, with River Gum communities and bunch grasslands on alluvial deposits in and associated with ranges. Arid with summer rainfall.

MAC MacDonnell Ranges

High relief ranges and foothills covered with spinifex hummock grassland, sparse acacia shrublands and woodlands along watercourses.

MGD Mitchell Grass Downs

Undulating downs on shales and limestones; *Astrebla* spp. grasslands and *Acacia* low woodlands. Grey and brown cracking clays.

MII Mount Isa Inlier

Rugged hills and outwash, primarily associated with Proterozoic rocks; skeletal soils; low open eucalypt woodlands dominated by *Eucalyptus leucophloia* and *E. pruinosa*, with a *Triodia pungens* understorey. Semi-Arid.

ML Mulga Lands

Undulating plains and low hills on Cainozoic sediments; red earths and lithosols; *Acacia aneura* shrublands and low woodlands.

MUR Murchison

Mulga low woodlands, often rich in ephemerals, on outcrop and fine-textured Quaternary alluvial and eluvial surfaces mantling granitic and greenstone strata of the northern part of the Yilgarn Craton. Surfaces associated with the occluded drainage occur throughout with hummock grasslands on Quaternary sandplains, saltbush shrublands on calcareous soils and Halosarcia low shrublands on saline alluvia. Areas of red sandplains with mallee-mulga parkland over hummock grasslands occur in the east.

NK North Kimberley

Dissected plateau of Kimberley Basin. Savanna woodland of Woollybutt and Darwin Stringy bark over high Sorghum grasses and *Plectrachne schinzii* hummock grasses on shallow sandy soils on outcropping Proterozoic siliceous sandstone strata. Savanna woodlands on *Eucalyptus tectifica* - *E. grandiflora* alliance over high Sorghum grasses on red and yellow earths mantling basic Proterozoic volcanics. Riparian closed forests of paperbark trees and *Pandanus* occur along drainage lines. Extensive Mangal occurs in estuaries and sheltered embayments. Numerous small patches of monsoon rainforest are scattered through the district. Dry hot tropical, sub-humid, summer rainfall.

OVP Ord-Victoria Plains

Level to gently undulating plains with scattered hills on Cambrian volcanics and Proterozoic sedimentary rocks; vertosols on plains and predominantly skeletal soils on hills; grassland with scattered Bloodwood and Snappy Gum with spinifex and annual grasses. Dry hot tropical, semi-arid summer rainfall. The lithological mosaic has three main components:

1. Abrupt Proterozoic and Phanerozoic ranges and scattered hills mantled by shallow sand and loam soils supporting *Triodia* hummock grasslands with sparse low trees.
2. Cambrian volcanics and limestones form extensive plains with short grass (*Enneapogon* spp.) on dry calcareous soils and medium-height grassland communities (*Astrebla* and *Dichanthium*) on cracking clays. Riparian forests of River Gums fringe drainage lines.
3. In the south-west, Phanerozoic strata expressed as often lateritised upland sandplains with sparse trees. This component recurs as the Sturt Plateau Region in central Northern Territory.

PCA Pine Creek- Arnhem

1. PCK Pine Creek: Hilly to rugged terrain on Proterozoic sandstones and siltstones; skeletal soils and shallow, silty profiles; Darwin Boxwood and Round-leaved Bloodwood woodland with sorghum understorey.
2. ARP Arnhem Plateau: Rugged dissected terrain and plateaux on Proterozoic sandstones; skeletal soils and rock outcrop; variable-barked Bloodwood and Darwin Woollybutt low open forest to woodland with spinifex understorey.

PIL Pilbara

There are four major components to the Pilbara Craton.

1. Hamersley. Mountainous area of Proterozoic sedimentary ranges and plateaux with Mulga low woodland over bunch grasses on fine textured soils and Snappy Gum over *Triodia brizoides* on skeletal sandy soils of the ranges.
2. The Fortescue Plains. Alluvial plains and river frontages. Salt marsh, mulga-bunch grass, and short grass communities on alluvial plains. River Gum woodlands fringe the drainage lines. This is the northern limit of Mulga (*Acacia aneura*).
3. Chichester. Archaean granite and basalt plains supporting shrub steppe characterised by *Acacia pyrifolia* over *Triodia pungens* hummock grasses. Snappy Gum tree steppes occur on ranges.
4. Roebourne. Quaternary alluvial plains with a grass savanna of mixed bunch and hummock grasses, and dwarf shrub steppe of *Acacia translucens* over *Triodia pungens*. Samphire, *Sporobolus* and Mangal occur on marine alluvial flats. Arid tropical with summer rain.

SEQ South East Queensland

Metamorphic and acid to basic volcanic hills and ranges (Beenleigh, D'Aguilar, Gympie, Yarraman Blocks) sediments of the Moreton, Nambour and Maryborough Basins, extensive alluvial valleys and Quaternary coastal deposits including high dunes. Humid. Eucalyptus-Lophostemon-Syncarpia tall open forests, Eucalyptus open forests and woodlands, rainforests often with *Araucaria cunninghamii* emergents (complex notophyll and microphyll), *Melaleuca quinquenervia* wetlands and Banksia low woodlands and heaths.

SEH South Eastern Highlands

Steep dissected and rugged ranges extending across southern and eastern Victoria and southern NSW. Geology predominantly Palaeozoic rocks and Mesozoic rocks. Vegetation predominantly wet and dry sclerophyll forests, woodland, minor cool temperate rainforest and minor grassland and herbaceous communities.

SSD Simpson - Strzelecki Dunefields

Arid dunefields and sandplains with sparse shrubland and spinifex hummock grassland, and cane grass on deep sands along dune crests

STP Stony Plains

Arid stony silcrete tablelands and gibber and gypsum plains with sparse low chenopod shrublands on duplex soils and calcareous earths

STU Sturt Plateau

Gently undulating plains on lateritised Cretaceous sandstones; neutral sandy red and yellow earths; variable-barked Bloodwood woodland with spinifex understorey.

TAN Tanami Desert

Mainly red Quaternary sandplains overlying Permian and Proterozoic strata which are exposed locally as hills and ranges. The sandplains support mixed shrub steppes of *Hakea suberea*, desert bloodwoods, acacias and grevilleas over *Triodia pungens* hummock grasslands. Wattle scrub over *T. pungens* hummock grass communities occur on the ranges. Alluvial and lacustrine calcareous deposits occur throughout. In the north they are associated with Sturt Creek drainage, and support *Crysopogon* and *Iseilema* short-grasslands often as savannas with River Gum. Arid tropical with summer rain.

TEC Top End Coastal

1. ARC Arnhem Coast: Gently undulating plains and low plateaux on lateritised Cretaceous sandstones and siltstones; sandy red and yellow earths and siliceous sands; Darwin Woollybutt/Darwin Stringybark open forest with sorghum understorey.
2. DAC Darwin Coastal: Gently undulating plains on lateritised Cretaceous sandstones and siltstones; sandy and loamy red and yellow earths and siliceous sands; Darwin Woollybutt/Darwin Stringybark open forest with sorghum understorey, and flood plains on recent alluvium; vertosols, sedgeland and grassland.
3. TIW Tiwi-Cobourg: Gently sloping terrain on lateritised Cretaceous sandstones and siltstones; sandy and loamy red and yellow earths and siliceous sands; Darwin Woollybutt/Darwin Stringybark/Melville Island Bloodwood open forest with sorghum understorey.

VB Victoria Bonaparte

Phanerozoic strata of the Bonaparte Basin in the north-western part are mantled by Quaternary marine sediments supporting Samphire - *Sporobolus* grasslands and mangal, and by red earth plains and black soil plains with an open savanna of high grasses. Plateaux and abrupt ranges of Proterozoic sandstone, known as the Victoria Plateau, occur in the south and east, and are partially mantled by skeletal sandy soils with low tree savannas and hummock grasslands. In the south east are limited areas of gently undulating terrain on a variety of sedimentary rocks supporting low Snappy Gum over hummock grasslands and also of gently sloping floodplains supporting *Melaleuca minutifolia* low woodland over annual sorghums. Dry hot tropical, semi-arid summer rainfall.

WT Wet Tropics

Tropical wet coastal ranges and plains; rainforest and forests.

YAL Yalgoo

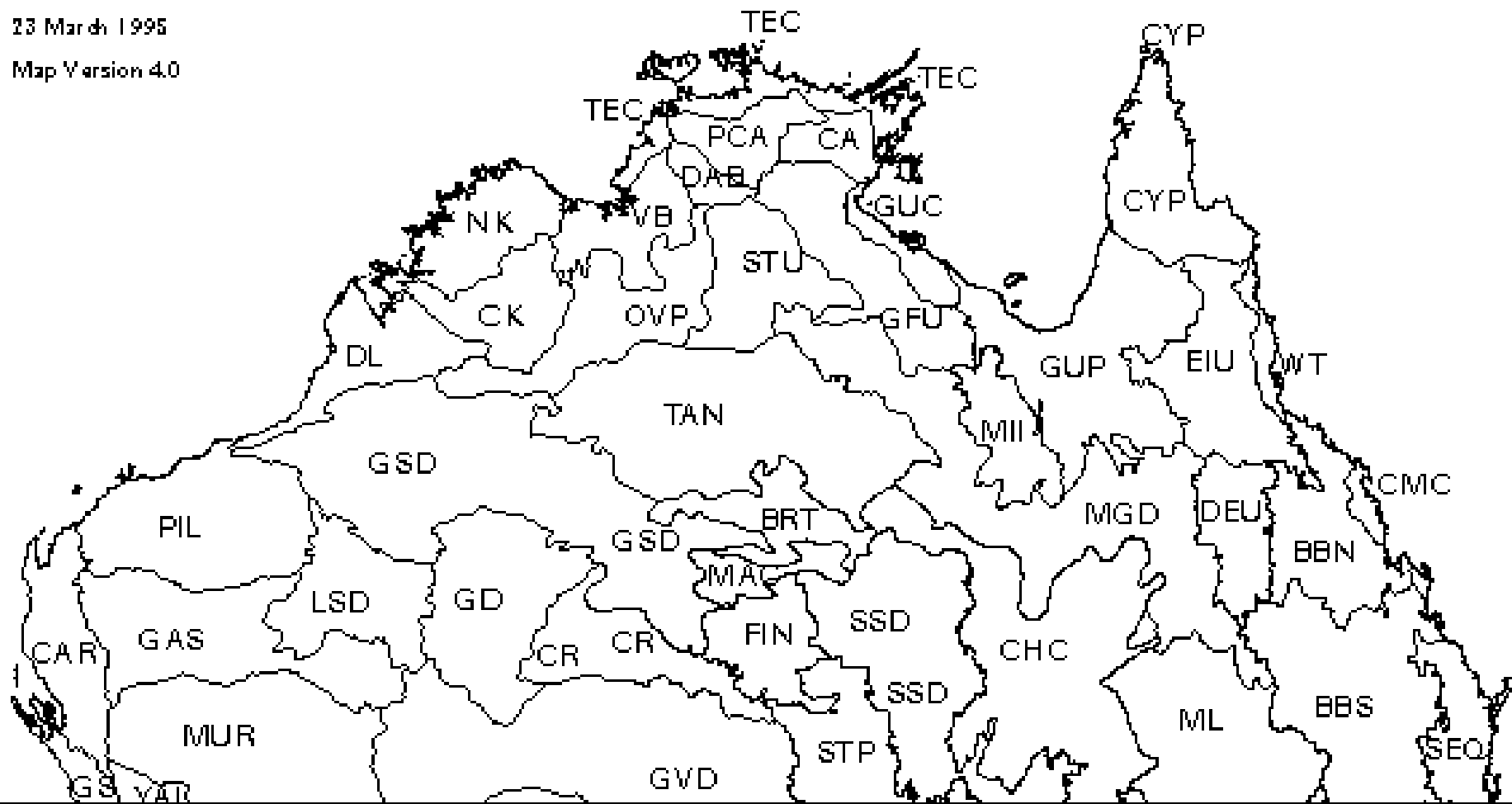
Mulga, *Callitris-E. salubris*, and Bowgada open woodlands and scrubs on earth to sandy-earth plains in the western Yilgarn Craton. Rich in ephemerals. This is an inter-zone. Arid to semi-arid warm Mediterranean.

Boundaries of IBRA Regions

Australian Nature Conservation Agency

23 March 1995

Map Version 4.0



Appendix B Contributing individuals

Individual	Affiliation	Location
Nancy Gannaway	Agriculture WA	Geraldton WA
Roderick O'Connor	Agriculture WA	Geraldton WA
Richard Aspinall	ATSIC	Cairns QLD
Rosemary Kenny	Baffle Creek Catchment Management Group	Agnes Water QLD
Gabi Bloecker	Bothkamp Aust. P/L	Kununurra WA
Bruce Lord	Brisbane Valley - Kilcoy Landcare Group	Linville QLD
Andrew Brodie	BSES	Tully QLD
Brendan Dyer	BSES	Tully QLD
Leonard Usher	Burnett Catchment Care (East)	Gin Gin QLD
Tim McGaffry	Bushfire Council NT	Noonawah NT
Chris Done	CALM	Kununurra WA
John Bartle	CALM	Perth WA
John McGrath	CALM	Bentley, WA
Tarnya Vernes	CALM	Kununurra WA
Jason Aridis	Cardwell Shire Catchment Resource Centre	Inisfail QLD
Diane Walker	Charters Towers Forest Growers	Charters Towers QLD
Raymond J Jones	CSIRO Davies Laboratory	Aitkenvale QLD
Tim Vercoe	CSIRO Forestry & Forest Products	Canberra ACT
Mike Webb	CSIRO Land and Water	Aitkenvale QLD
Dan Walker	CSIRO Sustainable Ecosystems	Townsville QLD
Stephen Tapsall	CSIRO Sustainable Ecosystems	Townsville QLD
Paul Reddell	CSIRO Tropical Forest Research Centre	Atherton QLD
Maire Vitelli	Dalrymple Landcare Committee	Charters Towers QLD
Beverly Herry	DNRM	Brisbane QLD
Chris Chilcott	DNRM	Toowoomba QLD
Grant Stone	DNRM	Brisbane QLD
Greg McKeon	DNRM	Brisbane QLD
John Carter	DNRM	Brisbane QLD
Peter Voller	DNRM	Dalby QLD
Simon O'Donnell	DNRM	South Johnstone QLD
Harry Bishop	DPI	Mackay QLD
Mike Shaw	DPI - Forest Industry Development Group	Brisbane QLD
Peter Byrne	DPI - Forest Industry Development Group	Brisbane QLD
Joe Baker	DPI Office of Chief Scientist	Brisbane QLD
Beau Robertson	DPI-F	Darwin NT

Bruce Sawyer	DPI-F	Darwin NT
Don Reilly	DPI-F	Darwin NT
Grant Flanagan	DPI-F	Darwin NT
Kurt Neitzel	DPI-F	Darwin NT
Neil Halpin	DPI-F	Beerburum QLD
Rohan Allen	DPI-F	Mackay QLD
Peter Brocklehurst	DPLE	Darwin NT
Michael Bent	Fitzroy Basin Association	Rockhampton QLD
Eric Pearson	Forest Farmers Association Qld Inc	Brisbane QLD
Andrew Radomiljac	Forest Rewards Ltd	Perth WA
Ian Scott	FPC	Perth WA
Michael Buckton	FPC	Perth WA
Peter Jones	FPC	Perth WA
Shane Baker	FPC	Perth WA
Mike Clark	GA	Darwin NT
Margaret Streamer	Herbert River Catchment Group	Ingham QLD
Tony Jack	Integrated Tree Cropping Ltd	Perth WA
Bob Congdon	James Cook University	Townsville QLD
Chris Gardiner	James Cook University	Townsville QLD
Heath Anderson	James Cook University	Townsville QLD
Joe Holtum	James Cook University	Townsville QLD
Mike Webb	James Cook University	Townsville QLD
Jeff Gooding	Kimberley Development Commission	Kununurra WA
Alf Salzqebo	Land Holder	Daly River NT
Barbara Hunt	Land holder	Kununurra WA
David Matthews	Land Holder	Kilcoy QLD
Garry Linden	Land holder	Katherine NT
Henry Van Tilburg	Land Holder	Adelaide River, NT
Ian & Miriam Golding	Land holder	Katherine NT
Jim Stuart	Land Holder	Howard Springs NT
John DeKoning	Land holder	Katherine NT
John Eccles	Land holder	Darwin NT
Les & Cyndy Pleitner	Land Holder	Dundel Beach NT
Maree Davis	Land Holder	Humpty Doo NT
Murray Longmore	Land holder	Darwin NT
Paul Mock	Land holder	Kununurra WA
Philip Brooks	Land Holder	Humpty Doo NT
Richard Lethbridge	Land holder	Kununurra WA
Tim Sullivan	Land Holder	Winnellie NT

Peter Brocklehurst	Lands, Planning and Environment	Palmerston NT
Sally Jacka	Litchfield Shire Council	Humpty Doo NT
R V Byrnes	Malanda & Johnstone Catchment Landcare Assn	Yangaluma QLD
	Mary River Catchment Co-ordinating Committee	Maryborough QLD
John Hoggard	Mary River Sawmill	Pine Creek
Judy Lambert	MLA	Fairlight NSW
William Goodwin	N.T. Forestry and Timber Products Network	Nightcliff NT
Graham Cossins	North Queensland Timber Co-Operative Ltd	Edge Hill QLD
Noeline Gross	Northern Gulf Resource Management Group	Georgetown QLD
Christine Hird	NQA	Cairns QLD
Garry Sexton	NQA	Cairns QLD
QLD John Carrol	NQA	Cairns QLD
Rod Collins	NQA	Townsville QLD
Sue Vize	NQA	Cairns QLD
Graham Cousins	NQTC	Cairns QLD
Max Bryant	NQTC	Cairns QLD
J R King	NT Forestry and Timber Products Network	Katherine NT
Jim Hughes	Ord River District Co-Operative Ltd	Kununurra WA
Robert Boshammer	Plantation Management Services	Kununurra WA
Lincoln Hedding	Plantation manager	Kununurra WA
Daryl Killin	Private Forestry North Queensland	Kairi QLD
Alison Gardner	QFRI	Brisbane QLD
Amana Yates	QFRI	Brisbane QLD
David Lee	QFRI	Gympie QLD
John Simpson	QFRI	Gympie QLD
Judy King	QFRI	Brisbane QLD
Mark Annandale	QFRI	Atherton QLD
Mark Hunt	QFRI	Gympie QLD
Mark Lewty	QFRI	Brisbane QLD
Michael Robinson	QFRI	Brisbane QLD
Mila Bristow	QFRI	Atherton QLD
Rosemary Lott	QFRI	Gympie QLD
Russ Haines	QFRI	Brisbane QLD
EJ Rider	QP&WS	Gympie QLD
Jane Blackwood	QPWS/DPI	Kairi QLD
Laurie Capill	SQFFDA	Brisbane QLD
Heather Smith	Taroom Shire Landcare Group Inc	Wandoan QLD
Dnie Nott	The Caves Landcare Assoc. Inc.	Rockhampton QLD
Arwen Rickert	Townsville Landcare Assn Inc	Townsville QLD

Judy Atkinson	TREM	Cairns QLD
Nigel Stork	TREM	Cairns QLD
Dino Deblasi	Tropical Forest Nurseries	Kununurra WA
Michael Pry	Tropical Forestry Services Ltd	Perth WA
John Childs	TSCRC	Darwin NT
David Lamb	UQ	Brisbane QLD
John Herbohn	UQ	Gatton QLD
Steve Harrison	UQ	Gatton QLD
Rick Hodel	Warroo Balonne Region Landcare Group	Surat QLD
Garry Lioden	Wilden Hardwoods	Katherine NT
Glen Rivers	Yates Forestry Limited	Perth WA

Appendix C Client and Researcher Questionnaires

CLIENT STAKEHOLDER QUESTIONNAIRE

The objective of this questionnaire is to find out from R&D client stakeholders, those who receive research results and benefit from R&D effort, the potential for agroforestry in their region. The questionnaire asks how additional information on agroforestry issues would assist in the development of agroforestry systems in their region. The outcome from this questionnaire will be the identification of R&D effort in target areas of northern Australia, and the prioritisation of R&D effort.

Agroforestry systems can be defined as the management of trees and shrubs integrated with agricultural systems for multiple products and benefits.

Please assist us by completing the questions below by ticking the appropriate box for your situation. Please then return the questionnaire **by 6th April 2001** to:
"JVAP Questionnaire" c/o Greenfield Resource Options Pty Ltd, PO Box 1957 Milton, Queensland 4064

Please provide some background information on agroforestry in your region

-
1. Please state the regional code(s) for your area from the map provided

Regional code:

-
2. Organisation represented by you, your name and methods of contact.

Name:

Organisation:

Mail:

Phone:

Fax:

Email:

3. Describe the type of group and membership represented by you.

Type of group; please tick box:

- | | |
|---------------------------------|---|
| Individual land owner | ☐ |
| Landcare group, catchment group | ☐ |
| Farmer organisation | ☐ |
| Forest grower group | ☐ |
| Regional Plantation Committee | ☐ |
| Aboriginal organisation | ☐ |
| Government agency | ☐ |
| Other | ☐ Please define: |

CLIENT STAKEHOLDER QUESTIONNAIRE

4. Please provide a brief description of the main farming activities in your regions.

5. Indicate below the types of products and benefits from **current activities** in agroforestry (if any) in your region, by ticking one or more box below.

6. Indicate below which agroforestry products and benefits present **opportunities** to increase the commercial returns from managed land in your region, by ticking one or more boxes below.

Please tick the appropriate boxes:

Agroforestry products and benefits	Current activities	Opportunities
Timber for roundwood (posts and poles)	☐	☐
Timber for sawing into boards	☐	☐
Timber for craft purposes	☐	☐
Fodder, shade and shelter for crops and stock	☐	☐
Protection of water	☐	☐
Soil protection	☐	☐
Soil improvement	☐	☐
Salinity control	☐	☐
Conservation of biodiversity	☐	☐
Biofuel	☐	☐
Firewood	☐	☐
Carbon capture for carbon credits	☐	☐
Food (bush tucker)	☐	☐
Fruit cropping	☐	☐
Pharmaceuticals	☐	☐
Extractives (tannins, essential oils)	☐	☐
Other	☐ Please define:	

CLIENT STAKEHOLDER QUESTIONNAIRE

7. Please indicate by ticking a box below the extent to which agroforestry is practiced by land owners in your region. Widely practiced would indicate that almost all land owners in your region had some form of agroforestry activity whereby they actively manage trees on the farm for overall commercial benefit. Moderately practiced would indicate that about half of the land owners in your region practiced some form of agroforestry.

Not practiced

☐

Moderately practiced

☐☐☐

Widely practiced

☐

*For the agroforestry products which present commercial **opportunities**, please indicate how **additional information** (if any) would assist those systems from being implemented. Please **rank the level of assistance** additional information would have on the development of agroforestry systems from **not assist** to **strongly assist**.*

8. Would more information on markets and their development for agroforestry products, both wood and non-wood based, assist growing these products?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

9. Are there existing cultural, legislative, policy or legal constraints to the development of agroforestry systems in your region?

No

☐

Yes

☐

If YES, please identify briefly:

If YES: how strongly would removal of existing cultural, legislative, policy or legal constraints assist the development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

10. Are there existing constraints to community participation and for sharing of costs and resources at a regional level?

No

☐

Yes

☐

If YES, please identify briefly:

How strongly would development of mechanisms for community participation and for sharing of costs and resources at a regional level, assist the development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

11. How strongly would more information on the influence of trees on water movement in the landscape assist the development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

CLIENT STAKEHOLDER QUESTIONNAIRE

12. How strongly would more information on the influence of trees on control of salinity assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

13. How strongly would more information on the contribution of agroforestry systems to biodiversity and nature conservation assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

14. How strongly would more information on the capacity of trees to capture carbon and information on carbon credits assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

15. How strongly would more information on the influence of soil properties on tree growth assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

16. How strongly would more information on the role of trees in protecting stock, crops and pastures and improving farm productivity assist development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

17. How strongly would more information on which genetic material (species and provenance or source of seed) to plant for which commercial purpose in your region assist development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

18. Is the availability of seed and seedlings an impediment to the development of agroforestry systems in your region?

No	Yes
☐	☐

If YES, please identify briefly:

If YES, how strongly would greater availability of seed and seedlings assist development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

CLIENT STAKEHOLDER QUESTIONNAIRE

19. How strongly would more information on wood processing technologies for small woodlots, and on-farm processing assist agroforestry development?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

20. How strongly would more information on cost effective management of trees in agroforestry systems, including requirements for soil cultivation, weed control and fertilisers, assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

21. How strongly would more information on initial spacing, pruning, thinning and harvesting trees and tree products from small woodlots assist development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

22. How strongly would more information on threats from and control of insects and other pests in agroforestry assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

23. How strongly would more information on the management of weeds in agroforestry systems assist the development of these systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

24. How strongly would more information on the threat of high winds and information on how to manage wind in agroforestry systems assist the development of these systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

25. How strongly would more information on the design options for multiple benefits of agroforestry systems (placement, species mix and spacing in the landscape) together with grazing and cropping systems assist development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

CLIENT STAKEHOLDER QUESTIONNAIRE

26. How strongly would more information on how to sustainably manage native forests on farmland for both commercial use and the protection of biodiversity and natural resources assist the sustainable management of this resource?

Not assist

Moderately assist

Strongly assist

☐☐☐☐☐

27. How strongly would more information on methods to quantify the financial and economic viability of agroforestry options assist development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

☐☐☐☐☐

28. How strongly would more information on methods to quantify threats to the financial and economic viability of agroforestry options assist development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

☐☐☐☐☐

29. How strongly would more frequent and useful information from research groups, and links with research information through extension activities assist agroforestry development?

Not assist

Moderately assist

Strongly assist

☐☐☐☐☐

30. We would like you to add any other information and express your views about the potential for agroforestry in your region, and the priorities for R&D and information to assist this.

RESEARCH STAKEHOLDER QUESTIONNAIRE

The objective of this questionnaire is to find out from R&D research stakeholders (ie those who provide R&D effort and research results), their perceptions of the potential for agroforestry in the regions in which they work. The questionnaire asks how additional information on agroforestry issues would assist in the development of agroforestry systems in their region. The outcome from this questionnaire will be the identification of R&D effort in target areas of northern Australia, and the prioritisation of R&D effort.

Agroforestry systems can be defined as the management of trees and shrubs integrated with agricultural systems for multiple products and benefits.

Please assist us by completing the questions below by ticking the appropriate box for your situation. Please then return the questionnaire **by 6th April 2001** to:

"JVAP Questionnaire" c/. Greenfield Resource Options Pty Ltd, PO Box 1957 Milton, Queensland 4064

Please provide some background information on your research area

1. Please state the regional code(s) for the areas covered by your research from the map provided

Regional code(s):

2. Organisation represented by you, your name and methods of contact.

Name:

Organisation:

Mail:

Phone:

Fax:

Email:

3. Describe the type of research group represented by you.

Type of research group; please tick more than one box if needed:

- | | |
|-----------------------------|---|
| University | ☐ |
| CSIRO | ☐ |
| Cooperative Research Centre | ☐ |
| State Government agency | ☐ |
| Federal Government agency | ☐ |
| Grower cooperative | ☐ |
| Private sector | ☐ |
| Other | ☐ Please define: |

RESEARCH STAKEHOLDER QUESTIONNAIRE

4. Please indicate your research area.

Please tick the appropriate boxes:

Agroforestry research area

Multi purpose timber production ☐

Timber processing ☐

Integration of trees & farming systems ☐

Hydrology ☐

Soil research ☐

Salinity research ☐

Conservation and biodiversity ☐

Carbon capture for carbon credits ☐

Food and fruit production ☐

Pharmaceuticals & extractives ☐

Farm and agroforestry economics ☐

Other ☐

Please define:

RESEARCH STAKEHOLDER QUESTIONNAIRE

5. Indicate below the types of products and benefits from **current activities** in agroforestry (if any) in your regions, by ticking one or more box below.
6. Indicate below which agroforestry products and benefits present **opportunities** to increase the commercial returns from managed land in your regions, by ticking one or more boxes below.

Please tick the appropriate boxes:

Agroforestry products and benefits	Current activities	Opportunities
Timber for roundwood (posts and poles)	☐	☐
Timber for sawing into boards	☐	☐
Timber for craft purposes	☐	☐
Fodder, shade and shelter for crops and stock	☐	☐
Protection of water	☐	☐
Soil protection	☐	☐
Soil improvement	☐	☐
Salinity control	☐	☐
Conservation of biodiversity	☐	☐
Biofuel	☐	☐
Firewood	☐	☐
Carbon capture for carbon credits	☐	☐
Food (bush tucker)	☐	☐
Fruit cropping	☐	☐
Pharmaceuticals	☐	☐
Extractives (tannins, essential oils)	☐	☐
Other. Please define:	☐	☐

RESEARCH STAKEHOLDER QUESTIONNAIRE

7. Please indicate by ticking a box below the extent to which agroforestry is practiced by land owners in the regions in which you carry out research. Widely practiced would indicate that almost all land owners in your region had some form of agroforestry activity whereby they actively manage trees on the farm for overall commercial benefit. Moderately practiced would indicate that about half of the land owners in your region practiced some form of agroforestry.

Region	Not practiced		Moderately practiced		Widely practiced
☐	☐	☐	☐	☐	☐
Region	Not practiced		Moderately practiced		Widely practiced
☐	☐	☐	☐	☐	☐
Region	Not practiced		Moderately practiced		Widely practiced
☐	☐	☐	☐	☐	☐
Region	Not practiced		Moderately practiced		Widely practiced
☐	☐	☐	☐	☐	☐

*For the agroforestry products which present commercial **opportunities**, please indicate how **additional information** (if any) which would assist those systems from being implemented. Please **rank the level of assistance** additional information would have on the development of agroforestry systems from **not assist** to **strongly assist**.*

8. Would more information on markets and their development for agroforestry products, both wood and non-wood based, assist growing these products?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

9. Are there existing cultural, legislative, policy or legal constraints to the development of agroforestry systems in your region?

No	Yes
☐	☐

If YES, please identify briefly:

If YES: how strongly would removal of existing cultural, legislative, policy or legal constraints assist the development of agroforestry systems?

Not assist		Moderately assist		Strongly assist
☐	☐	☐	☐	☐

RESEARCH STAKEHOLDER QUESTIONNAIRE

10. Are there existing constraints to community participation and for sharing of costs and resources at a regional level?

No

Yes

☐
☐

If YES, please identify briefly:

How strongly would development of mechanisms for community participation and for sharing of costs and resources at a regional level, assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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11. How strongly would more information on the influence of trees on water movement in the landscape assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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12. How strongly would more information on the influence of trees on control of salinity assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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13. How strongly would more information on the contribution of agroforestry systems to biodiversity and nature conservation assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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14. How strongly would more information on the capacity of trees to capture carbon and information on carbon credits assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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15. How strongly would more information on the influence of soil properties on tree growth assist the development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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Not assist

Moderately assist

Strongly assist

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RESEARCH STAKEHOLDER QUESTIONNAIRE

17. How strongly would more information on which genetic material (species and provenance or source of seed) to plant for which commercial purpose in your region assist development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

18. Is the availability of seed and seedlings an impediment to the development of agroforestry systems in your region?

No

☐

Yes

☐

If YES, please identify briefly:

If YES, how strongly would greater availability of seed and seedlings assist development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

19. How strongly would more information on wood processing technologies for small woodlots, and on-farm processing assist agroforestry development?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

20. How strongly would more information on cost effective management of trees in agroforestry systems, including requirements for soil cultivation, weed control and fertilisers, assist the development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

21. How strongly would more information on initial spacing, pruning, thinning and harvesting trees and tree products from small woodlots assist development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

22. How strongly would more information on threats from and control of insects and other pests in agroforestry assist the development of agroforestry systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

23. How strongly would more information on the management of weeds in agroforestry systems assist the development of these systems?

Not assist

☐☐

Moderately assist

☐☐

Strongly assist

☐

RESEARCH STAKEHOLDER QUESTIONNAIRE

24. How strongly would more information on the threat of high winds and information on how to manage wind in agroforestry systems assist the development of these systems?

Not assist

Moderately assist

Strongly assist

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25. How strongly would more information on the design options for multiple benefits of agroforestry systems (placement, species mix and spacing in the landscape) together with grazing and cropping systems assist development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

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26. How strongly would more information on how to sustainably manage native forests on farmland for both commercial use and the protection of biodiversity and natural resources assist the sustainable management of this resource?

Not assist

Moderately assist

Strongly assist

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27. How strongly would more information on methods to quantify the financial and economic viability of agroforestry options assist development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

☐
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☐

28. How strongly would more information on methods to quantify threats to the financial and economic viability of agroforestry options assist development of agroforestry systems?

Not assist

Moderately assist

Strongly assist

☐
☐
☐
☐
☐

29. How strongly would more frequent and useful information from research groups, and links with research information through extension activities assist agroforestry development?

Not assist

Moderately assist

Strongly assist

☐
☐
☐
☐
☐

30. We would like you to add any other information and express your views about the priorities for R&D for agroforestry in your regions or your research area.
